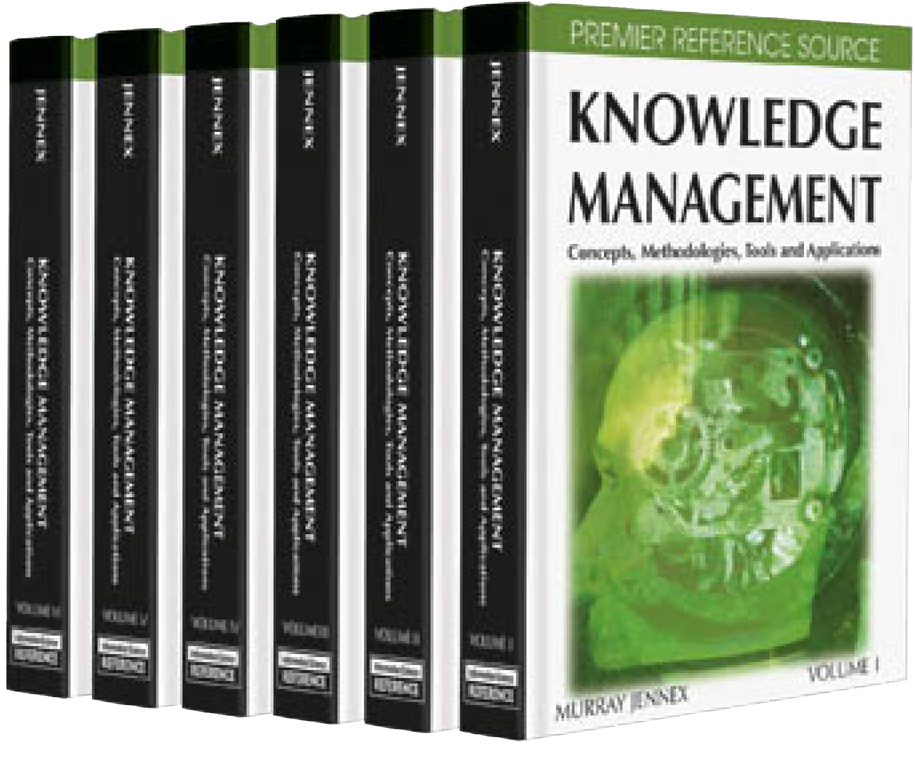
PREMIER REFERENCE SOURCE
KNOWLEDGE MANAGEMENT
Concepts, Methodologies, Tools and Applications
VOLUME I
MURRAY JENNEX

Knowledge Management:
Concepts, Methodologies, Tools, and Applications

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List of Contributors

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by Volume

VOLUME I

Section 1: Fundamental Concepts and Theories in Knowledge Management

This section serves as a foundation for this exhaustive reference tool by addressing crucial theories essential to the understanding of knowledge management. Research found in this section provides an excellent framework in which to position knowledge management within the field of information science and technology. Excellent insight into the critical incorporation of learning systems into global enterprises is offered, while basic, yet crucial stumbling blocks of information management are explored. With 43 chapters comprising this foundational section, the reader can learn and chose from a compendium of expert research on the elemental theories underscoring knowledge management discipline.

Section 2: Knowledge Management Development and Design Methodologies

This section provides in-depth coverage of conceptual architectures and knowledge management frameworks to provide the reader with a comprehensive understanding of the emerging technological developments within the field of knowledge management while offering research fundamentals imperative to the *understanding of research processes within the knowledge management discipline. On a more global scale, many chapters explore cultural and infrastructural issues related to the management of knowledge in developing countries. From basic designs to abstract developments, this section serves to expand the reaches of development and design technologies within the knowledge management community. Included in this section are 45 contributions from researchers throughout the world on the topic of information development and knowledge sharing within the information science and technology field.*

VOLUME II

Section 3: Knowledge Management: Tools and Technologies

This section presents extensive coverage of various tools and technologies available in the field of knowledge management that practitioners and academicians alike can utilize to develop different techniques. Readers are enlightened about fundamental research on one of the many methods used to facilitate and enhance the knowledge sharing experience while exploring the intrinsic value of technology and knowledge management. It is through these rigorously researched chapters that the reader is provided with countless examples of the up-and-coming tools and technologies emerging from the field of knowledge management. With more 28 chapters, this section offers a broad treatment of some of the many tools and technologies within the knowledge management community.

Section 4: Utilization and Application of Knowledge Management

This section discusses a variety of applications and opportunities available that can be considered by practitioners in developing viable and effective knowledge management programs and processes. This section includes more than 50 chapters, some of which review knowledge management literature published in top-tier journals, offering findings on the most popular trends researched within the academic community. Other chapters discuss the utilization of knowledge management within the governmental realm. Also considered in this section are the challenges faced when utilizing knowledge management with healthcare systems. The adaptability of governmental agencies in response to disasters is given consideration as well through research which investigates major hurdles faced in knowledge sharing in the face of disasters, spanning the globe. Contributions included in this section provide excellent coverage of today's global community and how knowledge management research is impacting the social fabric of our present-day global village.

VOLUME IV

VOLUME V

Section 6: Managerial Impact of Knowledge Management

This section presents contemporary coverage of the social implications of knowledge management, more specifically related to the corporate and managerial utilization of information sharing technologies and applications, and how these technologies can be facilitated within organizations. Core ideas such as training and continuing education of human resources in modern organizations are discussed through these more than 35 chapters. Also discussed is strategic planning related to the organizational elements and knowledge sharing program requirements that are necessary to build a framework in order to institutionalize and sustain knowledge management systems as a core business process. Equally as crucial, are the chapters which address the gap between theory and practical implementation within the knowledge sharing community. Directing the reader's focus forward, the final chapters found within this section help to establish a basis for assessing the value of knowledge management while evaluating its results within business enterprises.

VOLUME VI

Section 7: Critical Issues in Knowledge Management

This section contains 25 chapters addressing issues such as intellectual capital and knowledge management, communities of practice and critical social theory and ontology-supported web service composition. Within the chapters, the reader is presented with an in-depth analysis of the most current and relevant issues within this growing field of study while developing an excellent model for researchers and practitioners as attempts are made to simultaneously ease and expedite the transfer of knowledge from the private to the public sector. Forming frameworks in which to position the issues faced in this growing field are provided by research found in chapters that take the core psychological paradigms of sociology and translate them into applicable ideas within the exploding realm of information sharing. Crucial examinations serve to reinforce the ideas presented in this section while simultaneously enticing and inspiring the reader to research further and participate in this increasingly pertinent debate.

Section 8: Emerging Trends in Knowledge Management

This section highlights research potential within the field of knowledge management while exploring uncharted areas of study for the advancement of the discipline. Introducing this section is research that sets the stage for future research directions and topical suggestions for continued debate. Providing an alternative view of knowledge management are chapters that research the cultural dimension of knowledge management systems, particularly the relationship of learning and culture in knowledge management projects. The inevitable increase in complexity and quantity of the information that is available for students is also considered in this final section. Found in these 21 chapters concluding this exhaustive multi-volume set are areas of emerging trends and suggestions for future research within this rapidly expanding discipline.

Preface

Emphasis on knowledge and information is one of the key factors that differentiate the intelligent business enterprise of the 21st century. In order to harness knowledge and information to improve effectiveness, enterprises of the new millennium must capture, manage, and utilize information with rapid speed in an effort to keep pace with the continually changing technology. Knowledge management is an important means by which organizations can better manage information and, more importantly, knowledge. Not easily defined, knowledge management embodies a plethora of categories within the field of information science and technology.

Over the past two decades, numerous researchers have developed a variety of techniques, methodologies, and measurement tools that have allowed them to develop, deliver, and, at the same time, evaluate the effectiveness of several areas of knowledge management. The explosion of these technologies and methodologies have created an abundance of new, state-of-art literature related to all aspects of this expanding discipline, allowing researchers and practicing educators to learn about the latest discoveries in the field of knowledge management.

Rapid technological changes, combined with much greater interest in discovering innovative techniques to manage knowledge in today's modern organizations, have led researchers and practioners to continually search for literature that will help them stay abreast of the far-reaching effects of these changes, as well as to help develop and deliver more innovative methodologies and techniques utilizing new technological innovation. In order to provide the most comprehensive, in-depth, and recent coverage of all issues related to knowledge management, as well as to offer a single reference source on all conceptual, methodological, technical, and managerial issues, as well as the opportunities, future challenges, and emerging trends related to this subject, *Information Science Reference* is pleased to offer a six-volume reference collection on this rapidly growing discipline, in order to empower students, researchers, academicians, and practitioners with a comprehensive understanding of the most critical areas within this field of study.

This collection, entitled *Knowledge Management: Concepts, Methodologies, Tools, and Applications*, is organized in eight distinct sections, providing the most wide-ranging coverage of topics such as: (1) Fundamental Concepts and Theories; (2) Development and Design Methodologies; (3) Tools and Technologies; (4) Utilization and Application; (5) Organizational and Social Implications; (6) Managerial Impact; (7) Critical Issues; and (8) Emerging Trends. The following provides a summary of what is covered in each section of this multi-volume reference collection:

Section 1, ***Fundamental Concepts and Theories***, serves as a foundation for this exhaustive reference tool by addressing crucial theories essential to the understanding of knowledge management. Chapters such as, "Knowledge Management Success Models" by Murray E. Jennex, as well as, "Knowledge Synthesis Framework" by Kam Hou Vat provide an excellent framework in which to position knowledge management within the field of information science and technology. "Beyond Knowledge Management:

Introducing Learning Management Systems" by Audrey Grace and Tom Butler offers excellent insight into the critical incorporation of learning systems into the global enterprises, while chapters such as, "Knowledge Management, Communities of Practice, and the Role of Technology: Lessons Learned from the Past and Implications for the Future" by Wee Hin Leo Tan, Thiam Seng Koh, and Wei Loong David Hung address some of the basic, yet crucial stumbling blocks of information management. With 43 chapters comprising this foundational section, the reader can learn and chose from a compendium of expert research on the elemental theories underscoring knowledge management discipline.

Section 2, ***Development and Design Methodologies,*** provides in-depth coverage of conceptual architectures and knowledge management frameworks to provide the reader with a comprehensive understanding of the emerging technological developments within the field of knowledge management. *"Supporting Research and Development Processes Using Knowledge Management Methods"* by Thomas Hahn, Bernhard Schmiedinger, and Elisabeth Stephan offers research fundamentals imperative to the understanding of research processes within the knowledge management discipline. On a more global scale, Adekunle Okunoye and Nancy Bertaux's**, "**KAFRA: A Context-Aware Framework of Knowledge Management in Global Diversity" explores cultural and infrastructural issues related to the management of knowledge in developing countries. From basic designs to abstract development, chapters such as "Stages of Knowledge Management Systems" by Peter Gottschalk and "Autopoietic Approach for Information System Development" by El-Sayed Abou-Zeid serve to expand the reaches of development and design technologies within the knowledge management community. This section includes over 45 contributions from researchers throughout the world on the topic of information development and knowledge sharing within the information science and technology field.

Section 3, ***Tools and Technologies***, presents an extensive coverage of various tools and technologies available in the field of knowledge management that practioners and academicians alike can utilize to develop different techniques. Chapters such as Tobias Mueller-Prothmann's, "Use and Methods of Social Network Analysis in Knowledge Management" enlightens readers about fundamental research on one of the many methods used to facilitate and enhance the knowledge sharing experience whereas chapters like, "Technology and Knowledge Management: Is Technology Just an Enabler or Does it also Add Value?" by Helen Mitchell explore the intrinsic value of technology and knowledge management. It is through these rigorously researched chapters that the reader is provided with countless examples of the up-and-coming tools and technologies emerging from the field of knowledge management. With more 28 chapters, this section offers a broad treatment of some of the many tools and technologies within the knowledge management community.

Section 4, ***Utilization and Application***, discusses a variety of applications and opportunities available that can be considered by practioners in developing viable and effective knowledge management programs and processes. This section includes more than 50 chapters such as "Knowledge Management and the Leading Information Systems Journals: An Analysis of Trends and Gaps in Published Research" by Todd Peachey, Dianne J. Hall, and Casey Cegielski which reviews knowledge management literature published in top-tier journals, offering findings on the most popular trends researched within the academic community. Additional chapters such as Hyung Seok Jeong and Dulcy M. Abraham's, "Knowledge Management in Civil Infrastructure Systems" discuss the utilization of knowledge management within the governmental realm. Also considered in this section are the challenges faced when utilizing knowledge management with healthcare systems as outlined by Martin Orr's, "The Challenge of Privacy and Security and the Implementation of Health Knowledge Management Systems." The adaptability of governmental agencies in response to disasters is given consideration in chapters such as, "Knowledge Management and Hurricane Katrina Response" by Tim Murphy and Murray E. Jennex which investigates the major hurdles faced in knowledge sharing in the face of disasters, spanning the globe. Contributions included in this section provide excellent coverage of today's global community and how knowledge management research is impacting the social fabric of our present-day global village.

Section 5, ***Organizational and Social Implications***, includes a wide range of research pertaining to the social and organizational impact of knowledge management technologies around the world. Introducing this section is Daniel L. Davenport and Clyde W. Holsapple's chapter entitled, "Knowledge Organizations" providing a comprehensive introduction of the modern-day knowledge organization. Additional chapters included in this section such as "The Role of Culture in Knowledge Management: A Case Study of Two Global Firms" by Dorothy Leidner, Maryam Alavi, and Timothy Kayworth explore the difference in the community approach versus the process approach to knowledge management within two cultural paradigms. Also investigating a concern within the field of knowledge management is Bendik Bygstad's, "*Some Implementation Challenges of Knowledge Management Systems: A CRM Case Study*" which provides a study of the varying challenges when implementing knowledge management systems. The discussions presented in this section offer research into the integration of technology to allow access for all.

Section 6, ***Managerial Impact***, presents contemporary coverage of the social implications of knowledge management, more specifically related to the corporate and managerial utilization of information sharing technologies and applications, and how these technologies can be facilitated within organizations. Core ideas such as training and continuing education of human resources in modern organizations are discussed through these more than 35 chapters. "*Networks of People as an Emerging Business Model*" by Lesley Robinson discusses strategic planning related to the organizational elements and knowledge sharing program requirements that are necessary to build a framework in order to institutionalize and sustain knowledge management systems as a core business process. Equally as crucial, chapters such as "*Bridging the Gap from the General to the Specific by Linking Knowledge Management to Business Processes*" by John S. Edwards and John B. Kidd address the gap between theory and practical implementation within the knowledge sharing community. Concluding this section is a chapter by Catherine C. Schifter of Temple University, "*Faculty Participation in Distance Education Programs*". Directing the reader's focus forward, the final chapter of this section, "*Outcomes of Knowledge Management Initiatives*," by Vittal S. Anantatmula riteria helps to establish a basis for assessing the value of knowledge management while evaluating its results within business enterprises.

Section 7, ***Critical Issues***, contains 25 chapters addressing issues such as intellectual capital and knowledge management, communities of practice, and critical social theory and ontology-supported Web service composition. Within the chapters, the reader is presented with an in-depth analysis of the most current and relevant issues within this growing field of study. Franz Hofer's, "*Knowledge Transfer Between Academia and Industry*" develops an excellent model for researchers and practioners as attempts are made to simultaneously ease and expedite the transfer of knowledge from the private to the public sector. Forming frameworks in which to position the issues faced in this growing field are provided by research found in chapters such as, "*Communities of Practice and Critical Social Theory*" by Steve Clarke and "*Aristotelian View of Knowledge Management*" by David G. Schwartz—both chapters that take the core psychological paradigms of sociology and translate them into applicable ideas within the exploding realm of information sharing. Crucial examinations such as that presented in Richard L. Wagoner's chapter, "*We've Got a Job to Do - Eventually: A Study of Knowledge Management Fatigue Syndrome*" serves to reinforce the ideas presented in this section while simultaneously enticing and inspiring the reader to research further and participate in this increasingly pertinent debate.

The concluding section of this authoritative reference tool, ***Emerging Trends,*** highlights research potential within the field of knowledge management while exploring uncharted areas of study for the advancement of the discipline. Introducing this section is David G. Schwartz's, "*The Emerging Discipline* *of Knowledge Management*" which sets the stage for future research directions and topical suggestions for continued debate. Providing an alternative view of knowledge management is the chapter, "*Culture-Free or Culture-Bound? A Boundary Spanning Perspective on Learning in Knowledge Management Systems*" by Robert M. Mason. This chapter researches the cultural dimension of knowledge management systems, particularly the relationship of learning and culture in knowledge management projects. Another debate which currently finds itself at the forefront of research within this field is presented by Nieves Pedreira, Julián Dorado, Juan Rabuñal, and Alejandro Pazos' research, "*Knowledge Management as the Future of E-Learning*" which explores the inevitable increase in complexity and quantity of the information that is available for students of all backgrounds postulating that we must move towards a model that offers the student room for individual exploration and self-learning. Found in these 21 chapters concluding this exhaustive multi-volume set are areas of emerging trends and suggestions for future research within this rapidly expanding discipline.

Although the primary organization of the contents in this multi-volume is based on its eight sections, offering a progression of coverage of the important concepts, methodologies, technologies, applications, social issues, and emerging trends, the reader can also identify specific contents by utilizing the extensive indexing system listed at the end of each volume. Furthermore to ensure that the scholar, researcher, and educator have access to the entire contents of this multi volume set, as well as additional coverage that could not be include in the print version of this publication, the publisher will provide unlimited multi-user electronic access to the online aggregated database of this collection for the life of edition, free of charge when a library purchases a print copy. This aggregated database provides far more contents than what can be included in the print version in addition to continual updates. This unlimited access, coupled with the continuous updates to the database, ensures that the most current research is accessible knowledge seekers.

Knowledge management as a discipline has witnessed fundamental changes during the past two decades, allowing knowledge seekers around the globe to have access to information which two decades ago, was inaccessible. In addition to this transformation, many traditional organizations and business enterprises have taken advantage of the technologies offered by the development of knowledge management systems in order to expand and augment their existing programs. This has allowed practioners and researchers to serve their customers, employees, and stakeholders more effectively and efficiently in the modern virtual world. With continued technological innovations in information and communication technology and with on-going discovery and research into newer and more innovative techniques and applications, the knowledge management discipline will continue to witness an explosion of information within this rapidly evolving field.

The diverse and comprehensive coverage of knowledge management in this six-volume authoritative publication will contribute to a better understanding of all topics, research, and discoveries in this developing, significant field of study. Furthermore, the contributions included in this multi-volume collection series will be instrumental in the expansion of the body of knowledge in this enormous field, resulting in a greater understanding of the fundamentals while fueling the research initiatives in emerging fields. We at Information Science Reference, along with the editor of this collection, and the publisher hope that this multi-volume collection will become instrumental in the expansion of the discipline and will promote the continued growth of knowledge management.

Introductory Chapter: Contemporary Research in Knowledge Management

Murray E. Jennex
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INTRODUCTION

Knowledge management (KM) is a hot topic in academia and the business community. KM can be viewed as an evolution of decision support systems, DSS, and information systems, IS, that is helping organizations overcome the "productivity paradox" and to ensure that "IS matters." This six volume set presents current KM research that investigates the many facets of KM. Although, the title 'knowledge management' itself might suggest a rather simple definition, KM is a complex discipline with many different focuses. This introductory chapter presents the foundation of KM and places the research from these six volumes into the unified context of the KM discipline by presenting an overview of fundamental KM concepts and theories and then discusses the many technologies, applications, managerial and organizational implications, trends, and issues in KM.

FUNDAMENTAL CONCEPTS AND THEORIES IN KNOWLEDGE MANAGEMENT

Knowledge

Davenport and Prusak (1998) view knowledge as an evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. They found that in organizations, knowledge often becomes embedded in artifacts such as documents, video, audio or repositories and in organizational routines, processes, practices, and norms. They also say that for knowledge to have value it must include the human additions of context, culture, experience, and interpretation. Nonaka (1994) expands this view by stating that knowledge is about meaning in the sense that it is context-specific. This implies that users of knowledge must understand and have experience with the context, or surrounding conditions and influences, in which the knowledge is generated and used for it to have meaning to them. This also implies that for a knowledge repository to be useful it must also store the context in which the knowledge was generated. That knowledge is context specific argues against the idea that knowledge can be applied universally, however it does not argue against the concept of organizational knowledge. Organizational knowledge is considered to be an integral component of what organizational members remember and use meaning that knowledge is actionable.

Polanyi (1967) and Nonaka and Takeuchi (1995) describe two types of knowledge, tacit and explicit. Tacit knowledge is that which is understood within a knower's mind and which cannot be directly expressed by data or knowledge representations and is commonly understood as unstructured knowledge. Explicit knowledge on the other hand is that knowledge which can be directly expressed by knowledge representations and is commonly known as structured knowledge. Current thought has knowledge existing as neither purely tacit nor purely explicit. Rather, knowledge is a mix of tacit and explicit with the amount of explicitness (only one dimension needs to be measured) varying with each user. This is the knowledge continuum where purely tacit and purely explicit form the end points with knowledge existing somewhere on the continuum between the two end points. Smolnik, et al. (2005) have an individual position knowledge on the continuum through context explication where context explication reflects the experience and background of the individual. Nissen and Jennex (2005) expand knowledge into a multidimensional view by adding the dimensions of reach (social aggregation), life cycle (stage of the knowledge life cycle), and flow time (timeliness) to explicitness. Research is continuing to refine the concept of knowledge and its dimensions.

Knowledge transfer in an organization occurs when members of an organization pass tacit and explicit knowledge to each other. Nonaka and Takeuchi (1995) propose four modes of knowledge creation and transfer.

- Socialization is the process of sharing experiences and thereby creating tacit knowledge such as mental models and technical skills. Tacit knowledge can be obtained without using language through observation, imitation, and practice.
- Externalization is the process of articulating tacit knowledge in the form of explicit concepts, taking the shapes of metaphors, analogies, concepts, hypotheses, or models.
- Combination is the process of systemizing concepts into a knowledge system by combining different bodies of explicit knowledge. Explicit knowledge is transferred through media such as documents, meetings, email, and/or phone conversations. Categorization of this knowledge can lead to the generation of new knowledge.
- Internalization is the process of converting explicit knowledge to tacit knowledge and is closely related to learning by doing.

These four modes or processes show that the transfer of knowledge is dependent upon the transfer of a common understanding from the knower to the user of the knowledge. Common understanding consists of the context (the story behind the knowledge, the conditions and situations which make the knowledge understandable) and the experience (those activities which produce mental models of how the knowledge should be used) expressed in a culturally understood framework.

What is culture and context? The United Nations Educational, Scientific and Cultural Organization, UNESCO, states that culture is the "set of distinctive spiritual, material, intellectual and emotional features of society or a social group and that it encompasses, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs" (UNESCO, 2002). The American Heritage Dictionary (2000) defines context as the part of a text or statement that surrounds a particular word or passage and determines its meaning and/or the circumstances in which an event occurs. Culture forms the basis for how we process and use knowledge by providing belief frameworks for understanding and using the knowledge, context provides the framing for the knowledge explaining how it is created and meant to be used. Both are critical to the transfer and reuse of knowledge. We normally expect explicit knowledge to be easily transferred while we expect issues with transferring tacit knowledge. However, we are finding that transfer of either dimension of knowledge in a multicultural environment is not easy.

Jennex and Zakharova (2006) discuss why we need to consider culture and issued a call for further research into the impact of culture on KM. This discussion is based on Hofstede (1980, p. 25) who refines the definition of culture as: "Culture consists in patterned ways of thinking, feeling and reacting, acquired and transmitted mainly by symbols, constituting the distinctive achievements of human groups, including their embodiments in artifacts; the essential core of culture consists of traditions (i.e. historically derived and selected) ideas and especially their attached values." His work focuses on identifying cultural differences between nations and illustrates that value systems are not the same the world over. The key to the impact of culture on knowledge transfer is how values impact how different social groups will externalize metaphors, analogies, hypotheses, and models; how groups will systemize concepts; how groups internalize concepts; and how groups understand experiences. Differences in culture, and Hofstede (1980, 2001) show that there are significant differences between national cultures, can lead to differences between national groups within the same organization, which can cause those groups to either understand knowledge differently, or have significant barriers to participating in the sharing of knowledge. We must understand that culture is a unique component that is so deeply imbedded into peoples' lives that our ignorance of it usually leads to failures. Knowledge management systems (KMS) as well as other systems created to improve organization's performance should use all possible information about culture to escape system's mistakes due to lack of cultural awareness and understanding. Probably no theory ever will be capable to capture all or even full knowledge about a specific culture but there are enough theories (as discussed above) to establish a process and methodology for including cultural parameters in the design of KM initiatives and the system analysis and design activities.

Along with concerns about how national cultures affect the use and understanding of knowledge is the impact of organizational culture on knowledge use. Organizational culture impacts the flow of knowledge through the organization as well as the willingness of its members to share and reuse knowledge. Jennex and Olfman (2005) synthesized literature and research into a set of twelve critical success factors. Organizational culture was found to be a key critical success factor by several researchers (Alavi and Leidner, 1999, Bock and Kim, 2002, Chan and Chau, 2005, Davenport, et al., 1998, Forcadell and Guadamillas, 2002, Jennex and Olfman, 2000, Sage and Rouse, 1999, and Yu, et al., 2004). Issues related to organizational culture include organizational reward, incentive, and personnel evaluation systems and management and leadership styles and support for KM.

Why consider context? Davenport and Prusak (1998, p.5) found that for knowledge to have value it must include the elements of human context, experience, and interpretation. Nonaka (1994) expands this view by stating that knowledge is about meaning in the sense that it is context-specific. This implies that users of knowledge must understand and have experience with the context (surrounding conditions and influences) in which the knowledge is generated and used for it to be meaningful. This suggests that for a knowledge repository to be useful it must also store the context in which the knowledge was generated. The suggestion that knowledge is context specific argues against the idea that knowledge can be applied universally.

Context is the collection of relevant conditions and surrounding influences that make a situation unique and comprehensible to the users of the knowledge, Degler and Battle (2000). Context can be stored with knowledge and/or can be possessed by knowledge users. When a system's knowledge users are known, the knowledge that is captured is used to support specific activities. KMS users are readily known when the KMS is built to support a specific team, project, or process and the users are those involved with that team, project, and/or process. These users tend to possess a high degree of shared understanding where understanding incorporates context and experience. Experience is what knowledge users use to generate mental models of how to use or apply the knowledge, Degler and Battle (2000). Experience comes from the individual's own experience with the knowledge domain, other's shared experience with the knowledge domain, and/or a collective experience with the knowledge domain, Degler and Battle (2000). Combined, this means that knowledge users in teams, projects, or even processes understand the organizational culture, the structure of organizational documents, organizational terminology and jargon, and how the organization works and are able to use posted knowledge, even if it does not include context, as they implicitly understand the context in which the knowledge was created and have experience in using this knowledge. On the other hand, when KMS users are not known it is not possible to assume these users possess a common understanding or experience associated with the generation of the knowledge. This means the KMS will have to capture this context and experience for users to be able to utilize the captured knowledge effectively.

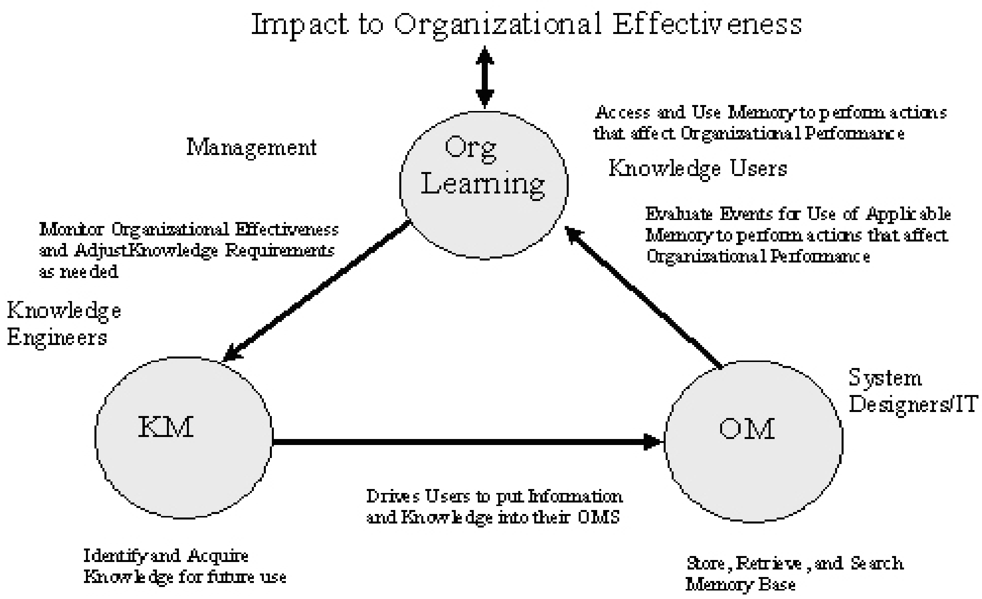
This section has presented current thought on what knowledge is, but the definition of knowledge is far from agreed upon. Knowledge is a difficult construct to define as most knowledge is context, culture, and time specific and is rarely viewed as universal, leading individuals to define knowledge uniquely. It is expected that the definition of knowledge will be debated for quite a while, perhaps as long as KM is researched. Ultimately I agree with Keen and Tan (2007) who believe that while it is important to understand what knowledge is, it is unproductive for researchers to get focused on trying to precisely define knowledge at the expense of furthering KM research.

Knowledge Management

Jennex (2005) utilized an expert panel, the editorial review board of the *International Journal of Knowledge Management* (IJKM), to generate a definition of KM as the practice of selectively applying knowledge from previous experiences of decision making to current and future decision making activities with the express purpose of improving the organization's effectiveness. Another key definition of KM includes Holsapple and Joshi (2004) who consider KM as an entity's systematic and deliberate efforts to expand, cultivate, and apply available knowledge in ways that add value to the entity, in the sense of positive results in accomplishing its objectives or fulfilling its purpose. Finally, Alavi and Leidner (2001) concluded that KM involves distinct but interdependent processes of knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. Taken in context, these definitions of KM focus on the key elements of KM: a focus on using knowledge for decision making and selective knowledge capture. This is important as the selective focus on knowledge capture separates KM from library science which attempts to organize all knowledge and information and the decision making focus emphasizes that KM is an action discipline focused on moving knowledge to where it can be applied. Ultimately, KM may best be described by the phrase "getting the right knowledge to the right people at the right time" and can be viewed as a knowledge cycle of acquisition, storing, evaluating, dissemination, and application.

KM is better understood when the concepts of organizational memory (OM) and organizational learning (OL) are incorporated. Jennex and Olfman (2002) found that the three areas are related and have an impact on organizational effectiveness. Organizational effectiveness is how well the organization does those activities critical to making the organization competitive. OL is the process the organization uses to learn how to do these activities better. OL results when users utilize knowledge. That OL may not always have a positive effect is examined by the monitoring of organizational effectiveness. Effectiveness can improve, get worse, or remain the same. How effectiveness changes influences the feedback provided to the organization using the knowledge. KM and OM are the processes used to identify and capture

Figure 1. The KM/OM/OL model (Jennex & Olfman, 2002)



critical knowledge. Knowledge workers and their organizations 'do' KM; they identify key knowledge artifacts for retention and establish processes for capturing it. OM is what IT support organizations 'do'; they provide the infrastructure and support for storing, searching, and retrieving knowledge artifacts. Figure 1 illustrates these relationships and the following sections expand on these concepts.

Organizational Learning

Organizational Learning is defined as a quantifiable improvement in activities, increased available knowledge for decision-making or sustainable competitive advantage (Cavaleri, 1994; Dodgson, 1993, Easterby-Smith, 1997; Miller, 1996). In this view organizations learn through individuals acting as agents for them. Individual learning activities are seen as being facilitated or inhibited by an ecological system of factors that may be called an organizational learning system. Learning in this perspective is based on Kolb's (1984) model of experiential learning where individuals learn by doing. Huber, Davenport, and King (1998) believe an organization learns if, through its processing of information, its potential behaviors are changed. Huysman, Fischer, and Heng (1994) as well as Walsh and Ungson (1991) believe organizational learning has OM as a component. In this view, OL is the process by which experience is used to modify current and future actions. Huber (1991) considers four constructs as integrally linked to OL: knowledge acquisition, information distribution, information interpretation, and organizational memory. In this case, OM is the repository of knowledge and information acquired by the organization. Organizational learning uses OM as its knowledge base.

A different perspective on OL from Sandoe, et. al. (1998) is that organizations do not learn; rather only individuals learn. During work, people gain experience, observe, and reflect in making sense of what they are doing. As they analyze these experiences into general abstractions, their perceptions on how work should be done changes. As these individuals influence their co-workers, the "organization" learns and the process is gradually changed. Learning in this perspective is also based on Kolb's (1984) model of experiential learning.

Organizational Memory

Stein and Zwass (1995) define OM as the means by which knowledge from the past is brought to bear on present activities resulting in higher or lower levels of organizational effectiveness. Walsh and Ungson (1991) define OM as stored information from an organization's history that can be brought to bear on present decisions. OM, like knowledge, can be viewed as abstract or concrete. It is comprised of unstructured concepts and information that exist in the organization's culture and the minds of its members, and can be partially represented by concrete/physical memory aids such as databases. It is also comprised of structured concepts and information that can be exactly represented by computerized records and files. Sandoe and Olfman (1992) and Morrison (1997) describe these two forms of OM as having two functions, representation and interpretation. Representation presents just the facts (or knowledge or expertise) for a given context or situation. Interpretation promotes adaptation and learning by providing frames of reference, procedures, guidelines, or a means to synthesize past information for application to new situations. Comparing to the definition of knowledge, it is obvious that knowledge and OM are related through experience and learning. We consider knowledge to be a subset of OM and the processes of KM a subset of OM processes.

Knowledge Management Systems

Jennex (2005) views a KM system, KMS, as that system created to facilitate the capture, storage, retrieval, transfer, and reuse of knowledge. The perception of KM and KMS is that they holistically combine organizational and technical solutions to achieve the goals of knowledge retention and reuse to ultimately improve organizational and individual decision making. This is a Churchman (1979) view of KM that allows KMS to take whatever form necessary to accomplish these goals. Alavi and Leidner (2001, p. 114) defined a KMS as "IT (Information Technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT (Information and Communication Technology) system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application. Stein and Zwass (1995) define an organizational memory information system (OMS) as the processes and IT components necessary to capture, store, and apply knowledge created in the past on decisions currently being made. Jennex and Olfman (2006) expanded this definition by incorporating the OMS into the KMS and adding strategy and service components to the KMS.

KMS Classifications

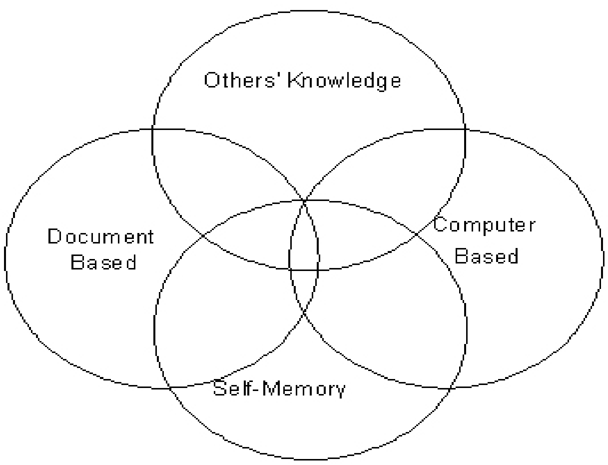
There are different ways of classifying a KMS and/or KMS technologies where KMS technologies are the specific IT/ICT tools being implemented in the KMS. Alavi and Leidner (2001) classify the KMS based on the Knowledge Life Cycle stage being predominantly supported. Marwick (2001) uses the mode of Nonaka's (1994) SECI model being implemented. Borghoff and Pareschi (1998) classifications are based on the class of the KM Architecture being supported. This architecture has 4 classes of components: repositories and libraries, knowledge worker communities, knowledge cartography/mapping, and knowledge flows. Hahn and Subramani (2001) classify by the source of the knowledge being supported: structured artifact, structured individual, unstructured artifact, or unstructured individual. Binney (2001) uses the Knowledge Spectrum. The Knowledge Spectrum represents the ranges of purposes a KMS can have. Zack (1999) classifies a KMS as either Integrative or Interactive. Integrative KMS support the transfer of explicit knowledge using some form of repository and support. Interactive KMS support the transfer of tacit knowledge by facilitating communication between the knowledge source and the knowledge user. Jennex and Olfman (2004) classify the KMS by the type of users being supported. Users are separated into two groups based on the amount of common understanding they have with each other resulting in classifications of: process/task based KMS for groups that have a common understanding and a generic/infrastructure KMS for groups that do not share a common understanding. An example of a group with a common understanding is a community of practice, CoP, which is a set of people who share a concern, a set of problems, or a passion about a topic (Wenger et al., 2002).

Knowledge Repositories

Key to the KMS is knowledge repositories. There are three types of knowledge repositories: paper documents, computer based documents/databases, and self memories:

- Paper documents incorporate all hard copy documents and are organization-wide and group-wide references that reside in central repositories such as a corporate library. Examples include reports, procedures, pictures, video tapes, audio cassettes, and technical standards.
- Computer based documents/databases include all computer-based information that is maintained at the work group level or beyond. These may be made available through downloads to individual workstations, or may reside in central databases or file systems. Additionally, computer documents include the processes and protocols built into the information systems. These are reflected in the interface between the system and the user, by who has access to the data, and by the formats of structured system inputs and outputs. New aspects of this type of repository are digital images and

Figure 2. Knowledge repositories



audio recordings. These forms of knowledge provide rich detail but require expanded storage and transmission capacities.

- Self-memory includes all paper and computer documents that are maintained by an individual as well as the individual's memories and experiences. Typical artifacts include files, notebooks, written and un-written recollections, and other archives. These typically do not have an official basis or format. Self-memory is determined by what is important to each person and reflects his or her experience with the organization.

Repositories have overlapping information and knowledge as shown in Figure 2. Paper documents are indexed or copied into computer databases or files, self memory uses paper and computer based documents/databases, computer databases or files are printed and filed. Spheres for self-memory and others' memory reflect that organizations consist of many individuals, and that the knowledge base contains multiple self-memories. Finally, the relative size of each sphere depends on the nature of the organization. Organizations that are highly automated and/or computerized would be expected to have a greater dependence on computer-based repositories while other organizations may rely more on paper or self-memory based repositories.

Use of Knowledge Repositories

Should organizations focus more on computerized repositories or on self-memory repositories? Computerized repositories provide a measure of permanence coupled with better tools for searching and retrieving knowledge. However, organizations should consider the transience and experience level of their workers when selecting repositories. Sandoe and Olfman (1992) found that the increasing transience of organizational workers requires a shift in the location of knowledge. Organizations that have large numbers of transient workers are at risk of losing knowledge if it is allowed to remain in self memories. These organizations need to capture and store knowledge in more concrete forms such as paper or computer-based repositories. They also suggest that stronger attempts should be made to capture the unstructured, abstract information and knowledge in concrete forms. Additionally, Jennex and Olfman (2002) found that new organizational workers have trouble using the document and computer-based repositories and rely on the self-memories of longer-term members. This continues until the new member gains sufficient context and culture to understand and use the information and knowledge in the paper and computer-based repositories. While these guidelines are contradictory because transient organizations will tend to have more new members, they do emphasize that organizations should minimize reliance on self-memories for the retention of concrete, structured knowledge while using self-memories as the mechanism for teaching organizational culture and passing on unstructured, abstract knowledge.

KM/KMS Success

Jennex, Smolnik, and Croasdell (2007) found KM success to be a multidimensional concept defined by capturing the right knowledge, getting the right knowledge to the right user, and using this knowledge to improve organizational and/or individual performance. KM success is measured using the dimensions of impact on business processes, strategy, leadership, efficiency and effectiveness of KM processes, efficiency and effectiveness of the KM system, organizational culture, and knowledge content.. KM success is considered the same as KM effectiveness and KM success is also equated to KMS success when the Churchman (1979) view of a KMS is used.

While these measures are useful for measuring success, it is also important to understand what is needed to have successful KM/KMS. Jennex and Olfman (2005) summarized and synthesized the literature from 17 studies on over 200 KM projects on KM/KMS critical success factors, CSFs, into an ordered set of twelve KM CSFs. The below twelve CSFs were ordered based on the number of studies identifying the CSF:

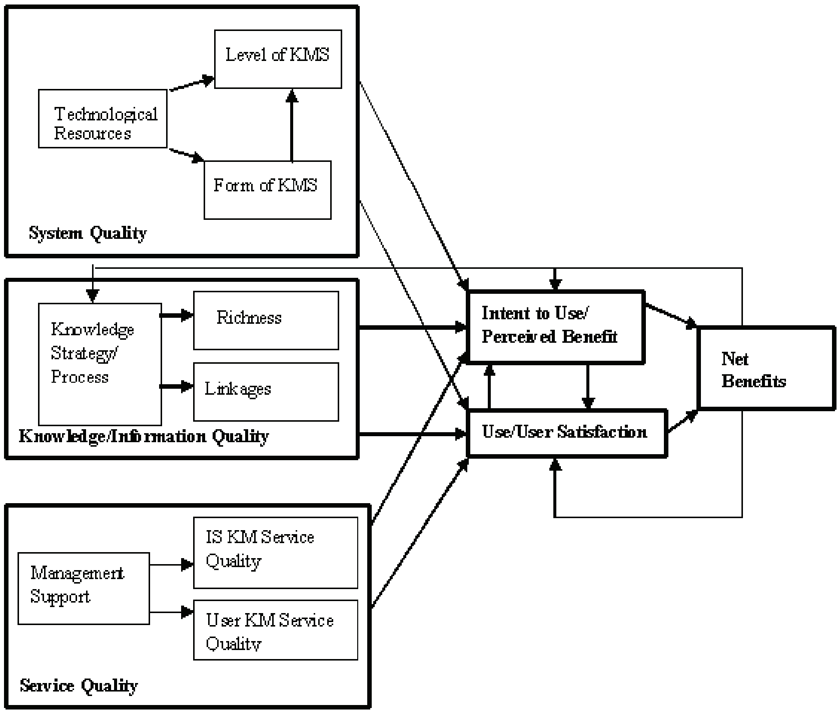
- A knowledge strategy that identifies users, sources, processes, storage strategy, knowledge and links to knowledge.
- Motivation and commitment of users including incentives and training
- Integrated technical infrastructure including networks, databases/repositories, computers, software, experts
- An organizational culture and structure that supports learning and the sharing and use of knowledge
- A common enterprise wide knowledge structure that is clearly articulated and easily understood
- Senior management support including allocation of resources, leadership, and providing training
- Learning organization
- There is a clear goal and purpose for the KMS
- Measures are established to assess the impacts of the KMS and the use of knowledge as well as verifying that the right knowledge is being captured
- The search, retrieval, and visualization functions of the KMS support easy knowledge use
- Work processes are designed that incorporate knowledge capture and use
- Security/protection of knowledge

While it is useful to identify the KM CSFs, it is more useful to express the CSFs in a model that relates them to KM success. The Jennex Olfman (2006) KM success model (Figure 3) is a causal model based on the DeLone and McLean (1992, 2003) IS Success Model. The Jennex Olfman (2006) KM Success Model is discussed because it has been shown to relate KM CSFs to KM success. It has three basic dimensions as antecedents to KM success: system quality which deals with the technical infrastructure; knowledge/information quality which deals with KM strategy for identifying critical knowledge and then how that knowledge is stored; and service quality which deals with management support and allocation of resources. The model also has the dimensions of perceived benefit, user satisfaction, and net benefits. These dimensions deal with ensuring that the KM initiative meets the needs of the users and the organization and ultimately expresses KM success in terms of impacts on organizational and individual work processes.

Of course other KM success/effectiveness models exist. Jennex and Olfman (2005) summarized and described these models and related them to KM success factors. The following is a listing of these models:

- Bots and de Bruijn (2002) The Knowledge Value Chain KM Success Model, based on the value chain approach to determining key processes.
- Massey, Montoya-Weiss, and Driscoll (2002) KM Success Model, a process-based KM success model derived from their Nortel case study.
- Lindsey (2002) KM Effectiveness Model, based on combining Organizational Capability Perspective theory (Gold, 2001) and Contingency Perspective Theory (Becerra-Fernandez and Sabherwal, 2001).
- Maier (2002) KMS Success Model, based on DeLone and McLean (1992) IS Success Model

Figure 3. Jennex Olfman (2006) KM success model



KNOWLEDGE MANAGEMENT DEVELOPMENT AND DESIGN METHODOLOGIES

Traditional information systems (IS) are developed and designed through the well known systems analysis and Design (SAD) process. This process is based on application of a systems development life cycle approach that based on identifying user requirements, designing and implementing the requirements into an IS, verifying the IS meets the requirements, then maintaining these requirements over the life of the system. While this process has been modified through the application of Extreme Programming and Agile Methods, the basic SAD process still remains focused on user requirements. A KMS is different than an IS. The incorporation of knowledge into a system adds complexity forcing system designers to consider using a process that Tauber and Schwartz (2006) label as the knowledge integrated systems analysis (KISA) process. KISA basically has system designers use parallel process, IS personnel use traditional SAD techniques to design the user and technical components of the KMS while the KM group analyzes for knowledge requirements. SAD techniques are well known and documented in the SAD literature. Knowledge analysis techniques are not. The key to knowledge analysis is understanding knowledge flow and usage. The following paragraph discusses current trends in knowledge process modeling techniques. It should be noted that these techniques, while based on IS methodology, include the modeling of organizational needs and are not just technology focused.

Knowledge process modeling is a key activity in the design of a KMS. Two new approaches come from Kim, et al. (2006) who proposes using Unified Modeling Language, UML, to model knowledge intensive processes; and from Froming, et al. (2006) who proposes a specification for a Knowledge Modeling and Descriptive Language, KMDL, that also assists in modeling knowledge intensive processes. Another aspect of knowledge process modeling understands the flow of knowledge. Social Network Analysis, SNA, is a technique used to determine key knowledge flow nodes. Cheuk (2006) applied SNA to an organization as a diagnostic tool for understanding knowledge flows through the organization. It is also important to be able to elicit information from KMS users. SAD uses standard interview techniques and approaches such as joint application development (JAD) to accomplish this. Taylor (2005) proposes the use of the critical decision interview method to help identify knowledge used in knowledge intensive processes. Finally, in the earlier discussion on knowledge the importance of culture and context were mentioned. Understanding how context and culture impacts the social, technical, and political environment in which a KMS operates is also essential. Okunoye and Bertaux (2006) propose the use of KAFRA, Kontext Aware FRAmework, as a means for developers to understand and analyze these issues.

UTILIZATION AND APPLICATION OF KNOWLEDGE MANAGEMENT

The following are examples of KM implementations in organizations. Two classes of approaches are used, Internet and enterprise based approaches. In general these examples are initially discussed based on the technology used to support the KMS. However, this chapter takes a Churchmanian approach to systems so the examples also include discussion of social and organizational issues that affected the example systems. The examples are not an all inclusive or exhaustive set. Their purpose is to illustrate how KM is being implemented in organizations and to provide context for how social and technical approaches are combined to create KMS and KM solutions.

Internet Based KMS

One of the most commonly cited KMS success factors (Jennex and Olfman, 2005) is having an integrated technical infrastructure including networks, databases/repositories, computers, software, and KMS experts. KM designers are using the Internet to obtain this integrated network and are using browsers as common software. Various approaches are being utilized by KMS designers to achieve common databases and repositories. Common taxonomies and ontologies are being used to organize storage of unstructured knowledge files and to facilitate knowledge retrieval while other Internet based KMS serve as interfaces to large enterprise databases or data warehouses. Some Internet KMS are being used to facilitate communication and knowledge transfer between groups. Knowledge portals are being used by organizations to push knowledge to workers and be communities of practice (COP) to facilitate communication and to share knowledge between community members. The following section describes some examples of Internet based KMS.

Internet networks can be scaled to fit any size KMS. Browsers can be tailored to fit processes as desired. Taxonomies can be created that support unstructured knowledge sharing for any size KMS. The following examples illustrate this flexibility as the examples include a project KMS, an industry wide project KMS, and enterprise KMS. Knowledge Portals can be scaled to fit either form of KMS but are more commonly used for enterprise KMS. Community of Practice KMS is a variation of process/task KMS.

Examples of Internet Based KMS

Project Based KMS for a Single Organization

Jennex (2000) discussed an Intranet based KMS used to manage knowledge for a virtual Y2K project team. This KMS used two different site designs over the life of the project. The purpose of the initial site was to facilitate project formation by generating awareness and providing basic information on issues the project was designed to solve. The design of this site was based on Jennex and Olfman (2002) that suggested a structure providing linkages to expertise and lessons learned were the knowledge needed by knowledge workers. This was accomplished by providing hot links to sites that contained Y2K knowledge, a project team roster that indicated the areas of expertise for each of the project team members and additional entries for individuals with expertise important to the project, and some basic answers to frequently asked questions. The site did not contain guidelines and accumulated knowledge as reflected in test plans, test results, inventories of assets referenced to the division who owned them, and general project knowledge such as project performance data, meeting minutes and decisions, presentations, and other project documentation. This information had not been generated at the time the site was implemented. Once generated, this information was stored on network servers with shared access to acknowledged project team members.

As the project team formed and began to perform its tasks the requirements for the Intranet site changed from generating awareness to supporting knowledge sharing. The site was redesigned and expanded to include detailed frequently asked questions (FAQs), example documents, templates, meeting minutes, an asset database, guidelines for specific functions that included lessons learned, etc. The knowledge content of the site was distributed into the other components of the site and persons were identified as being responsible for the information and knowledge content of their responsible areas. Additionally, access to the site was enhanced by the addition of a hot link to the Y2K site placed and prominently displayed on the Corporate Intranet home page. The basic layout of the site provided for access to seven specific sub-sites: Major Initiatives, Contacts, Documents, What's New, Hot Links, Issues and Questions, and Y2K MIS.

The effectiveness of the two sites was considered good. The first site was successful in generating interest and starting the project. The second site succeeded in taking a project that was performing in the bottom third of projects to being a leading project within six months after its release. Effectiveness of the sites was established using the model in Figure 3 and by ensuring the Information Quality was high and the System Quality, especially the search, retrieval, and infrastructure, was good.

KMS as a Knowledge Portal

This example, from Cross and Baird (2000) is an Intranet site built by Andersen Consulting. Consulting firms have had a long tradition of brokering their knowledge into business. In the early 1990s, Andersen Consulting began to produce global best practices CDs for distribution to project personnel. This evolved into the development of a Intranet site called KnowledgeSpace that provided consultants with various forms of knowledge including methodologies and tools, best practices, reports from previous like engagements, and marketing presentations. Support was also provided for online communications for online communities of practice and virtual project teams. The site was effective for personnel with access to the Internet and adequate bandwidth. It should be noted that current modem technology and improved dial in access, as well as the proliferation of broadband connections, have made sites such as this much more effective for field or remote personnel.

The second example, from Bartczak (2005), describes the system used by the United States Air Force to support the Material Command called the AFKM Hub. The AFKM Hub is the primary Web site for the AF Lessons Learned utility. Although the Website has evolved, Lessons Learned is still the centerpiece of the Hub. Lessons Learned have been captured and categorized by subject area and provide valuable knowledge about past processes and events. The AFKM Hub also acts as a portal for all other AFKM components and serves as the default AFKM home page. The AFKM Hub provides a conduit to select relevant information and knowledge resources and provides an avenue for creating a knowledge-sharing organization. The AFMC Help Center of the AFKM Hub allows AFMC customers to perform a natural language or keyword search of over 130 AFMC Websites and selected databases. It connects AFMC customers throughout the Air Force and Department of Defense with the appropriate AFMC information source or point of contact. The CoP Workspace supports the growing number of Air Force CoPs. CoP workspaces are virtual environments where members can exchange information to complete work tasks and solve problems. Each CoP serves a specific customer set. The AFKM Hub provides workspaces for a variety of CoPs and supports over 1300 active CoPs. The effectiveness of the AFKM Hub has also been mixed. Air Force leadership sees the value in KM and many examples of successful uses of knowledge have been recorded. However, articulating a knowledge and KM strategy has been difficult and has allowed for wasted effort in supporting Air Force KM needs.

KMS as a Topic Map

The last examples come from Eppler (2001). There are five types of knowledge maps: source, asset, structure, application, and development. A multimedia company Intranet site is used to illustrate a knowledge source map. This site provides graphical buttons representing individuals with specific expertise color-coded to indicate the expert's office location. The Knowledge Asset map provides a visual balance sheet of an organization's capabilities of a skills directory or core competency tree. Colors are used to indicate knowledge domains while the size of symbols indicates level of expertise. Knowledge Structure maps divides knowledge domains into logical blocks that are then broken into specific knowledge areas. The Knowledge Application map breaks an organization's value chain into its components parts and then indicates what knowledge, tools, or techniques are needed to implement the component part. The last example is a Knowledge Development map. This map is used to plot the activities needed to acquire the indicated knowledge competence. Clicking on the displayed competence displays the steps needed to develop the competence. Effectiveness of these maps has only been determined for the Knowledge Asset map. This map, developed for a telecommunications consultant firm, was found to be very useful for the planning of training activities and for identifying experts quickly when required during an emergency. IT should be noted that knowledge maps enhance the linkage aspects of information quality.

Enterprise System Support for KMS

As organizations strive to improve their competitive position/advantage, they are implementing enterprise wide systems. These systems integrate processes and data/information/knowledge across the enterprise and in many cases with suppliers and customers to improve efficiency and effectiveness (Koch 2002). This usually results in lowered operating costs and improved response times, economies of scale, and user satisfaction. Typical examples of these systems are enterprise resource planning (ERP), customer relationship management (CRM), supply cChain management (SCM), and data warehouse implementations. As these systems are refined and improved organizations are finding that incorporating knowledge and KM improves system performance. Unfortunately, there are also several issues involved in successfully using enterprise systems to support KM; chief among these are organizational culture issues. Many enterprises suffer from fragmentation, meaning that many organizations within the enterprise own and use their own data and systems. Enterprise systems seek to integrate these systems but to be successful they must overcome issues of ownership and a reluctance to share data, information, and knowledge. This issue is usually characterized by the presence of "silos" in the enterprise. Corral, Griffen, and Jennex

(2005) discuss this issue with respect to integrating data warehouses and KM. The following examples describe how enterprise systems and KMS are being fused together.

ERP and KMS

Li, et al. (2005) describe an ERP implementation in a Chinese paper manufacturing company. The ERP was implemented to help the company respond to market and customer changes more rapidly by integrating enterprise data information and knowledge and centralizing process control. Unfortunately, China lacked experience with ERP implementation and is not overly familiar with western concepts of centralized data, information, and knowledge management. This was an issue in getting the ERP implemented and utilized. Once this was accomplished, decision making was greatly enhanced through improved knowledge transfer provided by the ERP's integration of organizational data, information, and knowledge into a single accessible location. Other issues faced in implementing the ERP was management support for the various sub organizations being integrated into the ERP and creating a culture that used data, information, and knowledge in the expected way.

White and Croasdell (2005) describe ERP implementations in Nestle, Colgate-Palmolive, and Chevron-Texaco. Each of these implementations was performed to improve data, information, and knowledge integration with an expectation of improved decision making and transfer of key knowledge such as lessons learned and process improvements. All three implementations were ultimately successful after initial difficulties including cost overruns due to unrealistic project estimates of schedule and cost and overcoming employee resistance to changing to new processes and merging data, information, and knowledge ownership. These examples also incorporated the KMS success factor of metrics for measuring success and illustrate the importance of measuring KMS performance.

CRM and KMS

Al-Shammari (2005) describes a knowledge-enabled customer relationship management, KCRM, system in a large middle-eastern telecommunications company. The KCRM was composed of three major parts: Enterprise data warehouse (EDW), operational CRM, and analytical CRM. The KCRM initiative was designed to automate and streamline business processes across sales, service and fulfillment channels. The KCRM initiative was targeted at achieving an integrated view of customers, maintaining long-term customer relationship, and enabling a more customer-centric and efficient go-to-market strategy. The driver for the initiative was that the company faced deregulation after many years of monopoly. The company initiated a customer-centric KM program, and pursued understanding customers' needs and forming relationships with customers, instead of only pushing products and services to the market. Unfortunately, the KCRM program ended as an ICT project. The company didn't succeed in implementing KCRM as a business strategy, but did succeed implementing the KCRM as a transactional processing system. Several challenges and problems were faced during and after the implementation phase. Notable among these is that the CRM project complexity and responsibilities were underestimated, and as a result, the operational CRM solution was not mature enough to effectively and efficiently automate CRM processes. Changing organizational culture was also a tremendous effort in terms of moving towards customer-centric strategy, policy and procedures, as well as sharing of knowledge in a big organization with lots of business 'silos'. Employee resistance to change posed a great challenge to the project. Ultimately, this project failed to achieve to expectations.

Data Warehouse, Enterprise Databases, and KMS

White and Croasdell (2005) describe Xerox use of an enterprise database to facilitate the sharing of experience knowledge across the company. Xerox had difficulty in fostering best practice among its group of printer maintenance employees. The problem centered on an inability to circulate employee expertise using existing organizational infrastructure. To help the maintenance technicians share their experience and expertise, Xerox created a database to hold top repair ideas in order to share those ideas with other technicians in all areas. This strategy called for only the most favored ideas to be kept within the database as it often occurred that what one person thought useful others found the same the idea absurd or redundant. Xerox also realized that many databases had been created by managers who filled the databases with information they thought would be useful for their employees. However, most of those databases were rarely used by the employees. When Xerox created the Eureka database it also formed a process for entering and updating the ideas within the database. The process is based on a peer-review system. Within this practice the representatives, not the organization, supply and evaluate tips. In this way a local expert would work with the representative to refine the tip. Representatives and engineers evaluate the tips, calling in experts where appropriate. As of July of 2000 the Eureka database held nearly 30,000 ideas and was being utilized by 15,000 Xerox technicians who answered a quarter-million repair calls per year. The shared knowledge in Eureka saved Xerox about $11 million in 2000 and customers also saved money in terms of the reduction in downtime.

Eureka later extended the role of the Eureka Database to collect, share, and reuse solutions to software and network problems as well as those involving hardware.

KNOWLEDGE MANAGEMENT TOOLS AND TECHNOLOGIES

Although there is strong support for using the Internet as a Knowledge infrastructure, there are concerns. Chief among these concerns is the difficulty in organizing, searching, and retrieving unstructured knowledge artifacts. Ezingeard, et al. (2000) points out that Ernst & Young UK in the beginning of 2000 had in excess of one million documents in its KMS. Another concern is the tendency to not to use the system. Cross and Baird (2000) discusses this tendency but comes to the conclusion that repositories are essential. Jennex (2007a) found that use and importance for knowledge do not correlate suggesting that use is not a true measure of the value of a KMS. Jennex and Olfman (2002) found that voluntary use is enhanced if the system provides near and long term job benefits, is not too complex, and the organization's culture supports sharing and using knowledge and the system. Stenmark (2002) found that if the Internet is visualized as a system for increasing awareness of knowledge and the KMS, a system for retaining and sharing knowledge, and as a system for enhancing communication and collaboration between teams and knowledge experts and users; then it should be successful as a KMS. In all cases, researchers are experimenting with technologies that improve the handling of unstructured knowledge. These are discussed in the following paragraphs.

Newman and Conrad (2000) propose a framework for characterizing KM methods, practices, and technologies. This framework looks at how tools can impact the flow of knowledge within an organization, IT's role in manipulating knowledge artifacts, and the organizational behavior most likely to be affected. The framework also looks at the part of the KM process the tool works in. The Activity phase looks at the utilization, transfer, retention, and creation of Knowledge. This framework can be used to show that Internet and Browser based KMS tools are effective.

Gandon, et al. (2000) proposes using XML to encode memory and knowledge, and suggest using a multi-agent system that can exploit this technology. The proposed system would have improved search capabilities and would improve the disorganization and poor search capability normally associated with Internet systems. Chamberlin, et al. (2001) and Robie, et al. (1998) discuss using XML query language to search and retrieve XML encoded documents.

Dunlop (2000) proposes using clustering techniques to group people around critical knowledge links. As individual links go dead due to people leaving the organization, the clustered links will provide a linkage to people who are familiar with the knowledge of the departed employee. This technique would improve the reliability of the links to knowledge called for in Figure 2. Lindgren (2002) proposes the use of Competence Visualizer to track skills and competencies of teams and organizations.

Te'eni and Feldman (2001) propose using task-adapted Websites to facilitate searches. This approach requires the site be used specifically for a KMS. Research has shown that some tailored sites, such as ones dedicated to products or communities have been highly effective. This approach is incorporated in the examples in this paper with the exception of the use of dynamic adaptation.

Abramowicz, et al. (2002), Eppler (2001), and Smolnik and Nastansky (2002) discusses the use of knowledge maps to graphically display knowledge architecture. This technique uses an Intranet hypertext clickable map to visually display the architecture of a knowledge domain. Knowledge maps are also known as Topic Maps and Skill Maps. Knowledge maps are useful as they create an easy to use standard graphical interface for the Intranet users and an easily understandable directory to the knowledge.

The use of ontologies and taxonomies to classify and organize knowledge domains is growing. Zhou, et al. (2002) propose the use of ROD, Rapid Ontology Development, as a means of developing an ontology for an undeveloped knowledge domain.

Making sense of seemingly unrelated structured data, information, and knowledge can also be difficult. Data mining is being used as a method for identifying patterns in this data, information, and knowledge that can then be assessed for meaning. Zaima and Kashner (2003) describe data mining as an iterative process that uses algorithms to find statistically significant patterns in structured data, information, and knowledge. These patterns are then analyzed by business process experts to determine if they actually have meaning in the business process context. CRM tends to use this technology the most as illustrated by the example from Al-Shammari (2005).

Organizing and visualizing data and information into usable knowledge is a challenge that digital dashboard technologies are seeking to solve. Few (2005) describes dashboards as providing single screen summaries of critical data and information. Key to developing effective dashboards is the use of KM to identify critical knowledge for key decision making and then linking it to the appropriate context data and information that indicates the status of the key knowledge. Dashboards can be used with a Internet browser or any other KMS infrastructure.

ORGANIZATIONAL AND SOCIAL IMPLICATIONS OF KNOWLEDGE MANAGEMENT

KM is about capturing and sharing knowledge, capturing knowledge from knowledge creators and possessors and sharing knowledge to knowledge users. KM success hinges on several factors but some of the key CSFs that impact organizations and society are (Jennex & Olfman, 2005):

- A knowledge strategy that identifies users, sources, processes, storage strategy, knowledge and links to knowledge
- Motivation and commitment of users including incentives and training

- An organizational culture and structure that supports learning and the sharing and use of knowledge
- Learning organization
- Work processes are designed that incorporate knowledge capture and use

These CSFs impact organizations and society by changing expected behavior of individuals from being that of knowledge hoarders to that of knowledge sharers. This is an obviously disruptive discipline in the organization. However, as organizations find they must better utilize their knowledge in order to compete, they will do what is necessary, including changing their organizational culture, to ensure they better utilize and share their knowledge. Case study research on the implementation of KM in a variety of organizations is finding the issue of changing organizational culture is not a trivial or easy task. Several cases in this set explore this issue. Additionally, this is leading to two other impacts on society. The first is the impact of national culture on knowledge sharing and transfer. The second is the growing movement towards open source KM.

National culture impacts what we have to include with knowledge in order to make it useful to users from cultures other than the culture where the knowledge was created. This was previously discussed in the section discussing knowledge. A further consideration is how national culture affects organizational culture and the ability of an organization to transfer and share knowledge. Research investigating KM in various cultures has been recently published and it shows that this is a consideration that impacts the ability of an organization to implement KM successfully. The key societal implication of culture is this impact and its potential to increase the "digital divide" between those countries with cultures that support knowledge sharing and those whose culture inhibits knowledge sharing.

Open source KM is a new term (Jennex, 2006a) used to describe the concept of community cooperation. Open source KM is a form of KM where communities manage knowledge in a leaderless or semi-leaderless environment and tend towards using open source tools and systems. In other words, the communities are not focused on tightly bound business organizations; rather, they are focused on loosely bound social networks. Also, this KM is not necessarily focused on improving organizational performance. In many cases it is focused on improving social conditions. An example is the development and growth of Wikipedia, an open source, collaborative encyclopedia free to all to use. Another example is the various academic initiatives aimed at providing free access for publication and dissemination of research using online academic journals. A final example is the use of open source tools such as Wikis to facilitate community participation in disaster or emergency response such as PeopleFinder and ShelterFinder following Hurricane Katrina (Murphy & Jennex, 2006).

MANAGERIAL IMPACT OF KNOWLEDGE MANAGEMENT

KM is a disruptive influence in organizations and society as mentioned in the previous section. This is particularly true for management. KM is about improving decision making (Jennex, 2005) and this helps improve management's decision making. KM is also about collaboration and knowledge sharing. Organizations implementing KM increase the amount of knowledge sharing between their members, this also improves decision making but creates potentially uncontrolled knowledge flows and new social networks. Management that implement's a KM initiative does so with the expectation that they will better utilize their knowledge resources, make better decisions, and ultimately improve their competitive position. However, automating knowledge processes allows for decision making to be pushed to lower levels as knowledge becomes easier to find and access. This allows organizations to flatten out and decentralize as decision making is pushed closer to where the decision is. This can lower the power of managers and can cause tension in organizational cultures that aren't prepared to adjust their power structures.

Additionally, KM requires adjustment in corporate governance and management support. Jennex and Olfman (2006) include a management support dimension to KM success. This dimension focuses on management's role in establishing the direction and support an organization needs to provide to ensure that adequate resources are allocated to the creation and maintenance of KM, a knowledge sharing and using organizational culture is developed, encouragement, incentives, and direction is provided to the work force to encourage KM use, knowledge reuse, and knowledge sharing; and that sufficient control structures are created in the organization to monitor knowledge and KM use (Jennex & Olfman, 2006). Zyngier (2006) describes these functions along with risk management and leadership as KM governance. While Management Support or governance provides the leadership and risk management direction for the organization, it is the KM Strategy/Processes construct that provides the information needed to guide the KM initiative implementation. Jennex and Addo (2005) discuss the functions of KM strategy as including identifying knowledge to be captured, sources and users of knowledge, knowledge storage strategies, and processes for using and capturing knowledge. Zyngier, et al. (2006) establishes the relationship between KM governance, KM strategy implementation, and KM success or as in the case of the Jennex and Olfman (2006) KM Success Model, the relationship between the Management Support and the KM Strategy/Process constructs to KM success. Both are necessary for KM success and both are necessary for incorporating security into KM initiatives.

Ultimately, the managerial impact from KM is a loosening of knowledge control as organizations create more ways of collaborating and knowledge sharing. This can be disruptive to rigid and/or hierarchical management structures but will empowering to those management structures willing to embrace its enhanced flow of knowledge coupled with decision making being pushed to lower organizational levels.

CRITICAL ISSUES IN KNOWLEDGE MANAGEMENT

KM is growing in its importance and application to solving business problems. However, there are some critical issues that need addressing. These are discussed in the following paragraphs.

Perhaps the most critical issue facing KM is the incorporation of security and risk management into KM strategy and governance. Jennex (2007) discussed the importance of security to KM and issued a call for research. The key issue with respect to security and KM is that it isn't recognized as being needed, in fact, it is almost counter to the precepts of knowledge sharing and flow. Jennex and Olfman (2005) found that security was the lowest ranked KM CSF. While not emphasized as much as it should be, it is promising that KM security is recognized as a CSF. Key issues with respect to KM security are the identification of security policies and an emphasis on risk management through KM strategy. KM risk management looks at using standard risk management techniques to analyze KM strategy to identify where there are risks of not capturing or losing potentially critical knowledge. KM security policies focus on an establishing appropriate levels of confidentiality, integrity, and availability to knowledge stored in a KMS and recognize the need to address issues such as privacy, identity theft, data/knowledge retention, disposal of old knowledge, and secure transfer of knowledge. A final note on this issue is that KM security is less focused on developing new security technologies while more focused on identifying how to apply existing security technologies to implement KM security policies. Currently conferences such as the Secure KM workshop and the KM and risk management minitrack at the *Hawaii International Conference on System Sciences, HICSS*, are beginning to address this issue and future calls for the KM track at IRMA include this as a requested research paper topic.

KM and KMS success and measurement is another issue needing to be explored. It is imperative that managers and practitioners understand how to build successful KMS and how to define, measure, and recognize when their KM initiatives are successful. It is also important for the credibility of the KM discipline that we be able to define and measure KM success. Additionally, from the perspective of KM academics and practitioners, identifying the factors, constructs, and variables that define KM success is crucial to understanding how these initiatives and systems should be designed and implemented. This issue is receiving attention with the KM Success minitrack at HICSS addressing this issue, other conferences such as AMCIS and IRMA soliciting papers on the topic, several articles being published by the *International Journal of Knowledge Management* (IJKM) and with an outstanding call for this research by the IJKM. Additionally, several models that attempt to ground KM success in theory are being developed and tested (Jennex & Olfman 2005, 2006).

An ongoing set of issues that has been and still is critical is the identification of the social and organizational factors that influence the flow and transfer of knowledge between individuals and across organizations. Key aspects of these issues are the impact of national and organizational culture, incentive programs, barriers to knowledge flow, and stickiness of knowledge (stickiness refers to the tendency for knowledge to get locked up in individuals and not transferred.) These issues are more difficult to research, understand, and overcome than the technical issues in KM. These issues also seem to have a greater impact on KM success than the technical issues. This chapter has spent a great deal of discussion on the technical issues and this should not be construed as indicating that technical issues are more important. The research in these volumes will show that by far the hardest and most important issues to overcome are the social and organizational factors that influence the flow and transfer of knowledge between individuals and organizations.

The formulation and implementation of KM strategy is listed by Jennex and Olfman (2005) as the most mentioned CSF. This implies that this CSF is seen as the issue most often recognized in research as leading to successful or failed KM initiatives. What makes this a critical KM issue is that what this strategy needs to entail is still not completely understood. Jennex and Addo (2005), as discussed above, list the functions of KM strategy as including identifying knowledge to be captured, sources and users of knowledge, knowledge storage strategies, and processes for using and capturing knowledge. However, other researchers are postulating that KM strategy should include other issues and it is expected that future research is needed to fully define this CSF.

The final issue to be discussed in this chapter is the persistence of knowledge. Jennex (2006b) discusses issues related to the storage and retrieval of knowledge. In particular changing formats and media are causing knowledge to be lost. Organizations rarely update archived knowledge to new formats or new media if it hasn't been recently used. The result is that this knowledge may not be retrievable when needed. This has happened in the United States space program, specifically in relation to lunar exploration, and may happen to many organizations should they not have a strategy (see the above critical issue) for dealing with changing formats and media. A last concern focused on media is that storage media are not permanent. Compact Discs, tape, floppy disks, fixed disks; all have a discreet life span and will ultimately fail, probably within five years from start of use. This is an issue organizations definitely need to address as essentially current storage media will not survive as well as traditional paper.

EMERGING TRENDS IN KNOWLEDGE MANAGEMENT

KM is a young and evolving discipline. The last section of this chapter looks at some of the emerging trends affecting our discipline. Many of these trends have been discussed in relative detail in previous sections so they will just be summarized. The first trend is towards more formal measurement of KM success and performance. This is an indicator of discipline maturity, organizations are moving from "it's a good idea to do KM" to "KM has this impact on our performance."

A second trend is the growing interest in using KM to empower knowledge groups such as communities of practice, CoPs. KM was initially viewed as a formal process for managing organizational knowledge, this is still true but it is also being recognized that KM can enable groups and teams to self manage their knowledge. CoPs are groups who may or may not be in the same organization. What makes them a CoP is a shared common interest in a knowledge domain. CoPs have a shared context of understanding and may or may not share culture. CoPs self identify critical knowledge and transfer it to those in the CoP that need it. Finally, CoPs need technology that facilitates CoP communication and collaboration. Wikis and other open source tools as well as knowledge portals are examples of technology used by CoP. Murphy and Jennex (2006) illustrate how these tools in the hands of a CoP can lead to leaderless development in times of emergency and the quick creation of KM enabled systems.

This leads to growing use of KM in crisis/emergency response. KM is used to create knowledge bases that can be used to facilitate decision making and response generation in times of stress. Additionally, KM and CoPs are being used to help groups of predetermined and self organizing groups of experts collaborate and respond to the needs of crisis response managers. Organizations such as the International Society for Crisis Response and Management, ISCRAM, recognize this trend and are incorporating KM sessions in their international conferences.

As mentioned earlier, Risk Management is just being incorporated into KM. This is tool to be used by organization to assess the risk associated with use of knowledge, with not having the right knowledge, and with losing critical knowledge. This is management function that will be incorporated into KM governance.

Additionally, the Internet itself is changing. Efforts to improve the Internet's ability to facilitate collaboration and handle unstructured data, information, and knowledge, both by users and by software agents, is leading to the development of the Web 2.0 and Web 3.0/semantic web. Web 2.0 refers to improving the Web to handle social networking sites and collaborative technologies such as Wikis, blogs, and other community based sites (such as Craigslist, Skype, etc.). Web 3.0/semantic Web is predicted to be an environment where data, information, and knowledge can be understood and used by any user and software agent. Technologies used include Resource Description Framework, RDF, Web Ontology Language, OWL, and the Extensible Markup Language, XML. Both of these developments will improve the ability of the Web to store, search, and retrieve knowledge and to facilitate knowledge transfer.

Finally, there is a growing trend towards international KM and KMS by multinational organizations. This increases the impact of national culture on the use of knowledge and is increasing pressure on organizations to be aware of the national cultures impact on their KM users, those that create knowledge and those that use it. Organizations are finding that national cultures impact knowledge use and it is becoming critical to incorporate national culture concerns into KM strategy.

CONCLUSION

This chapter has attempted to summarize the state of the KM discipline. This is not an easy task. The six volumes of this research set do a better job of doing this. However, this chapter does establish a foundation to assist the reader in utilizing the research in this six volume set. To conclude this chapter it is stated that KM is a vital discipline. It aids organizations in utilizing the knowledge of its members and in building organizational knowledge. KM has an impact on organizational performance. Organizations that utilize their knowledge well tend to perform better and are more successful. It is hoped that users of this six volume research set will be able to better design and implement KM in their organizations.

REFERENCES

Abramowicz, W., Kowalkiewicz, M., and Zawadzki, P. (2002). Tell me what you know or I'll tell you what you know: Skill map ontology for information technology courseware. In *Proceedings of the 2002 Information Resources Management Association International Conference*.

Al-Shammari, M. (2005). Implementing knowledge-enabled CRM srategy in a large company: A case study from a developing country. In M. Jennex (Ed.), *Case Studies in Knowledge Management* (249-278).

Alavi, M., & Leidner, D.E. (1999). Knowledge management systems: Emerging views and practices from the field. Paper presented at the *32nd Hawaii International Conference on System Sciences.* IEEE Computer Society.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

American Heritage Dictionary of the English Language, Fourth Edition. (2000). Houghton Mifflin Company.

Bartczak, S.E., & England, E.C. (2005). Challenges in developing a knowledge management strategy for the Air Force material command. In M. Jennex (Ed.), *Case Studies in Knowledge Management* (104-128).

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Binney D. (2001). The knowledge management spectrum: Understanding the KM landscape. *The Journal of Knowledge Management, 5*(1), 33-42.

Bock , G.W., & Kim, Y. (2002), Breaking the myths of rewards: An exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal, 15*(2), 14-21.

Borghoff, U.M., & Pareschi, R. (1998). *Information technology for knowledge management*. Berlin: Springer-Verlag.

Bots, P.W.G., & de Bruiin, H. (2002). Effective knowledge management in professional organizations: Going by the rules. Paper presented at the *35th Hawaii International Conference on System Sciences*. IEEE Computer Society Press.

Cavaleri, S. (1994). Soft systems thinking: A pre-condition for organizational learning. *Human Systems Management, 13*(4), 259-267.

Chamberlin, D., Clark, J., Florescu, D., Simon, J., Robie, J., & Stofancscu, M. (2001). Xquery 1.0: An XML Query Language. WSC Working Draft 2001. Retrieved from www.w3.org/TRxquery

Chan, I., & Chau, P.Y.K. (2005). Getting knowledge management right: Lessons from failure. *International Journal of Knowledge Management, 1*(3), 40-54.

Cheuk, B.W. (2006). Using social networking analysis to facilitate knowledge sharing in the British Council. *International Journal of Knowledge Management*, *2*(4), 67-76.

Churchman, C. W. (1979). *The Systems Approach* (revised and updated). New York: Dell Publishing.

Corral, K., Griffin, J., & Jennex, M.E. (2005). Expert's perspective: The potential of knowledge management in data warehousing. *Business Intelligence Journal, 10*(1), 36-40.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 41-54.

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Degler, D., & Battle, L. (2000). Knowledge management in pursuit of performance: The challenge of context. *Performance Improvement, ISPI, 39*(6).

DeLone, W.H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*, 60-95.

DeLone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9-30.

Dodgson, M. (1993). Organizational learning: A review of some literatures. *Organization Studies, 14*(3), 375-394.

Dunlop, M.D. (2000). Development and evaluation of clustering techniques for finding people. In *Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, PAKM2000*.

Easterby-Smith, M. (1997). Disciplines of organizational learning: Contributions and critiques. *Human Relations, 50*(9), 1085-1113.

Eppler, M.J. (2001). Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. In *Proceedings of the Thirty-fourth Hawaii International Conference on System Sciences.* IEEE Computer Society.

Ezingeard, J.-N., Leigh, S., & Chandler-Wilde, R. (2000). Knowledge management at Ernst & Young UK: Getting value through knowledge flows. *Teaching Case*, 807-822.

Few, S. (2005). Dashboard fesign: Beyond meters, gauges, and traffic lights. *Business Intelligence Journal, 10*(1), 18-24.

Forcadell, F.J. & Guadamillas, F. (2002). A case study on the implementation of a knowledge management strategy oriented to innovation. *Knowledge and Process Management, 9*(3),162-171.

Froming, J., Gronau, N., & Schmid, S. (2006). Improvement of software engineering by modeling knowledge-intensive business processes. *International Journal of Knowledge Management, 2*(4), 32-51.

Gandon, F., Dieng, R., Corby, O., & Giboin, A. (2000). A multi-agent system to support exploiting an XML-based corporate memory. In *Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hahn, J., & Subramani, M.R., (2000). A framework of knowledge management systems: Issues and challenges for theory and practice. In *Proceedings of the Twenty-first International Conference on Information Systems, Association for Information Systems* (pp. 302-312).

Hofstede, G.H. (1980). *Culture's consequences.* Thousand Oaks, CA: Sage Publications.

Hofstede, G.H. (2001). *Culture's consequences: Comparing values, behaviors, institutions, and organizations across nations*. Thousand Oaks, CA: Sage Publications

Holsapple, C. W., & Joshi, K. (2004). A formal knowledge management ontology: Conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Huber, G.P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Huber, G.P., Davenport, T.H., & King, D. (1998). Some perspectives on organizational memory. In F. Burstein, G. Huber, M. Mandviwalla, J. Morrison, & L. Olfman (Eds.), *Unpublished Working Paper for the Task Force on Organizational Memory.* Paper presented at the at the 31st Annual Hawaii International Conference on System Sciences. Hawaii.

Huysman, M.H., Fischer, S.J., & Heng, M.S.H. (1994). An organizational learning perspective on information systems planning. *Journal of Strategic Information Systems, 3*(3).

Jennex, M.E. (2000). Using an intranet to manage knowledge for a virtual project team. In M. Divitini, T. Brasethvik, & D. G. Schwartz (Eds.), *Internet-Based Organizational Memory and Knowledge Management* (pp. 241-259). Hershey, PA: Idea Group Publishing.

Jennex, M.E. (2005). What is KM? *International Journal of Knowledge Management, 1*(4), i-iv.

Jennex, M.E. (2006). Classifying knowledge management systems based on context content. Paper presented at the *Hawaii International Conference on Systems Sciences*. IEEE.

Jennex, M.E. (2006a). Open source knowledge management. *International Journal of Knowledge Management, 2*(4), i-iv.

Jennex, M.E. (2006b). Why we can't return to the moon: The need for knowledge management. *International Journal of Knowledge Management, 2*(1), i-iv.

Jennex, M.E. (2007). Knowledge management and security: A call for research. *International Journal of Knowledge Management, 3*(1), i-iv.

Jennex, M.E. (2007a). Exploring system use as a measure of knowledge management duccess. Accepted by the *Journal of Organizational and End User Computing*.

Jennex, M.E., & Addo, T.B.A. (2005). Knowledge management strategy issues. In *Proceedings of the 2005 Information Resource Management Resource Conference*.

Jennex, M.E., & Olfman, L. (2000). Development recommendations for knowledge management/organizational memory systems. Paper presented at the *Information Systems Development Conference.*

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. Paper presented at the *35th Hawaii International Conference on System Sciences, HICSS35*. IEEE Computer Society.

Jennex, M.E., & Olfman, L. (2005). Assessing knowledge management success. *International Journal of Knowledge Management*, *1*(2), 33-49.

Jennex, M. E., & Olfman, L. (2006). A model of knowledge management success. *International Journal of Knowledge Management, 2*(3), 51-68.

Jennex, M.E., Smolnik, S., & Croasdell, D. (2007). Exploring knowledge management success. Paper presented at the *40th Hawaii International Conference on System Sciences, HICSS39*. IEEE Computer Society.

Jennex, M.E., & Zakharova, I. (2006). Culture, context, and knowledge management. *International Journal of Knowledge Management, 2*(2), i-iv.

Keen, P.G.W., & Tan, M. (2007). Knowledge fusion: A framework for extending the rigor and relevance of knowledge management. *International Journal of Knowledge Management, 3*(4), 1-xx.

Kim, S.K., Lim, S.B., & Mitchell, R.B. (2006). A method for knowledge modeling: Application of the Unified Modeling Language (UML) to knowledge modeling. *International Journal of Knowledge Management, 2*(4), 17-31.

Koch, C. (2002). The ABC's of ERP. *CIO.com*. Retrieved February 7, 2002, from http://www.cio.com/research/erp/edit/erpbasics.html

Kolb, D. (1984). *Experimental learning.* Upper Saddle River, NJ: Prentice-Hall.

Li, Z., Yezhuang, T., & Ping, L. (2005). Organizational knowledge sharing based on the ERP implementation of Yongxin Paper Company, Limited. In M.E. Jennex (Ed.), *Case Studies in Knowledge Management* (pp. 156-164). Hershey, PA: Idea Group Publishing.

Lindgren, R. (2002). Competence visualizer: Generating competence patterns of organizational groups. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*. IEEE Computer Society.

Lindsey, K. (2002). Measuring knowledge management effectiveness: A task-contingent organizational capabilities perspective. Paper presented at the *Eighth Americas Conference on Information Systems* (pp. 2085-2090).

Maier, R. (2002). Knowledge management systems: Information and communication technologies for knowledge management. Berlin: Springer-Verlag.

Marwick, A.D. (2001). Knowledge management technology. *IBM Systems Journal, 40*(4), 814-830.

Massey, A.P., Montoya-Weiss, M.M., & O'Driscoll, T.M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Miller, D. (1996). A preliminary typology of organizational learning: Synthesizing the literature. *Journal of Management*, *22*(3), 485-505.

Morrison, J. (1997). Organizational memory information systems: Characteristics and development strategies. In *Proceedings of the Thirtieth Annual Hawaii International Conference on System Sciences*. IEEE Computer Society Press.

Murphy, T., & Jennex, M.E. (2006). Knowledge management and hurricane Katrina response. *International Journal of Knowledge Management, 2*(4), 52-66.

Newman, B., & Conrad, K. (2000). A framework for characterizing knowledge management methods, practices, and technologies. In *Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Nissen, M., & Jennex, M.E. (2005). Knowledge as a multidimensional concept: A call for action. *International Journal of Knowledge Management, 1*(3), i-v.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). The knowledge-creating company: How Japanese companies create the dynamics of innovation. Oxford University Press.

Okunoye, A., & Bertaux, N. (2006). KAFRA: A context-aware framework of knowledge management in global diversity. *International Journal of Knowledge Management*, *2*(2), 26-45.

Polanyi, M. (1967). *The tacit dimension.* London: Routledge and Keoan Paul.

Robie, J., Lapp, J., & Schach, D. (1998). XML Query Language (XQL). *WWW The Query Language Workshop (QL).*

Sage, A.P., & Rouse, W.B. (1999). Information systems frontiers in knowledge management. *Information Systems Frontiers, 1*(3), 205-219.

Sandoe, K., Croasdell, D.T., Courtney, J., Paradice, D. Brooks, J., & Olfman, L. (1998). Additional perspectives on organizational memory. Unpublished Working Paper for the Task Force on Organizational Memory. Presented at the *31st Annual Hawaii International Conference on System Sciences*. Hawaii.

Sandoe, K., & Olfman, L. (1992). Anticipating the mnemonic shift: Organizational remembering and forgetting in 2001. In *Proceedings of the Thirteenth International Conference on Information Systems*. ACM Press.

Smolnik, S., Kremer, S., & Kolbe, L. (2005). Continuum of context explication: Knowledge discovery through process-oriented portals. *International Journal of Knowledge Management, 1*(1), 27-46.

Smolnik, S., & Nastansky, L. (2002). K-discovery: Using topic maps to identify distributed knowledge structures in groupware-based organizational memories. In *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*. IEEE Computer Society.

Stein, E.W., & Zwass, V., (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Stenmark, D. (2002). Information vs. knowledge: The role of intranets in knowledge management. In *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*. IEEE Computer Society.

Tauber, D., & Schwartz, D.G., (2006). Integrating knowledge management with the systems analysis process. In D. Schwartz (Ed.), *Encyclopedia of Knowledge Management* (pp. 259-266). Idea Group Reference: Hershey, PA.

Taylor, H. (2005). A critical decision interview approach to capturing tacit knowledge principles and applications. *International Journal of Knowledge Management, 1*(3), 25-39.

Te'eni, D., & Feldman, R. (2001). Performance and satisfaction in adaptive Websites: An experiment on searches within a task-adapted Website. *Journal of the Association for Information Systems, 2*(3).

UNESCO Universal Declaration on Cultural Diversity. (2002). UNESCO Universal Declaration on cultural diversity. Retrived October 2, 2005, from http://www.unesco.org/education/imld_2002/universal_decla.shtml

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Wenger, E., McDermott, R., & Snyder, W.M., (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.

White, C., & Croasdell, D. (2005). A comparative case study of knowledge resource utilization to model organizational learning. In M. Jennex (Ed.), *Case Studies in Knowledge Management* (pp. 235-248). Hershey, PA: Idea Group Publishing.

Yu, S.-H., Kim, Y-G., & Kim, M.-Y. (2004). Linking organizational knowledge management drivers to knowledge management performance: An exploratory study. Paper presented at *37th Hawaii International Conference on System Sciences*. IEEE Computer Society.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

Zaima, A., & Kashner, J. (2003). A data mining primer for the data warehouse professional. *Business Intelligence Journal, 8*(2), 44-54.

Zhou, L., Booker, Q.E., & Zhang, D. (2002). ROD: Toward rapid ontology development for underdeveloped domains. In *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*. IEEE Computer Society.

Zyngier, S. (2006). Knowledge management governance. In D.G. Schwartz (Ed.), *Encyclopedia of Knowledge Management* (pp. 373-380). Hershey, PA: Idea Group Reference.

Zyngier, S., Burstein, F, & McKay, J. (2006). The role of knowledge management governance in the implementation of strategy. Paper presented at the *39th Hawaii International Conference on System Sciences, HICSS.* IEEE Computer Society.

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Section 1
Fundamental Concepts and Theories in Knowledge Management

This section serves as a foundation for this exhaustive reference tool by addressing crucial theories essential to the understanding of knowledge management. Research found in this section provides an excellent framework in which to position knowledge management within the field of information science and technology. Excellent insight into the critical incorporation of learning systems into global enterprises is offered, while basic, yet crucial stumbling blocks of information management are explored. With 43 chapters comprising this foundational section, the reader can learn and chose from a compendium of expert research on the elemental theories underscoring the knowledge management discipline.

Chapter 1.1
An Overview of Knowledge Management

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ABSTRACT

One of the key factors that distinguishes the intelligent business enterprise of the 21st century is the emphasis on knowledge and information. Unlike businesses of the past, the fast, high-tech, and global emphasis of businesses today requires the ability to capture, manage, and utilize knowledge and information in order to improve efficiency, better serve customers, manage the competition, and keep pace with never-ending changes. Knowledge management is an important means by which organizations can better manage information and, more importantly, knowledge. Unlike other techniques, knowledge management is not always easy to define because it encompasses a range of concepts, management tasks, technologies, and practices, all of which come under the umbrella of the management of knowledge. This chapter takes a broad view of the topic of knowledge management and aims to provide a comprehensive overview of knowledge management — the technologies, processes, and concepts involved, and the challenges and future of this important area.

INTRODUCTION

Rapid changes in both personal computer technology and electronic communications during the past decade have given us the ability to create, gather, manipulate, store, and transmit much more data and information than ever before. It is now a fact that large amounts of information are transmitted via the Internet and other means on a daily basis (Chase, 1998; Sistla & Todd, 1998). In addition, the enhanced speed and capacity of communication has enabled the existence of a global market for many industries and business sectors (Chase, 1998). Moreover, the pressures of competition within the 24-hour global marketplace have greatly increased demands for better quality, less costly production, more accountability to both customers and shareholders, and improved information about materials, processes, customers and competitors (Chase, 1998; Drucker, 1993). This highly competitive, global environment has fostered the growth of management trends like total quality management, customer satisfaction, benchmarking, re-engineering, re-structuring, downsizing and outsourcing, strategic planning, organizational learning and, of course, knowledge management (Skyrme, 2001). Many emerging models of knowledge exchanges represent harbingers of extra-organizational collaborations that will be needed for the execution of an organization's knowledge work. In the 21st century, successful organizations have to be competitive, fast paced, first-to-market, and global in nature. Creating strategic advantage requires a new type of organization that has the capability to create knowledge to maximize organizational competitiveness and strategic success. Knowledge, like any other resource, is viewed as a resource that is critical to an organization's survival and success in the global market. Organizations should have mechanisms to create knowledge and manage knowledge as an asset. However, the bulk of organizations still have not approached knowledge management (KM) activity formally or deliberately. The cause of this inattention could be that most organizations are struggling to comprehend the KM concept. KM is still defining itself because the body of theoretical literature and research in this area is small, but growing (Skyrme, 2001). It is estimated that worldwide spending on knowledge management services will grow from US$776 million in 1998 to more than US$8 billion by 2003 and, as the industry moves into the so-called "second generation" phase, managers are being challenged to have in-depth understanding of the issues and need to demonstrate business performance and learning gains from investing in knowledge-based projects and initiatives. The New Wealth of Organizations is total quality management, re-engineering, and intellectual capital, and the companies that will succeed in the 21st century are those that master the knowledge agenda (Skyrme, 1997, 2000). While most business leaders appreciate the strategic value of knowledge and the need to manage their knowledge assets, many of them seem unable to derive real benefits from their efforts. Creating knowledge-based organizations will not be an easy exercise as organizations have to overcome tremendous hurdles in bringing disparate enterprise data sources into a cohesive data warehouse or knowledge management system (Allee, 1997). This chapter describes the overview of knowledge management concepts that may be required for creating knowledge-based organizations. The chapter has four sections. The first section describes the overview of knowledge management. The second section details the evolution of knowledge management. The next few sections describe knowledge representation, creation and generation and sharing. The next two sections describe the concepts of the learning organization and organizational memory that are useful for creating knowledge-based organizations.

OVERVIEW OF KNOWLEDGE MANAGEMENT

The importance of knowledge to the complex, competitive and global business environments which exist in the 21st century cannot be overemphasized, and those businesses that know how to effectively acquire, capture, share, and manage this information will be the leaders in their respective industries. We have moved into a period where competitive advantage is gained not just merely through access to information but, also — more importantly — from new knowledge creation (Drucker, 1994; Davenport & Prusak, 1997). Knowledge management is an emerging, interdisciplinary business model dealing with all aspects of knowledge within the context of the firm, including knowledge creation, codification, sharing, and using these activities to promote learning and innovation. It encompasses both technological tools and organizational routines of which there are a number of components. These include generating new knowledge, acquiring valuable knowledge from outside sources, using this knowledge in decision making, embedding knowledge in processes, products, and/or services, coding information into documents, databases, and software, facilitating knowledge growth, transferring knowledge to other parts of the organization, and measuring the value of knowledge assets and/or the impact of knowledge management. Knowledge management is becoming very important for many reasons. To serve customers well and to remain in business, companies must reduce their cycle times, operate with minimum fixed assets and overhead (people, inventory and facilities), shorten product development time, improve customer service, empower employees, innovate and deliver high quality products, enhance flexibility and adaption, capture information, create and share knowledge. None of these actions are possible without a continual focus on the creation, updating, availability, quality and use of knowledge by all employees and teams at work and in the marketplace (Leonard, 1998). Seven knowledge layers are possible in organizations as described in Table 1 (Skyrme, 1999, 2001).

There are many definitions of knowledge management. At a generic level, it can be defined as the collection of processes that govern the creation, dissemination, and utilization of knowledge. It involves creation of supportive organizational structures, facilitation of organizational members, putting IT instruments with emphasis on teamwork and diffusion of knowledge (e.g., groupware) into place. Knowledge is the full utilization of information and data coupled with the potential of people's skills, competencies, ideas, intuitions, commitments and motivations. A holistic view considers knowledge to be present in ideas, judgments, talents, root causes, relationships, perspectives and concepts. Knowledge is stored in the individual brain or encoded in organizational processes, documents, products, services, facilities and systems. Knowledge is action, focused innovation, pooled expertise, special relationships and alliances. Knowledge is value-added behavior and activities (Pfeffer & Sutton, 2000). Knowledge encompasses both tacit knowledge (in people's heads) and explicit knowledge (codified and expressed as information in databases, documents, etc.). Knowledge is not static; instead, it changes and evolves during the life of an organization (Skyrme, 2000, 2001). What is more, it is possible to change the form

Table 1. Seven knowledge levels

Lever	Key Activities
Customer Knowledge	Developing deep knowledge sharing relationships. Understanding the needs of your customers' customers. Articulating unmet needs. Identifying new opportunities.
Stakeholder Relationships	Improving knowledge flows between suppliers, employees, shareholders, community, etc. using this knowledge to inform key strategies.
Business Environment Insights	Systematic environmental scanning including political, economic, technology, social and environmental trends. Competitor analysis. Market intelligence systems.
Organizational Memory	Knowledge sharing. Best practice databases. Directories of expertise. Online documents, procedures and discussion forums. Intranets.
Knowledge in Processes	Embedding knowledge into business processes and management Decision making.
Knowledge in Products and Services	Knowledge embedded in products. Surround products with knowledge e.g. in user guides, and enhanced knowledge-intensive services.
Knowledge in People	Knowledge sharing fairs. Innovation workshops. Expert and learning networks. Communities of knowledge practice.

Table 2. Knowledge transformations

From/To	Tacit Knowledge	Explicit Knowledge
Tacit Knowledge	Socialization (Sympathized Knowledge) Where individuals acquire new knowledge directly from others.	Externalization (Conceptual Knowledge) The articulation of knowledge into tangible form through dialogue.
Explicit Knowledge	Internalization (Operational Knowledge) Such as learning by doing, where individuals internalize knowledge from documents into their own body of experience.	Combination (Systematic Knowledge) Combining different forms of explicit knowledge, such as that in documents or on databases.

of knowledge, i.e., turn existing tacit knowledge into new explicit knowledge and existing explicit knowledge into new tacit knowledge or to turn existing explicit knowledge into new explicit knowledge and existing tacit knowledge into new tacit knowledge. These transformations are depicted in Table 2.

The KM architecture and KM process model that could be used for knowledge capture, creation, distribution and sharing is shown in Figures 1 and 2.

Knowledge management draws from a wide range of disciplines and technologies. These include cognitive science, artificial intelligence

Figure 1. KM architecture

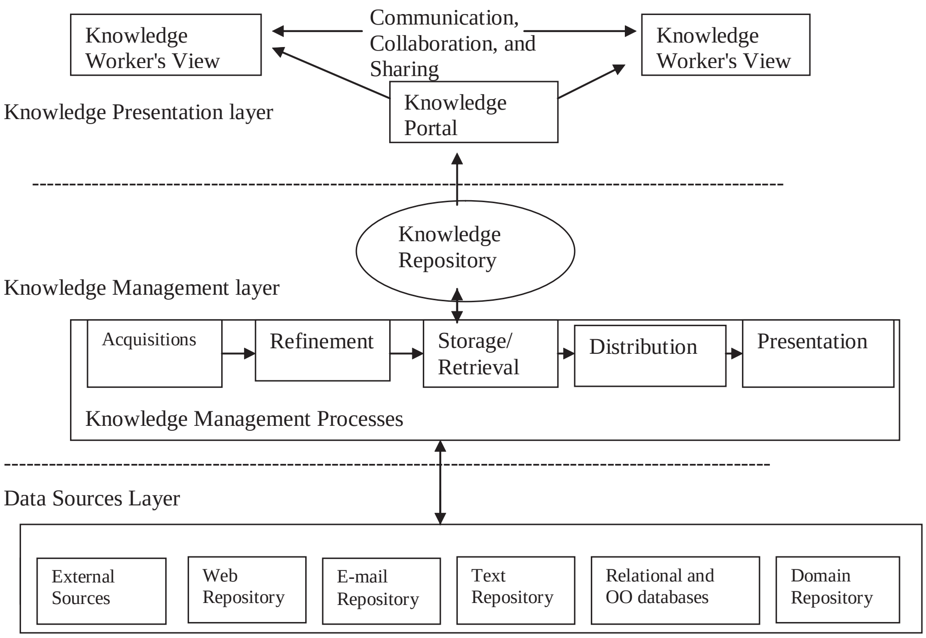
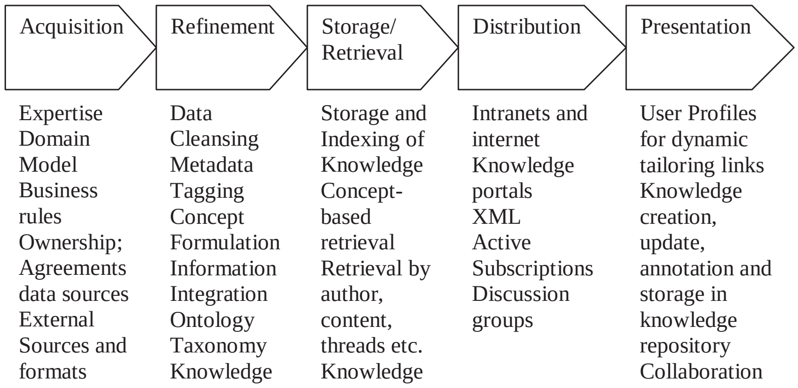


Figure 2. Knowledge management process model



and expert systems, groupware and collaborative systems, and various other areas and technologies as described in Table 3.

So in summary, we can describe knowledge management as an audit of "intellectual assets." Knowledge management complements and enhances other organizational initiatives such as total quality management (TQM), business process re-engineering (BPR) and organizational learning, providing a new and urgent focus to sustain competitive position. A wide variety of practices and processes are used in knowledge management. Some of the more common ones are shown in Table 4.

Over time, considerable knowledge is also transformed to other manifestations such as books, technology, practices, and traditions within organizations. Knowledge management for the organization consists of activities focused on the organization gaining knowledge from its own experience and from the experience of others and on the judicious application of that knowledge to fulfill the mission of the organization. These activities are executed by marrying technology, organizational structures, and cognitive- based strategies to raise the yield of existing knowledge and to produce new knowledge. Critical in this endeavor is the enhancement of the cognitive system (organization, human, computer, or joint human-computer system) in acquiring, storing and utilizing knowledge for learning, problem solving, and decision-making.

EVOLUTION OF KNOWLEDGE MANAGEMENT

The history and evolution of knowledge management has not always been that clear or straightforward given that the field has evolved from so many different disciplines and domains. A number of management theorists have contributed to the evolution of knowledge management, among them Peter Drucker, Paul Strassmann and Peter Senge in the United States. Drucker and Strassmann have stressed the growing importance of information and explicit knowledge as organizational resources, and Senge has focused on the "learning organization," a cultural dimension of managing knowledge. Chris Argyris, Christoper Bartlett and Dorothy Leonard-Barton of Harvard Business School have examined various facets of managing knowledge. In fact, Leonard-Barton's well-known case study of Chaparral Steel, a company which has had an effective knowledge management strategy in place since the mid-1970s, inspired the research documented in her book *Wellsprings of Knowledge — Building and Sustaining Sources*

Table 3. Wide range of disciplines and technologies for knowledge management

Disciplines and Technologies	Description
Cognitive science	Since knowledge management is related to how we learn and know, the study of cognitive science certainly has a usefulness towards gathering and transferring knowledge.
Expert systems, artificial intelligence and knowledge base management systems (KBMS)	AI and related technologies are directly applicable to knowledge management. Expert systems, for example, have as its goal the capture of knowledge within a computerized knowledge base
Computer-supported collaborative work (groupware)	K*nowledge management* is often closely linked with and in some cases is almost synonymous with *groupware and* Lotus Notes. Sharing and collaboration are clearly vital to organizational knowledge management — with or without supporting technology.
Library and information science	The body of research and practice that encompasses libraries, information science, and knowledge organization can be applied to management of knowledge. These include tools for thesaurus construction and controlled vocabularies.
Document management and technical writing	Originally concerned primarily with managing images, document management has moved on to making content more accessible and usable. Early recognition of the need to associate "metainformation" with a document object suggests a connection between document management and knowledge management. Technical writing (often known as *technical communication*) forms a body of theory and practice that is directly relevant to effective representation and transfer of knowledge.
Decision support systems	Decision Support Systems (DSS) have brought together insights from the fields of cognitive sciences, management sciences, computer sciences, and operations research, in key cognitive tasks, including organizational decision-making. The emphasis here is on quantitative analysis, and on tools for managers.
Semantic networks	Semantic networks are formed from ideas and the relationships among them — sort of "hypertext without the content," but with far more systematic structure according to meaning. Often used for such tasks as textual analysis, semantic nets are now in use in mainstream professional applications, including medicine, to represent domain knowledge in an explicit way that can be shared.
Relational and object databases	Currently, relational databases are used primarily as tools for managing "structured" data, and object-oriented databases for "unstructured" content. Of particular interest are the models on which they are founded, which relate to representing and managing knowledge resources.
Simulation	Knowledge Management expert Karl-Erik Sveiby suggests "simulation" as a component technology of knowledge management, referring to "computer simulations, manual simulations as well as role plays and micro arenas for testing out skills."
Organizational science	The science of managing organizations increasingly deals with the need to manage knowledge — often explicitly. Other technologies include: object-oriented information modeling; electronic publishing technology, hypertext, and the World Wide Web; help-desk technology; full-text search and retrieval; and performance support systems. (Barclay and Murray, 1997)

Table 4. KM practices and processes

Creating and Discovering	Creativity Techniques Data Mining Text Mining Environmental Scanning Knowledge Elicitation Business Simulation Content Analysis
Sharing and Learning	Communities of Practice Learning Networks Sharing Best Practice After Action Reviews Structured Dialogue Share Fairs Cross Functional Teams Decision Diaries
Organizing and Managing	Knowledge Centers Expertise Profiling Knowledge Mapping Information Audits/Inventory Measuring Intellectual capital

of Innovation (Harvard Business School Press, 1995). Everett Rogers' work at Stanford in the diffusion of innovation and Thomas Allen's research at MIT in information and technology transfer, both of which date from the late-1970s, have also contributed to our understanding of how knowledge is produced, used, and diffused within organizations. By the mid-1980s, the importance of knowledge as a competitive asset was apparent even though classical economic theory ignores knowledge as an asset, and most organizations still lack strategies and methods for managing it. Recognition of the growing importance of organizational knowledge was accompanied by a need to deal with exponential increases in the amount of available knowledge and the increased complexity of products and processes. The computer technology that contributed so heavily to this "information overload" started to become part of the solution in a variety of domains. Doug Engelbart's Augment (for "augmenting human intelligence"), which was introduced in 1978, was an early hypertext/groupware application capable of interfacing with other applications and systems. Rob Acksyn's and Don McCracken's knowledge management system (KMS), an open distributed hypermedia tool, is another notable example.

The 1980s also saw the development of systems for managing knowledge that relied on work done in artificial intelligence and expert systems, giving us such concepts as "knowledge acquisition," "knowledge engineering," "knowledge-base systems," and computer-based ontologies. The phrase "knowledge management" finally came into being in the business community during this decade. To provide a technological base for managing knowledge, a consortium of U.S. companies started the Initiative for Managing Knowledge Assets in 1989. Knowledge management-related articles began appearing in journals like *Sloan Management Review*, *Organizational Science*, *Harvard Business Review*, and others, and the first books on organizational learning and knowledge management were published (for example, Senge's *The Fifth Discipline* and Sakaiya's *The Knowledge Value Revolution*). By 1990, a number of management consulting firms had begun in-house knowledge management programs, and several well-known U.S., European, and Japanese firms had instituted focused knowledge management programs. Knowledge management was introduced in the popular press in 1991 when Tom Stewart published "Brainpower" in *Fortune* magazine. Perhaps the most widely read work to date is Ikujiro Nonaka's and Hirotaka Takeuchi's *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation* (1995). By the mid-1990s, knowledge management initiatives were flourishing, thanks in part to the Internet. The International Knowledge Management Network (IKMN) that began in Europe in 1989 went online in 1994 and was soon joined by the U.S.-based Knowledge Management Forum and other KM-related groups and publications. The number of knowledge management-based conferences and seminars is growing as organizations focus on managing and leveraging explicit and tacit knowledge resources to achieve competitive advantage. In 1994 the IKMN published the results of a knowledge management survey conducted among European firms, and the European Community began offering funding for KM-related projects through the ESPRIT program in 1995. Knowledge management, which appears to offer a highly desirable alternative to less successful TQM and business process re-engineering initiatives, has become big business for such major international consulting firms as Ernst & Young, Arthur Andersen, and Booz-Allen & Hamilton. In addition, a number of professional organizations interested in such related areas as benchmarking, best practices, risk management, and change management are exploring the relationship of knowledge management to their areas of special expertise (Lipnack & Stamps, 2000).

KNOWLEDGE REPRESENTATION

Knowledge representation—explicit specification of "knowledge objects" and relationships among those objects—takes many forms, with variations in emphasis and major variations in formalisms. Knowledge representation allows computers to reconfigure and reuse information that they store in ways not narrowly pre-specified in advance. *Concept mapping, semantic networks, hypertext, information modeling,* and *conceptual indexing* all exemplify knowledge representation, in somewhat different ways. **Concept mapping** seems to be rooted primarily in educational techniques for improving understanding, retention, and as an aid to writing. A concept map is a picture of the ideas or topics in the information and the ways these ideas or topics are related to each other. It is a visual summary that shows the structure of the material the writer will describe. **Semantic networks** are often closely associated with detailed analysis of texts and networks of ideas. One of the important ways they are distinguished from hypertext systems is their support of semantic typing of links, for example, the relationship between "murder" and "death" might be described as "is a cause of." The inverse relationship might be expressed as "is caused by." Semantic networks are a technique for representing knowledge. As with other networks, they consist of nodes with links between them. The nodes in a semantic network represent concepts. A concept is an abstract class, or set, whose members are things that are grouped together because they share common features or properties. The "things" are called instances of the concept. Links in the network represent relations between concepts. Links are labeled to indicate which relation they represent. Links are paired to represent a relation and its inverse relation. For example, the concept Femur is related to the concept Upper Leg with the relation has-location. The inverse of has-location is the relation location-of, which relates Upper Leg to Femur. Hypertext (an expanded semantic network), known to most people these days by its implementation in the World Wide Web, is sometimes described as a semantic network with content at the nodes. But the content itself, the traditional document model, seems to be the driving organizational force, not the network of links. In most hypertext documents, the links are **not** semantically typed, although they are typed at times according to the medium of the object displayed by traversing the link. **Information modeling** is concerned with precise specification of the meaning in a text and in making relationships of meaning explicit, often with the objective of rapid and accurate development of new software applications for business requirements. Some of the essence of information modeling is expressed in the following definition: "The process of eliciting requirements from domain experts, formulating a complete and precise specification understandable to both domain experts and developers, and refining it using existing (or possible) implementation mechanisms." **Conceptual indexing** is rarely discussed in the same breath as hypertext, conceptual maps, and semantic networks, perhaps because indexers themselves sometimes relish the aura of "black art" surrounding indexing, but the connection is fundamental. Conceptual indexes traditionally map key ideas and objects in a single work. An index is a structured sequence, resulting from a thorough and complete analysis of text, of synthesized access points to all the information contained in the text. The structured arrangement of the index enables users to locate information efficiently. The organization of topics into parent-child, synonym, and "see also" relationships is a critical part of an effective professional index. Good indexes are not flat lists of names and ideas.

Knowledge Sharing/Information Sharing

The terms *knowledge sharing* and *information sharing* are often used in conjunction with discussions of *ontologies* and *knowledge representation*. In the context of the following quote, the primary concern of information sharing is precision of expression and access in order to meet the objective of rapid product development. Information sharing and decision coordination are central problems for large-scale product development. This chapter proposes a framework for supporting a knowledge medium (Stefik, 1986): "a computational environment in which explicitly represented knowledge serves as a communication medium among people and their programs." The framework is designed to support information sharing and coordinated communication among members of a product development organization, particularly for the tasks of design knowledge capture, dynamic notification of design changes, and active management of design dependencies. The proposed technology consists of a shared knowledge representation (language and vocabulary), protocols for foreign data encapsulation and posting to the shared environment, and mechanisms for content-directed routing of posted information to interested parties via subscription and notification services. A range of possible applications can be explored in this framework, depending on the degree of commitment to a shared representation by participating tools. A number of research issues fundamental to building such a knowledge medium are introduced in the chapter.

Metadata/Meta-information/ [Document] Profile Information/ [Subject] Classification/Key Words/ "Attributes"

Metadata is simply information added to a document (or a smaller unit of information) that makes it easier to access and reuse that content. It's also referred to as simply "data about data." You'll find metadata in many different forms including key words in a software help system, the document profile information attached to documents in a document management system, and the classification information in a library card catalog. There are, of course, distinctions in how these various disciplines and technologies implement metadata, in substance as well as in formalisms. But the value of metadata for critical information is widely accepted as a basic element of knowledge management implementations.

Ontologies [Computer-based]

Computer-based *ontologies*, formal, structured representations of a domain of knowledge, are commonly associated with artificial intelligence technology where they were originally designed to serve as the raw material for computer reasoning and computer-based agents.

ACQUIRING AND GENERATING KNOWLEDGE

Critical to managing knowledge is the generation and dissemination of information, followed by shared interpretation of the processed information into “knowledge.” In order for an organization to be able to manage knowledge, it must have knowledge to work with in the first place. There are a number of ways in which to acquire and generate new knowledge for your firm. One of the most obvious ways to acquire new knowledge is either to acquire an organization with the knowledge which you desire, or alternately, to hire people who possess the same knowledge. While, in the case of acquiring a firm, it is not guaranteed that the knowledge (or people who possess it) will necessarily stay with the company, it is possible to retain a significant portion of it. It should also be noted that political and cultural aspects may come into play, affecting how well a new acquisition can be integrated into the parent firm (Nonaka & Takeuchi, 1995).

Another possibility is to “rent” knowledge through the hiring of outside consultants or to help generate new knowledge by supporting (financially or otherwise) the research being conducted at universities and research centers, with the promise of future benefits in terms of developing the technologies for commercial use (Davenport & Prusak, 2000).

Aside from the method of obtaining or generating knowledge externally, it is also possible to do it “in-house.” One way is to set up a research center within the auspices of a company with the specific purpose to generate new ideas, technologies and, eventually, commercial products. Notable examples of these include the Xerox PARC (Palo Alto Research Center), which among other things was where the concept of the GUI (graphical user interface), including menus, the mouse, and the use of icons originated. These were later incorporated into various models of the Apple Computer. Firms which have developed their own research centers include IBM, Motorola, and Sharp Electronics (Davenport & Prusak, 2000).

There are a number of other methods by which knowledge can be acquired or brought into an organization. These include data mining, text mining, and knowledge elicitation. Data mining is not a single technique or technology but a group of related methods and methodologies which are directed towards the finding and automatic extraction of patterns, associations, changes, anomalies and significant structures from data (Grossman, 1998). Data mining is emerging as a key technology which enables businesses to select, filter, screen, and correlate data automatically. Data mining evokes the image of patterns and meaning in data, hence the term which suggests the mining of “nuggets” of knowledge and insight from a group of data. The findings from these can then be applied to a variety of applications and purposes including those in marketing, risk analysis and management, fraud detection and management, and customer relationship management (CRM). With the considerable amount of information which is being generated and made available, the effective use of data-mining methods and techniques can help to uncover various trends, patterns, inferences, and other relations from the data which can then be analyzed and further refined. These can then be studied to bring out meaningful information which can be used to come to important conclusions, improve marketing and CRM efforts, and predict future behavior and trends (Han & Kamber, 2001). The possibilities for data mining from textual information are largely untapped, making it a fertile area of future research. Text expresses a vast, rich range of information, but in its original, raw form is difficult to analyze or mine automatically. As such, text data mining (TDM) has relatively fewer research projects and commercial products compared with other data mining areas. As expected, text data mining is a natural extension of traditional data mining (DM) as well as information archeology (Brachman et al., 1993). While most standard data mining applications tend to be automated discovery of trends and patterns across large databases and datasets, in the case of text mining, the goal is to look for patterns and trends like nuggets of data in large amounts of text (Hearst, 1999). Knowledge elicitation is the process of extracting information from an expert source, such as interviewing an expert in a given subject area, so that it can then be coded and otherwise stored in a form which can be accessed by others. Closely related to the term knowledge acquisition in the expert systems field, knowledge elicitation is a difficult process and is often referred to as a "bottleneck" in the acquisition of knowledge. Experts cannot often explain or express their reasoning and thought processes which causes the problem known as the "paradox of expertise."

As discussed above, there are a number of ways in which knowledge can be acquired or brought into an organization. These can include the acquisition of firms and organizations which hold the knowledge which is desired, the hiring of professionals who possess this knowledge, the hiring of outside consultants, or the derivation of new knowledge from such sources as data mining, text mining, and knowledge elicitation. All of these can enhance your firm's capabilities by the introduction of new knowledge into your organization.

CODIFYING KNOWLEDGE

Knowledge which is obtained needs to be captured and stored in a form which would allow it to be accessed by others or to be referenced when needed. This would allow the knowledge to be retained within a firm rather than having it be "carried in the heads" of the company founders or employees, which might result in it being lost if the person was to leave, die, or be otherwise unavailable. A number of different methods and technologies can be used with regards to codifying knowledge, and the specific method used could vary according to the specific type of information which is being coded. According to Davenport and Prusak (2000), the goal of codifying knowledge is to "convert knowledge into accessible and applicable formats." Included within this broad definition are steps and methods such as describing, categorizing, modeling, and mapping knowledge in a "coded" form. Coded knowledge is often put into a computerized form although the word "coded" does not always or necessarily mean coded into a computerized format. The important concepts to keep in mind include the need to decide what business goals the coded information will serve, how a certain set of knowledge will be used to meet these goals, how to select the right knowledge to be coded (form and content) and, finally, what is the medium or method which is to be used to code this information effectively. To start, there are different kinds of knowledge. Knowledge may be as straightforward as a set of rules or definitions (explicit knowledge) or as complex as the skills involved in something like playing a violin or hitting a baseball in the major leagues. This latter form of knowledge, called tacit knowledge, is one of the challenging areas of knowledge management in that it is very difficult to codify this kind of knowledge on paper or in a database. Tacit knowledge can be more formally defined as *"Knowledge that enters into the production of behaviors and/or the constitution of mental states but is not ordinarily accessible to consciousness."* The distinction between tacit knowledge and explicit knowledge has sometimes been expressed in terms of knowing-how and knowing-that, respectively (Ryle, 1949/1984, pp. 25-61), or in terms of a corresponding distinction between embodied knowledge and theoretical knowledge. On this account, knowing-how or embodied knowledge is characteristic of the expert who acts, makes judgments, and so forth without explicitly reflecting on the principles or rules involved. The expert works without having a theory of his or her work; he or she just performs skillfully without deliberation or focused attention. Knowing-that, by contrast, involves consciously accessible knowledge that can be articulated and is characteristic of the person learning a skill through explicit instruction, recitation of rules, attention to his or her movements, etc. While such declarative knowledge may be needed for the acquisition of skills, the argument goes, it no longer becomes necessary for the practice of those skills once the novice becomes an expert in exercising them and, indeed, it does seem to be the case that, as Polanyi argued, when we acquire a skill, we acquire a corresponding understanding that defies articulation (Polanyi, 1958/1974). Now that the differences between the two main types of knowledge have been explained, attention can be given to a method of codifying knowledge using knowledge maps. A knowledge map is not a collection of the knowledge or information itself but rather is a kind of roadmap or index to the knowledge. This is an important component to have, since a large mass of knowledge may be difficult to understand or manage if there is not some kind of map to guide the user.

TRANSFER OF KNOWLEDGE

The transferability of information and knowledge is a critical determinant of an organization's capacity to confer sustainable competitive advantage. The issue of transferability is paramount in both intra- (such as between functional units and management levels) and inter-organizational settings (such as supply chains, strategic alliances, and joint venture development). Critical to the flow of information and knowledge is the knowing how (tacit knowledge) and the knowing about (explicit knowledge) distinction of knowledge transferability. Knowledge transfer is an important aspect of knowledge management because knowledge, once captured or obtained by an organization, must be able to be shared from and by persons and groups within the organization. There are a number of techniques in which organizations transfer (and related to this, share) information. According to Nancy Dixon (2000), there are five main types of knowledge transfer/sharing. These include serial transfer, near transfer, far transfer, strategic transfer, and expert transfer. Each of these differs according to the purpose, method, and ways in which they are implemented. Serial transfer is a form of knowledge transfer where knowledge (both explicit and tacit) which is gained in one context or setting is then transferred to the next use when it is performed in a different setting. In general, this applies to the same team applying their knowledge from an earlier similar task to a slightly different context at a later date. This involves the management of both explicit and tacit knowledge and usually involves regular meetings, participation by all of the team members, and an emphasis on brief meetings. An example of this might be a team replacing an air conditioning system in an office building and then doing the same task in a different setting, such as an apartment complex. Knowledge gained from the one setting can be used in the new setting (Dixon, 2000). Near transfer differs in that the type of knowledge being transferred is basically explicit in nature, and the specific information which is key to doing a task by one team is then transferred to another team that will be doing a very similar task. This type of transfer is best suited for tasks which are generally routine, frequent, and generally similar when repeated. Often, this information is distributed through electronic means, and the information is both explicit and somewhat brief and concise in nature. For example, one team at the corporate headquarters has perfected a method of doing a certain kind of installation. The methods and steps can be recorded electronically (in e-mail or PDF file or other electronic means) and then distributed to other offices and teams throughout the organization, which can bring about better performance and productivity by the receiving teams. Far transfer focuses on the sharing of tacit knowledge between teams in an organization and often results in the collaboration between the teams, whether face-to-face or using other means. Because the information involved here is tacit, it cannot be easily recorded and transmitted as with the near transfer method. Far transfer of information is best suited to information which is non-routine in nature and for tasks which are likely to be frequently performed. Both teams can collaborate by mutually offering and receiving information. For instance, if a team has been tasked to work on a new and unique project, they may bring another team who has worked on similar projects in the past so that they can share and exchange information and come up with a viable solution to the problem (Dixon, 2000).

Strategic transfer focuses on the transfer of knowledge which can impact the organization as a whole. Involving both explicit and tacit knowledge, it is designed for situations which are neither frequent, nor routine and could involve tasks which are high-level within an organization, such as the knowledge required for corporate mergers and acquisitions. Strategic transfer frequently involves the identification of key knowledge needed by corporate executives and senior-level managers and then the collection and interpretation completed by knowledge specialists. Finally, there is expert transfer, which involves the gaining of explicit knowledge from experts when the scope of a task is outside of the knowledge of a team working on a task. The information in this case, because of its explicit nature, can be transmitted via electronic forums or networks and can be in the form of "bulletin boards," where a question can be posted and various knowledgeable experts who know the answer can then respond with the required knowledge. Having such a network in place can be extremely useful, since problems can occur at any time, and having a network of experts available when problems arise is a valuable resource (Dixon, 2000).

Another useful method of sharing and transferring information is through Communities of Practice (CoPs). A definition of a community of practice is "a group of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in an area by interacting on an ongoing basis" (Wenger et al., 2002). Although the term "Community of Practice" is new, CoPs are not. Such groups have been around ever since people in organizations realized they could benefit from sharing their knowledge, insights, and experiences with others who have similar interests or goals. The concept of a community of practice is an extension or a variation of the concept of special interest groups, clubs, medieval guilds, and even regions for certain industries (Silicon Valley for high-tech and Detroit for the automobile industry). One of the best-known examples of a CoP was one formed by the copy machine repair technicians at Xerox Corporation. Through networking and sharing their experiences, particularly the problems they encountered and the solutions they devised, a core group of these technicians proved extremely effective in improving the efficiency and effectiveness of efforts to diagnose and repair Xerox customers' copy machines. The impact on customer satisfaction and the business value to Xerox was invaluable (Wenger, 1999).

TECHNOLOGIES FOR KNOWLEDGE MANAGEMENT

As mentioned previously, knowledge management is an area which is not always easily defined because it is broad and spans various disciplines. The field encompasses the use of management techniques and methods, collaborative concepts and techniques, as well as the use of various computer and related technologies. The purpose of this section is to examine some of the important technologies which are used in the area of knowledge management.

The *computer-supported collaborative work* (CSCW) community has been addressing issues of shared development of knowledge for many years. *Groupware* is sometimes used as a synonym for CSCW, and Lotus Notes often appears to be the defining CSCW application, even though there are other groupware products including Netscape's Collabra Share. Recent developments in corporate *intranets* are likely to dramatically increase the

Table 5. Summary of various tools and technologies available for knowledge management

Technologies & Tools	Description
Expert systems	An expert system is regarded as the embodiment within a computer of a knowledge-based component from an expert skill in such a form that the system can offer intelligent advice or make an intelligent decision about a processing function. Expert systems are computer-based programs which are designed to record human expertise (knowledge) and then apply this knowledge to applications in a certain domain.
Distributed hypertext systems	*Distributed hypertext systems* have been concerned with the generation and leveraging of organizational knowledge for more than a dozen years. Theodor Holm Nelson coined the term "hypertext" in the 1960s, and his writings about representation, access, and management of knowledge -- embodied in his vision for Project Xanadu, a global "docuverse" that pre-figured the World Wide Web – are useful for managing information and knowledge.
Document management	*Document management* systems originally were primarily concerned with providing online access to documents stored as bit-mapped images. Document management technology -- already in widespread use in large, information-intensive companies-- is likely to become an integral part of virtually every "intranet" in one form or another.
Geographic information systems	*Geographic information systems*, a term associated with knowledge management, is used as a graphic tool for *knowledge mapping.* Known by the acronym GIS for short, the technology involves a digitized map, a powerful computer and software that permits the superimposition and manipulation of various kinds of demographic and corporate data on the map.
Help desk technology	*Help desk technology* is primarily concerned with routing requests for help from information seeker to the right technical resolution person within an organization
Intranets	*Intranets* -- intra-corporation networks that use the Internet's IP (Internet Protocol) standard -- not only permit sharing of information, but they also view the organization's information (including structured resources like relational databases as well as unstructured text) through Web browsers like Internet Explorer and Netscape Navigator.
Concept mapping	*Concept mapping* seems to be rooted primarily in educational techniques for improving understanding, retention, and as an aid to writing. A concept map is a picture of the ideas or topics in the information and the ways these ideas or topics are related to each other. It is a visual summary that shows the structure of the material the writer will describe
Semantic networks	*Semantic networks* are often closely associated with detailed analysis of texts and networks of ideas. One of the important ways they are distinguished from hypertext systems is their support of semantic typing of links -- for example, the relationship between "murder" and "death" might be described as "is a cause of." The inverse relationship might be expressed as "is caused by." Semantic networks are a technique for representing knowledge.
Hypertext (an expanded semantic network)	*Hypertext*, known to most people these days by its implementation in the World Wide Web, is sometimes described as a semantic network with content at the nodes. But the content itself -- the traditional document model -- seems to be the driving organizational force not the network of links. In most hypertext documents, the links are **not** semantically typed, although they are typed at times according to the medium of the object displayed by traversing the link.

Table 5. Summary of various tools and technologies available for knowledge management (continued)

Technologies & Tools	Description
Information modeling	*Information modeling* is concerned with precise specification of the meaning in a text and in making relationships of meaning explicit -- often with the objective of rapid and accurate development of new software applications for business requirements. Some of the essence of information modeling is expressed in the following definition "The process of eliciting requirements from domain experts, formulating a complete and precise specification understandable to both domain experts and developers, and refining it using existing (or possible) implementation mechanisms."
Conceptual indexes	*Conceptual* (or "back-of-the-book") *indexes* are rarely discussed in the same breath as hypertext, conceptual maps, and semantic networks -- perhaps because indexers themselves sometimes relish the aura of "black art" surrounding indexing -- but the connection is fundamental. Conceptual indexes traditionally map key ideas and objects in a single work. An index is a structured sequence -- resulting from a thorough and complete analysis of text -- of synthesized access points to all the information contained in the text. The structured arrangement of the index enables users to locate information efficiently.
Metadata	*Metadata* is simply information added to a document (or a smaller unit of information) that makes it easier to access and re-use that content. It's also referred to as simply "data about data." You'll find metadata in many different forms, including key words in a software help system, the document profile information attached to documents in a document management system, and the classification information in a library card catalog.

level of interest in CSCW as IP-based technologies replace or complement proprietary products like Notes.

Table 5 is a summary of various tools and technologies available for knowledge management.

LEARNING ORGANIZATION

In recent years, an increasing amount of global business school research and literature has focused on concepts such as the "knowledge-based economy," "organizational learning," "knowledge workers," "intellectual capital," "virtual teams," and the like in order to make sense of this "new discipline" (Gittell & Vidal, 1998). Organizational learning is a fairly recent way to think about learning in organizations. In a time of less organizational change (technological, societal, and economic), it was possible for an organization to develop a strategy for functioning and, assuming the strategy was initially effective, maintain that strategy for several decades. Current organizations, however, must change constantly in order to survive for even one decade. But change in and of itself is not sufficient. The change must be based on appropriate data gathered externally from the environment and internally from lessons learned. Both are a part of organizational learning, and both are critical to effective organizations (Skyrme, 1998, 2000, 2001). Learning organizations or organizational learning are defined in many different ways. A few selected definitions are:

"The essence of organizational learning is the organization's ability to use the amazing mental capacity of all its members to create the kind of processes that will improve its own" (Dixon, 1994);

and

"Organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to learn together" (Senge, 1990).

In general, we can define learning organizations as those that have in place systems, mechanisms and processes that are used to continually enhance their capabilities and those who work with it or for it to achieve sustainable objectives, both for themselves and for the communities in which they participate. Companies are seeking to improve existing products and services (continuous improvement) and innovation (breakthrough strategies). This has resulted in a plethora of initiatives such as TQM (Total Quality Management) and BPR (Business Process Re-engineering). But companies are finding that such programs succeed or fail depending on human factors, such as skills, attitudes and organizational culture (Garvin, 2000).

Types of Learning

A learning organization is not about "more training." While training does help develop certain types of skill, a learning organization involves the development of higher levels of knowledge and skill. There could be four different levels of learning. (See Table 6.)

Organizations need to follow different steps to convert themselves into learning organizations.

- **Learning Culture:** An organizational climate that nurtures learning. There is a strong similarity with those characteristics associated with innovation.
- **Management Processes:** Processes that encourage interaction across boundaries. These are infrastructure, development and management processes as opposed to business operational processes (the typical focus of many BPR initiatives).
- **Tools and Techniques:** Methods that aid individual and group learning, such as creativity and problem-solving techniques.
- **Skills and Motivation:** To learn and adapt.
- **Free Exchange and Flow of Information:** Systems are in place to ensure that expertise is available where it is needed and individuals network extensively, crossing organizational boundaries to develop their knowledge and expertise.
- **Commitment to Learning, Personal Development:** Support from top management;

Table 6. Four different levels of learning

Level of Learning	Description
Level 1.- Learning facts, knowledge, processes and procedures	Applies to known situations where changes are minor.
Level 2.- Learning new job skills that are transferable to other situations	Applies to new situations where existing responses need to be changed. Bringing in outside expertise is a useful tool here.
Level 3 - Learning to adapt	Applies to more dynamic situations where the solutions need developing. Experimentation and deriving lessons from success and failure are the mode of learning here.
Level 4 - Learning to learn	Is about innovation and creativity; designing the future rather than merely adapting to it. This is where assumptions are challenged and knowledge is reframed.

people at all levels encouraged to learn regularly; learning is rewarded. Time to think and learn (understanding, exploring, reflecting, developing).

- **Valuing People:** Ideas, creativity and "imaginative capabilities" are stimulated, made use of and developed. Diversity is recognized as a strength. Views can be challenged.
- **Fostering a Climate of Openness and Trust:** Individuals are encouraged to develop ideas, to speak out, to challenge actions.
- **Learning from Experience:** Learning from mistakes is often more powerful than learning from success. Failure is tolerated, provided lessons are learned.

Tools and Techniques

Tools and techniques include a wide range of learning and creativity skills in the following groups:

- **Inquiry:** interviewing, seeking information
- **Creativity:** brainstorming, associating ideas
- **Making Sense of Situations:** organizing information and thoughts
- **Making Choices:** deciding courses of action
- **Observing Outcomes:** recording, observation
- **Reframing knowledge:** embedding new knowledge into mental models, memorizing

Collective (team and organizational) learning requires skills for sharing information and knowledge, particularly implicit knowledge, assumptions and beliefs that are traditionally "beneath the surface." Key skills here are:

- Communication, especially across organizational boundaries
- Listening and observing
- Mentoring and supporting colleagues
- Taking a holistic perspective — seeing the team and organization as a whole
- Coping with challenge and uncertainty

ORGANIZATIONAL MEMORY

Organizational memory is the record of an organization that is embodied in a set of documents and artifacts. Organizational memory has become a hot topic recently due to the growing recognition that it appears to be so thoroughly lacking in contemporary organizations. The problem is not a scarcity of documents and artifacts for the organizational memory but rather the quality, content, and organization of this material. For example, an effective organizational memory would be able to answer such often-asked questions as, "Why did we do this?" and "How did such and such come to be the case?" Rarely is this possible now (Conklin, 1996).

Basically, the goal of an organization memory is to remember and learn a firm's past. Contemporary organizations seem to have only a weak ability to do this and are thus seeking to gain the capacity for "organizational memory." Networked computers might provide the basis for a "nervous system" that could be used to implement the capacity for organizational memory, but the technology (software and hardware) must provide for easy capture, recall, and learning. Moreover, for an organization to augment its memory, it must shift from the currently pervasive document- and artifact-oriented paradigm (or culture) to one that embraces process as well. This process-oriented paradigm requires the use of a system that integrates three technologies: hypertext, groupware, and a rhetorical method. Groupware allows the organizational record to be built in the course of everyday communication and coordination.

Hypertext provides the ability to organize and display this rich informational web. And a rhetorical method, such as IBIS, structures the memory according to content, not chronology. In addition to the computer technology, a shift in organizational culture toward an appreciation of process is required to implement organizational memory (Conklin, 1996).

Organizational memory is perhaps most clearly missing in industries where large numbers of people engage in the design and construction of large, complex systems over long periods of time such as defense, aerospace, utilities, pharmaceuticals, and telecommunications. Engineering organizations in these industries have serious limitations in transferring previous learning to current problems. The design rationale of large, complex systems is thoroughly and systematically lost. Such phrases as "reinventing the wheel," "going in circles," and "having the same discussion over and over," often heard in large engineering organizations, point to a striking phenomenon: while organizations don't seem to learn or remember very well, this limitation was, until recently, regarded as normal and inevitable. It is thus highly desirable to increase the capacity of organizations to remember and to learn. This means capturing more of the "documents and artifacts" of the organization in a way that they can be effectively recalled and reinterpreted. The growth of networked computers for all phases of information work creates the infrastructure – (i.e., the "nervous system") to support this increased capture and reuse of organizational memory (Conklin, 1996).

Three Tools For Organizational Memory

The most immediate barrier to capturing more of the process of work and making it part of organizational memory is that it seems to present an insurmountable and onerous documentation burden on the people doing the work. The key to overcoming this perception is to shift the notion of capturing the process data from being an additional documentation burden to "tapping into" the flow of communication that is already happening in an organization. Not surprisingly, this shift is also a shift from an artifact-oriented to a process-oriented perspective (Conklin, 1996).

The first element of the computer technology is hypertext, because the nature of the process-oriented approach is essentially non-linear, so the representation for capturing and organizing it must also be that rich. Moreover, as time goes by and the organizational record grows more convoluted and complex, the unlimited flexibility of hypertext as a representational medium is essential for ongoing restructuring and summarization.

The second element is groupware, for the same reason that e-mail is a natural first step toward easy capture of organizational process. An MCC/NCR field study showed clearly that it is critical that the technology used to capture rationale be as transparent as possible and that it must closely fit the existing practices and tools of the organization. Groupware by its very nature is not focused on capture, but rather on communication and coordination. The secret to capturing organizational memory then is to "tap into" the existing flow of process interactions between the members of the organization and to crystallize this on an ongoing basis into the key elements of the organizational memory. Groupware can provide the medium for organizational dialogues which, because they occur via the computer, create a computable record of semi-structured documents. The ability then exists to manipulate, distribute or share this information and intelligence throughout the organization or team effectively and on an ongoing basis, creating a memory and learning tool.

The third element of the technology for capturing organizational memory is the use of a rhetorical method, or conversational model, for structuring the conversations occurring with the technology. The reason for this is two-fold. A simple rhetorical method provides a structure for discussing complex problems that can immediately improve the quality of the dialogue process. The IBIS (Issue-Based Information System) method (Kunz & Rittel, 1970) provides this kind of structure and process improvement. IBIS organizes planning and design conversations into issues (stated as questions), positions which offer possible solutions, and arguments which support or object to the positions. Such a model provides a basis for structuring the conversational record which is not simply chronological (as in an e-mail or bulletin board type system). For example, conversations in the IBIS method are structured according to the issues being discussed, providing a content-based index within which the cumulative record of the organizational process is preserved and organized.

Taken together, the technologies of hypertext, groupware, and the IBIS method combine synergistically to form a communication device for teams and teamwork and the ability to create an effective organizational memory for an organization. Thus, the technology for organizational memory must, at a minimum, incorporate hypertext, groupware, and a rhetorical model. But this computer technology alone is not sufficient to create an effective organizational memory. While the technology must be very good and the user interface transparent, the organization must also shift to making capture and use of organizational memory an important and natural practice. This shift towards a process-oriented paradigm and culture requires organizational commitment, and it is the most challenging part of establishing a capacity for memory and learning in an organization.

CONCLUSION

Knowledge management, in an age where there is an overwhelming amount of information and perhaps not sufficient resources or understanding to manage all of it, is a critically important area of concern to 21st century organizations. The basic, yet important, terms and concepts associated with knowledge management and organization memory for learning organizations are discussed in this chapter. Extracting knowledge that already exists in the minds of employees is a difficult process for generating knowledge. Future knowledge extractors will focus on rewards for knowledge, hiring good knowledge creators and providing easy-to-use tools for capture. In the future, categorization and organization of knowledge will be a core competence for every firm. This will require strategic thinking about what knowledge is important, the development of a knowledge vocabulary, prolific creation of indices, search tools and navigation aids, and the constant refinement and pruning of knowledge categories. Knowledge editors will have to combine sources and add context to transform information into knowledge (Prichard et al., 2000).

REFERENCES

Abram, S. (1997). *Knowledge management: Is this the answer?* Presentation delivered to the Special Libraries Association Toronto Chapter, October 15, 1997.

Allee, V. (1997). *The Knowledge Evolution: Building Organizational Intelligence*. London: Butterworth-Heinemann.

Barclay & Murray (1997). *What is knowledge management?* Retrieved from the World Wide Web: http://www.media-access.com/whatis.html.

Bates, M. E. (1997, Fall). *Information audits: What do we know and when do we know it?* Library Management Briefings.

Blue, A. (1998). Davis drives home the importance of being knowledge based. *Information Outlook*, 2(5), 39.

Broadbent, M. (1998). The phenomenon of knowledge management: What does it mean to the information profession? *Information Outlook*, 2(5), 23-36.

Chase, R. L. (1998). Knowledge navigators. *Information Outlook*, 2(9), 18.

Choo, C. W. (1998a). *Information Management for the Intelligent Organization: The Art of Scanning the Environment*. Medford, NJ: Information Today.

Choo, C. W. (1998b). *The Knowing Organization: How Organizations Use Information to Construct Meaning, Create Knowledge, and Make Decisions*. New York: Oxford University Press.

Conklin, E. J. (1996). *Capturing Organizational Memory in Groupware and Computer-Supported Cooperative Work*. In R. M. Baecker (Ed.). San Mateo, CA: Morgan Kaufmann.

Conklin, E. J. & Burgess Yakemovic, K. C. (1991). A process-oriented approach to design rationale. *Human-Computer Interaction*, 6, 357-391.

Davenport, T. H. (1995). *Some principles of knowledge management.*

Davenport, T. H. & Prusak, L. (1997). *Information Ecology: Mastering the Information and Knowledge Environment*. New York: Oxford University Press.

Davenport, T. H. & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Boston, MA: Harvard Business School Press.

Davenport, T. H., Eccles, R. G. & Prusak, L. (1992). Information politics. *Sloan Management Review*, 34(1), 53-63.

Dixon, N. (1994). *The Organizational Learning Cycle*. New York: McGraw-Hill.

Dixon, N. M. (2000). *Common Knowledge: How Companies Thrive by Sharing What They Know.* Boston, MA: Harvard Business School Press.

Drucker, P. F. (1993). *Post-Capitalist Society*. New York: Harper Collins.

Drucker, P. F. (1994, November). The age of social transformation. *The Atlantic Monthly*, 53-80.

Garvin, D. (2000). *Learning in Action: A Guide to Putting the Learning Organization to Work*. Boston, MA: Harvard Business School Press.

Gittell, R. & Vidal, A. (1998). *Community Organizing: Building Social Capital As Development Strategy*. Thousand Oaks, CA: Sage Publications.

Graham, M. (1991). *Notes on Organizational Memory: Practice and Theory*. Unpublished Xerox PARC working paper.

Krogh, G., Ichijo, K. & Nonaka, I. (2000). *Enabling Knowledge Creation: How to Unlock the Mystery of Tacit Knowledge and Release the Power of Innovation*. New York: Oxford University Press.

Kunz, W. & Rittel, H. (1970). *Issues as elements of information systems*. Working Paper No. 131, Institute of Urban and Regional Development, University of California at Berkeley, Berkeley, California, USA.

Leonard, D. (1998). *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Boston, MA: Harvard Business School Press.

Liberman, K. (1996). Creating & launching knowledge products. Getting Out of the Box: The Knowledge Management Opportunity. Video package prepared and presented at an SLA Distance Learning Program in October 1996, Washington, D.C., Special Libraries Association.

Lipnack, J. & Stamps, J. (2000). *Virtual Teams: People Working Across Boundaries with Technology*, (2nd ed.). New York: John Wiley & Sons.

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company*. New York: Oxford University Press.

O'Dell, C. et al. (1998). *If Only We Knew What We Know: The Transfer of Internal Knowledge and Best Practice*. New York: Free Press.

Oxbrow, N. (1999). Information audits. *The route to getting value from your intranet.* Retrieved from the World Wide Web: http://www.tfpl.com/about_TFPL/reports_research/information_audits_article/information_audits_article.html.

Oxbrow, N. & Abell, A. (1998). *Putting knowledge to work: What skills and competencies are required? Knowledge Management: A New Competitive Asset.* Presented at SLA State-of-the-Art Institute, 25, Washington, D.C.

Pedler, M., Burgoyne, J. & Boydell, T. (1991). *The Learning Company: A Strategy for Sustainable Development.* New York: McGraw-Hill.

Peters, R. F. (1997). Information partnerships: Marketing opportunities for information professionals. *Information Outlook*, 1(3), 14-16.

Pfeffer, J. & Sutton, R, I. (2000). *The Knowing-Doing Gap: How Smart Companies Turn Knowledge into Action*.

Polanyi, M. (1974). *Personal Knowledge: Towards a Post- Critical Philosophy*. Chicago, IL: University of Chicago Press. (Original work published in 1958).

Prichard, C., Hull, R., Chumer, M. & Willmott, H. (eds.). (2000). *Managing Knowledge: Critical Investigations of Work and Learning.* London: Macmillan Business.

Remeikis, L. (1996). Acquiring the new skills and overcoming the barriers. Getting Out of the Box: The Knowledge Management Opportunity. Video package prepared and presented as an SLA Distance Learning Program in October 1996, Washington, D.C., Special Libraries Association.

Rogers, E. (1995). *Diffusion of Innovations.* New York: Free Press.

Ryle, G. (1984). *The Concept of Mind*. Chicago, IL: University of Chicago Press. (Original work published in 1949).

Senge, P. M., Roberts, C., Ross, R. B., Smith, B. J. & Kleiner, N. A. (n.d.). *The Fifth Discipline Fieldbook: Strategies and Tools for Building a Learning Organization*.

Sistla, M. & Todd, J. (1998). Warning: A killer mistake in business—Don't let technology drive your requirements. *Information Outlook*, 2(6), 19-24.

Skyrme, D. J. (1997, September). From Information to Knowledge Management. *Information Age*, 1(20), 16-18.

Skyrme, D. J. (1998, March). Knowledge Management: Solutions: The Role of Technology. *ACM SIGGROUP Bulletin*, Special Issue on Knowledge Management at Work.

Skyrme, D. J. (1999). *Knowledge Networking: Creating the Collaborative Enterprise*. Butterworth-Heinemann.

Skyrme, D. J. (2000). Developing a Knowledge Strategy: From Management to Leadership. In D. Morey, M. Maybury & B. Thuraisingham (Eds.), *Knowledge Management: Classic and Contemporary Works.* Boston, MA: MIT Press.

Skyrme, D. J. (2001). *Capitalizing on Knowledge: From E-business to K-business.* Butterworth-Heinemann.

Skyrme, D. J. & Amidon, D. (1997, September). The Knowledge Agenda. *Journal of Knowledge Management*, 1(1), 27-37.

Skyrme, D. J. & Amidon, D. M. (1999). The Knowledge Agenda. In J. D. Cortada & J. A.

Woods (Eds.), *The Knowledge Management Yearbook*. Butterworth-Heinemann.

The Steps to Take for Conducting an Information Audit. (1997). *The Information Advisor*, 9(9), S1-S4.

Wenger, E. (1999). *Communities of Practice: Learning, Meaning, and Identity.*

Zipperer, L. (1998). Librarians in evolving corporate roles. *Information Outlook*, 2(6), 27-30.

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Chapter 1.2
Theoretical and Practical Aspects of Knowledge Management

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INTRODUCTION AND BACKGROUND

The last decade of the 20th century saw the emergence of a new discipline within the realm of information systems, which became known as knowledge management (KM). As such, it has become one of the most discussed issues amongst academics and practitioners working in the information systems and human resource management arenas (Prusack, 2001). Amongst academics it has become an area of specialisation with research projects, journals, conferences, books, encyclopaedias, and numerous papers devoted to the topic. Businesses are investing heavily in buying or developing KM supportive systems. However, predominately researchers and practitioners in this area have tended to see (see for example, Alavi & Leidner, 2001; Baskerville, 1998):

1. consider the context in which knowledge management takes place as teams of knowledge workers in communities of practice, whose performance and the performance of their organisation, can be enhanced by knowledge sharing;
2. focus on the process—the creation and application of knowledge management programmes and systems as an organisational resource—neglecting, with some exceptions (Alvesson & Karreman, 2001; Swan & Scarborough, 2001; Schultze, 1999), the wider context in which knowledge management takes place and the fact that resources can be used in ways that can be both creative and destructive, facilitating and manipulative; and
3. stress the role of technology as the enabling agent for KM.

OBJECTIVES AND FOCUS

This article proposes to broaden the KM discourse by re-examining some of the foundations of knowledge management in order to show that much of the current discussion—including by those who are critical of the conceptual basis of KM—neglects or underplays some otherwise well-known aspects of the topic. Two aspects in particular need to be considered:

a. the notion that knowledge is managed for a purpose—it is used as an instrument to achieve some objective, sometimes explicit, but often hidden or tacit. We note that the purpose is not necessarily benign, and that this, the darker side of knowledge management, includes knowledge and information manipulation.
b. that knowledge has been managed since mankind invented speech, and that few purposeful activities do not include some elements of knowledge management. Examples are provided to illustrate the point.

The article is presented from the perspectives of the IS scholar in particular, and organisational studies in general, as both face KM as a new area of study. The article is intended to act as a warning to both scholars and practitioners interested in KM, and suggests that the rhetoric emerging from the KM field should be treated with caution.

The article concludes with some reflections on the ethical dimensions stemming from KM practices.

Outline Argument

The argument presented in the article may be briefly summarised as follows: knowledge is not some benign resource which is only managed for the good of the individual, the team, and the organisation. Knowledge can be, and is, used instrumentally to achieve a range of objectives, ranging from the criminal, the mischievous, to the constructive and benign. The argument focuses on the relationship between the provision, acquisition, and dissemination of information, and the formation and creation of knowledge. It is argued that information, as a building block of knowledge, can be, and in practice is, guided, managed, controlled, or manipulated for a desired outcome. The practice of research is cited in order to demonstrate the argument. Finally, by drawing on some familiar institutional canons of our culture such as education, marketing, (scientific) management, and law, the article takes the first steps in broadening the KM discourse looking at control, instrumentality, and power relations.

The Argument Expanded

There is almost complete unanimity in the academic literature that KM is an essential activity for a modern enterprise to flourish in a global competitive economy, and many practicing managers share this view. Two assumptions underlie the KM literature:

- that there is a positive relationship between knowledge and truth; and
- that knowledge is the sum of beliefs, values, insights, and experiences.

Both assumptions serve to hide the instrumentality of knowledge. The article notes that underlying the management of knowledge are the notions of purpose and control. One purpose of providing software to facilitate knowledge sharing may be to improve the productivity of the group. But a second purpose may be to control the way the group works, for example, by determining who can share in the knowledge. Again the purpose of a marketing campaign may ostensively be to provide knowledge for the consumer, but also to mislead the consumer and ultimately to control the consumer's behaviour.

Both assumptions raise questions about the ethical implications and the power dynamics of knowledge management. How do these assumptions work and what are their implications?

Assumptions

KM, as a concept, is a good example of "reification" (Thompson, 1990)—the use of various ideological strategies for the purpose of maintaining a particular order of things—of what is essentially a very old idea, that we can work/live together much more harmoniously and productively, if only we communicate better (and more) with each other. Naturalisation takes place by supporting that it is always good and desirable to communicate and exchange knowledge with each other. The notion has been provided with an agenda: that through technological development, we can create an infrastructure that enables us to communicate and exchange (share) knowledge more effectively. Finally, the ideas are given a label—KM—and presented as a natural development of historical events, such as the emphasis on knowledge work and the capabilities provided by ICT.

Nevertheless, it is well known that the above does not completely capture reality. The tools provided by the technology and by organisational architecture are as much used to manipulate or hide knowledge, as to reveal and share it. The activity of exclusion and inclusion, of amplification and distortion of data, can be strategic, and no amount of technical sophistication can prevent that. Indeed, the technology can be harnessed to assist in these activities. White-collar crime is a good case in point. The literature on white-collar crime does not use the terms 'knowledge management' or 'knowledge manipulation' in describing the various manifestations of the crime, but it is clear that these activities are central to the expansion taking place in that type of crime and ICT can play major role in facilitating criminal activity.

In the process of reifying knowledge as something to be harnessed and exploited, there is also a tendency in the literature to reify the organisation, and therefore to think about organisational knowledge in terms of the benefit derived by the organisation, where organisation usually refers to top management. The ensuing power dynamics and the politics of knowledge production and use are all too clear. Knowledge and organising are not the privilege of the few, but the "processes" (Hosking & Morley, 1991) that occur in spaces where individuals form and un-form social relations, and carry out formal and informal practices across the organisation. Entering into this space, whether as a researcher or as a KM "manager," or indeed any other stakeholder, has implications for the dynamics of that space.

Implications

The implications are explored by examining the practice of research looking at the notions of bias, involvement, and lay/expert knowledge.

An individual approaching anything will be doing so from a particular position, be that theoretical, methodological, historical, or political, consciously or unconsciously. Past experiences tend to inform future actions by constraining as well as enabling one's movements. As such, the assumption about the positive relationship between knowledge and truth is unfounded because of the natural bias—by virtue of our unique experiences—that we all have. For example, in the context of organisational research, the study may be intended to gain understanding (knowledge) of some aspect of the organisation's activity. The choice of research methodology, a facet of knowledge management, guides and constrains the researcher.

Exactly the same applies to the design, implementation, and development of any organisational system or project. For example, the choice of development tool, as Actor Network Theory suggests (Nijland, 2004), plays a key role in determining both what knowledge is utilised and the way that knowledge is used. Furthermore, ignoring the 'power' dimensions of the situation being studied gives the impression that organisational space is neutral, and that the action of entering the space is also neutral. For example, in the case of 'resistance to change' to new technology, it may not be so much an instance of resisting the technology, per se, but a form of protest against those (usually superiors) who implement new technology for the benefit of the organisation as a whole, with little knowledge or understanding of the actuality at subordinate levels of the organisation (Land, 1992).

Lessons drawn from different forms of research—from observational to action research—teach us that the moment of interaction or engagement with our subject of research is never without its power dynamics. Access to the organisation and acceptance of the research in the first place is dependent on some form of hierarchical 'buy-in'—that is, the support of people who are senior enough in the organisation and who have the power to 'open doors' for the researchers. But problems arise, particularly if a researcher is forced to choose between access and compromise in research design; following the management's agenda does not necessarily reflect the organisation's concerns. The knowledge that is produced is likely to benefit the particular group in question and the organisation as a whole, but only in so far as management (or the sub-class of management involved) represents the organisation. As such, one of the most obvious dangers involved in working with pre-selected groups in an organisation is perpetuation of a hierarchy of knowledge. Similarly, it may be said that KM initiatives and systems are yet another management tool designed to enhance the working of the management; the old "panopticon" (Foucault, 1979) in a new packaging.

Lessons from research demonstrate that the processes of knowledge production are far from neutral. This can be explored with respect to the so-called 'lay/expert' knowledge debate. According to Shenav's analysis (1999), scientific management was introduced into the organisation as a way of neutralising the political/power dimensions of organisational life. Furthermore, when this was done, engineers had a special role of "redefining industrial conflict as a mechanical problem rather than as a result of political struggles" (p.3; cited in Grint, 2002, p. 173). It would seem that in the case of KM, the 'K' neatly replaces the 'scientific' and the role of the KM system designer or manager is taking over from the engineer. In both the case of the engineer and the knowledge manager, the problem is one of manipulation of 'expert' knowledge.

The problem is manifest at both internal and external levels. At the internal level the assumption is that managers know—in other words, managers are experts, and subordinates follow. Stories from senior management are more likely to be taken as authoritative and representative of the organisation than stories told by lower-level employees. Yet experience suggests that on important issues, knowledge is more evenly distributed than the authority structure implies (Land, 1992), and that at the micro level those at the coal face have more knowledge than those in positions of authority. At the external level, the 'expert' problem is manifest in the form of the consultants' guides which are often based on a pre-designed, standardised formula. Expert knowledge uses "formal theories [that] are often developed by powerful and/or socially elite individuals who use the theory to influence and control others. Some elements of formal theory may be based on scientific research, but others are based upon unsupported assumptions" (Whyte, 1990. p. 13). The problem arises when 'unsupported assumptions' become equated with being 'objective' knowledge in order to uphold positions of control. So long as the KM literature continues to refer to knowledge in terms of beliefs, values, and experience, the 'knowledge' will be susceptible to control and manipulation.

In the following section we will give examples of other areas, beyond the research context, which can help us to broaden the discourse on knowledge management.

Examples

The introduction to this article suggested that manipulation of knowledge takes place at the interface between information and knowledge. Information can be guided, managed, controlled, or manipulated for a desired outcome. The following examples have been selected in that they illustrate both the instrumental use of information and knowledge, and the wide variety of human activity in which knowledge is an indispensable component subject to management and manipulation. They are given from a non-expert position and are intended as triggers for thinking about how the knowledge management discourse could be broadened.

EDUCATION

Education, a major institutional force in the socialisation of the individual, is at least in part about managing the transfer of information for the creation of knowledge between teacher and pupil(s). Let us consider the teacher-pupil interaction for a moment. A teacher is a trained expert in a particular field and uses different resources (books, articles) in order to teach a, usually, national curriculum. The different resources form the link between what the teacher needs to convey and what the pupils need to learn. This is an informational link on the one level. On another level, however, it intends to 'form' the pupil's knowledge of a particular subject. We know that education—whether at the level of the curriculum, school, or individual teacher—is not objective, and the information intended to form pupils' knowledge can be managed for a desired effect. The subject of history is a case in point. There are good criticisms of this form of education. The Socratic dialogue is probably the oldest form of criticism; more recent, and widely cited, is the work of Brazilian educator Paolo Freire (1970). The criticism is against individuals as "repositories" of information, and instead encourages the active questioning and dialogue between teacher, pupil, curriculum. Control is a central theme in this questioning.

MARKETING

Marketing, embracing advertising and public relations, is another area redolent of KM. Marketing, widely taught as a core discipline in business schools, epitomises the use of knowledge management to provide consumers with product or service knowledge in order to enable them to make informed choices on what to buy. In the domain of marketing, the manipulative aspect of KM is widely recognised—its use to manipulate information in an instrumental way designed to provide consumers with a very partial or even distorted picture of the goods or service on offer and those offered by the competition. Advertising and public relations are constrained to some extent by regulations, in recognition that left unregulated organisations will manage knowledge in an unprincipled way for competitive advantage and maximum profit. Organisations like the Consumer Association exist to redress the balance between vendor and consumer, and try to offset the sometimes tacit, but often explicit knowledge management of the vendor.

(SCIENTIFIC) MANAGEMENT

Taylor's (1911) "scientific management" provides a further source of ideas with regards to the control aspect of KM. The advocates of scientific management believe firmly in the need to manage knowledge in order not to clutter up the minds of employees and to distract them from the limited tasks they are assigned to. Hence someone of higher authority always determines, on the principle of providing knowledge on a strict 'need-to-know' basis, what information and knowledge is to be provided for the employee. Whilst the KM movement espouses the reverse view, in reality Taylorism is deeply embedded in managerial practices, for example so called modern ideas of industrial reorganisation such as Business Process Reengineering (Hammer, 1990; Hammer & Champy, 1993; Davenport, 1993, 1996). Practical implementations of KM suffer a similar fate by carefully defining what knowledge can be shared and with whom sharing is permitted.

LAW

The law itself, and its study, provides another perspective on KM. The law relating to intellectual property rights, for example, defines and limits the way knowledge about intellectual property can be shared. The controversy about the human genome illustrates the relationship of intellectual property rights to KM. One group of scientists working on the human genome project took their discoveries to be knowledge that they were entitled to treat as a commodity not available to anyone except as they determined and for a price. Another group of scientists working on a human genome project reached a very different conclusion. They held that their discoveries were not an 'invention', but merely knowledge derived from the decoding of a natural phenomenon and as such could not be regarded as a commodity, and hence freely available to all (Sulston & Ferry, 2002; Wickelgren, 2002). Debates about intellectual property rights, data retention, and privacy (Hosein, 2001; Tsiavos & Hosein, 2003; Drahos & Braithwaite, 2003) provide concrete examples around the discourse of ownership and control of information and knowledge.

The instruments that support KM in its benign or destructive forms are varied. They include organisational architectures such as the authority structure, organisational provisions such as social clubs, technology-based provisions such as data warehouses, expert systems, case-based reasoning, web facilities, the intranet, and many others and, as ENRON demonstrated, the humble shredder as a potent weapon of KM.

FUTURE TRENDS

Given the argument presented in this article, two trends are noted in particular. The first is the growing realisation that technological developments provide ever widening opportunities for the dark side of knowledge management to flourish, and hence that there is a need to develop both awareness of the potential problems and defence mechanisms. Such mechanisms will need to emerge out of critical research that no longer relies on linear, fixed representations of reality, but which allows for the representation of uncertainty and the unexpected. For an example, see Land, Amjad, and Nolas's approach (in another article in this encyclopedia, titled "Knowledge Management Processes").

The second is the growing awareness of the political aspects of organisational processes driving the use of information and knowledge. There is a need to take an ethical stance both in the design of KM systems, as well as in research about the KM systems and their relationship with and effects on organisational processes. This requires a more interdisciplinary approach that permits the researcher and practitioner to both learn from the past and critically engage with the future.

CONCLUSION

The article has shown that it is possible and insightful to trace notions that might be interpreted as knowledge management to a broad range of older disciplines, and that a study of these provides us with a richer picture and deeper understanding of

KM. It is as if—to use a metaphor—the study of KM in the literature of the subject has focused a light on an iceberg so that we can see it in its full glory, but omits to note that there is more under the water than above it. What this article has set out to do is to expose some of the underside of the iceberg.

It is clear from studies in KM that whilst management can create the conditions for the beneficial aspects of KM—for example, knowledge sharing by the provision of tools, or by providing the conditions for relationships to develop, or both—the outcomes are dependent on a range of other factors such as organisational culture (Ackerman, Pipek, & Wulf, 2003). On the other hand, knowledge sharing can and does take place without any management intervention at all—without a conscious KM.

Despite its eminence and the notion of KM as a subject of study, critiques around the notion do exist and have evolved around the definition of knowledge and the choice of tools to support KM, those being either technological or human. But neither the technology, nor the relationship-oriented models have specially noted that KM involves power dynamics, as well as ethical issues. We need to look elsewhere for the discourse with which to address power dynamics and ethical issues (Foucault, 1980; Sussman, Adams, & Raho, 2002).

Knowledge management is not a chimera. KM has been helpful in drawing attention to the value of knowledge and how it can be utilised for the benefit of organisations, individuals, and society. But much of the work currently defined as being about KM takes a one-eyed stance. The Mafia principle of 'omerta' is also a form of knowledge management, albeit at its most malign, and companies like ENRON prompt us to question the ethical problems for society as a whole, but also for the individual, whether in the role of employee, outside observer (for example, journalist), or researcher, in the management of knowledge.

If the study of KM is to have an enduring future, it must take a more dynamic and contextual approach, recognising that its antecedents come from many more disciplines than those which are cited in the literature. Of course, research into the part of the iceberg above water is easier, in the sense that the stories that are told about it reflect the views of those who want to extol its beauty. Diving into the cold water below the iceberg and explaining what is there is more difficult. The dark side of KM is protected against exposure. It is perhaps not surprising that it requires more than auditors or academic researchers to reveal what lies under the iceberg. But students, researchers, and practitioners alike have to recognise the instrumentality of which drives action and the problems it gives rise to in terms of values, truth, and ethics.

In presenting these arguments we have followed the advice of two very distinct views of scientific progress. On the one hand we follow Popper (1972) in believing that one function of the researcher is to provide warnings about the fallibility of current orthodoxies. The evidence provided by the examples goes some way to throw doubt on the interpretation of KM as set out in much of the current literature. The second source of advice comes from Foucault (1980) and critical theory, which alerts us to power and politics implicit in the process of knowledge creation and utilisation.

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REFERENCES

Ackerman, M., Pipek, V., & Wulf, V. (Eds.). (2003). *Sharing expertise: Beyond knowledge management.* Cambridge, MA: MIT Press.

Alvani, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alvesson, M., & Karreman, D. (2001). Odd couple: Making sense of the curious concept of knowledge management. *Journal of Management Studies, 38*(7), 995-1018.

Baskerville, R.L. (1998). *A survey and analysis of the theoretical diversity in knowledge management.* Georgia State University Computer Information Systems Department Working Paper No. CIS98-1.

Davenport, T.H. (1993). *Process innovation, reengineering work through information technology.* Boston: Harvard Business Press.

Davenport, T.H. (1996). Why reengineering failed: The fad that forgot people, fast company. *Premier Issue*, 70-74.

Drahos, P., & Braithwaite, I. (2003). *Information feudalism*. New Press.

Foucault, M. (1979). *Discipline and punish: The birth of the prison*. Harmondsworth: Penguin

Foucault, M. (1980). *Power/knowledge*. New York: Pantheon.

Friere, P. (1970). *Pedagogy of the oppressed*. London: Penguin.

Hammer, M. (1990). Don't automate—obliterate. *Harvard Business Review*, (July-August), 104-112.

Hammer, M., & Champy, J. (1993). Reengineering the corporation: A manifesto for business revolution. *Insights Quarterly*, (Summer), 3-19.

Hosein, I. (2001). The collision of regulatory convergence and divergence: Updating policies of surveillance and information technology. *The South African Journal of Information and Communications, 2*(1), 18-33.

Hosking, D.M., & Morley, I.E. (1991). *A social psychology of organizing: People, processes and contexts.* New York: Harvester

Land, F., Amjad, U., & Nolas, S.M. (2005). Introducing knowledge management as both desirable and undesirable processes. In D.G. Schwartz (Ed.), *The encyclopaedia of knowledge management.* Hershey, PA: Idea Group, Reference.

Land, F.F. (1992). The management of change: Guidelines for the successful implementation of information systems. In A. Brown (Ed.), *Creating a business-based IT strategy.* Chapman & Hall (and UNICOM).

Nijland, M.H-J. (2004). *Understanding the use of IT evaluation methods in organisations.* Unpublished PhD thesis, University of London, UK.

Popper, K.R. (1972). *Conjectures and refutations: The growth of scientific knowledge* (5th ed.). London: Routledge, an imprint of Taylor & Francis Books Ltd.

Prusack, L. (2001). Where did knowledge management come from? *IBM Systems Journal, 40*(4), 1002-1007.

Schultze, U. (1999). Investigating the contradictions in knowledge management. In T.J. Larsen, L. Levine, & J.I. DeGross (Eds.), *Information systems: Current issues and future changes* (pp. 155-174). Austria: Laxenberg.

Shevav, Y. (1999). Manufacturing rationality: The engineering foundations of managerial rationality. Reviewed by Grint, K. (2002). *Organization, 9*(1),173-175.

Sulston, J., & Ferry, G. (2002). *The common thread: A story of science, politics, ethics and the human genome.* Joseph Henry Press.

Sussman, L., Adams, A.J., & Raho, L.E., (2002). Organizational politics: Tactics, channel, and hierarchical roles. *Journal of Business Ethics, 40*, 313-329.

Swan, J., & Scarborough, H. (2001). Knowledge management: Concepts and controversies. *Journal of Management Studies, 38*(7), 913-991.

Taylor, F. (1911/1998). *The principles of scientific management.* Dover Publications.

Thompson, J.B. (1990). *Ideology and modern culture: A critical social theory in the era of mass communication.* Cambridge, UK: Polity.

Tsiavos, P., & Hosein, I., (2003, June 18-21). Beyond good and evil: Why open source development for peer-to-peer networks does not necessarily equate to an open society. *Proceedings of the 11th European Conference on Information Systems: New Paradigms in Organization, Markets and Society,* Naples.

Whyte,W.F. (1990). *Social theory for action.* CA: Sage Publications.

Wickelgren, I. (2002). *The gene masters: How a new breed of scientific entrepreneurs raced for the biggest prize in biology.* Times Books.

Chapter 1.3
Knowledge Management Success Models

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INTRODUCTION

Alavi and Leidner (2001, p. 114) defined knowledge management systems (KMSs) as "IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, access, search, and application. Stein and Zwass (1995) define an organizational memory information system (OMIS) as the processes and IT components necessary to capture, store, and bring to bear knowledge created in the past on decisions currently being made. Jennex and Olfman (2004) expanded this definition by incorporating the OMS into the KMS and adding strategy and service components to the KMS.

Additionally, we have different ways of classifying the KMS and/or KMS technologies, where KMS technologies are the specific IT and ICT tools being implemented in the KMS. Alavi and Leidner (2001) classify the KMS and KMS tools based on the knowledge life-cycle stage being predominantly supported. This model has four stages: knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. It is expected that the KMS will use technologies specific to supporting the stage for which the KMS was created to support. Marwick (2001) classifies the KMS and KMS tools by the mode of Nonaka's (1994) SECI model (socialization, externalization, combination, and internalization) being implemented. Borghoff and Pareschi (1998) classify the KMS and KMS tools using their knowledge management architecture. This architecture has four classes of components—repositories and libraries, knowledge-worker communities, knowledge cartography or mapping, and knowledge flows—with classification being based on the predominant architecture component being supported. Hahn and Subramani (2001) classify KMS and KMS tools by the source of the knowledge being supported: a structured artifact, structured individual, unstructured artifact, or unstructured individual. Binney (2001) classifies the KMS and KMS tools using the knowledge spectrum. The knowledge spectrum represents the ranges of purposes a KMS can have and include transactional KM, analytical KM, asset management KM, process-based KM, developmental KM, and innovation and creation KM. Binney does not limit a KMS or KMS tool to a single portion of the knowledge spectrum and allows for multipurpose KMS and KMS tools. Zack (1999) classifies KMS and KMS tools as either integrative or interactive. Integrative KMS or KMS tools support the transfer of explicit knowledge using some form of repository and support. Interactive KMS or KMS tools support the transfer of tacit knowledge by facilitating communication between the knowledge source and the knowledge user. Jennex and Olfman (2004) classify the KMS and KMS tools by the type of users being supported. Users are grouped into two groups based on the amount of the common context of understanding they have with each other, resulting in the classifications of process- or task-based KMS and KMS tools, or generic or infrastructure KMS and KMS tools.

Regardless of the classification of the KMS, once a KMS is implemented, its success needs to be determined. Turban and Aronson (2001) list three reasons for measuring the success of a knowledge management system.

- To provide a basis for company valuation
- To stimulate management to focus on what is important
- To justify investments in KM activities

All are good reasons from an organizational perspective. Additionally, from the perspective of KM academics and practitioners, the measurement of KMS success is crucial to understanding how these systems should be built and implemented.

To meet this need, several KM and/or KMS success models are found in the literature. Models of KM success are included as a Churchman (1979) view of a KMS can be defined to include the KM initiative driving the implementation of a KMS (also, the counterview is valid as looking at KM can also include looking at the KMS).

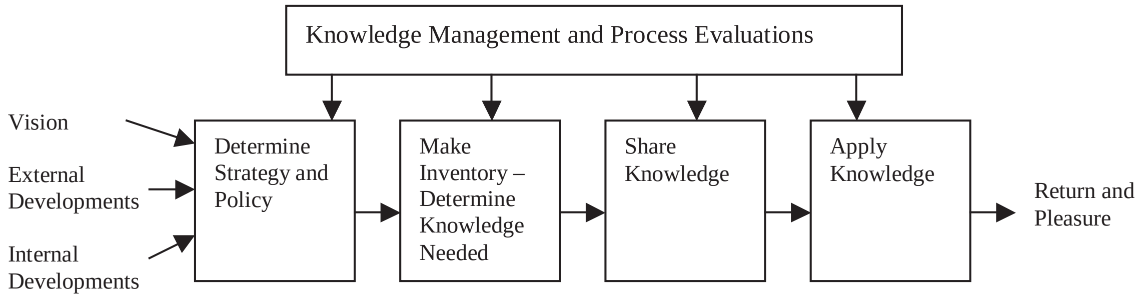
What is KM or KMS success? This is an important question that has not been fully answered as researchers are finding it difficult to quantify results of KM and KMS efforts. This article presents several KM and KMS success models. Two basic approaches are used to determine success. The first looks at the effective implementation of KM processes as the indicator of a successful implementation, with the expectation that effective processes will lead to successful knowledge use. These models identify KM processes by looking at KM and KMS success factors. The second approach looks at identifying impacts from the KM or KMS implementation, with the expectation that if there are impacts from using knowledge, then the KM or KMS implementation is successful. These models consider success a dependent variable and seek to identify the factors that lead to generating impacts from using knowledge. The following models, found through a review of the literature, use one or both of these approaches to determine KM or KMS success.

KNOWLEDGE MANAGEMENT SUCCESS MODELS

Bots and de Bruijn: Knowledge Value Chain

Bots and de Bruijn (2002) assessed KM and determined that the best way to judge good KM was through a knowledge value chain. Good KM

Figure 1. Bots and de Bruijn (2002) KM value chain



is defined as using KM to improve organizational competitiveness. However, measuring the KM impact on competitiveness is considered difficult, so ultimately it was concluded that good KM is when the KM initiative matches the model provided in Figure 1 and the KM processes are implemented well. KM is assessed for effectiveness at each step of the knowledge process and is good if each of the indicated activities is performed well with the ultimate factor being that the KM enhances competitiveness. Figure 1 illustrates the KM value chain. The model was developed by viewing and contrasting KM through an analytical (technical) perspective and an actor (user) perspective. These perspectives are conflicting, and KM assessment occurs by determining how well the KMS meets each perspective at each step.

Massey, Montoya-Weiss, and O'Driscoll KM Success Model

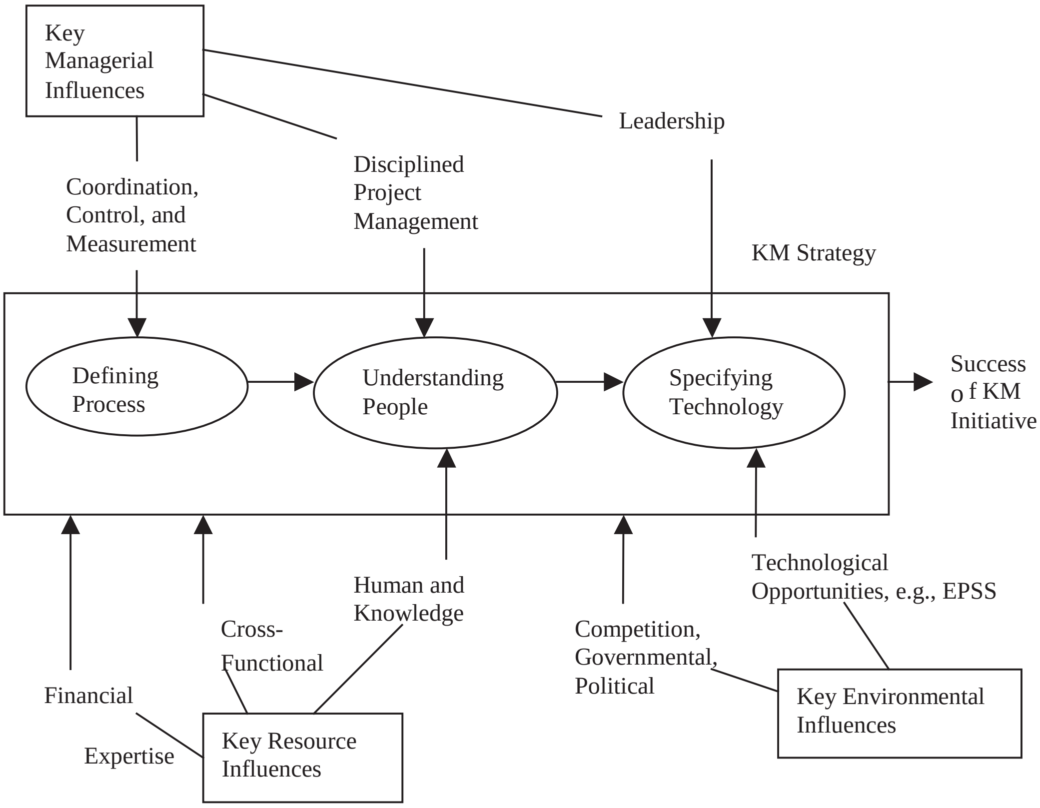
Massey, Montoya-Weiss, and O'Driscoll (2002) present a KM success model based on their Nortel case study. The model is based on the framework proposed by Holsapple and Joshi (2001) and reflects that KM success is based on understanding the organization, its knowledge users, and how they use knowledge. It recognizes that KM is an organizational change process and KM success cannot separate itself from organizational change success, with the result being that KM success is essentially defined as improving organizational or process performance. The model is presented in Figure 2. Key components of the model are the following.

- **KM Strategy:** The processes using knowledge and what that knowledge is; the sources, users, and form of the knowledge; and the technology infrastructure for storing the knowledge
- **Key Managerial Influences:** Management support through leadership, the allocation and management of project resources, and the oversight of the KMS through the coordination and control of resources and the application of metrics for assessing KMS success
- **Key Resource Influences:** The financial resources and knowledge sources needed to build the KMS
- **Key Environmental Influences:** The external forces that drive the organization to exploit its knowledge to maintain its competitive position

Lindsey KM Success Model

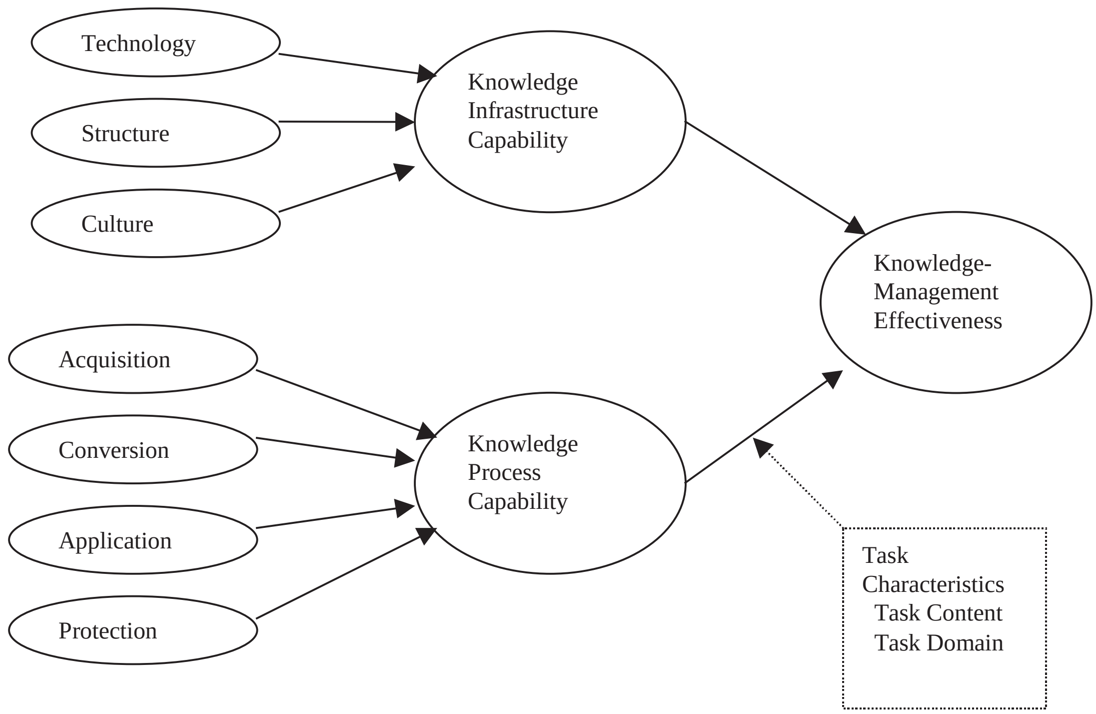
Lindsey (2002) considered KM success as being defined by Kaplan and Norton's (1992) balanced-

Figure 2. Massey et al. (2002) KM success model



scorecard approach and proposed a KM effectiveness model based on combining the organizational capability perspective theory (Gold, Malhotra, & Segars, 2001) and the contingency-perspective theory (Becerra-Fernandez & Sabherwal, 2001). The model defines KM effectiveness in terms of two main constructs: knowledge infrastructure capability and knowledge process capability, with the knowledge process capability construct being influenced by a knowledge task. The knowledge infrastructure capability represents social capital and the relationships between knowledge sources and users, and it is operationalized by the technology (the network itself), structure (the relationship), and culture (the context in which the knowledge is created and used). The knowledge process capability represents the integration of KM processes into the organization, and it is operationalized by acquisition (the capturing of knowledge), conversion (making captured knowledge available), application (degree to which knowledge is useful), and protection (security of the knowledge). Tasks are activities performed by organizational units and indicate the type and domain of the knowledge being used. Tasks ensure the right knowledge is being captured and used. KM success is measured as a combination of the satisfaction with the KMS and the effectiveness of KM processes. Figure 3 illustrates the Lindsey model.

Figure 3. Lindsey (2002) KM effectiveness model

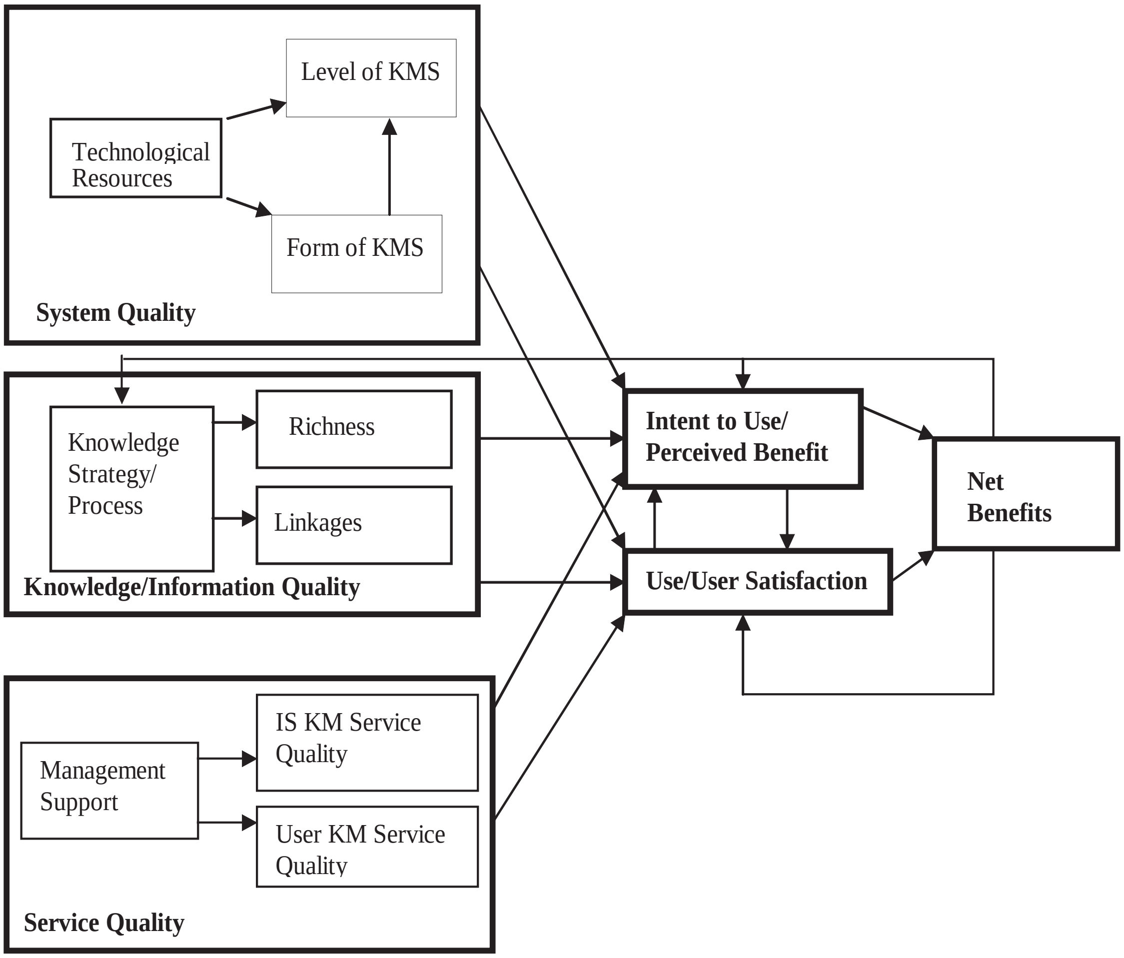


Jennex-Olfman KMS Success Model

Jennex and Olfman (2004) present a KMS success model that is based on the DeLone and McLean (1992, 2003) IS success model. Figure 4 shows the KMS success model. This model evaluates success as an improvement in organizational effectiveness based on the use of and impacts from the KMS. Descriptions of the dimensions of the model follow.

- **System Quality:** how well the KMS performs the functions of knowledge creation, storage and retrieval, transfer, and application; how much of the OM is codified and included in the computerized portion of the OM; and how the KMS is supported by the IS staff and infrastructure.
- **Knowledge and Information Quality:** ensures that the right knowledge and OM with sufficient context is captured and available for the right users at the right time.
- **Use and User Satisfaction:** indicates the actual levels of KMS use as well as the satisfaction of the KMS users. Actual use is most applicable as a success measure when the use of a system is required. User satisfaction is a construct that measures satisfaction with the KMS by users. It is considered a good complementary measure of KMS use when use of the KMS is required, and the effectiveness of use depends on users being satisfied with the KMS.
- **Perceived Benefit:** measures perceptions of the benefits and impacts of the KMS by users and is based on Thompson, Higgins, and Howell's (1991) perceived-benefit model. It is good for predicting continued KMS use when use of the KMS is voluntary, and the amount and/or effectiveness of KMS use

Figure 4. KMS success model of Jennex and Olfman (2004)



depends on meeting current and future user needs.

- **Net Impact:** An individual's use of a KMS will produce an impact on that person's performance in the workplace. Each individual impact will in turn have an effect on the performance of the whole organization. Organizational impacts are typically not the summation of individual impacts, so the association between individual and organizational impacts is often difficult to draw; that is why this construct combines all impacts into a single construct. This model recognizes that the use of knowledge and OM may have good or bad benefits, and allows for feedback from these benefits to drive the organization to either use more knowledge and OM or to forget specific knowledge and OM.

Maier KMS Success Model

Maier (2002) also proposes a KMS success model based on the DeLone and McLean IS success model (1992). This model is similar to the Jennex-Olfman model. A breakdown of the dimensions into constructs is not provided, but specific measures for each dimension are identified. This model is illustrated in Figure 5 and uses the following dimensions.

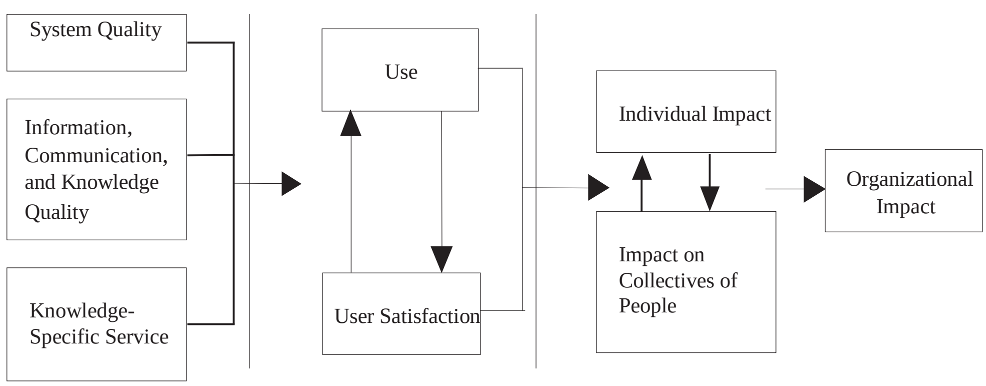
- **System Quality:** taken directly from DeLone and McLean (1992) and refers to the overall quality of the hardware and software
- **Information, Communication, and Knowledge Quality:** the quality of the stored data, information, and knowledge, and the quality of knowledge-flow methods
- **Knowledge-Specific Service:** how well subject-matter experts and KMS managers support the KMS
- **System Use and User Satisfaction:** taken directly from DeLone and McLean (1992) and refers to actual KMS use and the satisfaction users have with that use
- **Individual Impact:** taken directly from DeLone and McLean (1992) and refers to the impacts KMS use has on an individual's effectiveness
- **Impact on Collectives of People:** the improved effectiveness within teams, work groups, and/or communities that comes from using the KMS
- **Organizational Impacts:** taken directly from DeLone and McLean (1992) and refers to improved overall organizational effectiveness as a result of KMS use

FUTURE TRENDS

There are two areas needing research. The first is in defining KM and KMS success and quantifying the factors that define or reflect this success. Two promising approaches are in identifying success measurements with respect to DeLone and McLean's (2002) IS success model, or to Kaplan and Norton's (1992) balanced-scorecard approach.

The second area is to improve the generalizability of the models by establishing quantitative support across a broad range of organizations and users. This is necessary for showing that the models are not just reflective of the conditions observed in the case study leading to their generation.

Figure 5. Maier (2002) KMS success model



CONCLUSION

Many KM and KMS success and effectiveness models have been proposed. Most are based on case study research that looked in depth at KM or a KMS in an organizational setting. This type of research yields good insight into organizational and user processes and mechanics, giving researchers an excellent perspective from which to build models that explain their observations. Additionally, all of these models have some level of theoretical foundation. The use of established theory coupled with observation yields useful models. The models presented in this article are all useful to researchers exploring KM and KMS success and effectiveness. Also, these models are useful to practitioners and KMS designers as they provide guidance into what to look at when determining KM and KMS success, and what to include in a KMS.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Binney, D. (2001). The knowledge management spectrum: Understanding the KM landscape. *The Journal of Knowledge Management, 5*(1), 33-42.

Borghoff, U. M., & Pareschi, R. (1998). *Information technology for knowledge management.* Berlin, Germany: Springer-Verlag.

Bots, P. W. G., & de Bruiin, H. (2002). Effective knowledge management in professional organizations: Going by the rules. *Proceedings of the 35th Hawaii International Conference on System Sciences.*

Churchman, C. W. (1979). *The systems approach* (Rev. Ed.). New York: Dell Publishing.

DeLone, W. H., & McLean, E. R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3, 60-95.

DeLone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten year update. *Journal of Management Information Systems, 19*(4), 9-30.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hahn, J., & Subramani, M. R. (2000). A framework of knowledge management systems: Issues and challenges for theory and practice. *Proceedings of the 21st International Conference on Information Systems* (pp. 302-312).

Holsapple, C. W., & Joshi, K. D. (2001). Knowledge management: A three-fold framework. *The Information Society, 18*(1), 47-64.

Jennex, M. E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. *Proceedings of the 35th Hawaii International Conference on System Sciences, HICSS35.*

Jennex, M. E., & Olfman, L. (2004). Modeling knowledge management success. *Proceedings of the Conference on Information Science and Technology Management, CISTM.*

Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard: The measures that drive performance. *Harvard Business Review.*

Lindsey, K. (2002). Measuring knowledge management effectiveness: A task-contingent organizational capabilities perspective. *Proceedings* *of the 8th Americas Conference on Information Systems* (pp. 2085-2090).

Maier, R. (2002). *Knowledge management systems: Information and communication technologies for knowledge management*. Berlin, Germany: Springer-Verlag.

Marwick, A. D. (2001). Knowledge management technology. *IBM Systems Journal*, *40*(4), 814-830.

Massey, A. P., Montoya-Weiss, M. M., & O'Driscoll, T. M. (2002). Knowledge management in pursuit of performance: Insights from Nortel networks. *MIS Quarterly*, *26*(3), 269-289.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14-37.

Stein, E. W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research*, *6*(2), 85-117.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly*, *15*(1), 125-143.

Turban, E., & Aronson, J. E. (2001). *Decision support systems and intelligent systems* (6th ed.). Prentice Hall.

Zack, M. H. (1999). Managing codified knowledge. *Sloan Management Review*, *40*(4), 45-58.

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Chapter 1.4
Technology and Knowledge Management

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INTRODUCTION

Rapid and extensive advances in technology, particularly in the area of communications, have had a considerable impact on the way organizations operate and opened pathways to access vast amounts of information. Information, however, is static unless knowledge is applied to translate it into something meaningful and with the potential to be actionable. From the time organizations commence business, they accumulate information about the markets in which they operate, yet often, knowledge is not applied in a way that it can be exploited to bring benefit. The ability to share knowledge, to develop ideas, and to become more innovative is increasingly important for businesses, and the range of technologies now available provides a conduit for knowledge to flow through the organization to enable sharing to occur. Technology is frequently referred to as "just an enabler," but it can also be identified as a value-adder.

INFORMATION AND KNOWLEDGE

In their paper, Evans and Wurster (1997, p. 71) referred to changes that had taken place over the previous 10 years as organizations adapted their "operating processes" to "information technologies," recognizing that accessing information was going to have an important bearing on where industries would be going in the future. During this period, technology was moving forward at a rapid rate, and organizations were investing huge sums of money in information technology.

Information is defined as facts and data organized to describe a particular situation or problem. The definition used for knowledge is that by Davenport and Prusak (1998):

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. (p. 5)

Connectivity, it is suggested by Evans and Wurster (1997), provided the most important change in the information revolution: "What is truly revolutionary about the explosion in connectivity is the possibility it offers to unbundle information from its physical carrier" (p. 73). Amidon (1997) referred to the major change from information processing to knowledge processing that has taken place, "which includes the concepts of learning tools, intelligent electronic coaching, decision-making systems, and more" (p. 87). The availability of such tools, and their ongoing development, add considerable value to an organization by providing a means through which more efficient and effective management techniques can be introduced. This evolving of expectations indicates that organizations are not only anticipating more from technology but are also becoming more reliant upon it.

As interest grows beyond information per se, organizations are looking to technology to progress toward the development of knowledge management systems. Bhatt (2001) referred to business managers who believe computers and communication technologies provide an avenue for the harvesting of knowledge from data repositories of organizations, while other managers say knowledge "resides in human minds, and therefore, employee training and motivation are the key factors to knowledge management" (p. 68). The development of technology has taken the drudgery out of searching, analyzing, and converting data into information to which knowledge can be applied.

Technology and knowledge, however, do not stand in isolation. There are many interacting factors, not least of which is the environment in which the organisation operates. According to Bhatt (2001), the "…pattern of interaction between technologies, techniques and people is unique to an organization" (p. 69). Such uniqueness is important, because it is not easy to replicate. The organisation that promotes the value of the knowledge, skills, and competencies of its people, and recognizes the importance of technology, is providing well for its future (Carneiro, 2000; Bhatt, 2001).

From a productivity perspective, Grant (2000) indicated the value of digital technology. He referred to knowledge no longer being held exclusively by people. Codification and use of technology provides the opportunity for knowledge replication. While costly to create, replication and distribution can be reduced to almost "zero marginal cost" (Grant, 2000, p. 32). In the long term, and with the arrival of new technologies, the rate of productivity growth is likely to accelerate (Grant, 2000). People have skills and knowledge, but it is technology that enables them to access in a timely manner huge amounts of data available both internally and externally to the organization. While technology enables people to access data, the added value comes in its ability to allow the data to be assembled in a meaningful way for the purpose of decision making.

SHARING KNOWLEDGE

An environment in which knowledge sharing is encouraged leads to the creation of new knowledge, but as Marshall, Prusak, and Shpilberg (1996) indicated, it is not easy to encourage voluntary sharing of knowledge by employees. An organisation that develops a knowledge-sharing environment increases opportunities for the creation of new ideas that have the potential to add value to it.

Barriers to sharing knowledge exist, and for managers advocating knowledge sharing, they should examine the existing practices within the organization. It is possible that somewhere in the organization, the "knowledge is power" syndrome exists, and if so, it does not auger well for knowledge sharing. There may also be concern over job security, "if I share my knowledge, I am no longer of value to the organization, and therefore, my job will be in jeopardy." A barrier to knowledge sharing may simply rest on the premise that a person may not realize that knowledge acquired in another situation could be of value to the organization. Managers may need to look to changing the organizational culture to one that recognizes, and acknowledges, the value of shared knowledge.

Bhatt (2001), referring to the need for the distribution and sharing of knowledge throughout the organisation, suggested that interactions among technologies, techniques, and people have a direct bearing on the effectiveness of the distribution of knowledge.

RANGE OF TECHNOLOGIES

According to Frappaola and Capshaw (1999): "Knowledge management refers to the practices and technologies that facilitate the efficient creation and exchange of knowledge on an organizational level" (p. 44).

From the literature, it appears that there are a number of applications specifically designed for sharing knowledge (Davenport, 1997; LaPlante, 1997; Fahey & Prusak, 1998). The benefits of applications, such as groupware, data warehousing, knowledge maps, client server systems, and chat rooms, are recognized as providing the means through which knowledge can be shared. A useful aspect of such applications is that they allow for interaction and sharing of information that is highly unstructured in nature (Shani, Sena, & Stebbins, 2000). Research carried out by Mitchell in 1999 indicated that people are finding groupware applications useful mechanisms for sharing knowledge.

A number of writers, Allee (1997), Amidon (1997), Marshall (1997), Watt (1997), and Davenport and Prusak (1998), refer to the intranet as providing channels through which organizational knowledge can flow. E-mail is now well accepted as a useful and valuable medium of communication, and for knowledge to flow through an organization (Bontis, Fearon, & Hishon, 2003). The advent of electronic conferencing provides an avenue through which people geographically dispersed can interact without the time and cost involved in traveling. Networking, bulletin boards, and the establishment of virtual teams also provide opportunities for people to interact over distances and to share knowledge.

Reference is made by Beckett (2000) to the "Data warehousing knowledge set" containing reference data, defined as market trends, operational data, and customer performance needs. From this knowledge set, actions can be taken that ultimately benefit stakeholders and customers. While the knowledge set may be considerable, ideally, its value only becomes realistic when there is in place the means to allow for the "free" flow of knowledge throughout the organisation and when there are people who can recognize that value can be gained from it. It is most unlikely that organizations allow for a free flow of knowledge, because issues such as privacy and confidentiality, "need to know," and other constraints restrict access to knowledge. However, providing access to knowledge that can be made available should be the aim of organizations wanting to encourage a knowledge-sharing environment.

Technology has opened avenues to the customer to search for opportunities and products that may better serve their needs. The opportunity, however, is also open to the organization to exploit the potential of technology to create greater value for its customers.

KNOWLEDGE MANAGEMENT STRATEGY

Hansen, Nohria, and Tierney (1999) identified management consultants as being among the first to recognize the potential of information technology for the capture and dissemination of knowledge. It was found that organizations tend to employ two very different strategies for the management of knowledge. One is the "codification strategy," where maximizing the use of technology shows a strong focus on codifying knowledge and storing it in databases for access by anyone in the company. The second approach viewing knowledge being shared through person-to-person contacts is identified as the "personalization strategy" (Hansen, Nohria, & Tierney, 1999, p. 107).

From their research, Hansen et al. (1999) found that organizations pursuing "an assemble-to-order product or service strategy emphasized the codification and reuse of knowledge. Those that pursued highly customized service offerings, or a product innovation strategy, invested mainly in person-to person knowledge sharing" (p.112). Whichever strategy is used, there is inevitably the inclusion, as a support mechanism, of an element of the other strategy. Hansen et al. suggest an 80:20 split, that is, "80% of their knowledge sharing following one strategy, 20% the other." They go on to say that "Executives who try to excel at both strategies risk failing at both" (p. 112).

In his article, Beckett (2000) referred to the fastest knowledge-transfer vehicles, relating them to the work of Nonaka and Takeuchi (1995). The tacit/tacit transfer is fast, "because people use multiple sensors in working together in teams" (p. 317). Using electronic media for the transfer of explicit/explicit transfer can also be fast. However, there is evidence that "tacit/explicit transfers are slow, as specialist skills are needed to draw out and carefully enunciate tacit knowledge" (p. 317). Becket indicated that explicit/tacit transfers are similarly positioned, and provides the example of formal education.

Giving consideration to the perspectives of Hansen et al. (1999) and Beckett (2000), and others, such as Ericsson and Avdic (2003), Mockler and Dologite (2002), Jentzsch and Prekop (2002), and Frappaolo and Capshaw (1999), determining a knowledge management strategy needs careful thought if it is to meet the requirements of the organization.

TECHNOLOGY: ENABLER OR VALUE-ADDER?

Lloyd (1996) referred to the use by organizations of worldwide networks and said that new technology is "the catalyst which is forcing all organizations to re-evaluate what they know, what they do with that knowledge, and how they continually add value (or not) to that knowledge in meeting changing customer needs" (p. 576). Technology has advanced considerably since Lloyd made this comment, and it will continue to evolve in the years ahead, providing for greater enrichment of organizational operations. While the cost of "keeping up" with technological developments has always been a problem for organizations that have made a strong commitment to technology, others recognize that they need to work smarter with what they have.

If technology is just an enabler, what is it that adds value to the organisation? Binney (2001, p. 33) addressed the question of knowledge-management (KM) investments. What has emerged is the KM spectrum, in which he identifies KM applications and places them into "six common categories to establish the elements of the KM spectrum" (p. 34). Binney identified from the literature six categories to provide the elements of the KM spectrum: transactional, analytical, asset management, process, developmental, and innovation and creation. He then mapped KM applications to the elements:

1. Transactional—Order entry applications; help desk applications
2. Analytical—Data warehousing, customer relationship management, DSS, MIS
3. Asset management—Document management, intellectual property

4. Process—TQM, process automation, benchmarking
5. Developmental—Skills development, training
6. Innovation and creation—Communities, virtual teams, networking

The next stage of the process added to the various elements, enabling technologies:

1. Transactional—Expert systems, probability networks
2. Analytical—Intelligent agents, data analysis and reporting tools
3. Asset management—Document management tools, knowledge maps
4. Process—Workflow management, process-modeling tools
5. Developmental—Computer-based training, online training
6. Innovation and creation—Search engines, voice mail, groupware

The KM spectrum provides organizations with the means to identify their present positions and to make use of the framework to map their future investments in knowledge management. The examples given above illustrate the wide range of applications available to organizations, and their potential and value emerges through maximizing their use for the purpose of effective decision-making in an increasingly competitive environment.

Technology has provided the impetus for the growth of the information age, but it should not be regarded as a dominant partner. As Pemberton (1998) commented, "The IT exponents of KM tend to downplay the central role of human factors in KM…IT doesn't itself create knowledge any more than does a library, an office, or a classroom" (p.60). But, as Carneiro (2000) indicated, the combining of knowledge and information technology is a major success factor in strategic planning formulation. The future will bring ever more sophisticated advancements in technology providing new avenues of exploration for seeking, creating, and sharing knowledge.

CONCLUSION

Is technology just an enabler, or is it also a value-adder? From the literature, technology, while recognized as being important, tends to be regarded as an enabler rather than a value-adder. Yet the continual movement in technological progress, as shown in Binney's KM spectrum, clearly identifies the developments that have taken place in technology to enhance the operation of business. People provide value through the application of their knowledge, but their ability to do so is considerably enhanced by the availability of technology. Technology enriches opportunities for disseminating and sharing knowledge, and through providing the means to access information for decision making. While the role of technology may be seen as that of enabler to access information, value is added through the ability to assemble data, put it into meaningful information, and manipulate it into various scenarios before determining the best decision. Technology is adding value by allowing organizations to do this. Without the range of technology available to organizations, they would be considerably restricted in their ability to effectively manage their business. Therefore, technology should be identified as an adder of value.

REFERENCES

Allee, V. (1997). *The knowledge evolution: Expanding organizational intelligence*. Oxford: Butterworth-Heinemann.

Amidon, D. M. (1997). *Innovation strategy for the knowledge economy: The Ken Awakening.* Oxford: Butterworth-Heinemann.

Beckett, R. C. (2000). A characterization of corporate memory as a knowledge system. *Journal of Knowledge Management, 4*(4), 311–319.

Bhatt, G. D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68–75. Available at http://angelina.emeraldinsight.com/v1=…/rpsv/cw/mcb/13673270/v5n1/s6/p68.html

Binney, D. (2001). The knowledge management spectrum—Understanding the KM landscape. *Journal of Knowledge Management, 5*(1), 32–42.

Bontis, N., Fearon, M., & Hishon, M. (2003). The e-flow audit: An evaluation of knowledge flow within and outside a high-tech firm. *Journal of Knowledge Management, 7*(1), 6–19.

Carneiro, A. (2000). How does knowledge management influence innovation and competitiveness? *Journal of Knowledge Management, 4*(2), 87–98.

Davenport, T. H. (1997, June 15). Known evils: Common pitfalls of knowledge management. *CIO*, 34–36.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Cambridge, MA: Harvard Business School Press.

Ericsson, F., & Avdic, A. (2003). Knowledge management systems acceptance. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges.* Hershey, PA: IRM Press.

Evans, P. B., & Wurster, T. S. (1997, September–October). Strategy and the new economics of information. *Harvard Business Review*, 71–82.

Fahey, L., & Prusak, L. (1998, Spring). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265–275.

Frappaola, C., & Capshaw, S. (1999, July). Knowledge management software: Capturing the essence of know-how and innovation. *The Information Management Journal*, 44-48.

Grant, R. M. (2000). Shifts in the world economy: The drivers of knowledge management. In C. Despres & D. Chauvel (Eds.), *Knowledge horizons.* Oxford: Butterworth-Heinemann.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March–April). What's your strategy for managing knowledge? *Harvard Business Review,* 106–116.

Hurley, M. A., & Harris, R. (1997). Facilitating corporate knowledge: Building the data warehouse. *Information Management and Computer Security, 5*(5), 170–174.

Jentzsch, R., & Prekop, P. (2002). A conceptual model of collaborative information seeking. In D. White (Ed.), *Knowledge mapping and management.* Hershey, PA: IRM Press.

LaPlante, A. (1997, June 2). Sharing the wisdom. *Computerworld*, 73–74.

Lloyd, B. (1996). Knowledge management: The key to long-term organizational success. *Long Range Planning, 29*(4), 576–580.

Marshall, C., Prusak, L., & Shpilberg, D. (1996, Spring). Financial risk and the need for superior knowledge management. *California Management Review*, *38*(3), 77–101.

Marshall, L. (1997, September/October). New opportunities for information professionals. *Online*, 93–98.

Martiny, M. (1998, Autumn). Knowledge management at HP consulting. *American Management Association, Organizational Dynamics, 27*(2), 71–77.

Mockler, R. J., & Dologite, D. G. (2002). Strategically-focused enterprise knowledge management. In D. White (Ed.), *Knowledge mapping and management.* Hershey, PA: IRM Press.

Pemberton, J. M. (1998, July). Knowledge management (KM) and the epistemic tradition. *Records Management Quarterly*, 58–62.

Shani, A. B., Sena, J. A., & Stebbins, M. W. (2000). Knowledge work teams and groupware technology: Learning from Seagate's experience. *Journal of Knowledge Management, 4*(2), 111–124.

Watt, P. (1997, August). Knowing it all. *Intranet*, 17–18.

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Chapter 1.5
Smart Organizations in the Digital Age

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ABSTRACT

The chapter aims to present and explain the concept of the smart organization. This concept arose from the need for organizations to respond dynamically to the changing landscape of a digital economy. A smart organization is understood to be both internetworked and knowledge-driven, and therefore able to adapt to new organizational challenges rapidly. It is sufficiently agile to respond to opportunities of the digital age. The three networking dimensions of smart organizations, ICT-enabled virtuality, organizational teaming, and knowledge hyperlinking, are elaborated. This networking capability allows smart organizations to cope with complexity and with rapidly changing economic environments. The paper also shows how managing the smart organization requires a more "fuzzy" approach to managing smart resources: people, information, knowledge, and creativity. Research is also presented, mainly from the European perspective. It has been key to creating the conditions for organizations to become smart.

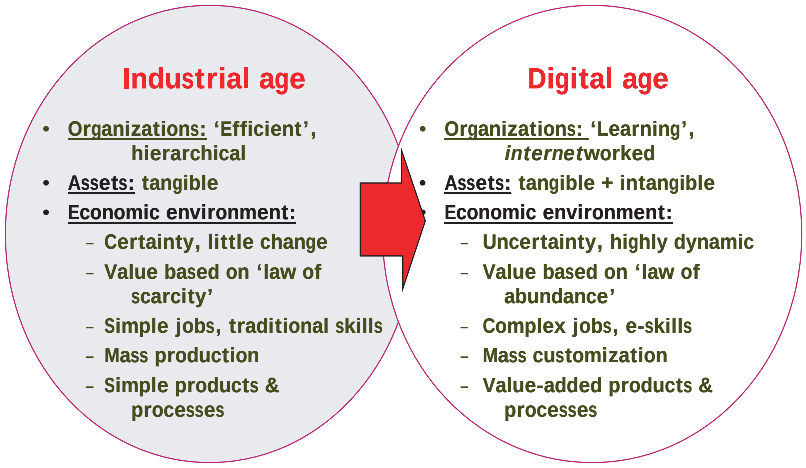
CHARACTERISTICS OF THE DIGITAL AGE

Over the last decades, information and communication technologies (ICT) have been the enabling factor in organizational change and innovation, and there is now evidence of their impact on industrial value chains. Organizations today strive to become agile and to operate profitably in an increasingly competitive environment of continuously and unpredictably changing markets.

The digital age is different from the industrial age in various ways (Figure 1). For example, today ICT represent a substantial—and increasing—part of the added value of products and services. ICT-intensive sectors include manufacturing, automotive, aerospace, pharmaceuticals, medical equipment, and agro-food, as well as financial services, media, and retail. In the automotive sector, for instance, an estimated 70% of innovations that happened over the last 20 years were related to ICT.

According to recent studies, more than half of the productivity gains in developed economies

Figure 1. Industrial vs. digital age characteristics



can be attributed to ICT (OECD, 2003; O'Mahony & van Ark, 2003). The gains stem both from the production of innovative, high-value goods and services based on ICT, as well as from improvements in business processes through a wider diffusion, adoption and use of ICT across the economy. Their impact on the economy and on society at large has led to remarkable changes.

A "Hyperlinked" Economy

The increased networking in a global economy is due to the pervasiveness of ICT and the Internet. Since business success depends on the ability to innovate, and since innovation comes from a clash of ideas, networks provide a natural environment for this. The Internet not only facilitates a hyperlinking of documents, but also a hyperlinking of people and of organizations (Levine, Locke, Searls, & Weinberger, 2000). The internetworked economy (Ticoll, Lowy, & Kalacota, 1998) is about the right set of connections between people and organizations in whatever role they may be in. In relationships that are fostered via networks, roles become blurred: The seller becomes the "buyer" of valuable feedback on his product. Smart business organizations today see customers, suppliers, regulators, and even competitors as stakeholders who can make valuable contributions to their success.

"Value" Redefined

Individuals and organizations today understand value as something different from value in its traditional sense—that is, not only attributable to something that is unique or scarce. Value in a networked economy grows with the number of intermediation opportunities (e.g., relationships). Network theory predicts an exponential growth of interactions with a growing number of involved members ("nodes"). The more nodes there are in a network community, the more each node becomes an intermediary to all others (Kelly, 1999).

Another reason for the new perception of value is the fact that economic value is no longer derived from tangible assets alone—for example, from investments in labor, plants, and machinery. "Smart" resources—such as information, content, software, knowledge, brands, and innovation capability—contribute increasingly to value creation in today's economy.

Intangible Assets

Brands and knowledge are becoming a source of value, not unlike capital. Brands, for example, represent accumulated surplus value turned into client loyalty, which translates into lower marketing costs, higher prices, or larger market share for the owner organization (Davis & Meyer, 1998). In digital markets, brands are an invaluable source of trust and orientation to consumers who are looking for quality and security. Many organizations invest heavily in building a reputation that is conveyed through a brand. Some businesses have even outsourced almost all other activities just to maintain their focus on managing the brand. In an internetworked economy, knowledge is a key intangible asset that requires effort to develop and to protect.

The Growing Need for Trust

A key question in the digital economy is: "How can you do business with somebody that you do not see?" (Handy, 1995). As business relies more and more on technologies and infrastructures that reduce geographical distance, open communication networks and associated information systems become vulnerable to integrity and security threats. Technologically, trust and dependability must be established and maintained through security technologies such as cryptography and electronic authentication (biometrics, electronic signatures, etc.) and by technologies that enhance privacy and help protect and manage intellectual rights, digital assets, and identities. In the socio-organizational context, trust becomes an essential element of management.

THE SMART ORGANIZATION

Most organizations are not designed—they evolve. This is why biological analogies may provide an appropriate means to describe organization phenomena. But not all organizations adapt equally well to the environment within which they evolve. Many, like dinosaurs of great size but with little brains, remain unchanged in a changing world. In a digital economy, the law of survival of the fittest will evidence its relevance to organizations as it does in the biological domain.

Handy (1999) sees the old understanding of alliances with suppliers, consultants, retailers, and agents changing into a new type—that is, stakeholder alliances with suppliers, customers, and employees, as well as alliances with competitors. As no organization today can afford to remain an "island entire unto itself," every organization is a network of other organizations. No discussion of structure can therefore rest content with the inside of the organization.

Some organizational metaphors include terms like adhocracy (Mintzberg, 1980), cluster organization (Mills, 1991), network organization (Foy, 1980; Imai & Itami, 1984), and organizational marketplace (Williamson, 1975). All these concepts share certain common characteristics, like flatter hierarchies, dynamic structures, empowerment of individuals, and high esteem of individuals' capabilities, intellect, and knowledge. However, although they may gain importance in the digital age, they cannot be considered a panacea to cure all management ills.

Despite the proposed new models, the basic duality between a hierarchical (bureaucratic) and a networked structure remains. In The Knowledge-Creating Company, Nonaka and Takeuchi (1995) argue that while for most of the 20th century organizational structures have oscillated between these two basic types, what is necessary for knowledge-driven organizations today is a smart combination of both. They propose the concept of the hyperlinked organization, which is able to maximize corporate-level (hierarchical) efficiency and local flexibility (networked teams) as it grows in scale and complexity while maintaining its basic capability to create value.

The implications of the above trends for organizations have led to a proliferation of adjectives applied primarily to enterprises—among others, the agile enterprise, networked organization, virtual company, extended enterprise, ascendant organization (Wickens, 1998), knowledge enterprise (Nonaka & Takeuchi, 1995), learning organization (Senge, 1990), ambidextrous organization (O'Reilly & Tushman, 2004). The definitions all have their nuances, deriving from the emphasis on one or another combination of the aspects above. Ultimately, however, they all point to the need to respond to the changing landscape of the digital economy in dynamic and innovative ways.

Within the European Commission's research program Information Society Technologies (IST, 2002), the term "smart organization" was coined for organizations that are knowledge-driven, internetworked, and dynamically adaptive to new organizational forms and practices, learning as well as agile in their ability to create and exploit the opportunities offered in the digital age. Smart organizations involve more than the capability of setting up and exploiting a digital infrastructure or the ability to enter into a virtual collaboration with other partner organizations (Filos & Banahan, 2001b).

The Three Networking Dimensions of Smart Organizations

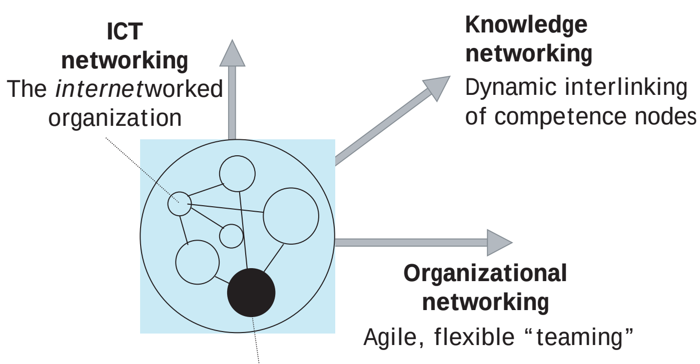
Smart organizations are networked in three dimensions: the ICT dimension, the organizational dimension, and the knowledge dimension (see Figure 2).

Networking at the ICT level enables organizations to move into extended or virtual organizational forms. This may not be enough, though, since the organizational structure and management cultures may need to move beyond steep hierarchies toward leaner business processes organized around flexible cross-functional teams. A further step lies in involving the knowledge dimension into the networking by empowering the individuals in those teams to become dynamically linked to each other and to share information and knowledge (Savage, 1996).

ICT-Enabled Virtuality

Smart organizations have the capability to enter into a virtual collaboration with other organizations. Virtual organizational forms are thus an essential characteristic of smart organizations in the digital age (Filos, 2005).

Figure 2. Smart organizations are networked in three dimensions (Filos & Banahan, 2001a)



While in the past the aim for organizations was to integrate the supply chain as tightly as possible, the focus is now shifting from vertical integration toward internetworked organizational forms. One characteristic is a focus on "core business", while noncore activities are "outsourced" over the Internet and through e-business exchanges to partners that may have the capability to perform specific tasks better or more cost-effectively.

Organizational Teaming

For businesses, large and small, collaborative partnerships have become central to competitive success in fast-changing global markets. Since many of the skills and resources essential to an organization's competence lie outside its boundaries, and outside management's direct control, partnerships are no longer an option but a necessity. Organizations today have to be "smart" in their ability to conceive, shape, and sustain a wide variety of collaborative partnerships. Hence the challenge: The "capacity to collaborate" becomes a core competence of an organization.

Collaborative partnerships are held together because of the added value they offer. Organizations that enter into a cooperation with others do so because of a variety of strategic goals they may pursue (Doz & Hamel, 1998). These can be:

- Resource optimization (sharing investment with regard to infrastructure, R&D, market knowledge and the sharing of risks, while maintaining the focus on one's own core competences)
- Creation of synergies, by bundling complementary competences and by offering customers a solution rather than a mere product or a service
- Attaining critical mass in terms of capital investment, shared markets, and customers
- Achieving increased benefits in terms of shorter time-to-market, higher quality, with less investment

Goldman, Nagel, and Preiss (1995) have described four strategic dimensions of agile behavior that are crucial to smart organizations. These are customer focus, commitment to intra- and inter-organizational collaboration, organizing to master change and uncertainty, and leveraging the impact of people (entrepreneurial culture) and knowledge (intellectual capital).

Knowledge Hyperlinking

Nonaka and Takeuchi (1995) see as a basic precondition for the growth of organizational knowledge the creation of a "hyper-text" organization, which is made up of three interconnected layers or contexts, such as the business system, the project teams, and the (corporate) knowledge base. The key characteristic of the knowledge-creating company is this capability to shift contexts. The bureaucratic structure efficiently implements, exploits, and accumulates new knowledge through internalization and combination. Project teams generate (via externalization) conceptual and (via socialization) synthesized knowledge. The efficiency and stability of the bureaucracy is combined in this model with the effectiveness and dynamism of the project team. But, according to Nonaka and Takeuchi, these two elements are not sufficient without the third context, the knowledge base, which serves as a "clearinghouse" for new knowledge to be generated inside both the enterprise and the project team contexts.

This hyperlinked organization has the organizational capability to convert knowledge from outside the organization by being an open system that features also continuous and dynamic knowledge interaction with partners outside the organization.

With the evolution of new organizational forms, such as networks, communities, and partnerships, the focus shifts from an ICT-centered to a human-centered perspective of knowledge management (KM). The knowledge sharing process is driven by people who work in a community that shares common interests and objectives. Evans and Roth (2004) elaborate on the basic premises and working principles of collaborative knowledge networks, which link communities together by providing a technical and social infrastructure for collaboration and knowledge management. Organizations that have implemented such environments report significant benefits in terms of knowledge transfer efficiency, response time, and innovation (Deloitte, 2002).

Lessons Learned from the Science of Complexity

The digital age is characterized by uncertainty and unpredictability, and organizations have to cope with it. This factor is radically changing the ways in which organizations relate to each other, and to the individuals who provide their core competence, and to their environment.

Sustainable innovation is the result of persistent disequilibrium between chaos and order. The internetworked economy resembles an ecology of organisms, interlinked and coevolving, constantly in flux, deeply tangled, ever expanding at its edges.

In their book The Complexity Advantage, Kelly and Allison (1999) discuss how six concepts derived from complexity science can be applied to business:

- In nonlinear dynamics, small differences at the start may lead to vastly different results. The so-called "butterfly effect" may prove valuable for business, particularly at turning points, such as the launch of a new product, the starting of a new division or investment in a new line of research.
- An open system is one in which the boundaries permit interaction with the environment. A good example for this is the living cell in a biological organism. Many organizations seem only partially open. Businesses, teams, leaders often shut out certain kinds of information and are open only to information that matches the way in which they see the world. However, it is critical for business organizations to also see the changing nature of their customers, markets, and competition in order to be able to offer genuine value.
- A feedback loop is simply a series of actions, each of which builds on the results of prior action and loops back in a circle to affect the original state. The final action either reinforces or changes the direction of the status quo. For example, although innovation is an important aspect of business success, an amplifying feedback loop might exaggerate the amount of innovation to the point at which nothing is ever produced or brought to the market. It is essential to identify such amplification and counterbalance it. Feedback loops, whether functional or dysfunctional, are a key part of the self-organization that emerges in all business.
- Fractal structures are those in which the nested parts of a system are shaped into the same patterns as the whole. Fractals do not define quantity but quality. This self-similarity applied to organizations can make them agile and responsive. For example, in an organization in which self-similarity of values and processes has emerged at all levels and in all geographic areas, effective teams can be assembled very quickly to take advantage of sudden opportunities or handle unexpected threats.
- In evolutionary theory, those species survive that are most capable of adapting to the environment as it changes over time. In rapidly changing global markets, the actions of one player trigger actions and reactions

of other players whose actions feed back on the actions of the former. This coevolution is the reason why companies today must run as fast as they can just to maintain their current position.

- Group self-organization enables a unity to emerge from individual diversity. Like individuals, work teams and organizations too can develop behavioral patterns.

Organizational Ecosystems

Like complex organisms, smart organizations have a "nervous system" which enables them to thrive on chaos and to guide them through turbulent times. Organizational nervous systems provide the functions of sensing and learning, communications—internal and external—coordination, and memory. In fast-moving, unpredictable digital environments, "nervous system" functions are essential to provide the organization with anticipatory, filtering, empathic, learning, and adaptive capabilities in real time (Por, 2000).

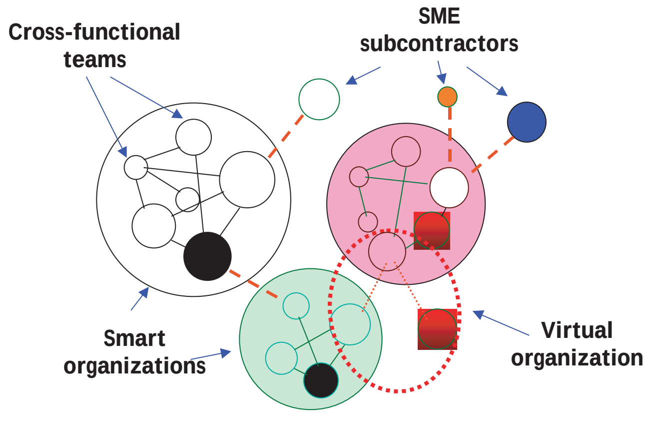
Second, economic activity is fractal, in that it shows the same structure and obeys the same rules for creating value at the level of the economy, the organization, and the individual. Therefore, smart organizations will need to be adaptive to their economic environment—that is, open with permeable boundaries, operating at the edge of chaos (Warnecke, 1992; Davis & Meyer, 1998).

Third, the fittest will survive. Smart organizations become fit through variety and diversity of thought, old and new ideas, that breed innovation. Cross-functional, multidisciplinary teams capable of creativity are an essential element to this. Combined with openness, through ideas from the market and interorganizational exchanges, organizational fitness grows.

Fourth, by being big and small at the same time. The essence of ecosystems is the balance between big and small organisms dependent on one another. Likewise, smart organizations must be big to afford large-scale investments, but they also must be small, nimble, unified around a purpose, and capable of paying attention to the details of important relationships (ecosystems of smart organizations, see Figure 3).

The smart organizations depicted in Figure 3 are composed of teams (dots) that are linked via ICT-enabled business processes between individuals and teams inside or outside the organization (connecting lines).

Figure 3. Ecosystem of smart organizations



MANAGING THE SMART ORGANIZATION

Organizations in the digital age, unlike industrial age ones, will not seek to control their environments. Rather, they will adapt to them, since they recognize that any attempt to control would at best fail, and at worst stifle the creativity and imagination necessary to support innovation. In a globally networked economy, participants are free to focus and re-focus their commitment as they see fit. With this in mind, management style is evolving from one, which used to place emphasis on planning, organizing, and controlling, to one, which emphasizes providing vision, motivation, and inspiration (Kostner, 1996).

Also, in the internetworked economy, the roles of "superior" and "subordinate" are becoming blurred and management becomes fuzzy—that is, more laid-back, less controlling, and trust-based (Filos & Banahan, 2001a).

A bureaucracy is an efficient organizational scheme for tackling recurring tasks in a sequential way. Its static structure guarantees stability and reliability. However, team-based (networked) organizations are better able to handle tasks that are nonroutine and which demand a high degree of flexibility and adaptability. They are also able to link expertise that is distributed throughout the organization. The flexible structure of teams thus guarantees a dynamic and competent response to ad hoc tasks (Figure 4).

The organization of work in the internetworked economy is shifting from stable, physically co-located functions to dynamic, competence-based virtual teams that create value by synthesizing information across geographical and organizational boundaries. As a consequence to this, organizational culture and management change as well.

The Self-Organizing Distributed Team

The face of work is changing, too. As the business world becomes more complex due to demands for flexibility and shorter response times, the nature of work has to keep pace with organizational change. Work in smart organizations is therefore marked by concurrent work practices, flexible and versatile teamwork, and creativity and intelligent use of ICT (Figure 5).

A virtual organization is a collection of geographically distributed, functionally, and/or

Figure 4. Organizational culture of the industrial vs. the digital age

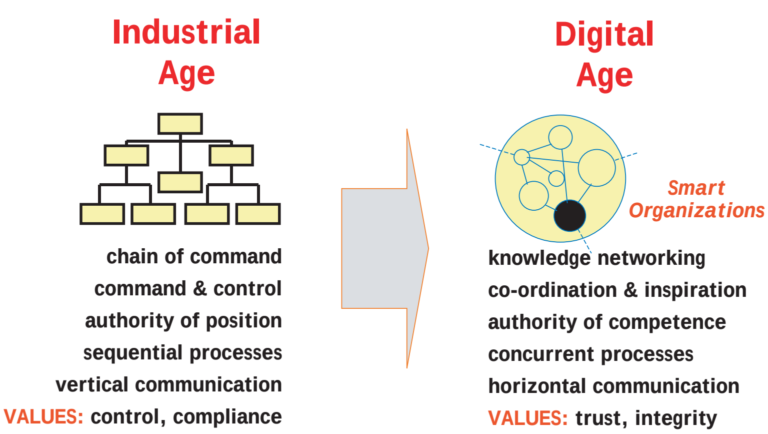
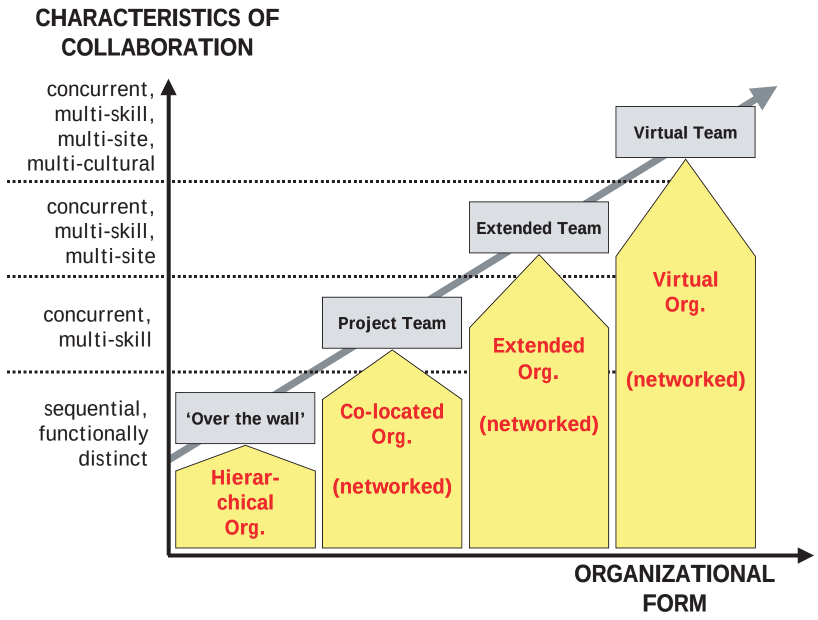


Figure 5. The evolution of collaborative work and the impact of organizational forms



culturally diverse entities that are linked through ICT and rely on lateral, dynamic relationships for coordination (Camarinha-Matos & Afsarmanesh, 1999; Filos & Ouzounis, 2003). Despite its diffuse nature, a common identity holds the organization together in the minds of its constituents. The virtual organization is managed via teams consisting of geographically dispersed employees, forming a "company without walls," a collaborative network of people working together, regardless of location or who "owns" them (DeSanctis & Monge, 1998). A major distinction between virtual and other organizational models consists in that the former are networked (via ICT), transcend organizational boundaries (Grabowski & Roberts 1998), and should therefore be viewed as metaphors of organization design that is held together, literally, by communication.

A virtual team is defined as a temporary, culturally, and/or functionally diverse, geographically dispersed, ICT-mediated communicating work group (Jarvenpaa & Leidner, 1998). As virtual teamwork is fast becoming a dominant way of working with many organizations, successful management of virtual teams constitutes a key component to managing virtual organizations. As virtual teams are made up of individuals with human needs for belonging, communicating, and togetherness, a radically new approach to and interdisciplinary understanding of virtual team management is required in order to harness the benefits and to develop the potential of this new socioeconomic paradigm.

Virtual Team Communication

When individuals are working together toward a common goal, the success of their undertaking depends, to a large extent, on the information exchanged, which is heavily dependent on the quality of communication between those involved. As communication between human beings involves far more than merely an exchange of information at a rational level, factors such as the emotional atmosphere, the social and cultural context, as well as nonverbal aspects may not be neglected. Contrary to earlier reservations, computer-mediated communication needs do not necessarily have a reductionistic impact on team work, but may rather contribute to "revolutionizing" its potential (Lipnack & Stamps, 1997; Devine & Filos, 2001).

In the traditional team environment, in which individuals are colocated, communication happens via conventional means, such as oral or written forms of interpersonal discourse. While written communication is almost exclusively perceived as formal and legally binding, oral communication is differentiated according to the informational settings (formal meetings or informal social events) in which it is embedded.

On the other hand, communication between individuals of remote teams has to rely almost exclusively on ICT. The distinction between the oral and the written, and with it the distinction between formal and informal discourse, may become blurred. Ong (1982) thus speaks of the "secondary orality" of the digital age. As a result, other distinctive features are likely to become important, such as ease of use, interactivity (which allows the user to feel involved), and even the noninteractivity of asynchronous communication tools (e.g., e-mail).

The Impact of Organizational Culture

The very technologies that offer individuals the freedom to work anytime and anywhere may also fray the ties that bind organization members to each other and to their employer. In particular, the cues that pull team members together in traditional organizational settings include dress codes, shared language, shared organizational culture (e.g., routines and processes), office buildings, and colocation. Consequently, since all these factors are less readily available and less indicative of meaning in the virtual context, the links between virtual team members may be less tangible, and thus more social and psychological in nature. Wiesenfeld, Raghuram, and Garud (1998), in their study on the effects of different communication media on the organizational identification of virtual workers, found that electronic media are particularly important to maintaining organizational identification due to the strong correlation of the frequency of use with it, whereas face-to-face contact may be more critical for creating it. Research on new organizational forms needs to consider the "system of work" and the "system of meaning." the institutional facets of the organization, specifically the values attached to the work engaged in (Scott, 1991). Organizational identification is a part of the larger construct that has to do with the creation and preservation of the "system of meaning" in new work forms.

Trust in the Virtual Context

Handy remarks (1995) that virtual teams are run on trust rather than on control. Indeed, the effective coordination and management of the virtual team seem to pose a real challenge. Although team cohesion may suffer from a lack of immediacy in team members' interactions due to geographical dispersion, divergence of expertise levels, or a socio-organizational heterogeneity, research results suggest that in cross-cultural virtual teams, trust takes on a form of "swift trust" that is based on clear role divisions among members who have well-defined specializations (Jarvenpaa & Leidner, 1998). Communication mediated by ICT provides the virtual platform for an informal and open sharing of thoughts, expectations, assumptions, and values. It offers an opportunity to form alliances of collective responsibility that may be different from the formal hierarchies of management relationships within the parent organizations. The virtual context may thus prove advantageous in providing clarification, sense making, and motivation for the individuals involved. This way, the value of team members' contributions is recognized and used better for the good of the community. In the end, high levels of virtually enabled trust, established between team members, may pioneer a strengthening of links between the member organizations partaking in a virtual collaboration (Grabowski & Roberts, 1998).

Leadership Conventions

Virtual teams enjoy the freedom to define for themselves the management and task assignment schemes that best suit their specific situation. Indeed, each team can build its own project culture, which can be tailored to its needs and goals, and it is certainly less "bureaucratic" than the culture in team members' organizations. Since the virtual context requires lateral communication and active involvement from each individual, it undeniably demonstrates a flat organizational structure, participatory management practices, and novel schemes of shared responsibility (e.g., management tasks performed in rotation).

In traditional teams, the focus on the team leader's role is prone to downgrade the position of the other team members. In that context, the most senior, most experienced, member is appointed as team leader. This hierarchical management scheme, as well as the assumption that teams require a single leader, is called into question in the virtual context, as teams here benefit from having different types of leaders performing complementary tasks, depending on project stage. In the virtual team, each member is empowered and responsibility is shared. Also, since there is no one person or institution to which all team members are accountable, penalties for noncompliance to the rules are imposed by the team members themselves (Jarvenpaa & Shaw, 1998).

Coping with Overabundant Information

In the digital age, the great problem may turn out not to be lack of information access but rather an overabundance of information. As Herbert Simon said, "the wealth of information creates a poverty of attention" (Shapiro & Varian, 1999). Even as passive partakers in the Information Society, people unconsciously become active contributors to this surplus of information. This is because ICT can make people vulnerable to accessing more information than they can "digest," and this can amount to a threatening drawback for organizational efficiency. Smart organizations will therefore need to manage relationships on the basis of techniques that help win the attention of people.

Weiser and Brown (1998) use human optical vision as an analogy to explain information overload and discuss possibilities to avoid it. ICT through their ubiquitous and voluminous provision of information, must engage a richer periphery. In trying to catch up with an increasing "volume of bits," users may be helplessly overwhelmed. The tools developed and used need to engage the periphery as well as the center. A balanced view must be sought continuously.

Nurturing the Knowledge Process

Managing knowledge is a core competence of the "smart" organization. In the digital economy knowledge becomes the primary raw material and result of economic activity.

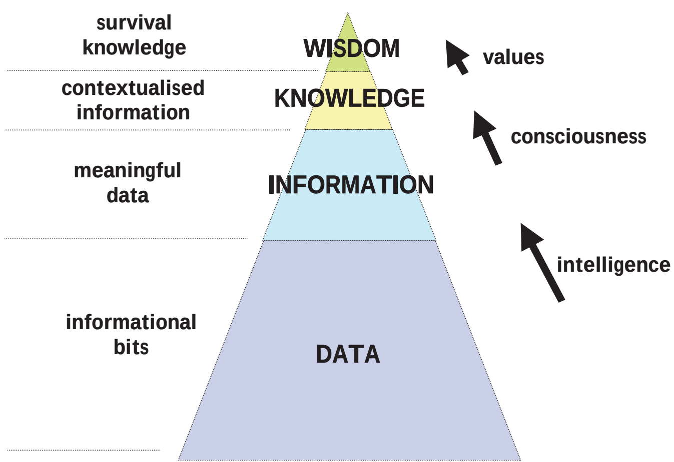
The initial challenge in moving toward organizational smartness, and in order to leverage the power of knowledge, one must know where to find it and once found, know what to do with it. Knowledge can be either explicit or tacit (Polanyi, 1966). In the case of the former, knowledge is formal and systematic and thus easy to capture, store, and communicate. Tacit knowledge on the other hand is personal, a combination of experience and intuition, and as such the organization's ability to capture and communicate it is heavily dependent on the individual owner's commitment to the organization and to its need to generate value from it. In this sense, a great deal of trust and loyalty between the individual and the organization is necessary to leverage organizational knowledge, including its tacit dimension.

It is therefore essential to make a proper distinction between the terms "data," "information," and "knowledge" (Figure 6). The interchangeable use of "information" and "knowledge" tends to obscure the fact that while it can be easy and quick to transfer information from one place to another, it may often involve a very difficult and slow process to transfer knowledge. Knowledge is a human capability that can be acquired and expanded through learning. In trying to define knowledge it can be helpful to realize that the human mind is considered capable of two kinds of knowledge, the rational and the intuitive.

In Western thinking, intuitive knowledge has been devalued in favor of rational scientific knowledge. In Eastern thinking however, the tradition has been to recognize the importance of the intuitive. Chinese philosophy has emphasized the complementary nature of the intuitive and the rational and has represented them by the archetypal pair yin and yang.

Recognition of the difficulties inherent in transferring knowledge from one person to another has tended to highlight the importance of tacit knowledge. This heuristic, subjective, and internalized knowledge is not easy to communicate and is learned through practical examples, experience, and practice. Where explicit, articulate knowledge may be stored in the form of a patent or as documented know-how, tacit, nonarticulate knowledge is communicated in social networks, or know-who. Debates over the meaning of knowledge are ongoing, and do not seem likely to end for some time to come. Similarly, there is no agreed definition of knowledge management. The term is used loosely to refer to a broad collection of organizational practices and approaches related to generating, capturing disseminating know-how, and other content relevant to an organization's business. Knowledge is thus not an explicit, tangible "thing", but information combined with experience, context, interpretation, and reflection. Also, knowledge involves the full person, integrating the elements of both thinking and feeling. Knowledge management is thus increasingly seen as signaling the development of a more organic and holistic way of understanding and exploiting the role of knowledge in the process of managing and doing work, and an authentic guide for individuals, teams, and organizations in

Figure 6. The knowledge pyramid: A tentative approach to explaining "slippery" terms



coping with the increasing complexity of modern business environments.

Stewart (1998) uses the term "intellectual capital" to denote intellectual material—knowledge, information, intellectual property, experience—that can be put to use to create wealth. Intellectual capital is to be seen as an asset for every organization residing in its people (human capital), its structures (structural capital), and its customers (customer capital).

Achieving and Maintaining a High Level of Creativity

Smart organizations embody cross-functional, multidisciplinary teams. Their creativity is based on knowledge networking within and across the organization's boundaries. This openness to ideas drives the creativity of the whole organization.

As Toffler (1981) illustrates, the distinction between producer and consumer diminishes as consumers begin to play an important role, such as in the development or the further improvement of a product. Mass customization enables smart organizations to see customers, suppliers, regulators, and even competitors as stakeholders with meaningful contributions.

Redundancy Frameworks

Building redundancy is a way to support creative teams. Redundancy comes from intensive communication on a common cognitive ground and the facilitation of tacit knowledge transfer. While team members share "overlapping" information, they can sense what others are struggling to articulate.

One way to achieve redundancy is to organize teams in competition with each other. In one sense, such internal competition is wasteful. However, when responsibilities are shared, information proliferates, and the organization's ability to develop and implement efficient concepts is accelerated.

Another way to enable redundancy is through rotation, especially between different functions such as R&D and marketing. Rotation helps employees understand the business from a multiplicity of perspectives. Changing roles and responsibilities helps create and maintain team spirit and commitment to the team objectives, but most importantly, it may drive innovation within the team, as a result of augmented lateral thinking and knowledge sharing.

Active Knowledge Sharing

Metes, Gundry, and Bradish (1997) propose a computer-mediated approach to facilitating knowledge management and creativity of distributed teams. The tool they propose is computer conferencing, also known as "chat" tool. They argue that in contrast to teams using the telephone, fax, e-mail, or audio and video conferencing, teams that use computer conferencing create a permanent shared record of their communication. This is specifically important because information is transmitted in its proper contextual setting, including situations, relationships, assumptions, expectations, and history. Adding context to information transforms it into knowledge (see Figure 6).

Investments in intellectual assets, unlike investments in physical assets, increase in value with use. Properly stimulated, knowledge and intellect grow exponentially when shared. If two people exchange knowledge with each other, both gain information and experience. And if both then share their new knowledge with others—each of whom feeds back questions, suggestions, and modifications—the benefits can grow exponentially. Once an organization gains a knowledge-based competitive edge, it becomes ever easier for it to maintain its lead and ever harder for competitors to catch up.

Professional intellect (Nonaka & Takeuchi, 1995) of an organization operates on four levels:

- Cognitive knowledge (know-what), the basic mastery of a discipline, achieved through extensive training and certification.
- Advanced skills (know-how), the ability to apply the rules of a discipline to complex, real-world problems.
- Systems understanding (know-why), a deep knowledge of the interlinked cause-and-effect relationships underlying a discipline.
- Self-motivated creativity (care-why), which consists of will, motivation, and adaptability for success. Here lies the reason why highly motivated creative teams often outperform teams with greater physical or financial resources. This level depends on the organizational culture.

The value of professional intellect increases when moving up the intellectual scale from cognitive knowledge to self-motivated creativity. Unfortunately, most organizations focus their training efforts on developing basic skills and only very few invest in developing systems and creative skills.

RESEARCH ON THE SMART ORGANIZATION

Research and development (R&D) has contributed substantially to the emergence of smart organizations. In Europe for example, successive research framework programs in the last 12 years have supported the development of technologies that facilitated electronic commerce and digital business. In the early 1990s, research focused on concurrent engineering (Fan & Filos, 1999), on computer-supported collaborative work and product and process data modeling. The work program of the European Strategic Program in Information Technologies (ESPRIT,1997), in the domains high-performance computing and networking, technologies for business processes, and integration in manufacturing supported R&D relevant to the virtual enterprise. Between 1994 and 1998, more than 50 industry-led projects were set up with around 100 million-Euro funding (shared cost funding with 50% industrial contribution). In addition to regular consultations with industry, a number of projects were established which brought together major industrial users of information technology (IT) and the vendor community. The common aim of these projects was to set long-term research targets for the IT industry in order to meet well-formulated industrial needs. The Advanced Information Technology initiative, for example, dealt with the automotive and aerospace industries (AIT, 2001). It comprised 22 R&D projects that also had a major impact on standardization developments. All these projects were operating concurrently within a harmonization framework (Garas & Naccari, 2001). Forty percent of organizations participating in ESPRIT were industrial user enterprises. In total, 65% of participants in ESPRIT were industrial companies. Until 1999, R&D support for the "virtual enterprise" in Europe was mainly through ESPRIT and its international cooperation activities under the Intelligent Manufacturing Systems (IMS, 2005) framework.

In 1999, the Information Society Technologies program (IST, 1999) emerged as an integrated program from previous programs ESPRIT, Advanced Communications Technologies and Systems (ACTS, 1998), and Telematics (TAP, 1998). In the work program of IST, the perspective had changed from "virtual enterprise" to any type of "virtual organization". Under the new program's Key Action II (New Methods of Work and Electronic Commerce), several calls for collaborative research proposals were launched under topics such as "dynamic networked organizations", "smart organizations", and "dynamic value constellations". In parallel, research in learning and cognition had led to the introduction of a new research field, "organizational knowledge management".

All these R&D efforts have contributed to a strong research foundation for the development of smart organizations in Europe (Filos & Ouzounis, 2003; Wagner et al., 2004).

Research on the Virtual Organization

In parallel to these European research activities, research relevant to the virtual organization in the United States was undertaken mainly under defense contracts funded by the Defense Advanced Research Projects Agency (DARPA) and through grants of the National Institute for Standards and Testing and the National Science Foundation (Goranson, 1999).

Between 1999 and 2002, under the European IST program, more than 200 R&D projects were launched on organizations research and on research in e-business and e-work, with a total funding of about 450 million Euro. These fall into three subareas: ICT; work, business and organizational aspects; and socioeconomic issues (Zobel & Filos, 2002; Filos, 2005; Camarinha-Matos et al., 2005).

ICT Aspects of Virtual Organizations

The part of the project portfolio dealing with activities related to the design and development of generic infrastructures to support collaborative business in a networked environment involved issues such as safe communications, interoperability and tools integration, information and knowledge sharing, repositories, coordination mechanisms, and collaborative environments. These projects worked towards the emergence of a general "plug-and-do-business" architecture for interoperability (Bacquet & Naccari, 2002; Doumeingts & Chen, 2003). Project GLOBEMEN aimed at creating an IT infrastructure to support globally distributed and dynamically networked operations in one-of-a-kind industries (Karvonen et al., 2003), COMMA and BUSINESS ARCHITECT made extensive use of modeling and knowledge sharing to support virtual enterprise process integration.

As far as the characteristics and requirements regarding interoperability and information exchange are concerned, innovative approaches were required. Interoperability was to become a "design principle" while aiming to preserve the diversity, autonomy, and heterogeneity of components and environments. For example, project ECOLNET sought to validate different business strategies for independent small- and medium-sized enterprises (SME) focusing on their national market, E-COLLEG investigated an infrastructure to establish a backbone for collaborative engineering (Witczynski & Pawlak, 2002), CO-OPERATE focused on coordination of manufacturing, planning, and control activities in supply chain management, and WHALES developed a planning and management infrastructure for distributed organizations working as networks on large-scale engineering projects.

The projects portfolio was strong in demonstrating the feasibility of operating the virtual organization. The technologies used involved the Java framework, CORBA, XML, Web services, multi-agents, and modeling tools based on UML. The general aim was to use standards whenever possible. This aspect is particularly clear with respect to de facto standards being proposed by industry groups such as the Object Management Group, the Workflow Management Coalition, the World Wide Web Consortium (W3C), and the UN Center for Trade Facilitation and Electronic Business (ebXML).

The significance of virtual organization modeling and interoperability of applications arose from the need to model the virtual organization as a means to properly understand and manage it. A problem with existing business process modelers lies in how to translate one model based on one proprietary modeling technique into an equivalent model represented by another. One strategy pursued in Europe was in agreeing on a basic language that makes such transformations possible. Consensus was reached and the Unified Enterprise Modeling Language was defined (UEML, 2004).

Some projects dealt with ontologies, conceptual information models that describe things that exist in a domain, whose purpose was

- To support human understanding and organizational communication.
- To be machine-processable and thus facilitate content-based access, and communication, and integration across different information systems.

A decade of international research has led to the creation of ontology languages, editors, reasoning techniques, and development guidelines. Various languages for ontology specification and implementation are now available. These languages have built-in reasoning techniques, and they also allow developing special purpose reasoning services.

An area of impact is the Semantic Web, in which computers "find the meaning" of data in automated Web services such as functional agents. The DARPA Agent Markup Language (DAML) and the Ontology Inference Layer (OIL) that was developed by the World Wide Web Consortium and the European OIL community (W3C, 2001), provide a rich set of constructs with which to create ontologies and to mark up information so that it becomes machine-readable. A significant number of European projects addressed knowledge technologies in the context of the virtual organization and business collaboration (Filos, 2002).

Work, Business, and Organizational Issues

This subarea involved reference models and architectures,such as the specification of logical reference architectures for new and emerging cooperative organizations by identifying the main functional blocks, interactions, actors and their roles, resources, and value systems, as well as the definition and the characterization of collaborative business models, the forms of cooperation in networked environments and means to assess the effectiveness of virtual organizations. Work involved virtual organization reference models, collaborative business models (and related case studies), cooperation methodologies and performance measurement. The projects addressed centralized support services as well as services that are distributed across the virtual organization (Hartel, Sonderegger, Kamio, & Zhou, 2002; Kazi, Hannus, & Ollus, 2002; Katzy & Sung, 2003).

Some projects addressed business functions of the various parts of the life cycle of a virtual organization. Research activities included partner registration and search, marketplace management, e-procurement and negotiation, distributed business process planning and management, and so forth, with a particular focus on domain-independent services covering the various phases of the life cycle of a virtual organization. They also comprised supervision and monitoring, as well as specialized services, such as contract modeling and negotiation, a support infrastructure to help virtual enterprises to address the legal issues involved, as well as a Web-based infrastructure for alternative online dispute resolution for SME (Gouimenou, 2001).

Through its IST program, the European Commission also supported a range of projects that aimed to accelerate e-business technology take-up in SME. The concept behind these projects was to transfer leading-edge technologies to industry and other end-users. Under Key Action II, between 1998 and 2002, more than 70 take-up projects were launched, which demonstrated the relevance of e-business, e-commerce, and e-work technologies for SME. Hundreds of SME throughout Europe participated together with so-called "catalysts"—local or regional organizations that worked with them to help them adapt their business processes toward better ICT use. The SME were able to "rethink" and adapt emerging technologies to their business needs by sharing development effort and jointly achieved results among one another. These take-up projects thus became a means to leverage the results of IST research and to contribute to the implementation of the European Commission's eEurope (2005) initiative at local level, by supporting SME directly or indirectly.

The 70 million Euro invested in this take-up project's pilot activity represent only a small fraction of the total European investment in e-business. They were essential, however, in demonstrating that investment in R&D and technology transfer can be a useful instrument to help increase SME competitiveness in today's global market places. Twenty-two showcases are presented in a book (eBiz, 2003). They complement European Member States' efforts, such as those under the GoDigital initiative (2002).

The Socioeconomic Perspective

Between 1999 and 2002, socioeconomic research within IST was a significant nontechnological research activity that aimed at complementing technology activities. It was implemented through a series of calls for proposals. The primary scope of this research was in methods and tools and in understanding the impact of ICT on the economy and on society at large. The main beneficiaries were the program's research community, industry, and policy makers (Hayfa & Filos, 2003). More than 40 projects addressed socio-organizational or socioeconomic issues: industrial and organizational aspects of the digital economy (e-business, e-work), as well as societal aspects; e-business models and intangible assets; impact assessment, mainly at microlevel; corporate social responsibility; statistical indicators. Also, a number of key legal and regulatory issues emerged as a result of this research activity. Some of them were explicitly addressed; for example, legal aspects of virtual enterprises, contract law (intra-/inter-organizational or that of individuals), alternative dispute resolution, digital rights management, intellectual property rights, consumer protection, and related legal aspects (Merz et al., 2001; Hassan, Carter, Seddon, & Mangini, 2001; Van Schoubroeck, Cousy, Droshout, & Windey, 2001; Carter, 2002). All these activities contributed to the definition of a virtual organizations framework (Camarinha-Matos et al., 2004).

Research in Knowledge Management

The European Commission has supported research in knowledge management since the late 1980s, long before knowledge management itself was a recognized term. Early contributions were made in areas such as information management, quality management, and the social sciences. The first formal initiative was launched in 1998 under the research theme "Learning and Training in Industry" (LTI), as part of the ESPRIT program. Under the LTI initiative 16 research projects were launched involving more than 100 research and user organizations. Although the situation has evolved considerably since then, many current projects have their roots in this initial incursion into the realities of organizational learning.

As knowledge management concepts and practices caught the attention of organizations across Europe, European-funded research moved squarely toward supporting the development of solutions that enable individuals to share knowledge within and among organizations as part of the innovation process. The main focus of research has been on supporting multidisciplinary solutions and practices for individuals and corporations to manage knowledge within networked organizations and communities of practice. Specifically, this included aspects such as:

- Integrated ICT platforms, including mobile, to manage the full lifecycle of knowledge (i.e., its capture, organization, maintenance, mining, sharing and trading) in support of both intra- and inter-organizational activities

- Personalized, context-, task- and role-sensitive functionality for the dynamic provision and sharing of timely and relevant knowledge.
- Solutions to organize and exploit heterogeneous, unstructured information sources, using ontologies, self-organization paradigms as well as semantic cross-lingual search, in support of e-work and e-commerce applications.
- Tools and environments for knowledge sharing, collaboration, and socialization within and among organizations which build on methodologies from areas such as organizational behavior, cognitive psychology, human factors, man-machine dialogue, as well as social and management sciences.

The research activities focused not just on technology development but also on its application. In addition to R&D projects, the European Commission also funded a variety of take-up and

Table 1. Knowledge management research in the IST (2002) program

Projects funded under the IST Program reflect a broad spectrum of KM approaches and theories. They can be classified broadly as follows:

First Generation KM

Information portals - tools and methodologies integrating to a greater or lesser extent information necessary for back and front office processes in organizations. These projects mainly originated from the first call for proposals in IST (1999).

Second Generation KM

Knowledge processes to business processes - tools and methodologies linking knowledge and business processes;

Assessment or measurement-type projects - which attempt to measure and benchmark knowledge management implementation within and between organizations and to manage and measure impact of knowledge lifecycles within the enterprise;

Collaboration and innovation spaces - tools, methodologies and good practices to accelerate creative exchanges between people working within and across organizations. The end objective of such projects is to support the transition of organizations into knowledge-based communities.

Third Generation KM

Knowledge and innovation ecologies - tools, methodologies and good practices which identify contextual barriers and enablers of absorptive and innovative capacities of organizations and attempt to replicate co-creation abilities across the enterprise or network;

Human-centered knowledge management - focus on people as unique holders of knowledge, and exchanges between people as primary generators of new knowledge for innovation.

Networks and working groups - which attempt to build critical mass within and outside the IST program.

support activities designed to help make knowledge management better known and accepted notably in small and medium enterprises.

Under the IST program, the "Knowledge Management Made in Europe" (KMME) initiative was launched after the start of the Fifth Framework Program (1999-2002), with an aim to "create a strong brand for European KM research and practice" and to "bring into the portfolio quality proposals". The overall goal of the initiative at the outset was to increase European competitiveness, to improve the working life of European individuals, and to build on European strengths of languages, cultural diversity, and industrial leadership.

One of the major epistemological directions the initiative declared was to pursue the challenge of complexity as a key factor in the knowledge economy, using a holistic approach. The initiative involved 58 research, take-up, and cluster projects with a total public investment of approximately 65 million Euro. Projects funded fell into the three categories outlined in Table 1.

The first category, or first set of projects to be funded, were denoted "first generation KM" (under LTI in 1998) and concentrated on themes and concepts such as information portals, tools and methodologies integrating to a large or lesser extent information necessary for back and front office processes in organizations.

The second wave, from 1999 to 2000, aimed at a more holistic treatment of primarily tacit knowledge in organizations and funded projects with concepts and themes such as linking knowledge processes to business processes, assessing KM implementation and collaboration and innovation spaces.

The third generation KM (2001-2002) represented a movement away from the classical knowledge management engineering approach, and aimed at funding projects with concepts and themes such as knowledge and innovation ecologies and human-centered KM.

One of the most conspicuous and most mentioned projects with the largest international profile is the European Knowledge Management Forum (EKMF), a cluster project which attempted to "build a sustainable network of Knowledge Management theoreticians and practitioners who are interested in Europe's journey into the knowledge economy, and what Knowledge Management methods and tools can contribute to this journey." (KnowledgeBoard, 2005).

An assessment of the KMME initiative (Sage, Stanbridge, & Shelton, 2004) to date shows that projects funded in the first wave are indicating a focus on classical, engineering approaches to knowledge management. This concentration is typical of early projects in knowledge management programs. The same phenomenon was observed in the U.S. in knowledge management research. Many of the projects in the first phase were industry- or sector-specific and helped to solve problems specific to the sector or industry, without addressing issues that were of benefit to different sectors or with impact on the industry value chain.

The second wave marks a shift from the engineering approach to a more centralist, best-practice approach. In the third wave, a significant number of projects were funded that are advanced on the mathematical complexity scale and address concepts such as intelligent agents and the Semantic Web.

However, only a few projects address the area of social complexity, which has high potential for KM that is related to the European context of linguistic and cultural diversity. The subject of complexity is not widely recognized within the KnowledgeBoard community.

The phenomenon of divergence between focus areas in knowledge management research in Europe, and a false dichotomy between human-centered approaches and engineering/mathematical approaches has been observed in the U.S. as well. The opportunity for Europe is to fund and initiate more research that is related to the human-centered approach, but also looks at social complexity.

CONCLUSION

This chapter aimed to draw a picture of the changing organizational paradigm in the digital age. Successive European R&D programs played a significant part in developing the technologies and concepts that are key to those developments. The research efforts aimed at understanding and improving knowledge management, the virtual organization and digital business processes. While many of the features of digital age organizations are not yet fully understood, there is hope that organizations in the future will become "smart" in various respects. The unprecedented opportunities offered by Information Society for individuals to relate with one another, to work, and to do business in digital environments will change the ways organizations relate to each other and to the individuals that are key to their core competences.

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REFERENCES

ACTS (1998). *Advanced Communications Technologies and Services program*. European Commission, Directorate-General XIII—Telecommunications, Brussels. Retrieved from http://www.cordis.lu/acts/

AIT (2001). *Advanced Information Technology* (Garas & Naccari, 2001). Similar initiatives for the process industries (PRIMA) and the construction (or large-scale engineering) industries (ELSEWISE, see Mitrovic et al., 1999; McAffer & Garas, 1999). Of similar impact for the furniture industry was FUNSTEP (Jardim-Gonçalves et al., 1999).

Bacquet, J., & Naccari, F. N. (2002). "Plug and do business" and the European R&D programs. In L. M. Camarinha-Matos (Ed.), *Collaborative business ecosystems and virtual enterprises, IFIP TC5/WG5.5 Third Working Conference on Infrastructures for Virtual Enterprises (PRO-VE'02)* (pp. 283-292). Boston: Kluwer Academic Publishers.

Camarinha-Matos, L. M., & Afsarmanesh, H. (1999). The virtual enterprise concept. In L. M. Camarinha-Matos & H. Afsarmanesh (Eds.), *Infrastructures for virtual enterprises: Networking industrial enterprises* (pp. 3-30). Boston: Kluwer Academic Publishers.

Camarinha-Matos, L. M., & Afsharmanesh, H. (Eds.). (2004). *Collaborative networked organizations: A research agenda for emerging business models*. Boston; Dordrecht; London: Kluwer Academic Publishers.

Camarinha-Matos, L. M., Afsharmanesh, H., & Ollus, M. (Eds.). (2005). *Virtual organizations. systems and practices*. New York: Springer Science + Business Media, Inc.

Camarinha-Matos, L. M., Afsharmanesh, H., & Rabelo, R. J. (Eds.). (2001). *E-business and virtual enterprises: Managing business-to-business cooperation*. Dordrecht: Kluwer Academic Publishers.

Carter, C. (2002). The impact of contractual support for ICTs on working practices. In B. Stanford-Smith, E. Chiozza, & M. Edin (Eds.), *Challenges and achievements in e-business and e-work* (pp. 1291-1298). Amsterdam: IOS Press.

Cunningham, P., Cunningham, M., & Fatelnig, P. (Eds.). (2003). *Building the knowledge economy: Issues, applications, case studies*. Amsterdam: IOS Press.

Davis, S., & Meyer, C. (1998). *Blurr—The speed of change in the connected economy*. Oxford: Capstone.

Deloitte & Touche. (2002). *Collaborative knowledge networks*. New York: Deloitte Consulting and Deloitte & Touche.

DeSanctis, G., & Monge, P. (1998). Communication processes for virtual organizations. *Journal of Computer-Mediated Communication, 3*(4). Retrieved from http://jcmc.indiana.edu/vol3/issue4/desanctis.html

Devine, M., & Filos, E. (2001). Virtual teams and the organizational grapevine. In L. M. Camarinha-Matos, H. Afsharmanesh, & R. J. Rabelo (Eds.), *IFIP TC5/WG5.3 Second Working Conference on Infrastructures for Virtual Organizations: Managing Cooperation in Virtual Organizations and Electronic Business towards Smart Organizations* (pp. 413-424).

Doumeingts, G., & Chen, D. (2003). Interoperability development for enterprise applications and software. In P. Cunningham, M. Cunningham, & P. Fatelnig (Eds.), *Building the knowledge economy: Issues, applications, case studies* (pp. 207-214). Amsterdam: IOS Press.

Doz, Y. L., & Hamel, G. (1998). *Alliance advantage: The art of creating value through partnering*. Boston: Harvard Business School Press.

eBiz (2003). *European e-business Showcases*, European Commission, Office for Official Publications, Luxembourg. Retrieved from http://europa.eu.int/information_society/ecowor/smes/

eEurope (2005). *eEurope 2005—An information society for all*. European Commission, Directorate-General Information Society and Media, Brussels. Retrieved from http://europa.eu.int/information_society/eeurope/2005/

ESPRIT (1997). *European Strategic Program for Research in Information Technologies, Building the Information Society*. Work Program 1997, European Commission, Directorate-General III—Industry, Brussels. Retrieved from http://www.cordis.lu/esprit/

Evans, S., & Roth, N. (2004). Collaborative knowledge networks. In L. M. Camarinha-Matos & H. Afsharmanesh (Eds.), *Collaborative networked organizations: A research agenda for emerging business models* (pp. 289-312). Boston, Dordrecht, London: Kluwer Academic Publishers.

Fan, I.-S., & Filos, E. (1999). Concurrent engineering: Esprit-supported R&D projects in a worldwide context. In N. Wognum, K. -D. Thoben, & K. S. Pawar (Eds.), *ICE'99, International Conference on Concurrent Enterprising* (pp. 177-189). Nottingham: University of Nottingham.

Filos, E. (2002). European collaborative R&D projects related to the "smart organization." A first evaluation of activities and implications for construction. In Z. Turk & R. Scherer (Eds.), *eWork and eBusiness in architecture, engineering and construction* (pp. 27-32). Lisse: Sweets and Zeitlinger..

Filos, E. (2005). Virtuality and the future of organizations. In G. Putnik & M. M. Cunha (Eds.), *Virtual enterprise integration: Technological and organizational perspectives*. Hershey, PA: Idea Group.

Filos, E., & Banahan, E. (2001a). Will the organization disappear? The challenges of the new economy and future perspectives. In Camarinha-Matos et al. (Eds.), *IFIP TC5/WG5.3 Second Working Conference on Infrastructures for Virtual Organizations: Managing Cooperation in Virtual Organizations and Electronic Business towards Smart Organizations*, December 4-6, 2000, Florianopolis, Santa Catarina, Brazil (pp. 3-20).

Filos, E., & Banahan, E. (2001b). Towards the smart organization: An emerging organizational paradigm and the contribution of the European RTD programs. *Journal of Intelligent Manufacturing*, *12*(2), 101-119.

Filos, E., & Ouzounis, V. K. (2003). Virtual organizations: Technologies, trends, standards and the contribution of the European R&D programs. *International Journal of Computer Applications in Technology*, *18*(1-4), 6-26.

Foy, N. (1980). *The ying and yang of organizations.* Grant McIntyre.

Garas, F. K., & Naccari, F. N. (2001). *Assessment of the AIT initiative*. Report to the European Commission, Directorate-General Information Society, Brussels. Retrieved from http://www.cordis.lu/ist/ka2/rptspolicyconf.htm

GoDigital (2002). *The 'GoDigital' initiative was an integral part of eEurope 2002.* Retrieved from http://europa.eu.int/information_society/topics/ebusiness/godigital/index_en.htm

Goldman, S. L., Nagel, R. N., & Preiss, K. (1995). *Agile competitors and virtual organizations: Strategies for enriching the customer.* New York: Van Nostrand Reinhold.

Goranson, T. H. (1999). *The agile virtual enterprise: Cases, metrics, tools.* Westport-London: Quorum.

Gouimenou, J. (2001). E-Arbitration-T: An alternative dispute resolution for SMEs. In B. Stanford-Smith & E. Chiozza (Eds.), *E-work and e-commerce: Novel solutions and practices for a global networked economy* (pp. 526-531). Amsterdam: IOS Press.

Grabowski, M., & Roberts, K. H. (1998). Risk mitigation in virtual organizations [Electronic version]. *Journal of Computer-Mediated Communication, 3*(4).

Handy, C. (1995, May-June). Trust and the virtual organization. *Harvard Business Review*, 25-50.

Handy, C. (1999). *Understanding organizations* (4th ed.). London: Penguin.

Hartel, I., Sonderegger, S., Kamio, Y., & Zhou, M. (2002). The information roadmap of virtual enterprises. In B. Stanford-Smith, E. Chiozza, & M. Edin (Eds.), *Challenges and achievements in e-business and e-work* (pp. 1380-1387). Amsterdam: IOS Press.

Hassan, T., Carter, C., Seddon, C., & Mangini, M. (2001). e-LEGAL: Dismantling the legal barriers to ICT up-take in virtual enterprises. In B. Stanford-Smith & E. Chiozza (Eds.), *E-work and E-commerce: Novel solutions and practices for a global networked economy* (pp. 602-608). Amsterdam: IOS Press.

Hayfa, T., & Filos, E. (2003). *How ICTs impact policy-making: Thirteen IST project examples.* European Commission, Directorate-General Information Society, Brussels. Retrieved from ftp://ftp.cordis.lu/pub/ist/docs/dir_c/rd_report_en.pdf

Imai, K., & Itami, H. (1984). Interpenetration of organization and market. *International Journal of Industrial Organization*, (2), 285-310.

IMS (2005). *Intelligent Manufacturing Systems initiative*. Retrieved from http://www.ims.org

IST (1999). *Information Society Technologies.* Work Program 1999, European Commission, Directorate-General Information Society, Brussels. Retrieved from http://www.cordis.lu/ist/library.htm

IST (2002). Retrieved from http://www.cordis.lu/ist/ist-fp5.html

Jardim-Gonçalves, R., Sousa, P. C., Pimentão, J. P., & Steiger-Garcão, A. (1999). Furniture commerce electronically assisted by way of a standard-based integrated environment. In N.

Wognum, K.-D. Thoben, & K. S. Pawar (Eds.), *ICE'99, International Conference on Concurrent Enterprising* (pp. 129-136). Nottingham: University of Nottingham.

Jarvenpaa, S. L., & Leidner, D. E. (1998). Communication and trust in global virtual teams [Electronic version]. *Journal of Computer-Mediated Communication, 3*(4).

Jarvenpaa, S. L., & Shaw, T. R. (1998). *Global virtual teams: Integrating models of trust. Proceedings VO-Net Workshop* (pp. 35-51).

Karvonen, I., van den Berg, R., Bernus, P., Fukuda, Y., Hannus, M., Hartel, I., et al.(Eds.). (2003). *Global Engineering and Manufacturing in Enterprise Networks*. GLOBEMEN. VTT Symposium [Electronic version].

Katzy, B. R., & Sung, G. (2003). State-of-the-art virtual organization modeling. In P. Cunningham, M. Cunningham, & P. Fatelnig (Eds.), *Building the knowledge economy: Issues, applications, case studies* (pp. 959-966). Amsterdam: IOS Press.

Kazi, A. S., Hannus, M., & Ollus, M. (2002). Layered architecture for inter-enterprise collaboration. In B. Stanford-Smith, E. Chiozza, & M. Edin (Eds.), *Challenges and achievements in e-business and e-work* (pp. 1373-1379). Amsterdam: IOS Press.

Kelly, K. (1999). *New rules for the new economy*. London: Forth Estate.

Kelly, S., & Allison, M. A. (1999). *The complexity advantage: How the science of complexity can help your business achieve peak performance*. New York: BusinessWeek Books, McGraw-Hill.

KnowledgeBoard (2005). *The Web site of the European Knowledge Management Forum (EKMF)*. Retrieved from http://www.knowledgeboard.com/

Kostner, J. (1996). *Virtual leadership: Secrets from the round table for the multi-site manager*. New York: Warner Books, Inc.

Levine, R., Locke, C., Searls, D., & Weinberger, D. (2000). *The Cluetrain Manifesto: The end of business as usual*. Cambridge, MA: Perseus.

Lipnack, J., & Stamps, J. (1997). Virtual teams: *Reaching across space, time, and organizations with technology*. New York: John Wiley & Sons.

McCaffer, R., & Garas, F. (Eds.). (1999). eLSEwise: European Large Scale Engineering Wide Integration Support Effort [Special Issue]. *Engineering Construction and Architectural Management, 6*(1).

Merz, M. et al. (2001). Electronic contracting in the construction industry. In B. Stanford-Smith & E. Chiozza (Eds.), *E-work and e-commerce: Novel solutions and practices for a global networked economy* (pp. 595-601). Amsterdam: IOS Press.

Metes, G., Gundry, J., & Bradish, P. (1997). *Agile networking: Competing through the Internet and Intranets*. Upper Saddle River, NJ: Prentice Hall.

Mills, D. Q. (1991). *Rebirth of the corporation*. New York: John Wiley & Sons.

Mintzberg, H. (1980). *Mintzberg on management: Inside our strange world of organizations*. New York: The Free Press.

Mitrovic, D., Hunter, I., & Male, S. (1999). Characteristics of networked enterprise in global construction. In N. Wognum, K.-D. Thoben, & K. S. Pawar (Eds.), *ICE'99, International Conference on Concurrent Enterprising* (pp. 447-454). Nottingham: University of Nottingham. See also McAffer & Garas (1999).

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

O'Mahony, M., & van Ark, B. (2003). *EU productivity and competitiveness: An industry perspec-*

tive. Can Europe resume the catching-up process? Luxembourg: European Commission.

O'Reilly, C. A., & Tushman, M. L. (2004). The ambidextrous organization. *Harvard Business Review*, April, 74-81.

OECD (2003). *The policy agenda for growth: An overview of the sources of economic growth in OECD countries.* Paris: OECD.

Ong, W. J. (1982). *Orality and literacy: The technologising of the word.* London: Methuen.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Por, G. (2000). Knowledge, intelligence, wisdom: The new economic value chain and its enabling technologies. In *Future Organizations and Knowledge Management,* Program Consultation Meeting, European Commission, Directorate-General Information Society, Brussels.

Sage, J., Stanbridge, P., & Shelton, R. (2004). *Business knowledge management: A study on market prospects, business needs and technological trends.* Final Report for the European Commission, DG Information Society, IBM Business Consulting Services. Retrieved from http://europa.eu.int/information_society/doc/library/business_knowledge_management.pdf

Savage, C. M. (1996). *5th generation management: Co-creating through virtual enterprising, dynamic teaming, and knowledge networking.* Newton, MA: Butterworth-Heinemann.

Schapiro, C., & Varian, H. R. (1999). *Information rules: A strategic guide to the network economy.* Boston: Harvard Business School Press.

Scott, W. R. (1991). Unpacking institutional arguments. In W. W. Powell & P. J. DiMaggio (Eds.), *The new institutionalism in organizational analysis* (pp. 164-182). Chicago: University of Chicago Press. Cit. Wiesenfeldt, B. M. et al. (1998).

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization.* London: Random House.

Slouka, M. (1995). *War of the worlds: Cyberspace and the high-tech assault on reality.* New York: Basic Books.

Soete, L. (Ed.). (1996). *Building the European information society for us all: First reflections of the high level group of experts,* Interim Report, European Commission, Directorate General V, Brussels.

Stanford-Smith, B., Chiozza, E. (Eds.). (2001). *E-work and e-commerce: Novel solutions and practices for a global networked economy.* Amsterdam: IOS Press.

Stanford-Smith, B., Chiozza, E., & Edin, M. (Eds.). (2002). *Challenges and achievements in e-business and e-work.* Amsterdam: IOS Press.

Stewart, T. A. (1998). *Intellectual capital: The new wealth of organizations.* London: Nicholas Brealy Publishing.

Stoll, C. (1995). *Silicon snake oil: Second thoughts on the information superhighway.* New York: Doubleday.

TAP (1998). *Telematics Applications Program*. European Commission, Directorate-General XIII - Telecommunications, Brussels. For further information see: http://www.cordis.lu/telematics/

Tapscott, D., Lowy, A., & Ticoll, D. (Eds.). (1998) *Blueprint to the digital economy: Creating wealth in the era of e-business.* New York: McGraw Hill.

Ticoll, D., Lowy, A., & Kalakota, R. (1998). Joined at the bit: The emergence of the e-business community. In D. Tapscott, A. Lowy, & D. Ticoll (Eds.), *Blueprint to the digital economy: Creating wealth in the era of e-business* (pp. 19-33). New York: McGraw Hill.

Toffler, A. (1981). *The third wave*. London: Pan Books.

UEML (2004). Retrieved from http://www.cimosa.de/Modelling/UEML02.html and http://www.rtd.computas.com/websolution/Default.asp?WebID=239

Van Schoubroeck, C., Cousy, H., Droshout, D., & Windey, B. (2001). Virtual enterprise legal issue taxonomy. In B. Stanford-Smith & E. Chiozza (Eds.), *E-work and e-commerce: Novel solutions and practices for a global networked economy* (pp. 609-615). Amsterdam: IOS Press.

W3C (2001). World-Wide Web Consortium, Web Ontology Working Group, See also: http://www.w3.org/2001/sw/WebOnt/, and http://www.ontoknowledge.org/oil/misc.shtml#ackn

Wagner, C., Bottermann, M., Freijen, E., Schmidt, L., Simmons, S., Van ´t Hof, C., et al. (2004). *Europe, competing: Market prospects, business needs and technological trends for virtual smart organisations in Europe*. Report for the European Commission, DG Information Society, RAND Corporation, MG-195-EC.

Warnecke, H. -J. (1992). *Die Fraktale Fabrik. Revolution der Unternehmenskultur* [The fractal company]. Berlin; New York: Springer-Verlag.

Weiser, M., & Brown, J. S. (1998). Center and periphery: Balancing the bias of digital technology. In D. Tapscott, A. Lowy, & D. Ticoll (Eds.), *Blueprint to the digital economy: Creating wealth in the era of e-business* (pp. 317-335). New York: McGraw Hill.

Wickens, P. D. (1998). *The ascendant organization* (revised and updated edition). London: MacMillan.

Wiesenfeld, B. M., Raghuram, S., & Garud, R. (1998). Communication patterns as determinants of organizational identification in a virtual organization. *Journal of Computer-Mediated Communication, 3*(4).

Williamson, O. E. (1975). *Markets and hierarchies: Analysis and anti-trust implications*. New York: The Free Press.

Witczynski, M., & Pawlak, A. (2002). Virtual organizations enabling net-based engineering. In B. Stanford-Smith, E. Chiozza, & M. Edin (Eds.), *Challenges and achievements in e-business and e-work* (pp. 908-915). Amsterdam: IOS Press.

Wognum, N., Thoben, K. -D., & Pawar, K. S. (Eds.). (1999). *ICE'99, International Conference on Concurrent Enterprising*. Nottingham: University of Nottingham..

Zobel, R., & Filos, E. (2002). Work and business in the e-economy: technology & policy issues. In B. Stanford-Smith, E. Chiozza, & M. Edin (Eds.), *Challenges and achievements in e-business and e-work* (pp. 52-66). Amsterdam: IOS Press.

Chapter 1.6
Knowledge Sharing

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INTRODUCTION

Knowledge sharing (KS) is critical to organizations that wish to use their knowledge as an asset to achieve competitive advantage. Knowledge management systems (KMSs) can be primary enablers of knowledge sharing in an organization.

A major focus of knowledge sharing is on the individual who can explicate, encode, and communicate knowledge to other individuals, groups, and organizations. In particular, the employment of some KMSs requires individuals to contribute their knowledge to a system rather than keeping it to themselves or sharing it only through personal exchanges.

Another major focus of knowledge sharing is on knowledge sharing in teams since teams have become so prominent in management thought and practice, and because some of the long-presumed benefits of teams such as "higher labor productivity, a flatter management structure and reduced employee turnover" have been validated (Glassop, 2002, p. 227).

A major distinction between knowledge sharing and knowledge transfer (terms that may sometimes be used interchangeably) is that transfer implies focus, a clear objective, and unidirectionality, while knowledge may be shared in unintended ways multiple directionally without a specific objective (see article titled "Knowledge Transfer").

Of course, knowledge may also be shared in intended ways, such as when a team attempts to develop mutual knowledge, a common ground, or knowledge that the parties know they share in common (Cramton, 2001).

BACKGROUND

Some people presumably have a tendency to share knowledge just as some people have a tendency to be talkative. Others follow the "knowledge is power" dictum, probably learned in organizational settings; these people may hoard knowledge and be reluctant to share it.

Knowledge sharing may occur between and among individuals, within and among teams, among organizational units, and among organizations. Sharing among individuals within teams is a particularly important focus whether the teams are temporary sets of interdependent individuals bound by a collective aim, problem-solving groups (also usually temporary in nature), self-managing teams, or cross-functional teams (Glassop, 2002). Virtual teams, those in which individuals primarily communicate using electronic means, are becoming a more important focus of KS.

Sharing behavior may be differentiated in terms of the sharing of explicit knowledge (that which is written down or encoded in some fashion) vs. the sharing of tacit knowledge (that which exists in the mind of an individual; Nonaka, 1994), or some combination of the two varieties. Individuals may have different propensities to share explicit and tacit knowledge. They may consider explicit knowledge, such as reports and memos that are in their possession, to be owned by the organization that paid them to produce the documents, whereas they may consider that knowledge that is in their heads belongs to them (Constant, Kiesler, & Sproull, 1994).

Knowledge-management systems of two general varieties are both driven primarily by knowledge sharing. The two types are referred to as repositories and networks, or as the codification and personalization types of KMS strategies (Kankanhalli, Tanudidjaja, Sutanto, & Tan, 2003). Repositories are databases of knowledge usually contributed by individuals, teams, or organizations for potential use by others. The best example is a best-practices repository. Networks facilitate communications among team members or among groups of individuals who are not necessarily identified a priori.

Information technology can enable both types: in the former case, enabling sharing across widely dispersed elements of an organization, and in the latter case, enabling communities of practice involving people who discover that they have common practices or interests to form and share knowledge either within an organization or among various organizations. Probably the best known interorganization community is that which develops and maintains the open-source Linux system (Lee & Cole, 2003).

ISSUES IN KNOWLEDGE SHARING

Organizations have taken different views on knowledge sharing. Some, believing that there is a danger in giving away secrets or viewing sharing as a diversion from individuals' primary work, have not encouraged sharing. Others, believing that there is great potential benefit in disseminating knowledge within an organization and perhaps beyond its boundaries, support it. Of course, the tenets of knowledge management presume that sharing is generally both beneficial and necessary if an organization is to realize its potential.

Many researchers and those organizations and managers that wish to encourage knowledge sharing have focused on how they might best motivate individuals to share their most valuable personally held knowledge. The concept of knowledge as a public good can serve to illustrate this issue.

Knowledge as a Public Good

A fundamental issue of KMS is demonstrated by the notion of knowledge as a public good. A public good is something that is available to all members of a community or organization regardless of whether they contributed to the constitution of the good. A fundamental problem with public goods is that they are subject to the free-rider problem whereby an individual enjoys the benefits without contributing to the institution or maintenance of the common asset, which may result in an undersupply of the good.

Thorn and Connolly (1987) conducted research that conceptualized information in a database as a public good. They identified cost as a factor for individuals considering sharing their valuable personally held information in terms of sharing cost: the time and/or effort that is required from the individual to share knowledge through a computer-based system. They concluded that this cost is something that is considered by the potential sharer when making the decision of whether to contribute.

Constant et al. (1994) identified positive motivators for individuals to contribute, even when the personal costs may be high. These include the enhancement of self-esteem, the reinforcement of an individual's understanding of their own knowledge, and the shared values of organizational citizenship (Bolino & Turnley, 2003).

Goodman and Darr (1999) identified the contextual conditions in the organization affecting an individual's decision to share his or her knowledge through a KMS. They determined that a sharing culture is necessary prior to the implementation of such a system. They also identified shared rewards as an important element in producing such a culture. Such intangible and cultural variables may well constitute the accepted wisdom among KMS practitioners.

Motivating Knowledge Sharing

Organizations generally rely on either formal supervisory controls or more general organizational support to motivate knowledge sharing. Examples of the former are guidelines that specify what is appropriate sharing behavior and the monitoring of the knowledge that individuals provide to a KMS. Illustrative of the latter is the development of cultural norms that promote sharing.

These quite-different views of how knowledge sharing can be motivated are illustrated in studies conducted by Perlow (1998) and Alvesson (1993).

Perlow (1998) studied knowledge workers in a software-development group where the management of the organization instituted a stringent means of controlling the employees. The company imposed strict demands by monitoring employees, standing over them, and routinely checking up on them. Management instituted mandatory meetings, deadlines, and extra work to ensure that the employees were working in the best interest of the firm. This approach is referred to as supervisory control.

Alvesson (1993) performed a case study of a computer consulting company. The study found that management felt that the company operated efficiently because management strove to have a strong interpersonal culture in the organization. This culture was based on focusing on the organization as a community instead of viewing it as merely a collection of individuals. This approach reflects a general approach referred to as social exchange.

Supervisory Control

Organizations can operate in formal ways that encourage knowledge sharing, for example, by using employment contracts that specify that knowledge and information that is collected or generated in the course of work belongs to the organization. However, such legalistic approaches are difficult to enforce.

However, other forms of supervisory control may have an impact on an individual's willingness to share his or her knowledge through a KMS (Loebecke, Van Fenema, & Powell, 1999). Supervisory control is defined as efforts by management to increase the likelihood that individuals will act in ways that will result in the achievement of organizational objectives (Stajkovic & Luthans, 2001).

Supervisory control is important because an assumption in agency theory, and in some other management literature, is that the goals of the employer and the employee are, to some degree, divergent, necessitating a need for control in order to align the goals of the two actors (Flamholtz, 1996). The exact nature of the supervisory-control mechanisms needed to produce goal congruence is unresolved because of the widely varied types of control mechanisms that have been utilized and studied. For example, supervisory-control mechanisms may consist of the use of power, leadership, building clans, or information processing.

Social Exchange

Social-exchange theory posits that people contribute to others commensurate with the contributions that they perceive are being made by others to them. This theory views the contributions that individuals make to an organization as reciprocal arrangements. Reciprocal arrangements occur when an individual performs some type of action for another individual, group, or organization. The action is performed without a specific economic contract that ensures that the action will be repaid. Rather, the individual who performs the action does so because he or she believes that the action will be reciprocated at some future time, though the exact time and nature of the reciprocal act is unknown and unimportant (Turnley, Bolino, Lester, & Bloodgood, 2003).

This exchange relationship develops from a series of mutual exchanges between two actors until such time as a relationship exists whereby mutual exchanges become a normative behavior. Unlike an economic-exchange relationship, in the social-exchange relationship, the potential result of any behavior is based on a trust that the relationship will proceed as in past exchanges (Meyer, Stanley, Herscovitch, & Topolnytsky, 2002).

This relationship of mutual exchange may exist between individuals or between an individual and an organization. Over a period of time, an individual may develop opinions about the exchange relationship between himself or herself and the organization by observing the relationship, the organization, other employees and their relationship with the organization, and individuals who are external to the organization. In this way, employees personify the organization through the actions of their supervisors and coworkers.

Research has demonstrated the relationship between social exchange and positive outcomes in organizations (Allen, Shore, & Griffeth, 2003). Social exchange has been found to be important in exploring why individuals have high feelings of loyalty to their organization. It has also been found to be important in explaining why individuals exhibit positive behaviors in their organizations when these positive behaviors are not formally required (Liao & Chuang, 2004).

Perceived Organizational Support

The emphasis on social exchange from an individual to an organization and vice versa was used by Eisenberger, Huntington, Hutchison, and Sowa (1986) in developing the concept of perceived organizational support (POS) to explain how individuals in organizations can become committed to their organizations. They proposed that "employees develop global beliefs concerning the extent to which the organization values their contributions and cares about their well-being" (p. 501). They developed a reciprocal view of the relationship between employee and employer in which the employee shares a strong level of commitment to his or her organization if he or she perceives that the organization has a strong commitment in return. They surmised that high levels of POS will create a feeling of obligation in the employee, whereby the employee will feel obligated to support organizational goals.

Other research supports this conclusion. Eisenberger, Fasolo, and Davis-LaMastro (1990) showed that POS demonstrated a positive relationship to conscientiousness in the performance of job-related responsibilities and a commitment to making the organization a better place through fostering innovation. Lynch, Eisenberger, and Armeli (1999) found a positive relationship between a high level of POS and a high level of extra-role behaviors, and that the reverse was also true; that is, if there is a low level of POS, there is a low level of extra-role behaviors from individuals in an organization. POS has become a much-used construct in various areas of social science and business (Fuller, Barnett, Hester, & Relyea, 2003).

The Effects of Supervisory Control and Organizational Support

Numerous studies have identified the differences between theories of economics (e.g., supervisory control) and theories of sociology (e.g., organizational support), and their impacts on the achievement of organizational goals. Often, these studies propose that the theories of economics and sociology rely on differing assumptions and therefore cannot be considered to be similar (Adaman & Madra, 2002). In fact, some even contend that the cross-pollination of the disparate theories is inappropriate and should be avoided (e.g., Oleson, 2003).

Modern consideration of rational man as a utility maximizer and social man as a conglomeration of complex motivational forces in an organization trace back to Barnard (1938), who recognized the importance of the "willingness of persons to contribute efforts to the cooperative system" (p. 83). This willingness was considered to be different than the tangible and more easily measurable elements of motivation derived from a supervisory-control system. He emphasized that if individuals in organizations were only concerned with a direct relationship with the structured control system as a means of dictating the exact amount of work that they would accomplish, then the organization would be unable to function. He posited that the helpful behaviors exhibited by employees that are difficult to measure acted as the glue that allowed operations in organizations to run relatively seamlessly.

Katz and Kahn (1966) further developed this idea by distinguishing between in-role behaviors and "innovative and spontaneous behaviors," positing that innovative and spontaneous behaviors make an organization "intrinsically cooperative and interrelated" (p. 339). They proposed that these behaviors are so ingrained in the fabric of the organization that they are seemingly transparent to management and thus are often taken for granted. However, these behaviors ought not to be so taken since much of the work that is accomplished in organizations is difficult for management to specify.

March and Simon (1958) approached organizations from the perspective of social psychology. They acknowledged that individuals make their decisions on much more than purely economic bases and presented propositions that allude to the vast array of influences in an organization that impact the decision-making processes of individuals. Specifically, they focused on the effects that group norms and expectations have on individuals. These norms and expectations are not easily measurable in an economic framework; however, they are important in an organization that is attempting to accomplish specific objectives.

Davis, Schoorman, and Donaldson (1997) contributed to this economics-vs.-sociology discussion by recognizing that viewing individuals as utility maximizers may not account for the complex set of factors that can motivate individuals to accomplish things that do not always seem to directly maximize their utility. They stressed that other motivational elements that are not based on economic assumptions of utility maximization are necessary to account for the motivational elements in individuals and organizations.

FUTURE TRENDS

The issue of how best to motivate individuals to share their most valuable personal knowledge is not completely resolved. The conventional wisdom is that the creation of a knowledge-sharing culture is the best way, although that is not empirically well validated (Goodman & Darr, 1999).

Among the other research findings related to knowledge sharing that appear to have value are the following:

a. Knowledge sharing involves both costs and benefits (not necessarily economic; Constant et al., 1994; Thorn & Connolly, 1987).
b. Contrary to some popular wisdom, supervisory control appears to be more important than perceived organizational support in terms of both the frequency of submissions and the perceived effort expended in contributing to a KMS (King & Marks, in press; since this study was done in a military organization, the results may be limited to similar contexts).
c. Concern with self-interest has a negative effect on sharing-related attitudes (Constant et al., 1994). This might suggest that an organization that creates a highly competitive culture, such as by having the policy of attempting to counsel 10% of the lowest performers out of the organization each year, might have difficulties in motivating knowledge sharing.
d. Dispersed (not colocated) computer-mediated teams have difficulties in knowledge sharing that are greater than those experienced in colocated teams in part because of the difficulties in establishing social presence—the degree to which the medium facilitates the awareness of other people and the development of interpersonal relationships (Cramton, 2001).
e. Systems variables, such as use and usefulness, appear to have important moderating effects on individuals' sharing behavior through a KMS (King & Marks, in press).

CONCLUSION

Economic, behavioral, and social factors must be considered when assessing the issue of how to motivate individuals to contribute their most valuable personally held knowledge to others who they may not even know, as in contributing to a KMS.

Most interest and research in knowledge sharing has focused on this supply-side issue: that is, how to motivate people to share. However, some researchers have focused on the demand side: individuals' knowledge-seeking and knowledge-acquisition behavior. This perspective addresses potential users of knowledge and how they search for it when they have a question or problem. Expert networks have been established in organizations such as Microsoft to enable such search, and of course, communities of practice also facilitate this demand-side viewpoint of sharing.

REFERENCES

Adaman, F., & Madra, Y. M. (2002). Theorizing the "Third sphere: A critique of the persistence of the economic fallacy". *Journal of Economic Issues, 36*(4), 1045-1078.

Alavi, M., & Leidner, D. (2001). Knowledge management systems: Issues, challenges, and benefits. *CAIS, 1*(7), 2-36.

Allen, D. G., Shore, L. M., & Griffeth, R. W. (2003). The role of perceived organizational support and supportive human resource practices in the turnover process. *Journal of Management, 29*(1), 99-118.

Alvesson, M. (1993). Cultural-ideological modes of management control: A theory and a case study of a professional service company. In S. Deetz (Ed.), *Communication yearbook 16* (pp. 3-42). London: Sage.

Barnard, C. (1938). *The functions of the executive*. Cambridge, MA: Harvard University Press.

Bolino, M. C., & Turnley, W. H. (2003). Going the extra mile: Cultivating and managing employee citizenship behavior. *Academy of Management Executive, 17*(3), 60-71.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-421.

Cramton, C. D. (2001). The mutual knowledge problem and its consequences for dispersed collaboration. *Organization Science: A Journal of the Institute of Management Sciences, 12*(3), 346.

Davis, J., Schoorman, F., & Donaldson, L. (1997). Toward a stewardship theory of management. *Academy of Management Review, 22*(1), 20-47.

Eisenberger, R., Fasolo, P., & Davis-LaMastro, V. (1990). Perceived organizational support and employee diligence, commitment, and innovation. *Journal of Applied Psychology*, 75, 51-59.

Eisenberger, R., Huntington, R., Hutchison, S., & Sowa, D. (1986). Perceived organizational support. *Journal of Applied Psychology, 71*(3), 500-507.

Flamholtz, E. (1996). *Effective management control: Theory and practice*. Boston: Kluwer Academic Publishers.

Fuller, J. B., Barnett, T., Hester, K., & Relyea, C. (2003). A social identity perspective on the relationship between perceived organizational support and organizational commitment. *Journal of Social Psychology, 143*(6), 789-791.

Glassop, L. I. (2002). The organizational benefits of teams. *Human Relations, 55*(2), 225-250.

Goodman, P., & Darr, E. (1999). Computer-aided systems and communities: Mechanisms for organizational learning in distributed environments. *MIS Quarterly, 22*(4), 417-440.

Kankanhalli, A., Tanudidjaja, F., Sutanto, J., & Tan, B. (2003). The role of IT in successful knowledge management initiatives. *Communications of the ACM, 46*(9), 69-74.

Katz, D., & Kahn, R. (1966). *The social psychology of organizations.* New York: Wiley.

King, W. R., & Marks, P. V. (in press). *Motivating knowledge sharing through a knowledge management system.*

Lee, G. K., & Cole, R. E. (2003). From a firm-based to a community-based model of knowledge creation: The case of the Linux Kernel development. *Organization Science: A Journal of the Institute of Management Sciences, 14*(6), 633.

Liao, H., & Chuang, A. (2004). A multilevel investigation of factors influencing employee service performance and customer outcomes. *Academy of Management Journal,* 47, 41-58.

Loebecke, C., Van Fenema, P., & Powell, P. (1999). Co-opetition and knowledge transfer. *Database for Advances in Information Systems, 30*(2), 14-25.

Lynch, P., Eisenberger, R., & Armeli, S. (1999). Perceived organizational support: Inferior versus superior performance by wary employees. *Journal of Applied Psychology, 84*(4), 476-483.

March, J., & Simon, H. (1958). *Organizations.* New York: John Wiley & Sons.

Meyer, J. P., Stanley, D. J., Herscovitch, L., & Topolnytsky, L. (2002). Affective, continuance, and normative commitment to the organization: A meta-analysis of antecedents, correlates, and consequences. *Journal of Vocational Behavior, 61*(1), 20-52.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Oleson, T. (2003). Debunking economics: The naked emperor of the social sciences. *Journal of Economic Issues, 37*(1), 228-231.

Perlow, L. (1998). Boundary control: The social ordering of work and family time in a high-tech corporation. *Administrative Science Quarterly, 43*(2), 328-357.

Stajkovic, A. D., & Luthans, F. (2001). Differential effects of incentive motivators on work performance. *Academy of Management Journal, 44*(3), 580-590.

Thorn, B., & Connolly, T. (1987). Discretionary data bases: A theory and some experimental findings. *Communication Research, 14*(5), 512-528.

Turnley, W. H., Bolino, M. C., Lester, S. W., & Bloodgood, J. M. (2003). The impact of psychological contract fulfillment on the performance of in-role and organizational citizenship behaviors. *Journal of Management, 29*(2), 187-207.

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Chapter 1.7
Knowledge Management on the Web

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INTRODUCTION

The importance of knowledge management has been recognized both in academia and in practice. In recent years, corporations have started talking about knowledge management, organizational learning, organizational memory, and computerized support. A few years ago, Microsoft®'s awareness of knowledge management and corporate memory was demonstrated by Bill Gates through his keynote speeches in the second and third Microsoft's CEO summits that attracted quite a few CEOs and other corporate executives from Fortune 1000 companies. Gates (1998) outlined his vision through a term he coined "digital nervous system," which is an integrated electronic network that can give people the information they need to solve business and customer problems. An effective digital nervous system should include access to the Internet, reliable e-mail, a powerful database, and excellent line-of-business applications, and should transform three major elements of any business: the relationships to customers and business partners—the e-commerce element; the information flow and relationships among workers within a company—the knowledge management element; and the internal business processes—the business operations element. The recent release of Windows® Tablet PC® edition is an example of a Microsoft tool that supports the concept of digital nervous system.

Even though knowledge management as a conscious practice is still young (Hansen et al., 1999), using information technology to support knowledge management is being explored and is well under way in many organizations. The Web technologies are not only changing the landscape of competition and the ways of doing business but also the ways of organizing, distributing, and retrieving information. Web-based technology is making effective knowledge management a reality, and Web-based knowledge management systems have been developed and deployed.

Currently, Web-based technology is enabling the management of knowledge at the document management level, in contrast to the traditional record-level data management. The record-level data management is basically the focus of traditional database management systems. The document level is higher than the record level. For example, we generally handle daily problems through communicating with each other by using documents and exchanging ideas or perspectives about an issue, rather than dealing with database fields or records. Document-level information management is generally viewed as a lower level of knowledge management.

In this chapter, Web-based knowledge management is explored. Four representative types of Web-based knowledge management models are identified and studied. The study of these models would shed light on the effective management of organizational knowledge, what should be contained in a knowledge management system, the levels of knowledge management support, and how knowledge management support systems can be technically implemented. This chapter is organized as follows. In the next section, some theoretical issues about knowledge management are reviewed. Then, it is justified why Web technology is an enabling technology to the effective knowledge management and why Web-based knowledge management is desirable. Then, the four types of Web-based knowledge management models are discussed and compared. Finally, the conclusion section summarizes the results of this chapter and discusses future directions of Web-based knowledge management.

BACKGROUND

Traditional Information Systems vs. Knowledge Management Systems

Traditional information systems were developed to capture data about daily business transactions (transaction-processing systems), and to access, process, and analyze those internal and external data to generate meaningful information to support management [management information system (MIS), decision support system (DSS), or enterprise integration system (EIS)]. These traditional systems help make an organization operate smoothly. However, they were developed at a time when the importance of knowledge management was not recognized. They all emphasize quantitative data processing and analysis. But an effective organization does not rely on quantitative analysis alone to deal with its problems. The nonquantitative side, such as knowledge creation and management, mental models, document sharing, human communications, information exchange, and meaning making, play a great role in an organization's growth and development. Thus, the nonquantitative areas also need to be supported. Knowledge management systems are supposed to fulfill this role. In other words, knowledge management systems should complement traditional systems in providing nonquantitative side support. A difficult task is to define what needs to be contained in the knowledge management system. A lot of existing studies provide only theoretic suggestions. A study described and discussed 10 knowledge management frameworks (Holsapple & Joshi, 1999). These frameworks are generally concentrated on conceptual knowledge creation or knowledge-building activities. They may be useful in deciding what functions a knowledge management system should eventually provide, but they fall short in suggesting what should be contained in a knowledge management system and how such a system may be implemented. In this chapter, the study of four types of Web-based knowledge management models should provide some practical advice about the content of a knowledge management system.

Knowledge vs. Information vs. Data and Knowledge Management

Commonly agreed, data is often defined as the raw facts, and information as the processed data. Davenport and Prusak (1998) defined knowledge as "a combination of experience, values, contextual information, and expert insight; and knowledge provides a framework for evaluating and incorporating new experiences and information." On the other hand, Applehans and coresearchers (1999) defined knowledge as the ability to turn information and data into effective action, which brings desirable outcomes for an organization. In this chapter, we follow a compromised approach to define knowledge: it is about the application of data and information for a given task so that the given task can be effectively performed.

The traditional view about the relationship between knowledge, information, and data is that knowledge is above data and information; data is a prerequisite for information; and information is a prerequisite for knowledge. This theory can be simply illustrated by the following diagram:

Data → Information → Knowledge

The second view, also a different view, is called a reversed knowledge hierarchy, which suggests that we first need to have the knowledge about what information we want, and then we will know what data to look for (Tuomi, 1999). In other words, data emerge only after we have information, and that information emerges only after we already have knowledge. This view can be simply illustrated by the following diagram:

Knowledge → Information → Data

The third view is also possible. We have a large amount of data collected but fail to make use of the data to create information because of our lack of relevant knowledge. An historical example is at point, which is about the making of the everyday weather map. For a long time in history, weather data were collected, and there were rich data available. But the usefulness was limited when these data are not combined with a map (Monmonier, 1999). Once we have the relevant knowledge about how to process data, how to visualize data, the boring data start making sense and generating meanings. In this situation, the knowledge is the catalyst that transforms data into information. This process can be simply illustrated by the following diagram:

Data → Knowledge → Information

These differing logics and understandings about the relationships and the sequences between data, information, and knowledge are meaningful, depending on the context. The development of the traditional information systems (TPS, MIS, DSS) basically follows the traditional view of data, information, and knowledge, while scientific research and inference statistics generally follow the second view (the reverse hierarchy) on data, information, and knowledge. In terms of knowledge management, the third view bears more impacts and implications. This third view suggests a fundamental fact in many organizations—there are a lot of documents (data) accumulated over years, and we need to know what to do to turn them into information to support a given task. All knowledge is tacit in nature and largely resides in the human mind, and to articulate knowledge is to create information about knowledge (Stenmark, 2002). The document is one place where information about knowledge can be found. Another place is the human mind, and the identification of the right human mind (expert) for a given task must be a responsibility of knowledge management. This help explains why the awareness of corporations to identify and utilize inside expertise for a given task has increased in recent years.

To summarize, knowledge management is concerned about how documents (data) may be organized, associated, and retrieved so that meaningful information can be produced for a certain task. This also includes identifying experts whose expertise can immediately help a given task. In other words, the following understanding about knowledge management is used in this chapter: Knowledge management is about meaningful organization of data (documents) and people who have expertise about a task, so that for a given task, meaningful information can be uncovered, associated, and retrieved, and experts with matching expertise can be identified.

THE WEB TECHNOLOGY

The content of a knowledge management system is not created by one individual. The content collection and the access of the content is a collective behavior. Therefore, the technological infrastructure installed must be able to facilitate the collective behavior of knowledge management. In a study where 31 knowledge management projects in 24 companies were examined, eight factors were identified to characterize a successful project (Davenport et al., 1998). One of these factors was the use of a technology infrastructure that includes common technologies for desktop computing and communications. Web technology has provided a common technological infrastructure to support the collective knowledge management, which is justified by the following observations in a separate study conducted by Zhang and Chen (1997):

- Web-based technology uses standard transmission-control protocol/Internet protocol (TCP/IP), which is mature and is supported by almost every vendor (Panko, 1997; Telleen, 1996; Strom, 1995).
- Information can be collected, retrieved, and shared through popular browsers like Netscape Navigator and Internet Explorer.
- A home page can be quickly developed, deployed, and shared.
- There are languages specially developed for Web-based applications, such as Java or VB script. Java applets can be embedded in Web home pages. The applets are executed on the client's PC and make it possible to develop interactive home pages with instant user responses and with multimedia features.
- With Web technologies, an organization enjoys platform independence or cross-platform operation. JAVA applets do not have to be rewritten to work with PC browsers, Macintosh browsers, and UNIX browsers (Panko, 1997).

In addition to the common technical infrastructure feature offered by Web technology, there are several major reasons why Web-based knowledge management is desirable:

1. The basic unit of knowledge is at the document level, which is equivalent to the level at which human beings normally communicate. Documents are usually created to deal with particular issues, and we live our everyday lives by dealing with issues. Different from an expert system, a document-based knowledge management system cannot automatically derive solutions. Instead, its usefulness lies in its large repository of classified documents, its multi-indexed powerful searching capabilities, the links between documents, the links within a document, and the potential of including other advanced features (e.g., animation). The interpretation of the documents provided by a knowledge management system largely lies with the users. The function of a document-based knowledge management system is largely to support relevant information for a task.
2. The intranet, which is based on Web technology, is the driver for new business applications. As one study has found, corporate intranets and the Internet have made the process of finding the right expert for a given task more feasible than ever before (Yiman & Kobsa, 2000). Another study has shown that intranets can provide useful and people-inclusive knowledge management environments (Stenmark, 2002).
3. The association between documents and tasks can be easily established by creating

hypertext links. Hypertext links can be created between documents and within a document. Hypertext links make explicit the meaningful documents relevant for a given task.

4. The collective behavior of knowledge management can be supported. A Web site can be easily configured to allow multiple users or contributors to edit existing documents or add new documents. When talking about the knowledge management architecture, Morey (1999) suggested that successful knowledge management architecture must have the following characteristics: be available, be accurate, be effective, and be accessible. Web-based technology has made it possible to have effective knowledge management architecture.

THE WEB-BASED KNOWLEDGE MANAGEMENT MODELS

Four Web-based knowledge management models are identified in this section. These models represent the current level of Web-based knowledge management. Nonetheless, these four types of models may not represent all of the Web-based knowledge management models. These four representative models are as follows:

- Library model
- Attachment/association model
- Directory model
- Press center model

Library Model

This model enables content-based document searches. Under this model, a large collection of documents is established. Both the attributes and the content of a document are indexed, in contrast to the traditional method where only the attributes of a document are indexed. The attributes of documents may include title, subject, author name(s), publication (creation) date, number of pages, and so on. Under this model, powerful search functions are provided, where not only these attributes (title, subject, etc.) are searched, but also the contents of documents are searched.

An example was provided by the ITKnowledge.com Web site, which is a large repository of information technology (IT)-related books. The contents of the books are fully available. The chapters in a book are hypertext-linked, and a book is essentially a set of hypertext documents. Not only the attributes of the books are classified and indexed and can be searched easily, but also the chapter titles (the content) are indexed by keywords and can be searched. This makes it possible to find a document with attributes (title, subject) that do not meet a search criterion but that may contain chapters that are relevant to the search criterion. In Figure 1, the ITKnowledge.com search screen is displayed. In Figure 2, a search result is returned. As can be seen in Figure 2, a chapter in the book Handbook of Data Management that is relevant to the search criterion "knowledge management" has been returned. If the book is only indexed by its title, this search result should not have been possible.

Attachment/Association Model

Under this model, information is organized around topics. If we search for a particular topic, all information associated with the topic will be returned. New information can be attached to a topic once it becomes available. In fact, anyone at any time can attach new information to a topic. The attachment creation is an ongoing process.

An example of this model is Amazon.com, which is also an example of successful e-commerce. Bookselling is its major business. Amazon.com maintains a large database of book titles. To help sell a book faster and to make users understand a book better, all information relevant to a book title is stored and organized around a book

Figure 1. IT Knowledge.com expert search screen

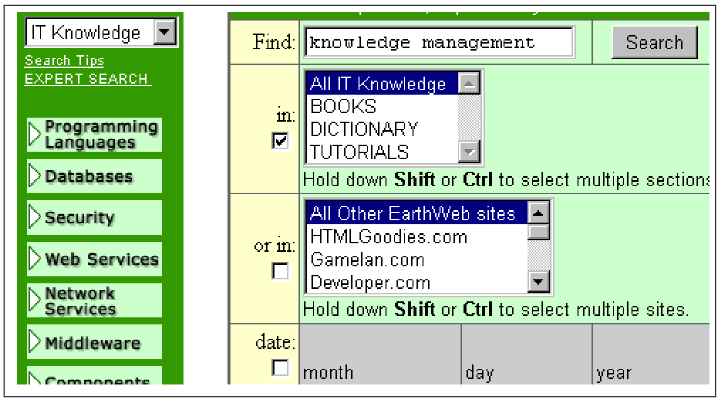
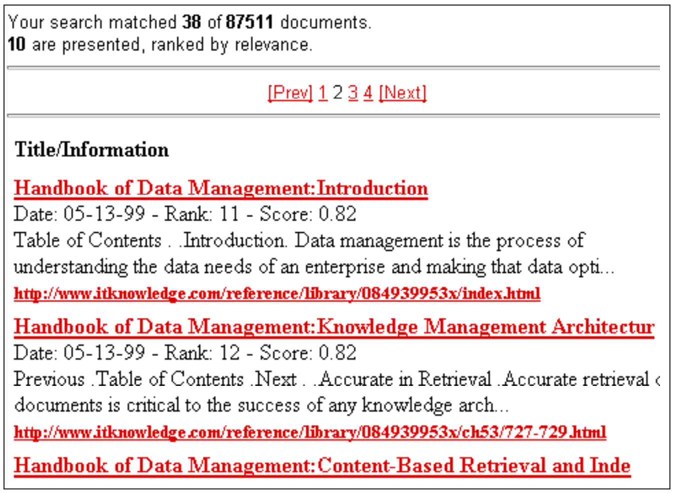


Figure 2. Search results returned



title. Therefore, essentially, the book database is more than just a collection of book attributes. Amazon.com provides users more than book titles. Suppose we want to find books that are relevant to "knowledge management."

After a title that matches the search criterion is returned, other relevant titles, and what other customers often purchase together with the current title, are returned and displayed. In addition, one can learn more about a book by reading the reviews attached to or associated with the book and other customers' comments attached to the book. If a reader wants, he or she can write comments about a book and easily attach his or her comments to the existing pool of information about this book.

Directory Model

Under this model, the experts in different areas are identified, and a directory of experts is created. The areas of expertise of these experts are classified and organized. A directory of experts, together with their areas of expertise, is provided.

A representative example of this model is the Round Table Group (round.table.com). Round Table Group (RTG) was founded in 1994 with a vision of being a virtual consulting firm where business leaders, management consultants, and litigation attorneys could shop for answers to critical questions from world-class thinkers, anywhere in the world, in Internet time (STVP, 1999). According to an STVP case study, RTG has formed a worldwide network of over 3,000 Round Table scholars—professors, researchers in well-known think tanks, and other experts. Essentially, RTG's most valuable competitive asset is its directory of professors from around the world who were available to consult with clients on demand. RTG provides answers-on-demand services to its clients. In Figure 3 below, the classified area of expertise by topic is displayed.

Press Center Model

Under this model, any information that can possibly be collected, including news, relevant articles, solution providers, publications, and discussions about a task is collected. A representative model is Kmworld.com, where a rich collection of relevant information about knowledge management can be found. If one is interested in knowledge management, a good starting point would be to visit a site like Kmworld.com. One could be overwhelmed by the information available, such as discussions, news, and solution providers. But, by spending some time and effort, one could figure out what is going on with a task, the current status, the issues, and history information on some issues.

A Comparison of the Models

The four types of Web-based knowledge management models as discussed above reflect the current level of Web-based knowledge management, which can be summarized as the content-based information retrieval and topic-oriented information organization.

These four models share the following common characteristics:

- Are basically document-based and content-indexed
- Have powerful searching capabilities

Figure 3. The identification of expertise by topic

Table 1. Key characteristics of Web-based knowledge management models

Model	Key Characteristic
Library	Content-based document retrieval
Association/attachment	Topic-oriented information organization/attachment
Directory	A well-organized directory of experts that can be searched for a given task
Press Center	A clearinghouse with rich organized information

- Focus on a specific application area (task-specific: IT knowledge, bookselling)
- Offer anytime, anywhere access
- Have potential to have more advanced features (e.g., multimedia, animation)
- All have an external orientation and are customer focused

On the other hand, the four models discussed above also have unique characteristics, which are indicated in Table 1.

FUTURE TRENDS AND CONCLUSIONS

Current Web-based knowledge management is essentially at the document management level—a lower level of knowledge management, but indeed beyond pure document management (pure classified collection of documents in a central file cabinet) to allow content-based retrieval, distributed access, and topic-oriented information organization and association. In this chapter, four different Web sites that represent four different models of Web-based knowledge management are discussed. But it is believed that a Web site could employ multiple models at the same time. For example, a Web site can be constructed based on the library model while supporting the association and attachment model. As a matter of fact, ITKnowledge.com is planning to include the association and attachment model in its site. It is expected that a sophisticated Web site will provide a menu of knowledge models for its users to choose from so that the potential of a Web site can be fully utilized.

A study, conducted by Hansen, Nohria, and Tierney (1999), discussed two strategies of knowledge management, based on the authors' studies on the practice of knowledge management in consulting firms, with computer vendors, and with health care providers. One strategy is called the personalization strategy, where knowledge is closely tied to the person who developed it and is shared mainly through direct person-to-person contacts. The computer information systems are used mainly to help people communicate knowledge, not to store it. Other examples like the use of groupware products to support the knowledge management process also fall into this category. This may be called the communication-based knowledge management level.

Another strategy, from the same study conducted by Hansen, Nohria and Tierney (1999), is called codification strategy, where knowledge (actually, a variety of documents) is codified and stored in databases to be used by anyone in the company. The knowledge is extracted from documents and may take the forms of interview guides, work schedules, benchmark data, or market segmentation analysis. These knowledge forms are codified and stored into a database with search capabilities. This is may be called the document-based knowledge management level.

The existing Web-based knowledge management, as evidenced by the four types of models identified and discussed in this chapter, basically corresponds to the knowledge management levels (especially the second). However, these levels are considered as lower levels of knowledge management, because they do not consider the support of meaning interpretation or sense making, they are generally text based, and they do not challenge whether the knowledge inherent in the document is accurately transmitted (knowledge transfer). But, after all, good steps on the right track have been made.

As future research directions about Web-based knowledge management, the higher levels of knowledge management may need to be addressed. Other functional areas should get involved, such as sales and marketing, customer support, and research and development. Other models about Web-based knowledge management may also need to be identified. Automatic and intelligent knowledge extraction and retrieval (knowledge agents) should also be studied for Web-based knowledge management.

REFERENCES

Applehans, W., Globe, A., & Laugero, G. (1999). *Managing knowledge: A practical Web-based approach*. Reading, MA: Addison-Wesley.

Davenport, T. H., De Long, D., & Beers, M. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2).

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Cambridge, MA: Harvard Business School Press.

Gates, B. (1998, 1999). *Keynote speech for the Microsoft's second and third annual CEO summit meeting*, Seattle, WA. Retrieved September 26, 2003, from http://www.microsoft.com/billgates/speeches.asp

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March–April). *What's your strategy for managing knowledge*. Harvard Business Review.

Holsapple, C. W., & Joshi, K. D. (1999). Description and analysis of existing knowledge management frameworks. In *Proceedings of the 32nd Hawaii International Conference on System Sciences.*

Monmonier, M. S. (1999). *Air apparent: How meteorologists learned to map, predict, and dramatize weather.* Chicago, IL: University of Chicago Press.

Morey, D. (1999). Knowledge management architecture. In *Handbook of data management.* Boca Raton, FL: CRC Press.

Panko, R. R. (1997). *Business data communications.* New York: Prentice Hall.

Stenmark, D. (2002). Information vs. knowledge: The role of intranet in knowledge management. In *Proceedings of the 35th Hawaii International Conference on System Sciences.*

Stewart, T. A. (1997). *Intellectual capital: The new wealth of organizations.* New York: Doubleday/Currency.

Strom, D. (1995). *Creating private intranets: Challenges and prospects for IS*. Retrieved from http://www.attachmate.com/Intranet

STVP (Stanford Technology Ventures Program). (1999, February 28). *Round Table group at a crossroads: Market maker or market driven?*

Telleen, S. L. (1996). *The intranet architecture: Managing information in the new paradigm.* Amdahl Corporation.

Tuomi, I. (1999). Data is more than knowledge. In *Proceedings of the 32nd Hawaii International Conference on System Sciences.*

Yiman, D., & Kobsa, A. (2000). DEMOIR: A hybrid architecture for expertise modeling and recommender systems. In *Proceedings of the IEEE Ninth International Workshops,* June 14–16.

Zhang, R., & Chen, J. (1997). An intranet architecture to support organizational learning. In *Proceedings of 1997 DSI Conference*.

Chapter 1.8
Business Process Outsourcing to Emerging Markets:
A Knowledge Management Approach to Models and Strategies

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ABSTRACT

A major phenomenon of globalization, outsourcing is a complex and controversial issue. It occurs when companies contract out activities previously performed in-house or in-country to foreign (usually offshore) companies globally. Couched in the terms of a SWOT analysis and using a modified Harvard-style case study that was subjected to the SWOT analysis, the chapter analyzes business process outsourcing (BPO) to emerging markets, frequently called outsourcing or offshoring in short. The overarching advantage of outsourcing is that it allows a business to focus on core activities as called for by core competence, strategic alliance, and competitive advantage theories of international business. Such a global restructuring of production has been sometimes called the true WMD (weapon of mass destruction) of jobs in the developed world. However, a more balanced approach could borrow the term "creative destruction" from the prominent Austrian economist Josef Schumpeter and emphasize the all-important transformational aspect of outsourcing. A transformational aspect of outsourcing is evidently very important for emerging markets but also for many companies in the developed world; therefore, BPO is sometimes called BTO (business transformational outsourcing). The global digital/knowledge economy offers unprecedented opportunities to produce and sell on a mass scale, reduce costs, and customize to the needs of consumers, all at the same time. Whether you live in a large country such as the U.S. or China, mid-sized country such as Canada or a smaller country such as Lithuania, your potential market is of the same global size. And you can source (netsource) inexpensively wherever you wish. Added to that are immensely increased opportunities to access new knowledge and technologies, driving productivity and living standards further up. BPO to emerging markets is *or should be driven by those fundamental reasons having to do with rapid organizational change, reshaping business models to make them viable in the long term, and launching new strategies. This is the essence of transformational outsourcing. In this chapter, BPO is used in the broader, integrated, and comprehensive understanding of changes in the company's business models and strategies but first of all the company's changing core competencies and competitive advantages: partnering with another company to achieve a rapid, substantial, and sustainable improvement in company-level performance. A knowledge management approach is advocated in this research that is to be continued in the future. The chapter concludes that outsourcing is a wave of the future. Postcommunist and other emerging markets countries are well advised to jump to these new opportunities as they represent the best chance yet to realize the "latecomer's advantage" by leapfrogging to technologies and models of doing business which are new for Western countries as well. The chapter analyzes and outlines some of the ways in which contemporary and future business models are deeply transformed by the global digital/knowledge economy. Global outsourcing provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non-core competencies to emerging markets. Therefore, suggestions for further research are included in the chapter as well.*

INTRODUCTION: WHAT DO WE KNOW ABOUT THE NATURE OF BUSINESS PROCESS OUTSOURCING?

Business process outsourcing (BPO) is generally defined as the transfer of the control of the business process to external suppliers. BPO deals with differentiated activities, such as finance and accounting, procurement and supply, customer relations' management, human resources, security and so forth.

BPO implies a more comprehensive — or business process oriented — approach to outsourcing information technology (IT) services, which is the original and narrower term. BPO contracts are seen as being more inclusive, covering a great deal of process redesign work, redeployment and retraining of the people doing the work, and almost always include the information and communication technology (ICT) or information and telecommunication technology (ITT) that enables and supports the business process. The goal is to provide an even greater opportunity for generating innovation, efficiency and speed in reaching markets and, ultimately, shareholder value through this more comprehensive, integrated approach. In this research, BPO is used in this broader, integrated, and strategic sense of changes in the enterprise's management models and strategies but first of all the enterprise's changing core competencies and competitive advantages.

Under the dual pressures of global competition and shareholder expectations, Western companies are driven to reduce operating costs and focus on core competencies. To accomplish this in the global economy, companies are turning to business process outsourcing (BPO), outsourcing or offshoring in short. BPO can be defined as the practice of turning over the operation of an internal business process, like customer care or transaction processing, to a third party service provider. Service providers use their process expertise, human resources, and available technologies to provide the required services. The client company ("client") manages and compensates the service provider by defining measurable performance metrics and then evaluating the service provider's performance using those agreed metrics. Service providers can be located onshore, nearshore or offshore. Companies assessing a service provider usually compare different service provider locations, as differences in culture, business strategies/models, and technical infrastructure affect price and other performance parameters.

Global outsourcing provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non-core competencies to emerging markets. Such a global restructuring of production has been sometimes called the true WMD (weapon of mass destruction) of jobs in the developed world, especially so in America. However, a more balanced approach could borrow the term "creative destruction" from the famous Austrian economist Josef Schumpeter and emphasize the all-important transformational aspect of outsourcing. A transformational aspect of outsourcing is evidently very important for emerging markets but also for many companies in the developed world. While global executives began outsourcing substantial portions of their operations more than a decade ago to offload activities regarded to be non-core to cut costs and refine their strategies, in modern outsourcing companies are looking around globally for more fundamental reasons — to facilitate rapid organizational change, to launch new strategies, and to reshape business models. In essence, they are engaging in transformational outsourcing, that is partnering with globally scattered companies to achieve rapid, substantial, and sustainable improvements in performance.

According to The McKinsey Institute (Agrawal & Farrell, 2003), on a practical level BPO can be executed through several business models depending on the process and the company's business strategies:

- Conventional outsourcing: where a company contracts with a service provider for services over a defined time period.
- Joint ventures: where a Western company partners with an offshore company to provide outsourcing services to the Western company and/or third parties.
- Build operate transfer (BOT): where a Western company engages with a service provider to establish an offshore facility, hire and train employees, transition the onshore process to the offshore operation and then run the facility and manage the workforce. The Western company then has the option, after a pre-defined time period, to purchase the offshore operation.

In conventional outsourcing and joint venture models, a company may transfer an entire functional area to a service provider on start up (transfer of assets).

STATE OF KNOWLEDGE ASSESSMENT: LITERATURE REVIEW AND THEORETICAL UNDERPINNING

There is no established body of literature dedicated to the business process outsourcing (BPO) per se. By 2005, what we have are fragmentary contributions to the understanding of the BPO process that is rapidly changing, evolving, and providing new empirical material. This is due to the novelty of the issue.

However, the proposition of this chapter is that, in deeper essence, the theoretical background of this research is based on the multinational production body of knowledge (Dunning 1996, 1998), especially the international alliance formation literature, foreign direct investment literature, and related contributions.

There exist different theories and models that are relevant to the study of BPO in general. Research on strategic alliances between firms has received increasing attention in the literature during the last decade, reflecting the increasing frequency, diversity, and importance of strategic alliances in regional and/or global business and finance. The main theoretical explanation for why firms form strategic alliances is offered by the transaction cost perspective. According to Williamson (1985, 1991), internalization is the strategy here and it can take different forms.

Two main streams of literature can be identified; one stream is mainly concerned with examining the underlying conditions favoring alliance formation (motivation for alliance formation or intent) (Harrigan, 1985; Teece, 1986; Contractor & Lorange, 1988; Hennart, 1988; Kogut, 1988; Oliver, 1990; Williamson, 1991), the other stream is occupied with investigating alliance outcomes and the impact of alliances on the partner firms (Kogut, 1989; Blodgett, 1992; Dussage & Garette, 1995; Doz, 1996; Mitchell & Singh, 1996; Park & Russo, 1996; Nakamura, Shaver, & Yeung, 1996). Recently, researchers have begun exploring issues related to alliance dynamics and related knowledge management issues (Singh & Mitchell, 1996; Gulati, 1998; Koza & Lewin, 1998). For more insights, please consult the structured and annotated references section.

Methodological Approaches

In this chapter, the researchers attempted to approach the subject using statistical and legal/institutional research couched in the SWOT analysis terms as well as using a modified Harvard-style case study that was also subjected to the SWOT analysis. The researchers also attempted to study broader actual empirical/practical processes, as they have been experienced in transition economies such as Lithuania, thus bringing important evidence and empirical insights into the subject of the analysis.

BACKGROUND, TRENDS, INTERPRETATIONS

By 2005, the debate about outsourcing focused upon its impact on the U.S. and other Western countries' jobs. But it is important to take a broader and longer-term view of what best serves the interests of the U.S. and Western countries in general. The West stands to gain tremendously by promoting a healthy and stable global economy, particularly important and challenging is the integration of emerging markets into the integral global economy. This is something that eluded globalization efforts in the 20th century.

No doubt, specific groups of workers in the West might lose out from outsourcing. Emerging markets do pose a competitive threat to some Western companies that stand to lose market shares due primarily to the shortage of their thinking and action about moving to new business models and strategies. But the costs to those specific companies are outweighed by the benefits to Western consumers, a much larger group. In case after case, they enjoyed far lower prices, and often more choice and better goods, after markets were opened to globalization, including BPO. Outsourcing to emerging markets will increase sharply as companies there develop a critical mass of competitive advantages due to restructuring, organizational learning, and organizational change in general. By 2005, skill-intensive Western sectors such as pharmaceuticals and auto parts have not shifted production overseas but are likely to feel the brunt of this next wave of outsourcing. By 2015, manufacturing imports from emerging markets to the United States could increase to more than 50% of total U.S. manufacturing imports, up from 42% in 2002 — a shift worth hundreds of billions of dollars (Agrawal & Farrell, 2003).

The benefits are substantial to emerging markets as well. The price of passenger cars in China, for instance, fell by more than 30% from 1995 to 2001, years when Ford Motor, General Motors, and Honda Motor entered the market. In Mexico, the "everyday low prices" of Wal-Mart stores ended a long history of hefty margins for leading domestic retailers and reined in fast-rising food prices so much that some analysts credit the company with helping to reduce the country's inflation rate. In

India, the price of air conditioners, television sets, and washing machines fell by roughly 10% in 2001 alone after foreign companies entered the market. Similarly, prices for cars declined by 8 to 10% a year during the 1990s after the government opened the sector, and the number of models available has now risen from a handful to more than 30. Lower prices have unleashed demand, and India's auto sector has grown by 15% a year.

Outsourcing IT and business processes generates more than $10 billion a year for India and gives employment to half a million of Indian workers. Suppliers to the companies that provide outsourced services employ another half million people. With wages in the sector 50 to 100% higher on average than those for other white-collar occupations, a new middle class of educated workers is being formed. Foreign direct investment played a key role in the creation of these industries: the fast-growing Indian companies that now dominate the global sector got started only after multinational companies pioneered the approach, showed the world that India was a viable outsourcing destination, and trained a critical mass of local employees. Foreign companies continue to provide healthy competition that forces Indian companies to improve their operations continually. They hone the efficiency and productivity of the local industries by bringing in new capital, technology, new business models, and management skills. Equally important, they increase the level of competition, forcing less efficient domestic companies to improve or go out of business (transformational aspect).

BPO is thus held in this chapter to be both very complex and very important to the realization of the benefits of transformation and global integration at both micro and macro levels in emerging market economies and in developed economies. A Schumpeterian "creative destruction" and micro foundations of growth perspective and approach is important in this research, as this approach is more and more relevant to processes in today's global (knowledge) economy. While there are, admittedly, theoretical controversies as to why firms grow (e.g., Romer's new growth theory) and how the growth process works specifically, it is the restructuring and outsourcing processes that shape the impact of corporate behavior and investment on economic performance via capital productivity and new competitive advantage building through technological and organizational innovations, adaptability, Schumpeterian change in general.

As a first stage of a larger research effort, the chapter attempts to contribute to the understanding of the theory and practice of BPO processes as they occur in the direction developed economies-emerging markets, with special reference to Central and Eastern Europe, Lithuania in particular, see the case study below. The authors tried to identify and define key policy areas and measures aimed at improving corporate governance, finance, and competitive advantage building in enterprises with regard to requirements of effective participation in BPO. They also tried to collect other theoretical and empirical evidence pertaining to the impact of the post-communist transformation (esp. privatization, enterprise restructuring, financial sector reform) and new information and communication technologies (ICT) on enterprise strategies/models, with special reference to further restructuring and competitive advantage building via BPO.

RESEARCH METHODOLOGY: THE ANALYTICAL FRAME

Given the complex nature of modern research topics, different aspects need to be analyzed and evaluated, not unlike in the biological systems that are very complex by nature. The Strengths-Weaknesses-Opportunities-Threats (SWOT) analysis lends itself very well to the study of such complex living or human-devised systems. The broader explanation and rationales for using the SWOT analysis are as follows.

SWOT Stands for: Strengths, Weaknesses, Opportunities, Threats

Strengths, Predominantly Internal

Every organization or country has some strengths. In some cases this is obvious; for example, dominant market shares. In other cases, it is a matter of perspective, for instance, a country is small and hence has the ability to move fast using certain strategic moves, like BPO. It is important to note that countries that are in a weak competitive position also have strengths. Whether these strengths are adequate is an issue for analysis.

Weaknesses, Predominantly Internal

Every organization or country also has some weaknesses. In some cases, this is obvious; for example, a stricter regulatory environment. It is important to note that companies or countries that are extremely competent in what they do (that stick to their core competencies) also have weaknesses. How badly these weaknesses will affect them is a matter of analysis.

Opportunities, Predominantly External

All organizations and countries have some opportunities that they can utilize by certain strategic moves. Identifying hidden opportunities is the matter of analysis.

Threats, Predominantly External

No organization or country is immune to threats in the global economy that is characterized by increased competitive pressures. These could be partially internal, such as falling productivity due to outdated technologies, or they could be almost entirely external, such as lower priced international competition.

TOWARDS A KNOWLEDGE BASE OF BUSINESS PROCESS OUTSOURCING

As stated above, due to the novelty of the topic of business process outsourcing to (and from) emerging markets, especially transition economies, there is no body of dedicated literature. However, the chapter looks for theoretical and empirical clues in some of the broadly relevant Western and Eastern literature, for example, on enterprise restructuring, corporate governance and finance, turnaround management, core competencies, competitive advantage building and so forth. The chapter takes a look at enterprise restructuring in Central and Eastern Europe (with special reference to Lithuania) and argues that the transformation from a state-owned enterprise into a truly capitalist firm involves more than reacting to economic stimuli. Enterprises need access to capital markets to finance investment and they have to acquire new capabilities (esp. identify and define core competencies, "polish" Porter's Diamond, etc.) to be able to grow and compete successfully in Europe and in the global knowledge economy (GKE). In the crucial areas - human resource development, investment capital including new technologies, new models of corporate governance and finance, overall competitive capability building — interaction with Western businesses can make a key contribution to transformations, within the European Union and globally. In general, global outsourcing provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non-core competencies to emerging markets so that a new and modernized global economic architecture is achieved.

Some broad hypotheses relating to common elements of the restructuring and BPO processes include a shift to flatter, less hierarchical organization structures within Williamson's markets-hierarchies dichotomy and related schemes; the adoption of Western knowledge management and financial/accounting practices, and the introduction of Kornai's hard(er) budget constraints; the evolution of the marketing function and the rationalization of product ranges in light of rapidly changing and increasingly global market needs. Moreover, in the global knowledge economy (GKE), what needs essential redefinition is the enterprise (firm) itself; one obvious point of departure here is the transaction cost theory and the Ronald Coase theorem. Below is a modern take on the Coase theorem relevant changes brought about by the Internet and the global knowledge economy in general (with special reference to emerging markets).

Why Firms Exist?

Ronald Coase's answer was that, due to a number of impediments (e.g., distance, shortage of information, coordination costs, etc.), it is many times difficult and/or costly to conduct such transactions. Consequently, it is a useful and cost-reducing proposition to "internalize" such transactions within a firm. A "transaction cost" model and strategy of business was born.

The Internet Revolution

How does the advent of the Internet change business models under the new paradigm of the global digital economy (GDE)?

The Death of Distance

The geographical distance used to play a very important role in the world economy, for example, expressed operationally in the gravitational models of international trade. Now distance is (almost) dead. Anybody on the Internet can collaborate or do business with any other Web-based individual or business at a small fraction of costs incurred in the pre-Internet era. This is true especially for the service sector but increasingly for the goods sector as well. Consequently, irrespective of whether one operates in small Lithuania or huge China or the U.S., the market is the same: the globe; anybody on the Internet faces a fully global competition, not just local/domestic or regional/international competition.

The Collapse of Time

The instant interactivity brought about by the Internet is fuelling change. Companies have to accept a strong culture of constant change known as the Schumpeterian "creative destruction" because in a world of instantaneous interactivity and connection there is a big premium on fast response and learning and adapting quickly to clients needs.

The Undoing of Old Paradigms:

The New Nature of Business and Comparative/Competitive Advantage

The old "bricks and mortal only" model of corporations is dead in a much shorter run than most people are inclined to think. In the global digital village, to paraphrase Marshall McLuhan, every individual or small business can go global and directly compete with any company. At the professional level, there will be fewer traditional 9-to-5 jobs and more outsourcing/contracting with free-agent skilled workers Web-based globally. Competition in the goods and services markets has been brought to new, higher levels, and permanently so.

Developed countries can no longer hide behind politically motivated barriers, physical or other walls to protect themselves from competition from developing countries or emerging markets. Rather than clinging to old models, individuals and corporations in developed and (increasingly) in developing or transition nations need to upgrade their competitive advantages through more education and training. It is far more important to improve human capital (human resources) than it is physical capital (buildings, machines, etc.) or "natural" capital (raw materials, geographical position, etc.).

New information and communication technologies (ICT), especially the Internet (increasingly wireless), bring new opportunities to concentrate on core competencies, specialize and increase trade and investment flows. For these gains to occur, however, what needs essential transformation is the corporation itself.

Corporations need to change the ways they do business; they must become less hierarchical and flatter. Above all, they must be more focused on their core competencies albeit see them dynamically (as constantly changing) and not statically (as, for example, "natural" gateways in trade). Also, they must rely less on their locally available "jack-of-all-trades" workforce and increasingly distribute tasks (outsource or "netsource" them) to other contributors Web-based globally. These new contributors (or teams of contributors) may or may not be full-time employees, but they will generally be equally or better qualified, more willing to learn, and offer greater flexibility, all of which will increase economic efficiency and create new competitive advantages that will become more sustainable.

The above means that corporations need to become much more flexible, amorphous networks of international professionals and knowledge managers working on particular projects. How such corporations should be governed is a new challenge before the managers working in the global knowledge economy. It is postulated in this chapter that a knowledge management (KM) approach should be adopted in trying to solve the above problems. Specifically, three elements of this KM approach are relevant: models and strategies of modern business, human resources, and underlying technologies, especially the Internet technologies.

CONCLUSIONS AND RECOMMENDATIONS

Under the dual pressures of global competition and shareholder expectations, Western companies are driven to reduce operating costs and focus on core competencies. To accomplish this in the global economy, companies are turning to business process outsourcing (BPO), outsourcing or offshoring in short. BPO can be defined as the practice of turning over the operation of an internal business process, like customer care or transaction processing, to a third-party service provider. Service providers use their process expertise, human resources, and available technologies to provide the required services. The client company ("client") manages and compensates the service provider by defining measurable performance metrics and then evaluating the service provider's performance using those agreed metrics. Service providers can be located onshore, near-shore or offshore. Companies assessing a service provider usually compare different service provider locations, as differences in culture, business strategies/models, and technical infrastructure affect price and other performance parameters.

Global outsourcing provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non-core competencies to emerging markets. Such a global restructuring of production has been sometimes called the true WMD (weapon of mass destruction) of jobs in the developed world, especially so in America. However, a more balanced approach could borrow the term "creative destruction" from the famous Austrian economist Josef Schumpeter and emphasize the all-important transformational aspect of outsourcing. A transformational aspect of outsourcing is evidently very important for emerging markets but also for many companies in the developed world. While global executives began outsourcing substantial portions of their operations more than a decade ago to offload activities regarded to be non-core to cut costs and refine their strategies, in modern outsourcing companies are looking around globally for more fundamental reasons — to facilitate rapid organizational change, to launch new strategies, and to reshape business models. In essence, they are engaging in transformational outsourcing, which is partnering with globally scattered companies to achieve rapid, substantial, and sustainable improvements in performance.

Couched in the terms of the SWOT analysis, the chapter concludes that outsourcing is a wave of the future. Outsourcing can create wealth both for the countries that send jobs offshore and for those that receive them.

Outsourcing is a major part or aspect of globalization. No longer can a company stay in its country of origin and remain competitive. Companies are roaming the globe (increasingly digitally) in search of the location(s) that will provide them with the economies of scale that will ensure efficiency with cost reduction and increased productivity. The U.S. economy gains more then $1 in new wealth for every dollar of corporate spending that U.S. companies outsource abroad. The primary objective of outsourcing should be to create added value. Value is added by providing the product at a lower price and maintaining or improving quality.

The U.S. and other Western countries will always have a competitive advantage in something. That something is shifting, however, up the ladder of competitive advantage towards higher value added activities (Americans want higher wages than those in China or India, for example), like research and development as opposed to IT, simple manufacturing or even the main elements of the business process that gets outsourced to emerging markets. In order to get up the ladder of competitive advantage, more Americans will need to upgrade their skills/education. The Internet technologies are making that possible through the lifelong process learning processes, especially online education of executives and other working professionals.

In the last few years, outsourcing has moved from "traditional outsourcing" to the next generation called "strategic outsourcing." Using the strategic outsourcing approach, many companies have reaped the benefits of improved performance, increased access to international markets, access to leading edge technologies, enhanced responsiveness to customer needs, contributed to organizational goals of increased productivity and efficiency, reduced costs, reduced cycle time, and improved quality of the goods and services in their organizations. In today's economy, the outsourcing approach is considered a viable option for achieving the best possible results, that is, in-depth business transformation.

In the future, outsourcing will be an even more effective and globally available model to reduce costs, boost productivity and exports, and increase profits. Thus, outsourcing will continue to be a viable business strategy, and even to the greater extent in the decade to come.

Business Process Outsourcing: Suggestions For Further Research and Knowledge Building

What is a corporation and how corporations should be structured and governed is a new challenge before the managers working in the global knowledge economy of the 21st century. It is postulated in this chapter that a comprehensive knowledge management (KM) approach should be adopted in trying to solve the above problems. Specifically, three elements of this comprehensive KM approach are most relevant: models and strategies of modern business, human resources, and underlying technologies, especially Internet technologies.

In the crucial areas — human resource development, investment capital including new technologies, new models of corporate governance and finance, overall competitive capability building — interaction with Western businesses can make a key contribution to transformations, within the emerging markets and globally. Global outsourcing provides a compelling platform to research the issues of upgrading competitive advantage in developed countries and contract out non-core competencies to emerging markets. In this context, outsourcing should be studied in connection with mergers and acquisitions (M&A) and foreign direct investment (FDI) as the two engines of global restructuring. Global financial institutions should be more active in research, explanation, and promotion of such a global restructuring. For the insights, please consult the structured and annotated reference section.

There are several promising lines of further research and fruitful approaches to outsourcing. One of them is the cluster method and strategy for modern growth developed at Harvard by Prof. Michael Porter (1990). The cluster method fosters high levels of productivity and innovation and lays out the implications for competitive strategy and economic policy. Economic geography in an era of global competition poses a paradox that is not well understood, needs further research. On one hand, location should no longer be a source of competitive advantage. Open global markets, rapid transportation, and high-speed communications should allow any company to source anything from any place at any time. But on the other hand, claims Prof. Porter, location remains important to competition. The global economic map is characterized by clusters: critical masses in one place of linked industries and institutions — from suppliers to universities to government agencies — that enjoy unusual competitive success in a particular field or fields. Porter explains how clusters affect competition in three broad ways: first, by increasing the productivity of companies based in the area; second, by driving the direction and pace of innovation; and third, by stimulating the formation of new businesses within the cluster. Geographic, cultural, and institutional proximity provides companies with special access, closer relationships, better information, powerful incentives, and other advantages that are difficult to tap from a distance, according to Porter. The more complex, knowledge-based, and dynamic the global economy becomes, the more this is true, claims Porter. Competitive advantage lies in local things - knowledge, relationships, and motivation — that distant rivals cannot replicate very efficiently, Prof. Porter continues. However, the advent of the Internet, knowledge management, and the global knowledge economy seems to be changing that and profoundly affecting the essence of "thinking globally but acting locally".

On top of more theoretical research (e.g., based on new growth theories) and the relevant argumentation advanced, there is a need to critically analyze outsourcing experience from a number of old and new and cases, etc, in such leading countries as China, India, Finland, Poland, U.S., Canada. Case-study type insights need to be presented on specific approaches that worked well within specific institutional/systemic settings called policy environments. Such policy environments (their parameters) are created mainly on the interaction of business, government (various levels), and other elements of a civil society in particular countries or integration groupings. Apparent failures in this regard are to be studied as well. By going deeper into the nature of policy environments (especially incentives they create), we need to refine the discussion on this issue and thereby build the knowledge base. The case study below is such an attempt.

THE CASE STUDY: LITHUANIA

Introduction

Full member of NATO and the EU since 2004, Lithuania is offering excellent business opportunities in a stable political, economic and social environment. Lithuania is strategically located in the gateway between the EU and the CIS. Being on a sea and land route, Lithuania is serving as an arterial road between the East and the West, the North and the South. In fact, one of geographical centers of Europe is located just north of Vilnius.

In spite of the heavy burden of the Soviet occupation legacies after regaining its independence in 1990, Lithuania embarked on a path of determined, radical, and sustained reforms aimed at re-establishing democracy and a functioning market economy. It succeeded remarkably and is now regarded Europe's transformation success story.

Lithuania in the European Union: Implications for Business Process Outsourcing

The widening and deepening of the European integration (especially the introduction of the euro) markedly increased competitive pressures, so companies began looking for new, sustainable and dynamic advantages. Given that the continent is aging pretty rapidly and immigration presents a problem for a number of reasons, a shortage of qualified labor is developing that can be best addressed by taking advantage of the digital/knowledge revolution and of the potential of new EU members such as Lithuania. Under these circumstances, a better use of the continent's resources has become critical to winning the competitive game or even survival in the unified Europe and the integrated world.

Large European and multinational corporations (e.g., BT, Buckman Labs, Nokia, Siemens, etc.) are the early adopters of new thinking. They first realized that high initial costs of research, human/intellectual capital costs, etc., are efficiently spread only over longer periods and larger geographical areas. The vision they have, specifically their new-frontier mentality and the ability to develop integrative thinking across functional areas of business, not only at the highest management levels but, what is even more important, at lower management levels resulted in knowledge-sensitive enterprise cultures and the resultant organizational learning regarding new business models and strategies. Also, such issues are pretty high on the EU institutions' agenda (e.g., Lisbon Strategy). The unique European competitive advantage (e.g., compared to the U.S.) is that EU institutions are able to give push and pull to many continent-wide initiatives that fall within the public goods category (e.g., earlier adoption of continent-wide standards for mobiles, knowledge management practices, etc.).

The chief criterion of readiness to become a full member of the EU is the capability to withstand the European competitive pressures. While in the first period lower labor costs do provide certain competitive advantages pretty much across the branches of economic activity, this factor is of rather short duration in the case of Lithuania or other transition economies. Lithuania will need to develop higher added-value market niches that will precisely call upon the Lithuanian capabilities to create an entrepreneurial economy that is integrated continentally and globally. BPO provides such opportunities especially in the context of knowledge and innovation in the European and global business.

Knowledge industries in Lithuania are still not very advanced, compared to global leaders. But some pioneering firms that were created around research institutes do have histories going back a decade or so, esp. those in biotechnology, laser research and so forth. A national political consensus was reached and the national agreement was signed calling for Lithuania to become a knowledge-based economy. Further development of the knowledge economy infrastructure (e.g., better access to high-speed Internet) is needed. That will necessitate a better public sector-private sector collaboration so as to arrive at innovative management models and strategies underpinning the knowledge economy in Lithuania. One such innovative scheme is the Sunrise Valley in Vilnius, deliberately modeled after the Silicon Valley, California. There are other such schemes at different stages of implementation. Among Lithuania's corporate leaders are SICOR Biotech, Fermentas, Alna, Sonex, Omnitel, Bite GSM, Ekspla, Laser Research Institute. They are members of The Knowledge Economy Forum of Lithuania.

The dominant challenge before Lithuania is how to use a considerable theoretical research (e.g., biotech, lasers, semiconductors, game theory) potential of the Lithuanian research institutes, universities, and industry. There is a need to develop a practice-oriented strategy for knowledge-based economy in Lithuania. The theory-practice gap has been something of a problem inherited from the communist period, as are the inter-institutional collaboration shortcomings. One important aspect of that challenge is the interdisciplinary and cross-disciplinary nature of modern business models that mandates integrative thinking and puts a premium on those managers who are able to integrate functional perspectives. Educational institutions in European countries are still somewhat attached to the subject-based teaching/learning; and this problem is therefore more pronounced in Europe than in North America. It could well be that BPO is that vehicle and that frame of mind that can help overcome such shortcomings.

Business Process Outsourcing: Lithuania's Strengths

Availability of Well-Trained, Competitive Labor Force

The annual number of university graduates per 1000 inhabitants is one of the highest in the region. The cost of labor is among the lowest. The average monthly wage in the manufacturing sector in Lithuania is about one tenth that of industrialized countries, including those in the EU.

Attractive Operating and Living Costs, Lifestyle

Utilities, rent, building, overhead, service and living costs are among the lowest in the EU. Thus, Lithuania has significant cost advantages while offering geographical proximity to the Eastern markets. Lithuania's modern European life style is predicated on its long national and statehood history and a largely unspoiled natural environment.

Well Developed Transportation Networks

The EU Transport Commission designated Lithuania as the region's transport hub, with two out of the 10 priority corridors in Europe intersecting in Lithuania.

A network of European-standard four-lane highways links major industrial centres. By most standards, Lithuania has a well-developed transportation system. Road construction is underway for connecting with the trans-European transportation network. It will be part of the transportation system around the Baltic Sea and a transportation axis linking Russia and the Baltic Sea. The country offers four international airports and an ice-free seaport on the eastern Baltic Sea.

Free Economic Zones and Industrial Parks

Lithuania's Free Economic Zones and Industrial Parks boast excellent infrastructure and trans-shipment facilities, highly qualified labor force, and offer investors very attractive incentives. There is also plenty of industrial land with direct access to ports, railroads, and highways available.

World Standard Export Production

Most foreign businesses invest in Lithuania for export production purposes. Many local producers have already obtained ISO 9000, ISO 14000, GMP and other standards. Lithuanian exports in 2004 wee 7.5 billion and growing.

Multinational Investor Satisfaction

Siemens, Telia, Philips, Motorola, Mars/Masterfoods, Sonera, Kraft Food International, Festo, Lancaster Steel, Partec, Kemira, Danisco, SEB, Carlsberg and Marzotto are among the multinationals that have chosen to locate production facilities in Lithuania.

Strong FDI Growth

Foreign investment in Lithuania has been steadily increasing and reached close to Euro 5 billion as of the end of 2004. There are attractive "greenfield" and privatization projects in infrastructure, transport, energy, to name a few sectors.

There are some forward-looking initiatives in Lithuania (e.g., Window to the Future, The Knowledge Economy Forum) that in some ways lead the Central and Eastern Europe. With regard to outsourcing, Outsource2Lithuania is a project worth a closer analysis.

Outsource2Lithuania: A Business Process Outsourcing Project

Outsource2Lithuania is a new project aimed at uniting Lithuania's information technology and telecommunications (ITT) corporations, who are potential exporters of products and/or services within the European and global outsourcing models and strategies. The goal of the Project is for the Lithuanian ITT corporations to take the leading positions among the providers of ITT outsourcing services in Europe and globally. It also seeks to develop Lithuanian ITT products and services, promote exports to international markets, and contribute to the establishment of a positive image of the Lithuanian ITT market. According to Gartner Inc. experts' evaluation, the growth of the Lithuanian ITT outsourcing market reached some 40% over 2003 alone. Lithuania is rated as one of the most attractive providers of this type of service in Eastern Europe.

The project is open for participation by member corporations of the Association Infobalt (grouping Lithuania's ITT and other high-tech companies), pursuing business related to cross-border activities, promotion of exports and so forth. It is expected that up to 40 Lithuanian ITT corporations could be attracted within the first stage of the project, working in such fields as system integration, software development, data center operation, as well as education establishments, marketing organizations, training facilities, etc; thus covering a major part of the entire BPO spectrum. According to the project's policy, any strategic decision on the project's activity shall be taken through a consensus of all the project members. Particular implementation task of the project are to be carried out by the Infobalt staff.

For achievement of the goals of the project, efficient international marketing efforts are to be employed including dissemination of the information on the Web portal, through international exports Web sites, specialized publications, presentation of the Lithuania's ITT potential at various ITT offshore services forums internationally, enticement of potential partners, as well as through relevant governmental institutions and agencies. The participants of the project are offered training courses, including topics like the management of outsourcing, marketing, exports, public relations in international business, participation in business missions and so forth.

Participation in the project is based on a fee. Each corporation willing to participate shall be charged a membership fee assessed in relation to it's sales, ranging from 1000 to 3000 litas (LTL) a year. Membership fees, however, shall by no means be the sole source of funding the project. Additional sources of financing shall be sought to expand the value added by the project.

Each member of the project is offered a Web space for the placement of its corporate information and sales pitch on the portal (www.outsource2Lithuania.com) and on a compact disk to be distributed to potential partners in outsourcing services in Europe and Asia. The information on the undertakings of the participating businesses, their services and products are to be distributed by the Association Infobalt and it's partners including The Lithuanian Development Agency, International Chamber of Commerce, and the Lithuanian Ministry of Foreign Affairs, as well as at international ITT events. Each project member is entitled to use the service mark "Member of the Project: Outsource2Lithuania".

BPO to Lithuania: Services

"Outsource2Lithuania" companies provide a substantial range of enterprise solutions. They help to plan, analyze, design, develop, deploy and sustain solutions in high business impact areas like:

- **B2B:** Business Intelligence, Customer Relationship Management, Enterprise Resource Planning, Document and Content Management, Supply Chain Management, Product Data Management, Enterprise Application Design and Development, Enterprise Application Integration, Enterprise Application Testing;
- **Development Services:** Software Development, Testing, Data Warehousing, Content Delivery Network, Digital Signal Processing, Embedded Software, Engineering Services, Middleware Verification and Validation Services;
- **ICT Infrastructure and Solutions:** Internet Infrastructure, IT Infrastructure Services, Hardware Design, Security Solutions, Storage Area Network, Voice over IP, Wireless Technologies, Broadband, Multimedia;
- **ICT-Enabled Services:** Process Support Services, Contact/Call Centers, Sales and Marketing Support.

Business Process Outsourcing to Lithuania: A SWOT Analysis

The World Trade Organization and the International Trade Centre (WTO&ITC, Geneva) team of experts carried out extensive consultations with the Lithuanian Ministry of the Economy, Ministry of Internal Affairs, Ministry of Transport and Communications, Communications Regulatory Authority, Committee on Development of Information Society, Association of Lithuanian Chambers of Commerce, The Lithuanian Development Agency, Infobalt, the Information Technology Centre, the Lithuanian Standards Board, the Internet Service Providers Association, leading ICT companies, leading banks, customs authorities and others. The purpose of these consultations was to assess and help develop a knowledge-based industry in Lithuania and the Baltic region so that it gains a major share of the global ICT marketplace.

The WTO&ITC team compared Lithuania's ICT industry with similar industries of countries in the region. The conclusion was that the industry is developing and expanding its activities across the region. In the EU market, activities related to sub-contracting or onshore software application were taking place. Although the Lithuanian ICT industry is relatively small compared to the ICT market of Poland, for example, it has good growth potential driven by niche areas and niche products.

Box 1 shows the results of the WTO & ITC team's and others' research on Lithuania's ICT industry based on analysis of its strengths, weaknesses, opportunities and threats (SWOT).

Box 1. The SWOT analysis of the Lithuanian ICT and other high tech industry: Summary and outline

STRENGTHS	**WEAKNESSES**
Human resources suitable for innovative activities and knowledge-based production; Healthy economy, growing most rapidly among the CEE (5-6% for 2001-2005); Well-developed high tech & other universities producing over 500 specialists in ICT and other disciplines annually; Other well-trained & low-cost human resources available; Modern telecom infrastructure with a digitalization ratio of 100% and mobile penetration of some 50%; Labor force versatile in English, German, Russian, and Polish; Open economy with rule-based system aligned to the EU & WTO – economic stability; Developed financial institutions & intermediaries; Location between the EU, Nordics, Commonwealth of Independent States (CIS); Capacity to promptly adapt to rapidly changing ICT & knowledge based economy; Full scale privatization accomplished; industry re-structured based on comparative advantages; Institutional support to SME development; Well developed IT infrastructure across the region; Sound linkages between academia and industry for development of applications EU and NATO integration to provide large market opportunities for ICT-enabled services.	Manpower adequately skilled but needs re-training on project management and quality management of ICT projects; Slow drafting and implementation strategies of ICT & other high tech; Vague long-term vision for ICT development including action plans or prioritization of funds; Comparatively small market - small investment by MNCs; Foreign economic relations still to be formulated on the basis of national and EU interests; Capital market in the development stage; ICT penetration not sufficient to give a substantial boost to e-commerce and e-business development; Logistics management poor - railway transport system physically inadequate; Public-private partnerships weak & cooperation among economic entities underdeveloped; Insufficient incentives for R&D by business.
OPPORTUNITIES	**THREATS**
Development of labor-intensive sectors like computer science and knowledge-based sectors to serve a larger market of EU and CIS; Availability of structural funds from the EU to provide support to business modernization, employment promotion, improvement in quality of life, etc; Industrialization processes based on FDI, advanced technology and international management experience to enhance competitiveness and leverage advantages to achieve export-led growth; EU accession to expand sales markets and provide preconditions for foreign trade; Globalization of financial resources will provide alternative possibilities for financing; Use of digital technologies will open wider markets and provide conditions for more efficient cooperation with advanced economies in ICT, BPO, R&D, and other IT enabled services; Possibility to establish positions in the transport service markets of continental Europe, with logistic centres in Kaunas, Klaipeda and Vilnius; Free movement of IT and high tech personnel to provide opportunities for application development and onshore software development;	Emigration weakens the intellectual potential of Lithuania; Potential closures of domestic ICT companies due to fierce competition unless they develop sustainable niche markets; Fear of becoming a center of higher cost production because of alignment with the high-cost EU and trade distortions imposed by third countries; Loss of General Preference Systems discounts for exports to North America and Japan; International environmental obligations may lead to higher costs of production; Advanced ICT countries may wrongly see Lithuanians as consumers and not as developers/partners for modern products and services thereby leaving Lithuania out of BPO networks; Lack of coherent vision of the Lithuanian industry; Inconsistent policies and inadequate communications may lead to fragmented growth of IT and other high tech industry.

Source: Based on the WTO & ITC research, Infobalt and the Lithuanian Government materials, and authors' own research.

REFERENCES

International Production Literature: A Theoretical Background of Business Process Outsourcing

Badaracco, J. L. (1991). *The knowledge link*. Boston: Harvard Business School Press.

Balakrishnan, S., & Koza, M. (1993). Information asymmetry, adverse selection and joint ventures, theory and evidence. *Journal of Economic Behavior and Organization*, 20, 99-117.

Beamish, P. W. (1988). *Multinational joint ventures in developing countries*. London: Routledge.

Birkinshaw, J., & Hood, N. (200l). Unleash innovation in foreign subsidiaries. *Harvard Business Review, 79*(3), 131-137.

Blodgett, L. L. (1992). Factors in the instability of international joint ventures: An event history analysis. *Strategic Management Journal, 13*(6), 475-481.

Borys, B., & Jemison, D. B. (1989). Hybrid arrangements as strategic alliances: Theoretical issues in organizational combinations. *Academy of Management Review, 14*(2), 234-249.

Brealey, R. A., & Myers, S. C. (2003). *Principles of corporate finance* (7th ed.). New York: Irwin/McGraw-Hill.

Case: La Société Générale de Belgique. (1994). In R. I. Tricker, *International corporate governance* (pp. 566-568). New York: Prentice Hall.

Chakrabarti, A., & Hauschildt, J., & Sueverkruep, C. (1994). Does it pay to acquire technological firms. *R&D Management, 24*(1), 47-56.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, 128-152.

Conner, K. R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm? *Journal of Management*, 17, 121-154.

Contractor, F. J., & Lorange, P. (1988). Why should firms cooperate? The strategy and economic basis for cooperative ventures. In F. J. Contractor & P. Lorange (Eds.), *Cooperative strategies in international business* (pp. 3-30). Lexington, MA: Lexington Books.

Doz, Y. L. (1996). The evolution of cooperation in strategic alliances: Initial conditions, or learning processes? *Strategic Management Journal, Summer Special Issue*, 17, 55-83.

Dunning, J. H. (1996, December). The geographical sources of the competitiveness of firms: Some results of a new survey. *Transnational Corporations, 5*(3), 1-29.

Dunning, J. H. (1998). *The eclectic paradigm as an envelope for economic and business theories of MNE activity*. Unpublished paper, Graduate School of Management, Rutgers University, Newark, NJ.

Dunning, J. H., & Lundan, S. M. (1998). The geographical sources of competitiveness of multinational enterprises: An economic analysis. *International Business Review*, 7, 132.

Dunning, J. H., &Wymbs, C. (1998). *The sourcing of technological advantage by multinational enterprises*. Unpublished paper, Graduate School of Management, Rutgers University, Newark, NJ.

Dussauge, P., & Garrette, B. (1995). Determinants of success in international strategic alliances: Evidence from the global aerospace industry. *Journal of International Business Studies*, 26, 505-530.

Dussauge, P., Garrette, B., & Mitchell, W. (2000). Learning from competing partners: Outcomes and durations of scale and link alliances in Europe, North America and Asia. *Strategic Management Journal*, 21, 99-126.

Eisenberg, E. M., & Witten, M.G. (1987). Reconsidering openness in organizational communication. *Academy of Management Review, 12*(3), 418-426.

Erramilli, M. K., & Rao, C. P. (1990). Choice of foreign entry modes by service firms: role of market knowledge. *Management International Review, 30*(2), 141.

Gammelgaard, J. (2000). How foreign subsidiaries develop into integrated competence centres. In J. Larimo & S. Kock, Recent studies in interorganizational and international business research (pp. 164-181). *Proceedings of the University of Vaasa, Reports 58*.

Gammelgaard, J. (2001). Knowledge transfers following acquisition: The impact of prior trust-based relations. *Proceedings of the University of Vaasa, Reports*.

Gassmann, O., & von Zedtwitz, M. (1999). New concepts and trends in international R&D organization. *Research Policy, 28*(2,3), 231-250.

Geringer, J. M. (1988). *Joint venture partner selection: Strategies for developing countries*. New York: Quorum.

Gertsen, M. C., & Soderberg, A. M. (2000). Tales of a trial and triumph. A narratological approach to acquisitions. In C. Cooper & A. Gregory (Eds.), *Advances in mergers and acquisitions* (pp. 239-272). London: JAI Press/Elsevier Science.

Gertsen, M. C., Soderberg, A. M., & Vaara, E. (2000). *Cultural change processes in mergers. A social constructionist perspective*. Working paper no. 38, Department of Intercultural Communication and Management, Copenhagen Business School, Copenhagen.

Gulati, R. (1995). Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal*, 38, 85-112.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal, 19*(4), 293-317.

Gulati, R. (1999). Where do interorganizational networks come from? *American Journal of Sociology, 104*(5), 1439-1493.

Hagedoorn, J., & Sadowski, B. (1999). The transition from strategic technology alliances to mergers and acquisitions: An exploratory study. *Journal of Management Studies, 36*(1), 87-107.

Harrigan, K. R. (1985). *Strategies for joint ventures*. Lexington, MA: Lexington Books.

Hennart, J. F. (1988). A transaction cost theory of equity joint ventures. *Strategic Management Journal, 9*(4), 361-374.

Hennart, J. F., Roehl, T., & Zietlow, D. S. (1999). Trojan horse or workhorse? The evolution of U.S.-Japanese joint ventures in the United States. *Strategic Management Journal, 20*(1), 15-29.

Hill, C. W. L. (2001). *Global business today, 2nd edition*. New York: Irwin/ McGraw-Hill.

Hirsch, S. (1993). The globalization of services and service-intensive goods industries. In Y. Aharoni (Ed.), *Coalitions and competition: The globalization of professional business services* (pp. 66-78). New York and London: Routledge.

Hof, R. D. (1999, October 4). A new era of bright hope and terrible fears. *Business Week, European edition*, 50-57.

Inkpen, A. C., & Dinur, A. (1998). Knowledge management processes and international joint ventures. *Organization Science, 9*(4), 454-468.

Keld, J., & Iwar, U. (2002). *Negotiating partnerships: Increase profits and reduce risks*. London: Pearson Education.

Kogut, B. (1988). Joint ventures: Theoretical and empirical perspectives. *Strategic Management Journal, 9*(4), 319-332.

Kogut, B. (1989). The stability of joint ventures: Reciprocity and competitive rivalry. *Journal of Industrial Economics*, 38, 183-198.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science*, 3, 383-397.

Koza, M. P., & Lewin, A. Y. (1998). The co-evolution of strategic alliances. *Organizational Science*, 9.

Larsson, R., & Finkelstein, S. (1999). Integrating strategic, organizational and human resource perspectives on mergers and acquisitions: A case survey study of synergy realization. *Organisation Science*, *10*(1), 1-26.

Latour, B. (1986). The powers of association. In J. Law (Ed.), *Power, action and belief* (pp. 264-280). London: Routledge and Kegan Paul.

Lei, D., & Slocum, J. W. (1992). Global strategy, competence-building and strategic alliances. *California Management Review, 35*(1), 81-97.

Lindahl, D. P., & Beyers, W. B. (1999, January). The creation of competitive advantage by producer service establishments. *Economic Geography*, 75, 1-20.

Lowendahl, B. P. (1993). Co-operative strategies for professional service firms: Unique opportunities and challenges. In Y. Aharoni Ed.), *Coalitions and competition: The globalization of professional business services* (p. 166). New York and London: Routledge.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science*, 2, 71-87.

Minshall, T. H. W., & Garnsey, E. W. (1999). Building production competence and enhancing organizational capabilities through acquisition: the case of Mitsubishi Electric. *International Journal of Technology Management, 17*(3), 312-333.

Mitchell, W., & Singh, K. (1996). Survival of businesses using collaborative relationships to commercialize complex goods. *Strategic Management Journal, 17*(3), 169-195.

Morgan G., & Smircich, L. (1980). The case for qualitative research. *Academy of Management Review, 5*(4), 491-500.

Nakamura, M., Shaver, J. M., & Yeung, B. (1996). An empirical investigation of joint venture dynamics: Evidence from U.S.-Japan joint ventures. *International Journal of Industrial Organization*, 14, 521-541.

Napier, N. K., Simmons, G., & Stratton, K. (1989). Communication during a merger: The experience of two banks. *Human Resource Planning, 12*(2), 105-122.

Nohria, N., & Ghoshal, S. (1997). *The differentiated network – Organizing multinational corporations for value creation*. San Francisco: Jossey-Bass Publishers.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create dynamics of innovation*. New York: Oxford University Press.

Oliver, C. (1990). Determinants of interorganizational relationships: Integration and future directions. *Academy of Management Review*, 15, 241-265.

Park, S. H., & Russo, M. V. (1996). When competition eclipses cooperation: An event history analysis of joint venture failure. *Management Science*, 42, 875-890.

Parkhe, A. (1993). Strategic alliance structuring: A game theoretic and transaction cost examination of inter-firm cooperation. *Academy of Management Journal*, 36, 794-829.

Porter, M. E. (1990). *The competitive advantage of nations.* New York: The Free Press.

Porter, M. E. (1998). *On competition*. Boston: Harvard Business Review Press.

Porter, M. E., & Fuller, M. B. (1986). Coalitions and global strategy. In M. E. Porter (Ed.), *Competition in global industries* (pp. 315-344). Cambridge, MA: Harvard University Press.

Powell, W. W. (1990). Neither market nor hierarchy: Network form of organization. In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior* (pp. 295-336). Greenwich, CT: JAI Press.

Powell, W. W., & DiMaggio, P. J. (1991). *The new institutionalism in organizational analysis.* Chicago: The University of Chicago Press.

Prahalad, C. K., & Hamel, G. (1990, May-June). The core competence of the corporation. *Harvard Business Review.*

Risberg. A. (1999). *Ambiguities thereafter. An interpretive approach to acquisitions.* Malmo: Lund University Press.

Sakakibara, M. (1997). Heterogeneity of firm capabilities and cooperative research and development: An empirical examination of motives. *Strategic Management Journal, Summer Special Issue,* 17, 143-164.

Schweiger, D. M., & DeNisi, A. S. (1991).Communication with employees following a merger: A longitudinal field experiment. *Academy of Management Journal, 34*(1), 110-135.

Seth, A. (1990).Value creation in acquisitions: A re-examination of performance issues. *Strategic Management Journal*, 11, 99-115.

Seth, A. (2000). Synergy, materialism or hubris? An empirical examination of motives for foreign acquisitions of U.S. firms. *Journal of International Business Studies, 31*(3), 387.

Simonin, B. (1999). Ambiguity and the process of knowledge transfer in strategic alliances. *Strategic Management Journal,* 20, 595-623.

Singh, K., & Mitchell, W. (1996). Precarious collaboration: Business survival after partners shut down or form new partnerships. *Strategic Management Journal, Summer Special Issue*, 17, 99-115.

Smircich, L. (1983). Concepts of culture and organizational analysis. *Administrative Science Quarterly*, *28*(3), 339-358.

Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, Special Issue*, 45-62.

Stalk, G., Evans, P., & Shulman, L. E. (1992, March-April). Competing on capabilities: The new rules of corporate strategy. *Harvard Business Review.*

Stewart, T. A. (1997). *Intellectual capital: The new wealth of organizations.* New York & London: Doubleday/Currency.

Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy,* 15, 285-305.

Weick, K. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publications.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

Williamson, O. E. (1985). *The economic institutions of capitalism. Firm, market, relational contracting.* New York: The Free Press.

Williamson, O. E. (1991). Strategizing, economizing, and economic organization. *Strategic Management Journal, Winter Special Issue*, 12, 75-94.

Young, M., & Post, J. E. (1993, Summer). Managing to communicate, communicating to manage: How leading companies communicate with employees. *Organizational Dynamics, 22*(1), 31-43.

Business Process Outsourcing Literature: Selected Items in Applied Approaches

Agrawal, V., & Farrell, D. (2003). Who wins in offshoring? *The McKinsey Quarterly,* Special Edition: Global Directions.

Arora, A., & Gambardella, A. (2004, June). *The globalization of the software industry: Perspectives and opportunities for developed and developing countries.* NBER working paper.

Bivens, J. (2004). *Globalization of IT hardware did not add $230 billion to U.S. GDP in 2002.* Economic Policy Institute Policy memo. Washington, DC: EPI.

Egger, P., & Pfaffermayr, M. (2004, November). Two dimensions of convergence: National and international wage adjustment effects of cross-border outsourcing in Europe. *Review of International Economics, 12*(5), 833-843.

Feenstra, R. C., & Hanson, G. H. (1995, May). *Foreign investment, outsourcing and relative wages.* NBER working paper.

Grossman, G. M., & Helpman, E. (2002, January). *Outsourcing in a global economy.* NBER working paper.

Price, L., & Bivens, J. (2004). *Perspectives on white-collar offshoring.* Economic Policy Institute briefing paper. Washington , DC: EPI.

General Resources on Outsourcing/Offshoring

Bardhan, A., & Kroll, C. (2004). *The new wave of outsourcing.* Fisher Center for Real Estate & Urban Economics research report. University of California, Berkeley.

Cline, W. (1997). *Trade and income distribution*. Washington, DC: Institute for International Economics.

Gordon, R. J. (2003). *Exploding productivity growth: Context, causes and implications.* Brookings Papers on Economic Activity, Volume 2. Washington, DC: The Brookings Institution.

Mann, C. (2003). *Globalization of IT services and white-collar jobs: The next wave of productivity growth*. Institute of International Economics policy brief. Washington, DC: IIE.

Oliner, S., & Sichel, D. (2002). *Information technology and productivity: Where are we now and where are we going?* Federal Reserve Bank of New York working paper.

Offshoring/Outsourcing Resources on the Web: Selected Annotated Items

- http://www.techsunite.org/news/techind/offshoring1.cfm
  TechsUnite is an association devoted to connecting IT workers to data critical to their careers. TechsUnite is a project of the Communications Workers of America collaborating with the a range of other partners, supporters, and stakeholders. This page is their stance on offshoring.
- http://www.cwa-union.org/misc/outsourcing.asp

The CWA outsourcing Web log; it tracks company announcements, news reports, and other breaking stories about outsourcing and offshoring jobs.

- http://www.aflcio.org/aboutaflcio/ecouncil/ec03112004i.cfm
  Statement by the AFL-CIO executive council regarding offshoring.
- http://www.ieeeusa.org/forum/POSITIONS/offshoring.html
  Statement by the Institute of Electrical and Electronics Engineers, the world's largest technical professional society.
- http://www.itaa.org/itserv/docs/execsumm.pdf
  Executive summary of a study commissioned by the Information Technology Association of America (ITAA) from the consulting firm Global Insight.

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Chapter 1.9
Keeping the Flame Alive:
Sustaining a Successful Knowledge Management Program

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EXECUTIVE SUMMARY

This case study looks at how to keep a knowledge management initiative going after it has been successful for a couple of years. This organization found that continuously measuring benefits from the knowledge management system and keeping the knowledge in the system fresh and relevant were key to long-term success. However, achieving this was difficult as improving quality added more work to the already-busy managers and measuring worth was difficult.

INTRODUCTION

Michelle Johnson was in a reflective mood. As director of System Management Solutions International's (SMSI) knowledge management staff, she had led a two-year project to turn the firm's experimental use of groupware into a viable and important corporate asset. Her vision of a technology-driven resource for sharing the corporation's expertise was in operation.

These first two years focused on the start-up issues that had stymied the knowledge management (KM) projects of others. Her team had managed to find a combination of formal and informal incentives that stimulated hundreds of staff members to share their experience with others around the firm. The technology architecture to connect the firm's worldwide offices was in place. Finally, senior management support for the effort was, for the moment, sufficient to fund the current effort.

Now she needed to consider what was next for the program. The satisfaction Ms. Johnson felt over the successful integration of KM techniques into the company was tempered by concerns about the program's future. Surveys showed that staff satisfaction and participation was quite high, and user feedback about the quality and breadth of the KM system was positive, though not as high as earlier in the year. There was particular uncertainty about the attitude of SMSI's partners, who paid for the program but did not receive the direct knowledge benefits seen by the field workers.

The planning for future KM activities at SMSI needs to focus on sustaining the momentum and effectiveness of the program as the firm moved from a booming consulting industry to one where projects were becoming more scarce. Thus, the critical issue becomes maintaining the current success of its KM initiatives and system, given both external and internal changes.

BACKGROUND

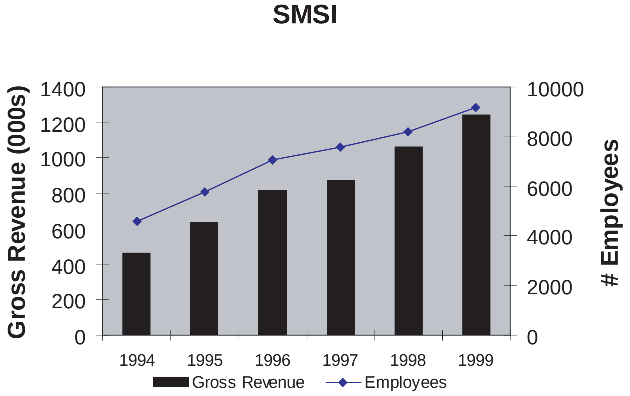
SMSI, founded in the early 1970s, is a publicly held business consulting and IT services firm. During the last three decades, the firm has completed tens of thousands of engagements, ranging in intensity from a few staff weeks to hundreds of staff years. While technology implementations were still the main focus of the firm, its expertise in change management and specialized content areas (e.g., human resource management, government operations, financial reporting) have become an important part of the firm's portfolio. By most measures, the firm has been very successful. Gross revenues of the firm have grown steadily since its founding, reaching $1 billion in the late 1990s. In parallel, staffing has grown from about 4,500 employees in 1994 to almost 9,000 by the end of 1999 (Figure 1).

SETTING THE STAGE

The Resource Structure of SMSI

SMSI is organized around lines of business and geographic regions. Within each region, it followed what is more or less a prototypical staffing model, consisting of three professional levels. Consultants are the "worker bees" responsible for the execution of specific tasks. Managers, the next level in the organization, organize, instruct, and review consultant work as well as develop work that requires more experience. Partners, at the high end of the structure, are responsible for leadership of major projects, define strategy for the firm, develop business opportunities, and maintain client relations. These three roles are "the grinders, the minders, and the finders" of the consulting business (Maister, 1997). These professional roles are backstopped by a support organization that sustains the day-to-day operations of the firm.

Figure 1. SMSI revenues and staffing



The Role of KM

Consulting is fundamentally a knowledge-based business. Clients use consultants to provide hard-to-develop skills, retaining them for short periods, the duration of a project, or sometimes longer. Over the last decade a transition has occurred in the consulting business, away from treating every problem as a unique opportunity, and toward rapid leverage of experience. This creates a new perspective on the role of the consultancy, where consultants act as information brokers, using connections across industries and projects to identify classes of problems, and applying their collective skills to solve them (Sarvary, 1999). Consulting firms act as a resource hub, with networks of staff that can reuse their knowledge for multiple clients. Finding the right skills within the consultancy and bringing them to bear quickly is a key selling point. Therefore, consulting firms need to find techniques for sharing their experience quickly, and creating the linkages and team structures that attract clients.

Staffing and Knowledge Retention

Every year consulting firms organize hiring plans based on their projected project demand. Many recruit from undergraduate and graduate programs, preferring to train staff in their unique approach to business and clients. New consultants face a great deal of work pressure and competition for managerial positions, and a large proportion of them leave before moving to the managerial ranks. The combined effects of long work hours, uncertain career paths, and competitive pressure for recognition all exert adverse pressure on junior staff. Similarly, there is churn in the managerial ranks as experienced professionals try to develop the client relationships required to support promotion to partner. A small proportion of managers achieve partner status; the remainder may change firms or launch other opportunities. There is something of an "up-or-out" structure, similar to that seen in law firms.

Concern about turnover is of greater concern during upswings in the market, as there is more competition for talented staff. In these times, firms must replace staff recruited away by competitors as well as recruit new consultants to meet swelling demand for services. These two forces have generated hiring rates as high as 40% per year for some large companies, which in turn create a great strain on the firms to train and integrate these new employees into the firm.

Turnover also affects the knowledge available to the firm. When experienced staff leave the firm, they take their knowledge with them. Rather than risk the loss of this knowledge, consulting firms actively collect and codify project-based materials, write practice guides and methodologies, and synthesize their experience in written, oral, and multimedia forms. When new inexperienced staff arrive, these codified assets provide significant leverage. The "push" model of individual training and mentoring of juniors by seniors has given way to a "pull" model, where experience is made available on demand through databases and communications networks.

KM in Consulting Companies

The staggering rate of change in the volume of information has accelerated the need for information and knowledge management. Individuals and companies that have their fingers on the pulse of the newest and most useful information can command a high price for their knowledge, if they can bring it to their clients quickly. This, in turn, means that the experts must access and leverage their own knowledge acquisition and retention, so that they always have the best information for their clients.

The consulting environment has always required mobility and flexibility, and the knowledge resources of the firm must be at the fingertips of consultants in the field. As one manager put it, "We're all road warriors now." It's not clear if staff spend more time on the road than in the past, or if they are just expected to be available and productive whether in or out of the office. Consultants are expected to use technology, primarily e-mail, and to remain connected to the corpus of the firm. In these firms, successful knowledge management implementations mean that the road warriors can bring the intellectual resources of the firm with them to client sites. It is not surprising that large consulting firms were also early adopters of knowledge management technologies (e.g., Alavi, 1997; Bartlett, 1996; Chard, 1997; Reimus, 1997). Knowledge management is a competency of interest to consulting clients, and the ability to demonstrate internal implementation competence and benefit validates the credentials of the firm to potential clients.

CASE DESCRIPTION

For SMSI, the ability to leverage its existing experience through KM technology came none too soon. The late 1990s were very busy times for technology and management consultants, and SMSI rode the leading edge of the boom. To meet customer demand, SMSI hired staff at an unprecedented rate. At the same time, staff turnover was very high, peaking at about 20% per year, as the combination of work pressure and opportunities in a skill-seller's market makes retaining staff difficult. Much of the turnover was among staff with experience in the most current software platforms. As new skills were learned, many staff left SMSI to chase better offers. This staff churn created a continuing outflow of knowledge from the firm's resources.

Surging growth, technical change, and high turnover created great pressure within the firm to capture and disseminate knowledge and experience. Lessons learned in one project might be immediately useful elsewhere, and certainly would provide value to someone else in the firm. When the firm was smaller, staff with questions could discuss them with others in the same office; now, expertise was more scattered and less available. Individuals did not know each other as well as they did in the past, and there has been a sense of reluctance to contact individuals outside the immediate workgroup.

Long-time employees are concerned about the effects of rapid growth on the organization's culture of information sharing. One termed the effect "intellectual sprawl," where consultants in different business units were re-creating the same work products and techniques independently. In their view, there was not enough sharing of the lessons of technology and engagement management, at a time when the proportion of inexperienced staff grew. While the knowledge management program attempts to facilitate sharing, there was still a sense that the best ideas were not always available, and that human contacts were superior to the use of an information system.

Developing SMSI's KM Program

The development of a formal KM program at SMSI was facilitated by the firm's history in information systems consulting. From a practical standpoint, the firm was well positioned to implement the complex technological infrastructure associated with KM. The firm's leadership committed to solve the technical success and the cultural and social challenges that KM presents. This recognition allowed SMSI to avoid some of the stumbling blocks that less sophisticated firms faced.

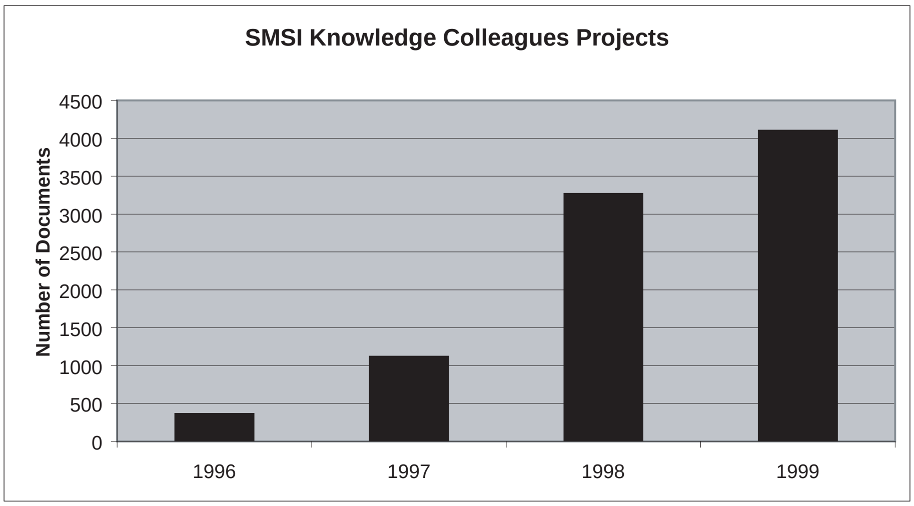
Experimentation with KM technologies started in 1992, with the introduction of Lotus Notes as a groupware tool. By 1998, almost 100 Notes servers were in place, and all office-based personnel had desktop access to the tool; most field personnel had shared access through one or more Internet-enabled computers. When the tool was adopted as a firm-wide standard, a number of special interest groups (SIGs) were established, and used Lotus Notes as a tool to facilitate discussions across offices on topics of mutual interest as well as an e-mail backbone. Most were informal discussions on emerging technologies; these discussions rarely lasted more than a few months as individual knowledge needs changed. Often they became places to ask direct questions from individuals across the firm, with additional follow-up through telephone calls. Occasionally some synthesized databases stimulated working papers or, eventually, encapsulations of SMSI's best practices.

To stimulate further development and sharing of information, SMSI established a Knowledge Colleagues program. Staff working in business units proposed short-term technology experiments or projects, resulting in the development of a paper or prototype to share throughout the firm. Individuals were released from their project work for two weeks to work on their tasks, with the expectation that they would also contribute additional time to complete their work. A series of activities dealing with knowledge sharing was established in late 1996, facilitating transfer of information across several core disciplines around the firm. The initial series included systems development, business process reengineering, customer value management, engagement management, change management, advanced technologies, and decision analytics. Knowledge management and electronic commerce were added in 1998, along with the firm-wide rollout of the technology platform.

During these first few years, the list of completed contributions grew from 400 to over 4,000 topics (Figure 2). This growth was a mixed blessing. Ms. Johnson noted that the more recent documents were not as useful as earlier ones. The initial topics tended to be of more general interest, and later ones were more specialized to particular problems and industries, and less relevant to the general population. In addition, there was less review of the contents as the number of documents grew.

SMSI's KM program extended beyond the development of the Colleagues program. A small headquarters-based unit acted as a clearinghouse for the firm's current and past activities. Databases of current activities across the firm, model

Figure 2. SMSI knowledge colleagues projects



deliverables, and frequently asked questions were made available. They were representative samples of well-received project materials, client proposals, templates, and general advice on the topics at hand. Experts and thought leaders in the topic area were identified, and their particular expertise highlighted. Discussion databases, where questions may be posed to these experts, received several postings a day. These discussion databases could be initiated by anyone in the firm, and there were literally thousands of them. No central repository was maintained, and the contents were often informal and somewhat wild and wooly.

SMSI's Knowledge Colleagues also agreed to participate in the discussion databases and make themselves available for ad hoc questions around the firm. Through their responses, the Colleagues extend the informal information network that corporate growth was dissolving. The time they spend in this role was not billable to any project, and went largely unmonitored. Here, more than anywhere, the altruistic nature of the knowledge-sharing experiment was seen, as individuals who answered questions were often contacted off-line for further explanations.

CURRENT CHALLENGES

The success of the SMSI KM program was quite remarkable. Almost all of SMSI's staff used the KM system in some fashion. The most pleased were the junior and mid-level consultants, who found ready reference for their project needs and routine questions about the firm. Managers and partners used the system to locate experts for use in proposals and to fill staffing gaps for projects. This was particularly valuable when there were few available resources, and there seemed to be a constant scramble to match client needs with experienced consultants.

Of all the various facets, Ms. Johnson was proudest of the Knowledge Colleagues program. Here, more than 800 members of the professional staff, almost 10% of the firm's employees, were volunteering time to share their experience with others around the firm. This was the essence of the cultural change that SMSI needed to leverage its knowledge capital. The program's participants were eager to add new materials to the collections available across the firm, as their contributions were noted in their annual performance reviews as an important contribution to the culture of the firm. While not a large measure, there was clearly some recognition in the review process that was felt to factor into raises and promotions.

Now that the program is in place, Ms. Johnson's challenge is to establish that SMSI's KM can continue to provide value. Will the KM system continue to provide useful information? She considered the primary driver of the KM program's success to date: the perceived positive effect on users and the firm.

User value is subjective, resting in how the user applies the knowledge to the problem at hand. A KM system may provide a specific answer to a direct question, or it may provide some insights into an issue that add value in a new context. In a knowledge-intensive industry, the results of answers may be easy to measure (such as the foregone cost for work that could be borrowed, rather than repeated), or may be very difficult to quantify (as with the value of a confirming perspective prior to taking a decision).

To facilitate the acceptance of the KM program, there was no cost to using the system. It was hoped that a free system to share knowledge would demonstrate its value organically, rather than through a pricing mechanism. It was expected that the free system would demonstrate particular deliverables (i.e., training courses) that might be subject to internal development charges.

With KM systems, as with other types of decision support tools, users who do not like the tool may choose to ignore it or not contribute to it. Thus one measure of user value is the level of participation. In traditional transaction-oriented

IT systems, users have little choice about using the technology. They may love it, or they may hate it, but the computer is still integral to performing their jobs, and users are compelled to make do with the system. Thus continued participation and inquiry of a KM system may be used as a surrogate for satisfaction.

In turn, satisfaction with a KM system often generates additional demands for knowledge. The more value users found with the information contained in the system, the more likely staff were to come back with additional requests and inquiries (and the higher the costs of the system to develop new materials). The evidence that requests were growing was the major justification for continued funding of KM efforts at SMSI.

A more formal measure of effect was still elusive. In manufacturing environments, it is possible to identify the value of knowledge through reductions in defects, worker productivity, or other production-based metrics. In consulting, the results of learning and transferred experience through the use of KM tools tended to be a better quality of ideas, rather than simply finishing work more quickly. One consultant noted, tongue-in-cheek, that finishing work more quickly might even be against the firm's principles, particularly if the client was paying by the hour. The senior managers reviewing the effects of KM on the organization were asked to think about softer and more anecdotal measures than they were used to, with user satisfaction being a primary indicator of continued success.

Of course, reasoned Ms. Johnson, this would likely work in reverse as well: A KM system that did not address the needs of the users would get less use. Requests would taper off, starting a possible downward spiral toward obsolescence. Such a spiral would be hard to identify beforehand, and would be difficult to reverse. Thus sustaining a KM program requires several critical adjustments to the KM program to maintain the positive momentum and continually demonstrate the KM system's value to users and the firm. Yet, Ms. Johnson thought, how does SMSI (or any firm for that matter) meet these challenges?

Encouraging the collection of knowledge from a large number of contributors had several unanticipated consequences. The most concrete was a large accumulation of materials, not all of which were adding to the available knowledge for several reasons. First, redundant materials have little incremental impact. At the outset of the Knowledge Colleagues program all contributions were welcome. In response, staff posted their planning tools, interim deliverables, and project documents for use by others. Over time, though, the incremental value of these postings to others decreased. When searching for a topic, many users looked only at the first few hits. Having seven or eight or 15 examples of a project schedule made little difference in outcome, but they do consume resources.

Second, collected materials become obsolete, and their effects on the organization decrease. The collection of project materials and examples permitted the dissemination of new information quickly. Over time, though, the older materials became less useful as techniques change and market requirements shift. In the fast-changing world of information technology consulting, some materials were really only useful for a few weeks or months. After that, they might be misleading or just plain wrong. If users of the KM system find that materials are not current, their satisfaction will drop, and they are less likely to ask for information in the future.

Third, the "core knowledge" needed by the firm was about to change because the marketplace was about to change as well. When SMSI's KM program was launched, the firm was struggling with integrating thousands of newly hired employees into the fabric of the firm. When a new hire arrives, the KM system gives him or her a ready source for contacts around the firm and exposure to SMSI's project portfolio. This eased the transition into the firm, and made these new hires much more productive.

With the slowing of the consulting marketplace, however, the firm may not be hiring staff as quickly, and the value of indoctrination-focused knowledge falls. In a declining market, emergent needs revolve around developing and maintaining customers and looking for new opportunities, rather than sharing knowledge about techniques to complete projects. The SMSI partners, who made up the firm's marketing and management teams, needed support in their quest to obtain work. Internal data sources, while providing information on the firm's existing project and resource portfolios, provided limited value in their search.

SMSI was willing to pay for the KM infrastructure and support participation in knowledge activities. This senior management support came from the desire to retain and reward key employees, and less from any formal calculation of the knowledge benefits to the firm. In a time of high turnover, any reasonable technique to retain staff through formal and informal recognition was deemed useful. Even in the absence of financial value, the firm's partners and senior executives believed that the program was helping the firm manage its growth in a time of technical change and rapid expansion of staff.

The belief in the potential of KM to sustain the company through this period of growth was most manifest in the recognition of Knowledge Colleagues. Participation in the program was specifically considered during staff personnel reviews, and Colleagues were given special business cards that identified them as participants. This provided both financial and psychological incentives to participate.

As she considered these observations, Ms. Johnson saw that they interacted in a complex way. Firm growth stimulated demand for knowledge, and the programs she developed helped to meet that need. The internal programs and incentives created an active knowledge-sharing environment. Was there more "knowledge sharing" than could be maintained while preserving quality? Should there be additional screening or reviews put in place? What effects would such changes have on the culture of the firm and incentives to provide knowledge?

Forces external to the firm would also affect what direction KM should take. SMSI had benefited from the explosive growth in e-commerce paired with the millennial-driven Y2K systems revisions. The suddenness of these industry changes created an extreme demand for information and solution reuse, which provided great leverage from the collected knowledge assets of the firm. There was little expectation that this type of work would continue at the same pace, and much of this previously valuable information would no longer be needed. The cost of keeping existing materials is small, as long as they are correct.

What new knowledge needs would emerge when markets start to decline? Integrating new staff was going to be less important. What knowledge will be needed to maintain SMSI's revenue and opportunities for growth? Are there unmet internal markets for knowledge that might still be exploited? This is another area Ms. Johnson wanted to explore.

The internal KM program at SMSI needed to shift its focus from creating a knowledge-sharing organization to one that manages its knowledge as an asset that depreciates over time. The success of the program would be based on maintaining the value and quality of its contributions to its users. In addition, a somewhat shaky forecast for SMSI's services would affect the willingness to support programs that do not demonstrate bottom-line contributions. Was there a way to directly demonstrate the value of knowledge sharing to the partners of the firm?

She believed that ongoing investment is needed, but was not sure how should it be applied. Is the development of new knowledge more important than cleaning up and review of older information? Are the incentives in place adequate to keep the internal knowledge channels open? What about developing new markets for KM? What should be the focus of her team's activities?

EPILOGUE

The Manager's Actions

In late 1999, Ms. Johnson unveiled her plans for creating a sustainable KM program for SMSI. There were two major threads to her plan. First, she believed that it was necessary to maintain the KM resource as a source of reliable, solid information. While the Knowledge Colleagues program had engaged thousands of people in the firm, some of the materials were not well regarded. Second, she needed to establish the worth of the program in a formal manner.

To meet the first objective, she revised the Colleagues program's structure. Starting in 2000, all new contributions were reviewed by senior managers of the firm to ensure their applicability and accuracy before they were accepted for distribution. In addition, all the existing materials were reread for continuing value, with revisions or deletions as required. A cap of 500 new topics per year was put in place, roughly the same number of contributions as in the first year of the program. Ms. Johnson felt that this was about the maximum number of documents that could be adequately reviewed each year.

At first, limiting the number of contributions did increase the quality of the contributions, as there was now a need to weed out weaker materials. This had a secondary effect, however, as rejected materials discouraged participation in other aspects of knowledge sharing among previously enthusiastic junior staff.

The increased emphasis on quality necessarily also increased the workload on the managers and partners who participated in the Colleagues program. These staff had the experience and breadth of knowledge to evaluate the usefulness of contributions to the firm, and their applicability beyond a particular project. The change of their role from creator to reviewer was unwelcome, and their enthusiasm for the voluntary nature of the program was shaken. To counter this anticipated shift in collegial spirit, SMSI agreed to maintain the formal (i.e., financial) recognition for those staff still participating in the program.

The second goal, establishing the worth of the KM program, remained elusive. Throughout the program's introduction, the KM staff was careful to collect any anecdote about the financial worth of materials obtained through its offices. War stories of projects working on opposite sides of the globe shared information and materials were disseminated. A set of user surveys were conducted to ask for estimates of value from users; these yielded highly suspect results, particularly one that estimated that the KM program yielded half the net revenue of the firm for 1998. The continuing internal support of the program was still largely based on the belief that it was working, and that competitors were doing it as well, rather than concrete value.

Longer-Term Results

The emergent recognition of the need to balance volume of collected knowledge and maintaining quality and was disrupted by forces outside the control of Ms. Johnson and the KM staff. The postmillennial slowdown in IT consulting drastically changed the SMSI workplace, and in turn, the KM program. The initial changes came from a drastic drop in new project work. As projects completed, there were fewer new assignments, and more staff went unassigned. By late 2000, hiring was frozen, and the turnover rate dropped to about 2% as competitors no longer hired skilled staff away.

In an attempt to shore up their finances, SMSI stopped funding all activities that did not directly contribute to revenue. Development of knowledge materials for training and indoctrination work was curtailed, particularly as virtually no new staff was joining the company. KM programs, while believed important, were carried as an overhead expense to the firm, and the financial support was withdrawn.

The nonfinancial incentives for participating dried up as well, as staff became more concerned about maintaining their own positions than assisting others for the good of the firm. There was great pressure to "tend to one's own garden," and use whatever time was available to develop leads for potential projects, rather than participating in the Colleagues program. Indeed, this was a rational perspective, as a series of layoffs dropped the payroll to 7,200 by 2001.

By mid-2001, much of the KM program, including the Knowledge Colleagues program, had been dismantled. Ms. Johnson left SMSI to join a new consultancy firm that specialized in knowledge management, along with many of her staff. The KM program continued at a much smaller scale, focusing on market intelligence and skill building for the SMSI staff.

Lessons Learned

The final straw for the KM system was the weakness in SMSI's markets, and the reaction of its management to reduce funding. This was not in the scope of control of the KM managers. Nevertheless, there are several elements that may be taken away from the case.

- More is not always better. Developing a community of knowledge-sharing staff was a particular concern to SMSI's KM managers. To this end, their program emphasized a broad-based, inclusive approach that encouraged participation and knowledge sharing. After some time, however, the quality of the knowledge shared was not equal to the quantity that was available. This perception of dropping quality may have contributed to the program's later weakness. This problem would become more visible as the collection of accepted knowledge grew. A more selective process for accepting contributions, along with a process of vetting and reviewing the content of the system, might have mitigated.
- Monitoring usage. Integrating a usage or rating scale into the knowledge system would have assisted in identifying materials that were outdated or not widely applicable. More modern KM systems than that available at SMSI recognize this need, and assign weights to materials that have been evaluated by the users as useful or not. Examples where this is present include the customer service sites at Symantec and Microsoft, which ask users to rate the usefulness of retrieved items.
- Recognizing the stakeholders. While the SMSI program clearly recognized the needs of junior consultants and managers, it was less successful in developing the same kind of respect among partners, who ultimately paid for the system. For this group, the anecdotal evidence that the KM program was useful was not sufficient to continue its funding as the financial position of SMSI worsened. In comparison, a competitor firm spent considerable effort developing marketing and prospect management knowledge bases for the partners. When faced with the same declining market, this competitor continued to fund its own KM system, in large part because it provided direct benefits to those making financial decisions about its future. The axiom "Follow the money" continues to ring true.

REFERENCES

Alavi, M. (1997). *KPMG Peat Marwick U. S.: One giant brain* (Case Study No. 9-397-108). Boston: Harvard Business School.

Bartlett, C. (1996). *McKinsey & Company: Managing knowledge and learning* (Case Study No. 9-396-357). Boston: Harvard Business School.

Chard, A.M. (1997). *Knowledge management at Ernst and Young* (Case Study No. M-291). Palo Alto, CA: Stanford University.

Maister, D.H. (1997). *Managing the professional services firm.* New York: Free Press.

Reimus, B. (1997). *Knowledge sharing within management consulting firms.* Retrieved June 14, 1999, from www.kennedyinfo.com/mc/gware.html

Sarvary, M. (1999). *Knowledge management and competition in the consulting industry.* California Management Review, 41(2), 95–107.

Additional Sources

General Readings on KM:

www.KMWorld.com - KM World Magazine

www.km-forum.org/ - The Knowledge Management Forum

www.cio.com/research/knowledge/ - CIO Magazine KM Research Center

Specific Readings on KM Sustainability:

Rich, E. (1998, July 20–23). Limits to groupware-facilitated organizational learning in a consulting firm. Paper presented at the *Proceedings of the Sixteenth International Conference of the System Dynamics Society,* Quebec City, Canada.

Rich, E., & Duchessi, P. (2004, January 5–8). Modeling the sustainability of knowledge management programs. Paper presented at the *Proceedings of the Hawai'i International Conference on System Sciences,* Big Island, HI.

Chapter 1.10
Knowledge Transfer

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INTRODUCTION

The term knowledge transfer (KT) is often used in a generic sense to include any exchange of knowledge between or among individuals, teams, groups, or organizations, whether intended or unintended.

However, knowledge transfer, as it has been formally studied, reflects intended unidirectional exchange, as when an enterprise resource planning (ERP) systems consultant transfers implementation knowledge to a potential user of a system, or when a franchiser's training team transfers knowledge about how to operate a franchise to a franchisee's team. Such knowledge transfers are between a clearly defined source and a recipient, have a focus, and have a clearly identified objective.

Although this unidirectional, focused, objective-oriented view is widely held among those who have a professional or academic interest in the KT process, there are different schools of thought concerning exactly when transfer can be said to have taken place between a source and a recipient. Some adopt the view that knowledge must both be communicated and applied before it has been transferred; others take the view that if the recipient of knowledge has the capacity to apply it, transfer has occurred. Still, others assume that if it has been cognitively transferred (e.g., understood), it has been transferred. Each of these viewpoints appears to be useful in certain circumstances, so there is no universal agreement on which is best.

However, there is agreement that knowledge transfer is different from knowledge sharing, which may be an unfocused exchange among individuals or groups who have little intention to send or receive knowledge (see article titled "Knowledge Sharing" in this encyclopedia). Of course, knowledge sharing may also have a focus as when persons engage in a brainstorming group session in order to generate new ideas or enhance creativity.

Perhaps the best way to conceptualize knowledge transfer and knowledge sharing is that they are at two ends of a spectrum. The knowledge transfer end is formalized, with a clearly defined purpose, and is unidirectional. The knowledge-sharing end is multidirectional, informal, and has no clear objective and few rules. Between these extremes lies a wide range of possible combinations involving individuals, teams, groups, organizational units, and organizations. Different people may use different terminology to describe these possible situations, but the end points are well grounded in theory and in practice.

BACKGROUND

Knowledge that is transferred may be either tacit, explicit, or a combination of both (Nonaka, 1994). When a master craftsman works to develop the skill and knowledge of an apprentice, he is transferring tacit knowledge. When a physician highlights a finding in a medical research paper and sends it to an associate, she is transferring explicit knowledge. When an ERP consultant shows a potential system user how to use tools and tables to implement a system, he or she is transferring a combination of tacit and explicit knowledge.

Knowledge transfer is very important because without it, every problem-solving approach or operating skill would have to be reinvented each time that the knowledge is needed. Indeed, it may not be overstating the case to say that knowledge transfer is a fundamental process of civilization. Certainly, it is a focus of learning, which is critical to all advancement.

As treated here, knowledge transfer is the communication of knowledge from a source so that it is learned and applied by a recipient (Argote, 1999; Darr & Kurtzberg, 2000). The source and recipient may be individuals, groups, teams, organizational units, or entire organizations in any combination.

Knowledge is usually defined as a justified belief that increases an individual's capacity to take effective action (Alavi & Leidner, 2001). Explicit knowledge is transmittable in formal, systematic language. Tacit knowledge "dwells in a comprehensive cognizance of the human mind and body" (Nonaka, 1994).

One of the central tenets of KT relates to the ease of transfer across individuals, groups, and organizations. Codified knowledge may be transferred in the form of documents and manuals. When the codified knowledge is of the know-what (concerning the state of the world) variety, the passage of the materials may complete the transfer. However, when the codified knowledge is of the know-how (competence) variety, complementary discussion or practice involving both the source's and recipient's tacit knowledge is often necessary to complete the transfer (Edmondson, Pisano, Bohmer, & Winslow, 2003).

When the knowledge to be transferred is tacit, the proximity of the source and recipient and their interpersonal interactions influence the likelihood of successful KT. Some tacit knowledge may be verbalized, explicated, codified, and communicated to others. This is an important mechanism of knowledge transfer, although many other processes are valid and useful as well. Some tacit knowledge may not be transferable, or at least will require demonstrations by the source and practice by the receiver.

Commercial knowledge, which may be either explicit or tacit, "... is not truth, but effective performance; not right, but 'what works' or even 'what works better'" (Demarest, 1997). Commercial knowledge is an important focus of practical knowledge transfer in organizations. It is exemplified by the implementation knowledge—sets of rules, tools, guidelines, and ways to effectively employ them—that is conveyed by a consultant who is aiding a client in implementing or customizing a complex information system in the client's organization. For instance, in this context, consultants may transfer knowledge about testing procedures to clients who learn and apply this knowledge as evidenced by the clients developing test scripts, conducting tests of individual modules, and running integration tests to ascertain whether data are correctly passed between modules.

ISSUES IN KNOWLEDGE TRANSFER

The best way to measure KT has not been uniquely determined. First, there are the conceptual issues, noted earlier, concerning when transfer shall be deemed to have taken place. Whichever definition is adopted, transfer is usually measured through surrogates. For instance, Szulanski (1996) measures "stickiness": the difficulty in transferring knowledge in an organization. A few studies (e.g., Ko, Kirsch, & King, 2005) have used direct measures for specific contexts, for instance, by observing a recipient's ability to perform tasks that are related to the objectives of the transfer. However, most studies have not used behavioral measures of successful KT.

A major issue in knowledge transfer has to do with the antecedents, or determinants, of effective KT. In other words, what factors most importantly influence successful knowledge transfer?

Argote (1999) depicts four categories of antecedents for knowledge transfer between organizations: characteristics of the relationships among organizations, characteristics of the knowledge transferred, characteristics of the organizations, and characteristics of the transfer process. After examining a number of such factors, Szulanski (1996) identified two categories of antecedent factors: knowledge barriers and motivational barriers to the transfer of best practices between sets of individuals in an organization. Ko et al. (2005) added communications factors because such factors have been found to be important in KT in information systems implementation processes (Hartwick & Barki, 2001).

Knowledge-Related Factors

An arduous relationship, causal ambiguity, shared understanding, knowledge observability, and absorptive capacity are widely believed to be important knowledge-related antecedent factors for successful KT. These factors are related to the source's and/or recipient's knowledge base or ability to acquire knowledge when it is needed, as well as to their knowledge relationship. An arduous relationship refers to the quality of the relationship between the source and recipient. Successful transfer usually requires many interactions for the knowledge to be successfully transferred. An arduous relationship, one that is emotionally laborious and distant, is likely to adversely influence knowledge transfer (Faraj & Sproull, 2000).

Causal ambiguity refers to "ambiguity about what the factors of production are and how they interact during production" (Szulanski, 1996, p. 30). Taken literally, this refers to the production of goods, but it may also apply to the production of knowledge. Although this interpretation is untested, it is not unreasonable to posit that if the source and recipient understand how knowledge has been produced and to what it relates, this relative absence of ambiguity might facilitate transfer.

Shared understanding represents the extent to which a source's and recipient's work values, norms, philosophies, problem-solving approaches, and prior work experience are similar. Studies suggest that having similar heuristics and similar shared experiences are important to knowledge transfer (Hansen, Nohria, & Tierney, 1999). Without shared understanding, there is a tendency for the source and recipient to disagree, which leads to poor outcomes. Shared understanding probably removes barriers to understanding and acceptance between the two parties and enhances their ability to work toward a common goal.

Knowledge observability leads to more effective transfer. Knowledge observability is "how easy it is to understand the activity by looking at and examining different aspects of the process or final product" (Zander, 1991, p. 47). The basic premise underlying this concept is that knowledge may be a sticky asset, making it difficult to transfer (Szulanski, 1996). Knowledge observability makes knowledge less sticky, which should enable better transfer (Birkinshaw, Frost, & Ensign, 2002).

Absorptive capacity is the ability of a recipient to recognize the value of the source's knowledge, assimilate it, and apply it. This capacity is largely a function of the recipient's existing stock of knowledge prior to the transfer, which enables a recipient to value, assimilate, and apply new knowledge successfully (Galbraith, 1990).

Motivational Factors

Factors such as a lack of incentives, a lack of confidence, "turf protection," and the "not-invented-here" syndrome are considered to be motivational factors that may influence knowledge transfer. Not all of these have been extensively studied, but motivation in general has been shown to be a positive factor in transfer. For instance, in a technological transfer context, knowledge-acquiring firms were found to accelerate the speed of KT when other companies were perceived to be developing similar products (Zander & Kogut, 1995).

For practical purposes, it is useful to distinguish between intrinsic and extrinsic motivation. Intrinsic motivation exists when the activity "... is valued for its own sake and appears to be self-sustained" (Calder & Shaw, 1975, p. 599). In contrast, extrinsic motivation comes from external sources. Intrinsic motivation in an organizational setting can be influenced by appropriate personnel selection. Extrinsic motivation can, on the other hand, be influenced by specific rewards for transferring knowledge, the inclusion of knowledge transfer as an element of personnel evaluations, and other explicit forms of reward or recognition.

A best-practices repository is a good illustration. Technically, this involves knowledge sharing since one person or unit contributes a practice to be shared by initially unidentified others. However, once a best practice has been identified by a potential user, the source is typically contacted with questions and requests for complementary tacit knowledge. At that point, it becomes a KT process. In such instances, it has been found that careful screening of the ideas that are submitted provide the best results. Many firms have a committee that carefully evaluates each best-practice submission. Only those that are the best of the best actually get put into the repository. The submitter's name is prominently displayed on the best practice, thereby conferring status on those whose ideas have passed this rigorous test. Similar recognition is given to those who make significant contributions to the well-known open-source Linux software (Lee & Cole, 2003).

Communications Factors

The information systems literature has identified various communications factors as impediments to successful system implementation (e.g., Hartwick & Barki, 2001). Among the most important are source credibility and communications competence.

Source credibility is a communications factor that reflects the extent to which a recipient perceives a source to be trustworthy and an expert (Grewal, Gotlieb, & Brown, 1994). When source credibility is high, the knowledge presented is perceived to be useful, thereby facilitating transfer. When source credibility is low, recipients tend to be less-readily persuaded and may heavily discount the value of the knowledge that is the focus of the intended transfer. The transfer of knowledge between departments in a firm has been found to be importantly influenced by the credibility of the source (Slaughter & Kirsch, 2000).

Communications competence is the ability to demonstrate the appropriate communications behavior in an organizational setting. Communications within a dyad requires both the encoding and decoding of messages. Encoding competence is the ability to clearly put ideas into words or symbols, have a good command of language, and be easily understood. A study of communications encoding competence suggests that subordinates form either positive or negative perceptions about their supervisor based on this ability (Berman & Hellweg, 1989).

Decoding competence refers to a recipient's ability to listen, be attentive, and respond quickly. This capability has also been shown to affect working relationships and to create opportunities to improve relationships.

Many studies have shown that communications competence is important for resolving conflicts, having effective teams, and providing opportunities to improve the quality of relationships; all of these outcomes are correlated with successful knowledge transfer.

FUTURE TRENDS

The KT source and recipient model appears to be a powerful analytic tool for many situations in which knowledge must be communicated and learned by someone who is less experienced and is less qualified than the source.

A major need that is beginning to be filled is for measures of successful knowledge transfer that incorporate the impact aspect of transfer whether it is cognitive or behavioral.

Some research results that are either widely accepted or recently developed are the following:

1. An arduous relationship between the source and recipient negatively affects KT (e.g., Szulanski, 1996).
2. Shared understanding between the source and recipients is particularly important to successful KT (Ko et al., 2005).
3. Absorptive capacity has long been believed to be important in influencing effective KT (e.g., Galbraith, 1990).
4. Knowledge observability is important to successful KT (e.g., Birkinshaw et al., 2002).
5. Intrinsic motivation may be more important than extrinsic motivation in KT.
6. Source credibility is important in KT, while the source's encoding competence may not be so important (e.g., Ko et al., 2005).

CONCLUSION

Knowledge transfer is done more efficiently when the knowledge to be transferred is relatively more explicit and relatively less tacit. Most organizations use structures and processes such as routines and standard procedures to codify as much of the knowledge that is to be transferred as is possible (Cohen & Bacdayan, 1994; March & Simon, 1958).

This is important because in the general situation of transferring knowledge, there is the assumption that meaning is universal and that the contexts of the sender and receiver are relatively homogeneous. In fact, the meaning that is given to knowledge is situational, cultural, and contextual. Thus, knowledge transfer should be more successful when these factors are similar for the sender and receiver. This is why the transfer of knowledge in complex systems implementation and in franchisee training is based on so many standard procedures, routines, and documented knowledge, and why individuals are chosen to offer and receive such training that come from the same backgrounds. For example, the trainers have invariably served in the operating capacities for which they are instructing the trainee.

Of course, some tacit knowledge cannot be explicated, so it can only be transferred through demonstrations, as in apprentice training. This is a very expensive and time- consuming process, so the goal in most organizational settings is to put knowledge that needs to be transferred into as explicit a form as is feasible.

Other practical guidelines involving successful knowledge transfer are the following: (largely derived from Ko et al., 2005).

1. It is important to create situations where the source and recipient can interact frequently, thereby nurturing their relationship and enhancing the flow of knowledge.
2. Individuals who have the least need for new knowledge should be selected to be the initial recipients of knowledge (because the recipient's absorptive capacity is so important for effective KT). This means that KT in a professional setting should not initially be viewed as training.
3. When widespread training is necessary, a two- stage strategy may be useful. First, have those with the least need (those that are already best qualified) take part in the KT process; then have them transfer knowledge to those that are more in need of the new knowledge.
4. Personnel with the highest level of intrinsic motivation should be assigned to KT; extrinsic rewards are not effective, except perhaps in the earliest stages of KT.
5. Consulting firms and others who are being evaluated as potential sources of knowledge should be required to commit to the use of specific individuals in the KT process since the abilities of the individuals' sources are critical.

REFERENCES

Alavi, M., & Leidner, D. (2001). Knowledge management systems: Issues, challenges, and benefits. *CAIS*, *1*(7), 2-36.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge*. Boston: Kluwer Academic Publishers.

Berman, S. J., & Hellweg, S. A. (1989). Perceived supervisor communication competence and supervisor satisfaction as a function of quality circle participation. *Journal of Business Communication*, *26*(2), 103-122.

Birkinshaw, J. M., Frost, T. S., & Ensign, P. C. (2002). Centers of excellence in multinational corporations. *Strategic Management Journal*, *23*(11), 997-1019.

Calder, B. J., & Shaw, B. M. (1975). Self-perception of intrinsic and extrinsic motivation. *Journal of Personality and Social Psychology*, *31*, 599-605.

Cohen, M. D., & Bacdayan, P. (1994). Organizational routines are stored as procedural memory: Evidence from a laboratory study. *Organization Science: A Journal of the Institute of Management Sciences*, *5*(4), 554-569.

Darr, E. D., & Kurtzberg, T. R. (2000). An investigation of partner similarity dimensions on knowledge transfer. *Organizational Behavior & Human Decision Processes*, *82*(1), 28-45.

Demarest, M. (1997). Understanding knowledge management. *Long Range Planning*, *30*(3), 374-385.

Edmondson, A., Pisano, G. P., Bohmer, R., & Winslow, A. (2003). Learning how and learning what: Effects of tacit and codified knowledge on performance improvement following technology adoption. *Decision Sciences*, *34*(2), 197-223.

Faraj, S., & Sproull, L. (2000). Coordinating expertise in software development teams. *Management Science*, *46*(12), 1554-1568.

Galbraith, C. S. (1990). Transferring core manufacturing technologies in high technology firms. *California Management Review*, *32*(4), 56-70.

Grewal, D., Gotlieb, J. B., & Brown, S. W. (1994). Consumer satisfaction and perceived quality: Complementary or divergent constructs? *Journal of Applied Psychology, 79*(6), 875-886.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Hartwick, J., & Barki, H. (2001). Interpersonal conflict and its management in information system development. *MIS Quarterly, 25*(2), 195-228.

Ko, D. G., Kirsch, L. J., & King, W. R. (2005). Antecedents of knowledge transfer from consultants to clients in enterprise system implementations. *Management Information Systems Quarterly, 29*(1), 59-85.

Lee, G. K., & Cole, R. E. (2003). From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organization Science: A Journal of the Institute of Management Sciences*, *14*(6), 633.

March, J. G., & Simon, H. A. (1958). *Organizations.* New York: John Wiley & Sons.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Slaughter, S., & Kirsch, L. J. (2000). *Transferring evaluative knowledge: The case of software metrics* (GSIA Working Paper No. 2000-08). Pittsburgh, PA: Carnegie Mellon University.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*, 27-43.

Zander, U. (1991). *Exploiting a technological edge: Voluntary and involuntary dissemination of technology*. Doctoral dissertation, Institute of International Business, Stockholm School of Economics, Stockholm, Sweden.

Zander, U., & Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organization Science: A Journal of the Institute of Management Sciences, 6*(1), 76-93.

Chapter 1.11
Knowledge Management

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Knowledge is an important organizational resource. Unlike other inert organizational resources, the application of existing knowledge has the potential to generate new knowledge. Not only can knowledge be replenished in use, it can also be combined and recombined to generate new knowledge. Once created, knowledge can be articulated, shared, stored, and re-contextualized to yield options for the future. For all of these reasons, knowledge has the potential to be applied across time and space to yield increasing returns (Garud & Kumaraswamy, 2005).

The strategic management of organizational knowledge is a key factor that can help organizations to sustain competitive advantage in volatile environments. Organizations are turning to knowledge management initiatives and technologies to leverage their knowledge resources. Knowledge management can be defined as a systemic and organizationally specified process for acquiring, organizing, and communicating knowledge of employees so that other employees may make use of it to be more effective and productive in their work (Kankanhalli, Tan, & Wei, 2005).

Knowledge management is also important in interorganizational relationships. Interorganizational relationships have been recognized to provide two distinct potential benefits: short-term operational efficiency and longer-term new knowledge creation. For example, the need for continual value innovation is driving supply chains to evolve from a pure transactional focus to leveraging interorganizational partnerships for sharing information and, ultimately, market knowledge creation. Supply chain partners are engaging in interlinked processes that enable rich (broad-ranging, high-quality, and privileged) information sharing, and building information technology infrastructures that allow them to process information obtained from their partners to create new knowledge (Malhotra, Gosain, & El Sawy, 2005).

CHARACTERISTICS OF KNOWLEDGE

Knowledge is a renewable, reusable, and accumulating resource of value to the organization when applied in the production of products and services. Knowledge cannot, as such, be stored in computers: it can only be stored in the human brain. Knowledge is what a knower knows; there is no knowledge without someone knowing it.

The need for a knower in knowledge existence raises the question as to how knowledge can exist outside the heads of individuals. Although knowledge cannot originate outside the heads of individuals, it can be argued that knowledge can be represented in and often embedded in organizational processes, routines, and networks, and sometimes in document repositories. However, knowledge is seldom complete outside of an individual.

In this book, knowledge is defined as information combined with experience, context, interpretation, reflection, intuition, and creativity. Information becomes knowledge once it is processed in the mind of an individual. This knowledge then becomes information again once it is articulated or communicated to others in the form of text, computer output, spoken or written words, or other means. Six characteristics of knowledge can distinguish it from information: knowledge is a human act, knowledge is the residue of thinking, knowledge is created in the present moment, knowledge belongs to communities, knowledge circulates through communities in many ways, and new knowledge is created at the boundaries of old. This definition and these characteristics of knowledge are based on current research (e.g., Poston & Speier, 2005; Ryu, Kim, Chaudhury, & Rao, 2005; Sambamurthy & Subramani, 2005; Tanriverdi, 2005; Wasko & Faraj, 2005).

Today, any discussion of knowledge quickly leads to the issue of how knowledge is defined. A pragmatic definition defines the topic as the most valuable form of content in a continuum starting at data, encompassing information, and ending at knowledge. Typically, data is classified, summarized, transferred, or corrected in order to add value, and become information within a certain context. This conversion is relatively mechanical and has long been facilitated by storage, processing, and communication technologies. These technologies add place, time, and form utility to the data. In doing so, the information serves to inform or reduce uncertainty within the problem domain. Therefore, information is united with the context, that is, it only has utility within the context (Grover & Davenport, 2001).

Knowledge has the highest value, the most human contribution, the greatest relevance to decisions and actions, and the greatest dependence on a specific situation or context. It is also the most difficult of content types to manage, because it originates and is applied in the minds of human beings. People who are knowledgeable not only have information, but also have the ability to integrate and frame the information within the context of their experience, expertise, and judgment. In doing so, they can create new information that expands the state of possibilities, and in turn allows for further interaction with experience, expertise, and judgment. Therefore, in an organizational context, all new knowledge stems from people. Some knowledge is incorporated in organizational artifacts like processes, structures, and technology. However, institutionalized knowledge often inhibits competition in a dynamic context, unless adaptability of people and processes (higher order learning) is built into the institutional mechanisms themselves.

Our concern with distinctions between information and knowledge is based on real differences as well as technology implications. Real differences between information and knowledge do exist, although for most practical purposes these differences are of no interest at all. Information technology implications are concerned with the argument that computers can only manipulate electronic information, not electronic knowledge.

Business systems are loaded with information, but without knowledge.

Davenport and Prusak (1998) define knowledge as a fluid mix of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories, but also in organizational routines, processes, practices, and norms. Distinctions are often made between data, information, knowledge, and wisdom:

- Data are letters and numbers without meaning. Data are independent, isolated measurements, characters, numerical characters, and symbols.
- Information is data that are included in a context that makes sense. For example, 40 degrees can have different meaning depending on the context. There can be a medical, geographical, or technical context. If a person has 40 degrees Celsius in fever, that is quite serious. If a city is located 40 degrees north, we know that it is far south of Norway. If an angle is 40 degrees, we know what it looks like. Information is data that make sense, because it can be understood correctly. People turn data into information by organizing it into some unit of analysis, for example, dollars, dates, or customers. Information is data endowed with relevance and purpose.
- Knowledge is information combined with experience, context, interpretation, and reflection. Knowledge is a renewable resource that can be used over and over, and that accumulates in an organization through use and combination with employees' experience. Humans have knowledge; knowledge cannot exist outside the heads of individuals in the company. Information becomes knowledge when it enters the human brain. This knowledge transforms into information again when it is articulated and communicated to others. Information is an explicit representation of knowledge; it is in itself no knowledge. Knowledge can both be truths and lies, perspectives and concepts, judgments and expectations. Knowledge is used to receive information by analyzing, understanding, and evaluating; by combining, prioritizing, and decision making; and by planning, implementing, and controlling.
- Wisdom is knowledge combined with learning, insights, and judgmental abilities. Wisdom is more difficult to explain than knowledge since the levels of context become even more personal and thus, the higher-level nature of wisdom renders it more obscure than knowledge. While knowledge is mainly sufficiently generalized solutions, wisdom is best thought of as sufficiently generalized approaches and values that can be applied in numerous and varied situations. Wisdom cannot be created like data and information, and it cannot be shared with others like knowledge. Because the context is so personal, it becomes almost exclusive to our own minds, and incompatible with the minds of others without extensive transaction. This transaction requires not only a base of knowledge and opportunities for experiences that help create wisdom, but also the processes of introspection, retrospection, interpretation, and contemplation. We can value wisdom in others, but we can only create it ourselves.

These are the definitions applied in this book. Grover and Davenport (2001) calls these definitions pragmatic, as a continuum is used, starting from data, encompassing information, and ending at knowledge in this book. The most valuable form of content in the continuum is knowledge. Knowledge has the highest value, the most human contribution, the greatest relevance to decisions and actions, and the greatest dependence on a specific situation or context. It is also the most difficult of content types to manage, because it originates and is applied in the minds of human beings.

It has been argued that expert systems using artificial intelligence are able to do knowledge work. The chess-playing computer called Deep Blue by IBM is frequently cited as an example. Deep Blue can compete with the best human players because chess, though complex, is a closed system of unchanging and codifiable rules. The size of the board never varies, the rules are unambiguous, the moves of the pieces are clearly defined, and there is absolute agreement about what it means to win or lose (Davenport & Prusak, 1998). Deep Blue is no knowledge worker; the computer only performs a series of computations at extremely high speed.

While knowledge workers develop knowledge, organizations learn. Therefore, the learning organization has become a term frequently used. The learning organization is similar to knowledge development. While knowledge development is taking place at the individual level, organizational learning is taking place at the firm level. Organizational learning occurs when the firm is able to exploit individual competence in new and innovative ways. Organizational learning also occurs when the collective memory—including local language, common history and routines—expands. Organizational learning causes growth in the intellectual capital. Learning is a continuous, never-ending process of knowledge creation. A learning organization is a place where people are constantly driven to discover what has caused the current situation, and how they can change the present. To maintain competitive advantage, an organization's investment decisions related to knowledge creation are likely to be strategic in nature (Chen & Edgington, 2005).

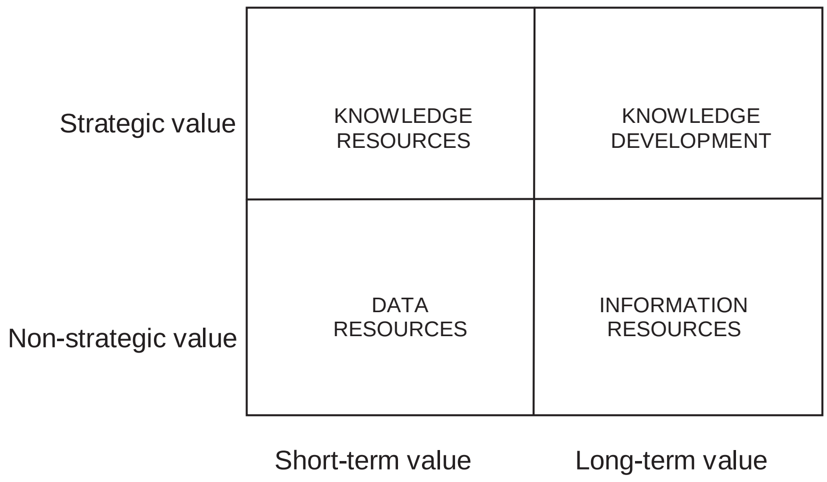
Alavi and Leidner (2001) make the case that the hierarchy of data-information-knowledge can be of a different nature. Specifically, they claim that knowledge can be the basis for information, rather than information the basis for knowledge. Knowledge must exist before information can be formulated and before data can be measured to form information. As such, raw data do not exist: the thought or knowledge processes that led to its identification and collection have already influenced even the most elementary piece of data. It is argued that knowledge exists that when articulated, verbalized, and structured, becomes information that when assigned a fixed representation and standard interpretation, becomes data (Alavi & Leidner, 2001, p. 109):

Critical to this argument is the fact that knowledge does not exist outside an agent (a knower): it is indelibly shaped by one's needs as well as one's initial stock of knowledge. Knowledge is thus the result of cognitive processing triggered by the inflow of new stimuli. Consistent with this view, we posit that information is converted to knowledge once it is processed in the mind of individuals and the knowledge becomes information once it is articulated and presented in the form of text, graphics, words, or other symbolic forms. A significant implication of this view of knowledge is that for individuals to arrive at the same understanding of data or information, they must share a certain knowledge base. Another important implication of this definition of knowledge is that systems designed to support knowledge in organizations may not appear radically different from other forms of information systems, but will be geared toward enabling users to assign meaning to information and to capture some of their knowledge in information and/or data.

KNOWLEDGE VALUE LEVEL

It is not difficult to agree with this reasoning. In fact, our hierarchy from data via information to knowledge is not so much a road or direction as

Figure 1. Value levels of resources in the organization



it is a way of suggesting resource value levels. Knowledge is a more valuable resource to the organization than information, and information is a more valuable resource than data. This is illustrated in Figure 1. The figure illustrates that it is less the knowledge existing at any given time, per se, than the organization's ability to effectively apply the existing knowledge to develop new knowledge, and to take action that forms the basis for achieving long-term competitive advantage from knowledge-based assets.

According to Grover and Davenport (2001), knowledge processes lie somewhere between information and the organization's source of revenue: its products and services. This process can be generically represented in three subprocesses: knowledge generation, knowledge codification, and knowledge transfer/realization. Knowledge generation includes all processes involved in the acquisition and development of knowledge. Knowledge codification involves the conversion of knowledge into accessible and applicable formats. Knowledge transfer includes the movement of knowledge from its point of generation or codified form to the point of use.

One of the reasons that knowledge is such a difficult concept is because this process is recursive, expanding, and often discontinuous. According to Grover and Davenport (2001), many cycles of generation, codification, and transfer are concurrently occurring in businesses. These cycles feed on each other. Knowledge interacts with information to increase the state space of possibilities, and provide new information that can then facilitate generation of new knowledge. The knowledge process acts on information to create new information that allows for greater possibilities to fulfill old or possibly new organizational needs. This process is often discontinuous, where new needs and their fulfillment mechanism could be created.

In our resource-based perspective of knowledge, data is raw numbers and facts, information is processed data, and knowledge is information combined with human thoughts. Knowledge is the result of cognitive processing triggered by the inflow of new stimuli. Information is converted to knowledge once it is processed in the mind of individuals, and the knowledge becomes information once it is articulated and presented to others. A significant implication of this view of knowledge is that for individuals to arrive at the same understanding of information, they must share the same knowledge framework.

In Figure 1, we can imagine that data are assigned meaning and become information, that information is understood and interpreted by individuals and becomes knowledge, and that knowledge is applied and develops into new knowledge. We can also imagine the opposite route. Knowledge develops in the minds of individuals. This knowledge development causes an increase in knowledge resources. When the new knowledge is articulated, verbalized, and structured, it becomes information and causes an increase in information resources. When information is assigned a fixed representation and standard interpretation, it becomes data and causes an increase in data resources.

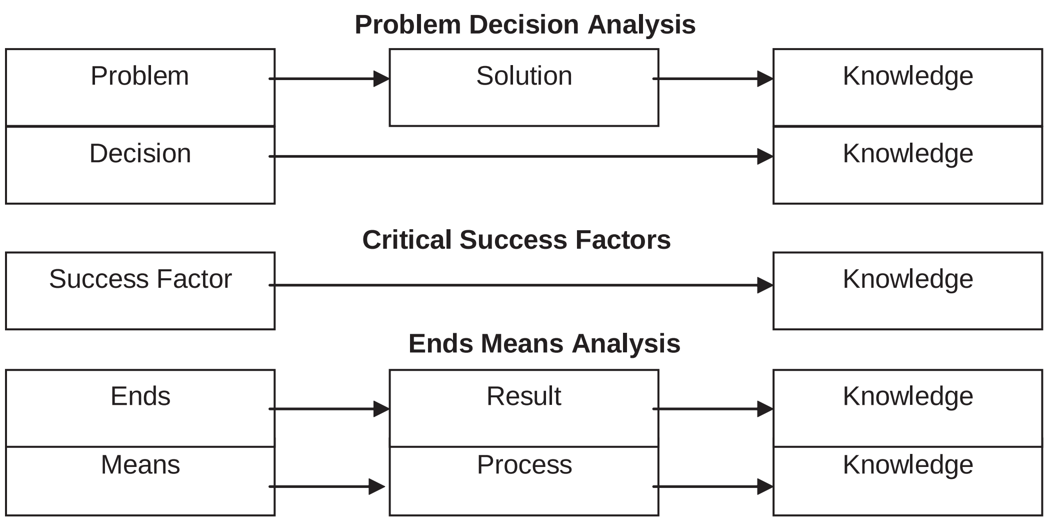
There are alternatives to our perspective of knowledge as a resource in the organization. Alavi and Leidner (2001) list the following alternatives: knowledge is state of mind, knowledge is an object to be stored, knowledge is a process of applying expertise, knowledge is a condition of access to information, and knowledge is the potential to influence action.

This book applies the resource-based theory of the organization, where the knowledge-based perspective identifies the primary role of the organization as integrating the specialist knowledge resident in individuals into goods and services. The task of management is to establish the coordination necessary for this knowledge integration. The knowledge-based perspective serves as a platform for a view of the organization as a dynamic system of knowledge production and application.

IDENTIFICATION OF KNOWLEDGE NEEDS

To classify knowledge as a resource, there has to be a need for that knowledge. Hence, identification of knowledge needs in an organization is important. Three supplementary methods exist

Figure 2. Methods to identify knowledge needs



to identify needs for knowledge, as illustrated in Figure 2:

- Problem decision analysis. This method aims at identifying and specifying problems that knowledge workers have, solutions they can find, decisions they have to make, and what knowledge they need to solve problems and make decisions. For a lawyer, the problem can be an insurance claim by a client, the decision can be how to approach the insurance company, and the knowledge need can be outcomes of similar cases handled by the law firm.
- Critical success factors. This method aims at identifying and specifying what factors cause success. Success can be at firm level, individual level, or individual case level. For a lawyer, critical success factors at the individual case level can be quality of legal advice and service level of advice delivery. Critical knowledge in this case includes legal knowledge as well as procedural knowledge.
- Ends means analysis. This method aims at identifying and specifying external demands and expectations to goods and services from the firm. For a lawyer, the client expectation might be that she or he wins the case. The end is winning the case. Knowledge needs associated with winning a case includes legal, procedural, and analytical knowledge of successful cases in the past. The means for winning a case might be access to resources of various kinds, such as client documents and client funds. Knowledge needs associated with means include historical records and analysis of legal client practice.

KNOWLEDGE CATEGORIES

Many researchers have tried to define categories and dimensions of knowledge. A common distinction is made between explicit and tacit knowledge. Explicit knowledge can be expressed in words and numbers and shared in the form of data, scientific formulae, specifications, manuals, and the like. This kind of knowledge can be readily transmitted between individuals, both formally and systematically. Tacit knowledge is, on the other hand, highly personal and hard to formalize, making it difficult to communicate or share with others. Subjective insights, intuitions, and hunches fall into this category of knowledge. Tacit knowledge is deeply rooted in an individual's actions and experience as well as in the ideals, values, or emotions he or she embraces. Tacit knowledge is embedded in the human brain and cannot be expressed easily, while explicit knowledge can be easily codified. Both types of knowledge are important, but Western firms have focused largely on managing explicit knowledge (Grover & Davenport, 2001).

Tacitness may be considered as a variable, with the degree of tacitness being a function of the extent to which the knowledge is or can be codified and abstracted. Knowledge may dynamically shift between tacit and explicit over time, although some knowledge always will remain tacit. Nonaka et al. (Nonaka, Toyama, & Konno, 2000) have suggested that knowledge creation is a spiraling process of interactions between explicit and tacit knowledge. This spiraling process consists of socialization, externalization, combination, and internalization, as we will see later in this chapter.

The concept of tacit knowledge corresponds closely to the concept of knowledge with a low level of codification. Codification is the degree to which knowledge is fully documented or expressed in writing at the time of transfer between two persons. The complexity of knowledge increases with lower levels of codification. A similar distinction, which scholars frequently make, is between practical, experience-based knowledge and the theoretical knowledge derived from reflection and abstraction from that experience.

A distinction is sometimes made between codification and personalization. This distinction is related to the tacit vs. explicit concept. It involves an organization's approach to knowledge transfer. Companies using codification approaches rely primarily on repositories of explicit knowledge. Personalization approaches imply that the primary mode of knowledge transfer is direct interaction among people. Both are necessary in most organizations, but an increased focus on one approach or the other at any given time within a specific organization may be appropriate (Grover & Davenport, 2001).

Explicit knowledge is sometimes called articulable knowledge (Hitt, Bierman, Shumizu, & Kochhar, 2001). Articulable knowledge can be codified, and thus can be written and easily transferred. Tacit knowledge is not articulable, and therefore cannot be easily transferred. Tacit knowledge is often embedded in uncodified routines and in a firm's social context. More specifically, it is partially embedded in individual skills and partially embedded in collaborative working relationships within the firm. Tacit knowledge is integral to professional skills. As a result, tacit knowledge is often unique, difficult to imitate, and uncertain. It has a higher probability of creating strategic value than articulable knowledge.

Distinctions can be made between core, advanced, and innovative knowledge. These knowledge categories indicate different levels of knowledge sophistication. Core knowledge is that minimum scope and level of knowledge required for daily operations, while advanced knowledge enables a firm to be competitively viable, and innovative knowledge is the knowledge that enables the firm to lead its industry and competitors:

- Core knowledge is the basic knowledge required to stay in business. This is the type of knowledge that can create efficiency barriers for entry of new companies, as new competitors are not up to speed in basic business processes. Since core knowledge is present at all existing competitors the firm must have this knowledge, even though it will provide the firm with no advantage that distinguishes it from its competitors. Core knowledge is that minimum scope and level of knowledge required just to play the game. Having that level of knowledge and capability will not assure the long-term competitive viability of the firm, but does present a basic industry knowledge barrier to entry. Core knowledge tends to be commonly held by members of an industry and therefore, provides little advantage other than over nonmembers (Zack, 1999).

In a law firm, examples of core knowledge include knowledge of the law, knowledge of the courts, knowledge of clients, and knowledge of procedures. For a student in the business school, core knowledge includes knowledge of what subjects to study this term and where the lectures take place.

According to Tiwana (2002), core knowledge is the basic level of knowledge required just to play the game. This is the type of knowledge that creates a barrier for entry of new companies. Since this level of knowledge is expected of all competitors, you must have it, even though it will provide your company with no advantage that distinguishes it from its competitors. Let us take two examples: One from the consumer electronics (hard product) business and one from Internet programming (soft product). To enter the modem manufacturing market, a new company must have extensive knowledge of these aspects: a suitable circuit design, all electronic parts that go into a modem, fabricating surface mount (SMD) chip boards, how to write operating system drivers for modems, and familiarity with computer telephony standards. Similarly, a company developing Web sites for, say, florists, needs server hosting capabilities, Internet programming skills, graphic design skills, clearly identified target markets, and necessary software. In either case, just about any competitor in those businesses is assumed to have this knowledge in order to compete in their respective markets; such essential knowledge, therefore, provides no advantage over other market players.

- Advanced knowledge is what makes the firm competitively visible and active. Such knowledge allows the firm to differentiate its products and services from that of a competitor through the application of superior knowledge in certain areas. Such knowledge allows the firm to compete head on with its competitors in the same market and for the same set of customers. Advanced knowledge enables a firm to be competitively viable. The firm may have generally the same level, scope, or quality of knowledge as its competitors, although the specific knowledge content will often vary among competitors, enabling knowledge differentiation. Firms may choose to compete on knowledge head-on in the same strategic position, hoping to know more than a competitor. They instead may choose to compete for that position by differentiating their knowledge (Zack, 1999).

In a law firm, examples of advanced knowledge include knowledge of law applications, knowledge of important court rulings, and knowledge of successful procedural case handling. For a student in the business school, advanced knowledge includes knowledge of important articles and books that are compulsory literature in subjects this term.

According to Tiwana (2002), advanced knowledge is what makes your company competitively viable. Such knowledge allows your company to differentiate its product from that of a competitor, arguably, through the application of superior knowledge in certain areas. Such knowledge allows your company to compete head on with its competitors in the same market and for the same set of customers. In the case of a company trying to compete in modem manufacturing markets, superior or user-friendly software or an additional capability in modems (such as warning online users of incoming telephone calls) represents such knowledge. In case of a Web site development firm, such knowledge might be about international flower markets and collaborative relationships in Dutch flower auctions that the company can use to improve Web sites delivered to its customers.

- Innovative knowledge allows a firm to lead its entire industry to an extent that clearly differentiates it from competition. Such knowledge allows a firm to change the rules of the game by introducing new business practices. Such knowledge enables a firm to expand its market share by winning new customers, and by increasing service levels to existing customers. Innovative knowledge is that knowledge that enables a firm to lead its industry and competitors, and to significantly differentiate itself from its competitors. Innovative knowledge often enables a firm to change the rules of the game itself (Zack, 1999).

In a law firm, examples of innovative knowledge include knowledge of standardizing repetitive legal cases, knowledge of successful settlements, and knowledge of modern information technology to track and store vast amounts of information from various sources. For a student in the business school, innovative knowledge includes knowledge of important topics within subjects, links between subjects, typical exam questions, and knowledge of business cases where theory can be applied.

According to Tiwana (2002), innovative knowledge allows a company to lead its entire industry to an extent that clearly differentiates it from competition. Innovative knowledge allows a company to change the rules of the game. Patented technology is an applicable example of changing the rules. Innovative knowledge cannot always be protected by patents, as the lawsuit between Microsoft and Apple in the 1980s should serve to remind us. Apple sued Microsoft for copying the look and feel of its graphical user interface (GUI). The Supreme Court ruled that things like look and feel cannot be patented; they can only be copyrighted. Microsoft won the case since it copied the look and feel, but used entirely different code to create it in the first place.

Many more categories and dimensions of knowledge have been suggested by researchers. The problem with most of these classifications is that they do not seem to satisfy three important criteria for classification. The first requirement is that a classification should always be complete, there should be no category missing. The second requirement is that each category should be different from all other categories, that is, there should be no overlap between categories. The final requirement is that each category should be at the same level, there should be no category including another category. Consider the following categories suggested by researchers: formal knowledge, instrumental knowledge, informal knowledge, tacit knowledge, metaknowledge, and context-independent knowledge. These categories seem to violate some of the classification rules. For example, there seems to be an overlap between informal knowledge and tacit knowledge. Maybe Long and Fahey's (2000) classification into human knowledge, social knowledge, and structured knowledge satisfy our requirements:

- Human knowledge. This constitutes the know-what, know-how, and know-why of individuals. Human knowledge is manifested in individual skills (e.g., how to interview law firm clients) or expertise (e.g., why this case is similar to a previous case). Individual knowledge usually combines explicit and tacit knowledge. This type of knowledge may be located in the body, such as knowing how to type touch on a PC or how to ride a bicycle. This type of knowledge may be cognitive, that is, largely conceptual and abstract.
- Social knowledge. This kind of knowledge exists only in relationships between individuals or within groups. For example, high-performing teams of tax lawyers share certain collective knowledge that is more than the sum of the individual knowledge of the team's members. Social or collective knowledge is mainly tacit knowledge, shared by team members, and develops only as a result of team members working together. Its presence is reflected by an ability to collaborate effectively.
- Structured knowledge. This is embedded in an organization's systems, processes, tools, routines, and practices. Knowledge in this form is explicit and often rule based. A key distinction between structured knowledge and the first two types of knowledge is that structured knowledge is assumed to exist independently of individual knowers. It is, instead, an organizational resource. However, to be complete, this knowledge has to be in the heads of individuals.

Two dimensions have been introduced to classify knowledge. The first dimension is concerned with whether an individual knows. The second dimension is concerned with whether an individual knows whether he or she knows. This is illustrated in Figure 3. I can either have the knowledge (I do know) or not have the knowledge (I do not know). I can either be aware of it (I know it) or not be aware of it (I do not know it).

Some researchers have argued that the real tacit knowledge is found in the right upper quadrant. In this dimension, I do know, but I do not know that I know. Tacit knowledge in this sense is also called hidden knowledge or nonaccessible knowledge. In this book, we do not use this extremely

Figure 3. Dimensions of individual knowledge

I do know	I know that I know	I don't know that I know
I don't know	I know that I don't know	I don't know that I don't know

limited definition of tacit knowledge. We define tacit knowledge as personal and difficult, but not impossible to communicate.

Classification of knowledge into categories and dimensions may depend on industry. For example, there are likely to be different knowledge categories in a bank compared to a law firm. At the same time, there will be certain generic knowledge categories such as market intelligence and technology understanding in most companies, independently of industry. When classifying knowledge in a firm, it is important to do the analysis without the organization chart. If you classify knowledge into technology knowledge, production knowledge, marketing knowledge, and financial knowledge, it may be because the firm, according to the organization chart, consists of a development department, production department, marketing department, and financial department. It might be more useful to introduce new knowledge categories, such as product knowledge, that include knowledge of development, production, marketing, and finance. By identifying cross-sectional knowledge categories and dimensions, solutions for improved knowledge flows in the organization will emerge.

A law firm is a good example. A law firm is organized according to legal disciplines. Some lawyers work in the tax department, while others work in the department for mergers and acquisitions. The types of knowledge involved in the practice of law can be categorized as administrative, declarative, procedural, and analytical knowledge (Edwards & Mahling, 1997):

- Administrative knowledge, which includes all the nuts and bolts information about firm operations, such as hourly billing rates for lawyers, client names and matters, staff payroll data, and client invoice data.
- Declarative knowledge, which is knowledge of the law, the legal principles contained in statutes, court opinions, and other sources of primary legal authority; law students spend most of their law school time acquiring this kind of knowledge.
- Procedural knowledge, which involves knowledge of the mechanisms of complying

with the law's requirements in a particular situation: how documents are used to transfer an asset from Company A to Company B, or how forms must be filed where to create a new corporation. Declarative knowledge is sometimes labeled know-that and know-what, while procedural knowledge is labeled know-how.

- Analytical knowledge, which pertains to the conclusions reached about the course of action a particular client, should follow in a particular situation. Analytical knowledge results, in essence, from analyzing declarative knowledge (i.e., substantive law principles) as it applies to a particular fact setting.

Classification of knowledge into categories and dimensions has important limitations. For example, the classification into explicit and tacit knowledge may create static views of knowledge. However, knowledge development and sharing are dynamic processes, and these dynamic processes cause tacit knowledge to become explicit, and explicit knowledge to become tacit over time. Tacit and explicit knowledge depend on each other, and they influence each other. In this perspective, Alavi and Leidner (2001) argue that whether tacit or explicit knowledge is the more valuable may indeed miss the point. The two knowledge categories are not dichotomous states of knowledge, but mutually dependent and reinforcing qualities of knowledge: tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge.

According to Alavi and Leidner (2001), the linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge are able to exchange knowledge. They suggest the existence of a share knowledge space that is required in order for individual A to understand individual B's knowledge. The knowledge space is the underlying overlap in knowledge base of A and B. This overlap is typically tacit knowledge. It may be argued that the greater the shared knowledge space, the less the context needed for individuals to share knowledge within the group and, hence, the higher the value of explicit knowledge. For example in a law firm, lawyers in the maritime law department may have a large knowledge space so that even a very limited piece of explicit knowledge can be of great value to the lawyers. Alavi and Leidner (2001, p. 112) discuss knowledge space in the following way:

Whether tacit or explicit knowledge is the more valuable may indeed miss the point. The two are not dichotomous states of knowledge, but mutually dependent and reinforcing qualities of knowledge: tacit knowledge forms the background necessary for assigning the structure to develop and interpret explicit knowledge. The inextricable linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge can truly exchange knowledge: if tacit knowledge is necessary to the understanding of explicit knowledge, then in order for Individual B to understand Individual A's knowledge, there must be some overlap in their underlying knowledge bases (a shared knowledge space). However, it is precisely in applying technology to increase 'weak ties' in organizations, and thereby increase the breadth of knowledge sharing, that IT holds promise. Yet, absent a shared knowledge space, the real impact of IT on knowledge exchange is questionable. This is a paradox that IT researchers have somewhat eschewed, and that organizational researchers have used to question the application of IT to knowledge management. To add to the paradox, the very essence of the knowledge management challenge is to amalgamate knowledge across groups for which IT can play a major role. What is most at issue is the amount of contextual information necessary for one person or group's knowledge to be readily understood by another.

It may be argued that the greater the shared knowledge space, the less the context needed for individuals to share knowledge within the group and, hence, the higher the value of explicit knowledge and the greater the value of IT applied to knowledge management. On the other hand, the smaller the existing shared knowledge space in a group, the greater the need for contextual information, the less relevant will be explicit knowledge, and hence the less applicable will be IT to knowledge management.

Some researchers are interested in the total knowledge within a company, while others are interested in individual knowledge. Dixon (2000) was interested in the knowledge that knowledge workers develop together in the organization. Employees gain this knowledge from doing the organization's tasks. This knowledge is called common knowledge, to differentiate it from book knowledge or lists of regulations or databases of customer information. Some examples of common knowledge are what medical doctors in a hospital have learned about how to carry out certain kinds of surgery, what an organization has learned about how to introduce a new drug into the diabetes market, how to reduce cost on consulting projects, and how to control the amount of analysis in maritime law cases. These examples all include the how-to rather than the know-what of school learning. Moreover, it is know-how that is unique to a specific company. In the law firm example, procedural knowledge was classified as know-how.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Chen, A. N. K., & Edgington, T. M. (2005). Assessing value in organizational knowledge creation: Considerations for knowledge workers. *MIS Quarterly*, *29*(2), 279-309.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Dixon, N. M. (2000). *Common knowledge*. Boston: Harvard Business School Press.

Edwards, D. L., & Mahling, D. E. (1997). Toward knowledge management systems in the legal domain. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work Group* (pp. 158-166). The Association of Computing Machinery ACM.

Garud, R., & Kumaraswamy. A. (2005). Vicious and virtuous circles in the management of knowledge: The case of Infosys technologies. *MIS Quarterly*, *29*(1), 9-33.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems*, *18*(1), 5-21.

Hitt, M. A., Bierman, L., Shumizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Academy of Management Journal, 44*(1), 13-28.

Kankanhalli, A., Tan, B. C. Y., & Wei, K. K. (2005). Contributing knowledge to electronic knowledge repositories: An empirical investigation. *MIS Quarterly*, *29*(1), 113-143.

Long, D. W., & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *Academy of Management Executive, 14*(4), 113-127.

Malhotra, A., Gosain, S., & El Sawy, O. A. (2005). Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation. *MIS Quarterly, 29*(1), 145-187.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, Ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34.

Poston, R. S., & Speier, C. (2005). Effective use of knowledge management systems: A process model of content ratings and credibility indicators. *MIS Quarterly, 29*(2), 221-244.

Ryu, C., Kim, Y. J., Chaudhury, A., & Rao, H. R. (2005). Knowledge acquisition via three learning processes in enterprise information portals: Learning-by-investment, learning-by-doing, and learning-from-others. *MIS Quarterly, 29*(2), 245-278.

Sambamurthy, V., & Subramani, M. (2005). Special issue on information technologies and knowledge management. *MIS Quarterly, 29*(1), 1-7; and 29(2), 193-195.

Tanriverdi, H. (2005). Information technology relatedness, knowledge management capability, and performance of multibusiness firms. *MIS Quarterly, 29*(2), 311-334.

Tiwana, A. (2002). *The knowledge management toolkit—practical techniques for building a knowledge management system* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly, 29*(1), 35-57.

Zack, M. H. (1999). Developing a knowledge strategy. *California Management Review, 41*(3), 125-145.

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Chapter 1.12
Enhancing Performance Through Knowledge Management:
A Holistic Framework

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ABSTRACT

Knowledge management (KM) has gained increasing attention since the mid-1990s. A KM strategy involves consciously helping people share and put knowledge into action. However, before an organization can realize the promise of KM, a fundamental question needs to be asked: What performance goal(s) is the organization trying to achieve? In this paper, we develop and offer a framework that provides a holistic view of the performance environment surrounding organizational knowledge work. We illustrate the KM framework using two organizational case studies. Then, based on the KM framework and further insights drawn from our case studies, we offer a series of steps that may guide and assist organizations and practitioners as they undertake KM initiatives. We further demonstrate the applicability of these steps by examining KM initiatives within a global software development company. We conclude with a discussion of implications for organizational practice and directions for future research.

INTRODUCTION

Knowledge management (KM) is a topic that has gained increasing attention since the mid-1990s. Knowledge about customers, products, processes, past successes, and failures are assets that may produce long-term sustainable competitive advantage for organizations (Huber, 2001;

Leonard & Sensiper, 1998; Stewart, 2001). KM proponents argue that these assets are as important as managing other organizational assets like labor and capital. A survey conducted by Knowledge Management magazine and the International Data Corporation suggests that KM is evolving from a discrete undertaking to a strategic component of business solutions (Dyer & McDonough, 2001).

A KM strategy entails consciously helping people share and put knowledge into action by creating access, context, and infrastructure, and by simultaneously shortening learning cycles (Alavi & Leidner, 2001; Davenport, DeLong & Beers, 1998; Davenport & Prusak, 1998; O'Dell & Grayson, 1998). It takes place within a complex system of organizational structure and culture and is often enabled through information technology (IT) (Alavi, 2000; Alavi & Leidner, 2001). While technology drove the initial interest in KM, both academics and practitioners have begun to realize that effective KM initiatives and solutions will be based on a more holistic view of the knowledge work environment (Grover & Davenport, 2001; Holsapple & Joshi, 2002; Massey & Montoya-Weiss, 2002; Rubenstein-Montano et al., 2001). Specifically, before an organization can realize the promise of KM, a fundamental question needs to be asked: What performance goal(s) is the organization trying to achieve? Addressing this question will direct the organization to what knowledge should be managed and how it should be managed.

Improving customer service, shortening product development cycles, growing revenues, and improving profits are commonly cited as goals motivating KM initiatives. If the intent of a KM initiative is to enhance organizational performance, organizations first need to understand the performance environment surrounding and driving the underlying knowledge work. For example, improving customer service and shortening product development cycles require that firms look to their processes, which may be reengineered to capitalize on or to expand organizational knowledge resources and capabilities (Gold, Malhotra, & Segars, 2001; Hammer & Champy, 1993; Maier & Remus, 2001). Generating performance improvements via a KM initiative thus requires a deep understanding of how process work is organized, what knowledge is inherent to and derived from it, what factors influence knowledge workers, and how all of these factors relate to an organization's business environment (Massey & Montoya-Weiss, 2002).

In this paper, we offer a framework that provides a holistic view of the performance environment surrounding organizational knowledge work. The framework provides a useful means to identify, define, analyze, and address knowledge-based problems or opportunities relative to multi-level (business, process, and knowledge-worker) performance goals and requirements. Our perspective responds to a current call in the literature for KM frameworks that take a holistic, systems-oriented perspective by considering problems and opportunities in their entirety (Rubenstein-Montano et al., 2001; Senge, 1990). We draw from and integrate literature concerned with approaches to dealing with complexity and purposeful (i.e., performance-oriented) systems (Checkland & Howell, 1998), business process reengineering (Hammer & Champy, 1993), and human performance (Stolovich & Keeps, 1999). Rather than suggesting that KM requires a whole new perspective with its own special laws, our framework purports that KM sits well within our current understanding of what drives performance (Soo, Devinney, Midgley, & Deering, 2002).

We illustrate the efficacy of our framework to KM using case studies conducted at IBM and Nortel Networks. In addition, based on the framework and the insights we drew from our case studies, we offer a series of steps that can help direct organizations as they undertake KM initiatives. Finally, we illustrate the generalizability of these steps by demonstrating them in context of the software development process, using insights gained from a study with a software development firm. We conclude our paper with a discussion of broader implications for organizational practice and directions for future research.

BACKGROUND AND MOTIVATION

The general goal of KM is to capitalize on knowledge assets in order to achieve maximum attainable business performance (Barney, 1991; Becerra-Fernandez & Sabherwal, 2001; Davenport & Prusak, 1998). Organizations are faced with two key questions: What should an organization consider before undertaking a KM initiative? and How can KM become a strategic asset?

In a review of existing KM frameworks, Rubenstein-Montano and colleagues (2001) suggest that most frameworks to date have been prescriptive and focused primarily on knowledge flows. As such, they do not provide a comprehensive, holistic approach to integrate KM practices with strategic goals of the organization to realize potential for improving performance. Moreover, they do not consider non-task-oriented aspects that ultimately influence knowledge workers as they carry out business process activities. A further review of the literature suggests that KM has considered a broad array of issues and approaches, addressing things such as capturing and sharing best practices, building databases and intranets, measuring intellectual, establishing corporate libraries, installing groupware, enacting cultural change, and fostering collaboration (Ackerman, Pipek, & Wulf, 2003; Alavi & Leidner, 1999, 2001; Fahey & Prusak, 1998; Grover & Davenport, 2001; O'Dell & Grayson, 1998; Stewart, 2001). Thus, while no generally accepted framework has been adopted, it seems that KM has involved all kinds of approaches, practical activities, measures, and technologies.

In order to make KM a strategic asset and to realize the potential for improving performance, there is a need for a unifying framework that considers KM relative to the entirety of the organizational system as well as its subcomponents (i.e., the business, its processes, and knowledge workers) (Soo et al., 2002). Such a framework should provide a general sense of direction (i.e., be prescriptive) for KM initiatives in order to ensure that the same general requirements are addressed across the organization, but it also should be descriptive in that it considers factors that ultimately influence KM success or failure (Rubenstein-Montano et al., 2001; Tsoukas, 1996).

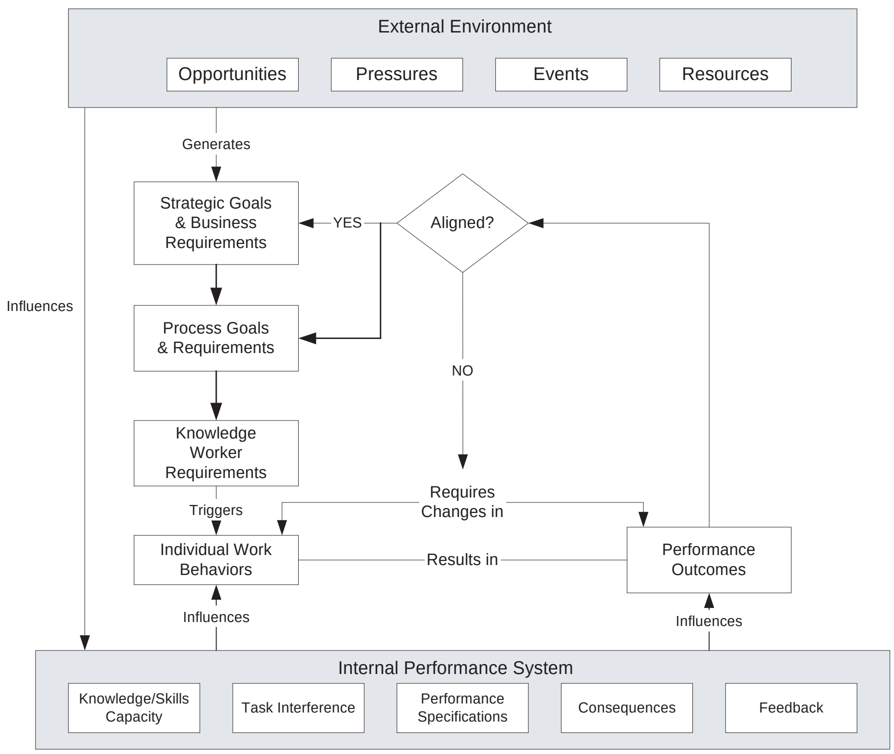
A systems approach to KM can ensure a holistic and purposeful (performance-oriented) consideration of the interrelationships between the business, its processes, and knowledge workers (Ackoff & Emery, 1972). The objective is to enhance understanding of and responsiveness to a problem by examining relationships between various parts of the system (Checkland, 1981; Checkland & Howell, 1998; Gao, Li & Nakamori, 2002). A systems approach can enhance KM initiatives by examining and depicting the complex relationships among components such that an organization can ascertain where and how KM might respond (Rubenstein-Montano et al., 2001). In the following section, we develop and offer a holistic KM framework that considers the complex interdependencies among the business, its processes, and knowledge workers surrounding organizational knowledge work. When applied, the framework offers a systematic way to identify, define, and analyze performance problems or opportunities and their drivers and causes at multiple levels (business, process, and individual). By doing this, desired performance outcomes at all levels can be described, and behaviors that will produce those outcomes can be identified (Gordon, 1996). With this robust understanding, organizations can more precisely specify and implement interventions to address problems or capitalize on opportunities and ultimately improve performance (Gery, 1997; Massey & Montoya-Weiss, 2002; Rosenberg, 1995; Stolovitch & Keeps, 1999).

A HOLISTIC FRAMEWORK FOR KM

In Figure 1 we offer a framework to ensure that KM initiatives and multi-level requirements are addressed in a similar vs. an ad hoc fashion across the organization. Described next, the framework draws from and integrates literature concerned with approaches to dealing with complexity and purposeful (i.e., performance-oriented) systems (Checkland & Howell, 1998), business process reengineering (Hammer & Champy, 1993), and human performance (Rummler & Brache, 1992; Stolovich & Keeps, 1999). It possesses both prescriptive (task-oriented activities) and descriptive (consideration of factors that influence success or failure) elements, which, in turn, facilitate a holistic perspective. Importantly and consistently with a systems approach, the framework does not imply that the same methodologies will be used for all situations; rather, the framework facilitates a method to KM that is adaptive and responsive to different situations.

Since knowledge is context-specific, and since KM will be most powerful when applied to a specific domain (Sviokla, 1996), a component of our framework is its focus on core business processes. Thus, at the process level, we draw from the business process reengineering (BPR) literature, which is concerned with a fundamental rethinking of and redesign of business processes in order to achieve performance improvements (Hammer & Champy, 1993). Although BRP involves the analysis and design of workflows, it does not explicitly consider the complex environment that influences knowledge workers (Davenport & Short, 1990). Without consideration of the human element in

Figure 1. A holistic framework for knowledge management (adapted from Rummler & Brach, 1992; Stolovich & Keeps, 1999)



knowledge-intensive processes, BPR rarely will be successful. Therefore, by leveraging literature concerned with human performance (Stolovich & Keeps, 1999; Rummler & Brach, 1992), our KM framework includes factors that influence individual work behaviors and performance. It is likely that a KM initiative that only considers isolated subcomponents of the overall system will not enhance performance. Rather, success will hinge on understanding how each part — strategic goals, business process, knowledge workers — influences and interacts with other parts.

As illustrated, the external environment presents an organization with opportunities, pressures, events, and resources (Holsapple & Joshi, 2000, 2002). In response, an organization generates business and process requirements — a set of actions that allows the organization to capitalize on external opportunities and/or respond to threats. For example, to remain competitive, a strategic business performance goal may be to increase market acceptance of new products (Moorman & Rust, 1999). In a software-related business, the business-level requirement may be to increase the rate of new software introduction into the marketplace. This business requirement generates process-level requirements (e.g., the new product development process must produce a stream of continuous new products or services).

Gaps between current process capabilities and defined requirement(s) may force the organization to reengineer the business process such that the process performs at the required level of performance (Davenport, 1993; Hammer & Champy, 1993; Teng, Grover & Fiedler, 1994). Recognizing that processes are knowledge-intensive (Davenport, DeLong & Beers, 1998; Massey & Montoya-Weiss, 2002), reengineering efforts should focus on decomposing and structuring the process such that data, information, knowledge activities, and workflows between activities are clearly defined (Davenport & Short, 1990; Hammer & Champy, 1993; Teng et al., 1994). Importantly, structuring the process and identifying knowledge exchange activities inherent to the process will assist in identifying knowledge worker requirements (Leonard & Sensiper, 1998; O'Dell & Grayson, 1998). In particular, this involves defining what knowledge and what types of knowledge (i.e., tacit or explicit) are needed to accomplish activities. It also involves identifying who or what are the sources and receivers of knowledge (e.g., human, archives, etc.) as well as defining desired performance outcomes of process-level work. A purposeful and seamless flow of data, information, and knowledge — a defined knowledge cycle — then can occur among collaborating knowledge workers tasked with various process activities.

In addition to rethinking how a process work should be done via reengineering (Davenport, 1993; Hammer, 1990), it is important to consider the knowledge worker(s) who will be tasked with carrying out process activities. Thus, in addition to specifying the knowledge cycle, we must consider factors that influence the behaviors and performance of knowledge workers at the task/activity level (Checkland, 1981; Rubenstein-Montano et al., 2001; Rummler & Brache, 1992). As shown in Figure 1, the task/activity level factors are referred to as a knowledge worker's internal performance system. Here, it becomes important to recognize that individual (or often team) performance is not simply a function of knowledge, skills, or capacity. Rather, other factors influence performance, including: the nature and clarity of the business process work tasks and whether anything (e.g., lack of resources) interferes with task completion, clarity of performance specifications and goals, positive and negative work consequences, and performance feedback (Rummler & Brache, 1992). By taking a broader view of knowledge workers, cause(s) of poor performance and/or opportunities to enhance performance (beyond knowledge, skills, and capacity) can be identified.

As described previously, the framework enables a holistic examination of the interrelationships among multi-level goals and requirements that allows for the identification of problems or opportunities that should be addressed in order to enhance performance (Senge, 1990). In the following section, we illustrate the framework based on our work with IBM and Nortel. Our purpose is not to provide detailed case studies; rather, our intent is to illustrate key elements and interrelationships (see Massey, Montoya-Weiss, & Holcolm, 2001; and Massey, Montoya-Weiss & O'Driscoll, 2002 for further in-depth case studies).

PERFORMANCE-DRIVEN KM INITIATIVES

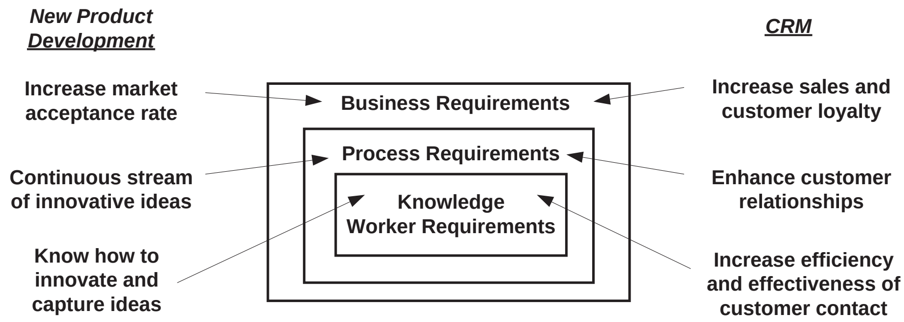
In the latter half of the 1990s, both IBM and Nortel Networks were facing significant external pressures. With regard to IBM, from 1986 to 1992, its market share dropped from 30% to 19%, with each percentage point representing $3 billion in revenues. Rather than paying attention to customer needs, IBM focused on its own financial needs and tried to reduce costs by cutting customer service staff and levels of support. In the end, customers were driven away. Thus, by the mid-1990s, the changing market environment and downsizing necessitated that IBM rethink the basic way they serviced customers in order to reduce customer defections and to increase sales. Throughout the 1980s and early 1990s, IBM's primary points of contact with its customers were through business partners, direct catalog, and the traditional "blue suits." Given that these points of contact were not supporting the business-strategic goals and requirements to remain competitive, an internal task force was charged with reengineering IBM's customer relationship management (CRM) process.

CRM involves attracting, developing, and maintaining successful customer relationships over time (Berry & Parasuraman, 1991; Day, 2000, 1994). At the core of CRM is the development of a learning relationship that engages customers in a two-way collaborative dialogue that is effective and efficient for both customers and the firm (Peppers, Rogers, & Dorf, 1999). When effective, this knowledge-based process leads to a relationship that gets smarter and deeper through every interaction. The task force charged with addressing the business problem recognized that advanced information technology, the burgeoning Internet, and the emerging network-centric environment presented great opportunities for reengineering IBM's CRM process and leveraging its knowledge assets.

Similarly, at Nortel Networks, the Telecommunications Reform Act of 1996 produced intense competition in the telecom industry, yielding an explosion in the development of innovative telecommunications technology. The new rules of the deregulated telecommunications marketplace forced Nortel to recognize that differentiation through innovation was one of the few strategies that might allow the company to continue to succeed. Like IBM, an internal group was charged with the task of addressing this strategic business goal and requirement. After preliminary research, the group discovered that the generation and existence of innovative ideas within Nortel was not the issue. Rather, Nortel's existing new product development (NPD) process had no formal mechanism to systematically capture, develop, and manage internally generated ideas (i.e., ideas that could be developed into product or service concepts and evaluated for funding). Developing ideas and evaluating concepts is knowledge-intensive work based on the individual and collective expertise of employees. The Nortel task force set out to reengineer its NPD process in order to leverage its knowledge assets. As described, the efforts of both the IBM and Nortel initiatives were guided by strategic business goals and requirements that, in turn, led to them to focus on business processes most relevant to achieving desired performance (Figure 1).

As shown in Figure 2, core business processes like CRM and NPD represent the fundamental link between business and knowledge workers performance. The reality for both IBM and Nortel

Figure 2. Examples of interdependent multi-level performance requirements



was that their respective business requirements would be achieved through processes, and both organizations were only as good as its processes, which ultimately depended on the behaviors of knowledge workers. Driven by this performance reality, IBM's reengineered CRM process was designed to enhance the customer relationship, while Nortel's reengineered NPD process was designed to produce a continuous stream of products and services. Although the specific details of the process reengineering efforts are beyond the scope of this paper (details are available upon request), both organizations structured their new processes by decomposing the process into knowledge-based activities, simultaneously identifying the required flows of data, information, and/or knowledge among activities and knowledge workers. The analysis led to the specification of the knowledge-based drivers (types, sources, and receivers) of each activity, decision, or information flow. In their reengineering efforts, both task forces went through several process prototype iterations (Davenport & Short, 1990), simultaneously considering whether (or not) the new process could, in fact, support business goals and requirements. As one IBM task force member put it:

We had done things the same way for so long. We realized early on that any changes to our [CRM] process had to demonstrate they would, in fact, improve business performance or nobody — our reps or our customers — would buy in. We continually asked ourselves whether the new process supported our business [level] goals.

This quote illustrates the strong link between business and process levels shown in Figure 1 and how important it is not only to decompose the levels but to integrate them, as well.

The reengineering of IBM's CRM process and Nortel's NPD process created new knowledge worker performance requirements, triggering requisite changes to individual work behaviors. As one Nortel task force member observed:

While we believed our new [NPD] process could perform as desired, we were not sure if our people could or would actually carry out the new process. We needed to gain a better understanding of their capabilities and motivations.

Given this, both organizations sought to understand the internal performance system of its various knowledge workers in light of the reengineered processes and requirements (see Figure 1). Specifically, did they possess the knowledge/skills/capacity to carry out reengineered or new process activities? Did they possess and/or understand the inputs required to carry out process tasks? Did anything exist that would interfere with task requirements? Did they understand the desired performance outcomes intended to support business and process requirements? What contextual factors would motivate or demotivate knowledge workers to share knowledge and carry out the new process (i.e., consequences and feedback)?

Answers to these questions enabled a collaborative learning relationship between IBM representatives and customers and a more collaborative relationship between the engineers and managers involved in the NPD process at Nortel. For example, Nortel's NPD process called for idea generators (often engineers) to develop a raw product or service idea into a robust concept along the lines of marketing, business, technology, and human factors (areas used by managers to make funding decisions). While engineers are technically knowledgeable, they typically do not possess sufficient knowledge in the other areas required in the new NPD process. This drove Nortel's team to consider interventions to support the specific knowledge gaps of workers engaged in this process activity. Similarly, IBM's team considered the factors that would influence the behavior of CRM knowledge workers. For example, IBM sales representatives felt threatened by the CRM reengineering effort, due to their perception that the customer relationships would be transferred largely from human contacts to technology. In response, IBM undertook efforts to show sales representatives that the new CRM process would, in fact, allow them to more proactively sell and market products and services.

Ultimately, both IBM and Nortel designed and implemented technology-based interventions to support the performance of knowledge workers. Drawing from the disciplines of KM and CRM, IBM developed an Internet-based system called Inside IBM. The system allowed customers to link directly to IBM's intranet and back-end, cross-functional, knowledge-based resources. Inside IBM was subsequently adopted as a corporate standard leading to IBM's e-Services as it is known today. Deploying artificial intelligence, information systems, and user-centered design, Inside IBM aggregated IBM's accumulated product support knowledge into a single system and enabled collection of information about its customers. IBM's efforts facilitated a collaborative and learning relationship between IBM and its customers. This led to improved decision making for both the customer and the organization's sales and service workforce, leading to increased sales and customer loyalty. IBM estimated that $525 million of incremental revenue and $50 million of productivity savings were realized over a three-year period as a result of this initiative (see Massey et al., 2001, for further details concerning IBM's initiative).

Similarly, Nortel developed a KM system called Virtual Mentor. Virtual Mentor supported both the performance of knowledge workers (engineers) engaged in developing raw ideas into robust concepts and decision makers (managers) tasked with making funding decisions. Virtual Mentor subsequently was integrated into a broader corporate time-to-market strategy that is in place today. Nortel's efforts led to decreased time-to-market, increased time-to-market acceptance, and improved funding decisions. Over a three-year period, Nortel's new product introduction rate increased by over 50% (see Massey et al., 2002, for further details concerning Nortel's initiative).

Clearly, the bottom line for IBM and Nortel was to increase profitability, sales, share, and return on investment by leveraging and managing its knowledge assets. As evidenced, IBM and Nortel's KM initiatives were guided by a holistic understanding of interdependent multi-level (business, process, knowledge-worker) performance goals and requirements. This facilitated problem/opportunity identification and definition, diagnoses of the changes required, and the subsequent design of suitable interventions needed to affect the performance of knowledge workers tasked with process activities. Addressing what to do from a performance perspective drove the reengineering of two knowledge-intensive business processes. Both processes called for improvements to cross-functional coordination, collaboration and learning, and knowledge exchange in business, technology, and marketing (and other relevant areas). Considering how to do it and simultaneously understanding the behavioral factors that influenced knowledge workers informed the development and implementation of interventions designed to enhance performance. In the end, both IBM and Nortel were directed by a deep understanding of the complex interdependencies inherent to their organizational systems. In their respective efforts, they not only decoupled the organizational environment into its smaller parts (business, process, knowledge worker), but also continually considered how the parts were linked in hierarchies to form the whole performance environment.

In the following section, we present a series of steps that underlie our framework and provide direction for KM initiatives. We then illustrate the efficacy of our approach in a software engineering context. Our data in this context are based on interviews with managers and developers regarding KM systems currently in use at TechCo (a pseudonym), a well-known Indian software development firm that has several centers certified at Level 5 of the Capability Maturity Model (Paulk, Weber, Curtis, & Chrissis, 1995).

STEPS FOR KM INITIATIVES

Step 1: Select a Target Business Process

Once an organization has identified its business goals and requirements, a KM initiative then must identify the firm's key leverage points for achieving business results. As noted earlier and as evidenced at IBM and Nortel, since knowledge is context-specific (Sviokla, 1996), KM likely will be most powerful when it addresses a particular domain, such as new product development, operations, sales, and customer service. Organizations should start where advocacy exists for doing something different. Processes such as those targeted for improvement by the organizations we studied is where work is accomplished. Once the process is identified, establish a process and project owner and ensure that the new initiative is managed as a business change project, not an information technology project (as many early KM projects were managed). In this step, it is also important to establish performance measures for the business case. Demonstrating success with a single process may lead to acceptance for other processes.

Step 2: Model the Process

This step requires that the inherent, underlying process structure be found or defined in order for an initiative to move forward. Oftentimes, process activities and the data, information, and knowledge flows among activities are poorly defined. Clarifying activities and promoting an integrative view of the whole process is the starting point for managing knowledge and improving performance. For example, in the front end of the NPD process, idea-to-concept development and concept selection activities often are called the fuzzy, because they involve ill-defined activities and ad hoc decisions carried out by multiple and diverse stakeholders (Cooper & Kleindschmidt, 1995). Via careful analysis and benchmarking, Nortel reengineered and enhanced the front end of its NPD process by defining a consistent and structured approach for developing, screening, and cataloging new product ideas.

Step 3: Identify Activity-Based Knowledge Exchange Processes

This step requires understanding the context of work (i.e., the knowledge needs associated with each process activity defined in Step 2). For example, in IBM's CRM process, in order for customer representatives to target sales and marketing proactively, they had to determine how to acquire knowledge concerning customer requirements. Similarly, at Nortel, different knowledge workers and functions had different pieces of data, information, and knowledge relevant to the NPD process. These pieces needed to be exchanged in order to create a common and logically organized bank of knowledge about a product or service concept. The objective of this step is to identify the knowledge exchange processes that are or must be in place to support value-creating activities.

Step 4: Identify Desired Knowledge Exchange Performance Outcomes

When individuals or teams exploit knowledge in a business process, it is reflected in the quality of a valued outcome that benefits the organization. This step involves specifying the performance outcomes that should be derived from the knowledge exchange processes identified in Step 3. For example, in Nortel's NPD process, one desired outcome was that a decision maker (manager) could make an informed decision regarding further funding for product development. Another was when the right combination of product-related data (e.g., marketing, business, and technology) needed to be readily accessible in the right format for different tasks and functional areas. Alternatively, in IBM's CRM process, a desired outcome was that the right people, information, and services would be readily accessible to the customer.

Step 5: Identify the Knowledge Drivers of Each Process Activity, Decision, and Information Flow

This step requires the identification of the types of knowledge required, the sources of that knowledge (internal and/or external people, archived data), and the receivers of knowledge (people, other databanks). In Nortel's case, this step required identification of the specific knowledge required by an idea generator (i.e., an engineer or knowledge worker source) so he or she could develop a raw idea into a robust concept in the areas of marketing, business, human factors, and technology. With this knowledge, a raw idea could be developed into a complete and robust concept so that decision makers (i.e., manager or knowledge worker receiver) could evaluate the concept and make a funding decision.

Step 6: Identify and Develop Interventions

In concert, Steps 2 through 5 specify the knowledge inputs, exchange processes, sources and receivers, and desired outcomes associated with the targeted and defined business process. The factors that influence individual work behaviors (i.e., the internal performance system of knowledge workers) also must be considered to ensure that desired performance outcomes are achievable. With this holistic understanding available, an organization now can specify more precisely its KM interventions or solutions in order to support individual and/or teamwork. Interventions reflect both responses to identified causes of performance problems and opportunities for improving performance. Potential interventions could include the development of individuals or teams (e.g., training) or solutions that focus on rewarding performance (e.g., incentive/reward systems). Interventions also may include information technology-based KM systems (Alavi, 2000; Alavi & Leidner, 2001; Gery, 1997; Hinds & Pfeffer, 2003; Rosenberg, 1995). Intervention selection should be done in light of appropriateness (internally and externally), economics, feasibility (given organizational constraints or barriers to implementation), and acceptability to the organization and knowledge workers. Again, by taking a holistic view and understanding the performance environment first rather than starting with a solution looking for a problem, interventions can be identified more appropriately and precisely.

One key issue to be considered when supporting activities within a business process context is the issue of language translation. Knowledge workers deploy local languages relative to their areas of expertise. Thus, successfully enabling the flow of data, information, and knowledge between process activities and diverse knowledge workers may require language translation. For example, as noted earlier in our Nortel case, we found that idea generators (engineers) did not speak the language of decision makers (managers). Nortel's KM solution, Virtual Mentor, thus was designed to depict and translate knowledge in forms that were appropriate for different audiences (engineers, managers, process owners). For example, through concept development and rating forms designed in the language of engineers, idea generators provided knowledge concerning a new concept and its potential application(s). Virtual Mentor then translated the contextual structure of this concept information into a form so decision makers could conduct a SWOT—strengths, weaknesses, opportunities, threats—analysis. Virtual Mentor enabled collaboration by supporting the local languages of disparate knowledge workers who must exchange knowledge in order to improve decision making. Another issue that needs to be dealt with is the differential navigational needs of the various stakeholders. As an example, the navigation needs of a customer representative in the CRM process seeking to acquire customer requirements differs significantly from the needs of a customer seeking information.

AN APPLICATION OF THE STEPS FOR KM INITIATIVES

In this section, we provide further evidence that demonstrates the validity of our holistic framework and underlying steps identified in the previous section. Here, we describe the path taken by TechCo in arriving at the KM solutions in use today. TechCo is one of the leading software services and consulting organization in Southeast Asia, providing systems development and integration services to Global Fortune 500 clients.

During the 1990s, TechCo saw a significant increase in competition in the offshore software development arena. With a business goal of maintaining its position as one of the market leaders in this arena, TechCo sought to gain a competitive edge by focusing its efforts on improving the quality of its core software development processes. This effort was very similar to Nortel's efforts described earlier, which focused on enhancing its NPD process.

Software development, by its very nature, is a knowledge-intensive process that involves many people working on several different activities and phases (Rus & Lindvall, 2002; Ward & Aurum, 2004). Success hinges on the creation, acquisition, identification, adaptation, organization, distribution, and application of knowledge within and between projects. It is also a dynamic process, evolving with technology, organizational culture, and development practices (Ward & Aurum, 2004). Inherent to software development is knowledge embedded in products and meta-knowledge concerning not only the products but also the development processes (Rus, Lindvall, & Sinha, 2001). While individuals engaged in software development projects make decisions based on personal knowledge, the sharing of this knowledge historically has been limited to informal means (Rus & Lindvall, 2002) (see Rus et al., 2001, for a review of KM and software engineering).

TechCo's focus on process improvement initiatives was driven by a desire to provide a measure of control and accountability within complex software development projects. Example processes that could be targeted in a software lifecycle context include the requirements analysis, software development and software maintenance processes, as well as more managerial processes, such as the project management or change management process (Jalote, 2000; Rus et al., 2001). TechCo sought to address several of these processes through its efforts to achieve the Carnegie Mellon Institute's Capability Maturity Model Level 5 certification (Paulk et al., 1995).

Having identified a set of target processes to reengineer (Step 1 of our checklist), TechCo began to specify and document the standard activities and information flows for each major process in the software development life cycle. This activity (a requirement in order to be certified at Level 3 of the CMM) helped TechCo to achieve the objectives stated in Step 2 of our KM checklist. Each process was broken down into stages consisting of activities that, in turn, were divided into subactivities. Key participants for each stage also were identified as part of the process definition. For example, the requirements analysis process was divided into the activities of preparation, eliciting requirements, analyzing requirements, and so forth. Examples of subactivities that were identified for the requirements analysis activity included the creation of logical data models and process models.

Steps 3 and 4 of our KM initiative checklist were achieved as a natural consequence of TechCo's efforts to detail the activities that comprised each process. TechCo used the ETVX (Entry, Task, Verification, and eXit) model (Radice, Roth, O'Hara & Ciarfella, 1985) to define the details of each stage in a process. The entry criteria and input specification together defined the primary knowledge inputs to each activity, while the exit criteria and associated metrics defined the knowledge exchange outcomes associated with each activity.

Step 5 of our checklist deals with the identification of the knowledge sources and receivers for each activity. At TechCo, the knowledge sources and receivers for each activity were defined in the process definition handbooks. These handbooks contained generic guidelines for performing activities such as group reviews, defect prevention, and so forth, as well as detailed checklists for accomplishing activities such as high-level design, functional design, code review, and so forth. In addition, TechCo created a series of templates for producing various types of documents generated during the software development process (e.g., requirements specification, unit test plan, and acceptance test documents). Specifying these items to a sufficient level of detail such that every project could follow the guidelines as well as produce documents in a standardized fashion was a key step in helping TechCo achieve Level 5 certification. These templates represented a codification of knowledge that then could be exchanged among the various sources and receivers.

Having defined in detail its software engineering processes, TechCo began to examine the best mechanism by which it could support the activities of the knowledge workers executing these processes (Step 6 of our checklist). It is well known that software development requires coordination and collaboration among various stakeholders (Kraut & Streeter, 1995) (i.e., project leaders, module leaders, analysts, developers, and members of quality assurance groups). Armed with an understanding of the individual tasks performed by each knowledge worker, the types of knowledge exchanged among the various stakeholders and the coordination and communication needs of knowledge workers during each phase of the life cycle, TechCo was able to design a project level KM system, the Project Reporting and Management System (PRMS). PRMS facilitates efficient knowledge sharing among the workers by providing support for essential collaborative activities, such as (1) configuration management of work products (e.g., documents and code); (2) division, scheduling, and assignment of subactivities to various knowledge workers; (3) support for testing and problem reporting; and (4) change management. In addition, PRMS captures various metrics relating to defects per stage, effort spent per stage, and so forth. In essence, PRMS is a project-level KM that serves as a one-stop shop for sharing key knowledge related to a given project, including informal knowledge generated during the course of the project.

By achieving the high level of process maturity and control over its software development processes and the use of tools such as PRMS, TechCo was able to maintain its competitive edge in the marketplace. However, it still did not have any organization-wide mechanism in place to facilitate knowledge sharing across various projects. This often resulted in wasted effort and costly mistakes in personnel and time estimation. For example, there was no easy mechanism to solve the problems related to the "who knows what" issue that plagues large organizations. Moreover, no mechanisms for sharing knowledge regarding best practices and processes were in place.

To address these problems, TechCo developed and deployed an organization-level KM system in the form of an electronic knowledge asset library (KAL). This system served as a repository for knowledge about its software development process (i.e., guidelines, checklists, templates, etc.). TechCo organized knowledge generated from prior projects based on two criteria: industry vertical (e.g., manufacturing, pharmaceutical) and technology characteristics (e.g., languages, tools, databases). Detailed knowledge from each project (captured in the PRMS) in the form of all final documents produced during the various phases of the lifecycle (e.g., requirements documents, high-level design documents, program code, and records of quality assurance reviews, was stored in this system. Furthermore, because of its highly mature processes, TechCo was also able to capture quantitative information (e.g., effort and defects per stage) in the system. This system also served as a forum for posting white papers and tutorials on emerging technology topics. Each knowledge item in the system had associated with it a contact person's information, thus creating knowledge about where expertise resides within the organization.

The knowledge captured in KAL is accessible to all users in the organization. Access to the library is provided through a groupware system based on Lotus Notes® technology. Common navigation functionality, such as ability to search projects based on keywords and other criteria, is provided. Thus, using this system, a project leader initiating a project using J2EE technology in the financial industry can retrieve documents related to prior J2EE projects in the financial industry and use the knowledge in the system to estimate the manpower and time needed to execute the new project successfully. The project leader is able to find and communicate with other project leaders with experience in that domain and to make requests for software engineers, who have performed well in a specific domain. At the same time, a developer can read tips on how to develop wireless applications using J2ME. Similar systems (i.e., the process asset database [PDB] and Knowledge Map) are in use at Infosys, one of TechCo's chief competitors (Ramasubramanian & Jagadeesan, 2002). To encourage the sharing of knowledge via these KM systems, TechCo linked knowledge worker financial incentives to systems use, which TechCo believes led to performance improvements.

Through the use of these KM systems, TechCo has been able to deliver consistently high-quality software products by reducing the barriers of time and space associated with virtual software development (Carmel & Agarwal, 2001). It is worth noting that the process of accomplishing the six steps has taken more than five years. TechCo's efforts were spent on defining and refining the details of the software development processes (Steps 1 through 5) and the needs and motivations of its knowledge workers prior to considering and designing the subsequent technology-based KM system interventions. In the end, TechCo's efforts reflect its response to external competitive pressures and desire to improve interdependent, multi-level (business, process, and knowledge worker) performance (Figure 1). The fact that TechCo has been able to maintain its leadership position in an extremely competitive IT outsourcing/offshoring space provides evidence of the value of the KM initiatives. Thus, the TechCo case reiterates the importance of taking a holistic, performance-centric view of KM.

IMPLICATIONS FOR PRACTICE AND RESEARCH

Successful organizations like IBM, Nortel, and TechCo are searching for ways to improve performance by leveraging knowledge assets more effectively. New products, services, and customer relationships are key drivers of growth for sales and profitability, particularly for firms facing intense competition and rapid technological change (Alavi, 2000; Huber, 2001). Viability often hinges directly upon the competitive quality and exploitation of a firm's underlying knowledge base. Relative to their own environment, every organization will respond differently to the fundamental question posed earlier in this paper: What performance goal(s) is the organization trying to achieve by managing its knowledge assets? While KM cannot be applied generically, we have provided an overseeing framework and underlying steps that may assist organizations in addressing this question (Rubenstein-Montano et al., 2001; Tsoukas, 1996).

For practice, our perspective is both adaptive and responsive to different situations. Importantly, our approach considers the entire KM process — strategic objectives, operational factors, the role of technology, and people/culture — as well as underlying knowledge types, flows, tasks, and learning that must to be considered when considering the fit of a KM initiative to a particular organization. As evidenced in our cases, any KM initiative must be aligned with the existing strategic environment (Liebowitz & Beckman, 1998). An organization should assess the relationship of the initiative to current value chain processes, the level of change, the resources required to implement the envisioned solution, and the level of senior management support. Senior level support establishes an appreciation of knowledge assets and is essential for the ongoing funding and investment for necessary human and technical resources (Holsapple & Joshi, 2000). A KM initiative must fit with the operational environment. Interventions may change workflow and interpersonal relationships and thus may necessitate new roles and/or skills for knowledge workers. Deploying information technology in the form of a KM system also requires consideration of the existing technical environment (Flanagin, 2002; Holsapple & Joshi, 2002; Huber, 2001). The solution must be compatible with networks and platforms, and the organization must be ready to deal with the level of investment and change necessary to implement desired technical functionality. Perhaps the most challenging issue is the assessment of the fit between a KM initiative and the cultural environment. Creating a culture of knowledge sharing is critical to success (Davenport et al., 1998; Fahey & Prusak, 1998; Grover & Davenport, 2001). Given this, an organization needs to assess incentive and reward systems and identify internal inconsistencies. Understanding the internal performance system of a knowledge worker will assist in identifying factors that positively or negatively influence the behavior of knowledge workers.

For researchers, while we recognize the limits of a case study approach to generalizability, we maintain that the very nature of our framework requires holistic study of its application. This suggests a need for additional qualitative case studies conducted in collaboration with organizations that have engaged in or that are considering KM initiatives. It is only when a sufficient amount of systematic qualitative case study research has been conducted that themes and relationships inherent to our framework can be validated further via quantitative research methods.

CONCLUSION

A KM strategy entails developing a portfolio of strategically focused initiatives required to achieve business results. Organizations must prioritize these initiatives based on business value, enterprise support, and funding. As such, holistically and systematically understanding the performance environment surrounding organizational knowledge work takes on heightened importance (Massey & Montoya-Weiss, 2002; Rubenstein-Montano et al., 2001). With both prescriptive and descriptive elements, the framework and associated steps developed and offered in this paper should guide future research and assist organizations interested in undertaking and leading KM initiatives.

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REFERENCES

Ackerman, M., Pipek, V., & Wulf, V. (2003). *Sharing expertise: Beyond knowledge management.* Cambridge, MA: MIT Press.

Ackoff, R.L., & Emery, F.E. (1972). *On purposeful systems.* Chicago: Aldine Atherton.

Alavi, M. (2000). Managing organizational knowledge. In R.W. Zmud (Ed.), *Framing the domains of IT management research: Glimpsing the future through the past.* Cincinnati, OH: Pinnaflex Educational Resources.

Alavi, M., & Leidner, D. (1999). *Knowledge management systems: Issues, challenges, and benefits.* Communications of the Association for Information Systems, 1. Retrieved from http://cais.isworld.org/articles/1-7/article.htm

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Berry, L.L., & Parasuraman, A. (1991). *Marketing services.* New York: Free Press.

Carmel, E. & Agarwal, R. (2001). Tactical approaches to alleviating distance in global software development. *IEEE Software, 18*(2), 23-29.

Checkland, P.B. (1981). *Systems thinking, systems practice.* Chichester, UK: Wiley.

Checkland, P.B. (1998). *Information, systems and information systems: Making sense of the field.* New York: John Wiley & Sons.

Cooper, R., & Kleindschmidt, E. (1995). An investigation into the NPD process: Steps, deficiencies, impact. *Journal of Product Innovation Management, 12,* 374-391.

Davenport, T.H. (1993). *Process innovation: Reengineering work through information technology.* Cambridge, MA: Harvard Business School Press.

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Davenport, T.H., & Short, J.E. (1990). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review*, 11-27.

Day, G.S. (1994). The capabilities of market-driven organizations, *Journal of Marketing, 58*(4), 37-52.

Day, G.S. (2000). Managing marketing relationships. *Journal of the Academy of Marketing Science, 28*(1), 24-31.

Dyer, G., & McDonough, B. (2001, May). The state of knowledge management. *Knowledge Management*, 31-36.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Flanagin, A.J. (2002). The elusive benefits of the technology support of knowledge management. *Management Communication Quarterly, 16*(2), 242-248.

Gao, F., Li, M., & Nakamori, Y. (2002). Systems thinking on knowledge and its management: Systems methodology for knowledge management. *Journal of Knowledge Management, 6*(1), 7-17.

Gery, G. (1997). Granting three wishes through performance-centered design. *Communications of the ACM, 40*(7), 54-59.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Gordon, J. (1996). Performance technology. In D. Zielinski (Ed.), *The effective performance consultant* (pp. 1-7). Minneapolis, MN: Lakewood Publications.

Grover, V. & Davenport, T.H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Hammer, M. (1990). Reengineer work: Don't automate, obliterate. *Harvard Business Review*, 104-112.

Hammer, M., & Champy, J. (1993). *Reengineering the corporation: A manifesto for business revolution*. New York: Harper Collins.

Hinds, P.J., & Pfeffer, J. (2003). Why organizations don't "know what they know": Cognitive and motivational factors affecting the transfer of expertise. In M. Ackerman, V. Pipek, & V. Wulf (Eds.), *Sharing expertise: Beyond knowledge management* (pp. 3-26). Cambridge, MA: MIT Press.

Holsapple, C.W., & Joshi, K.D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information Systems, 9*, 235-261.

Holsapple, C.W., & Joshi, K.D. (2002). Knowledge management: A three-fold framework. *The Information Society, 18*(1), 47-64.

Huber, G.P. (2001). Transfer of knowledge in knowledge management systems: Unexplored issues and suggested studies. *European Journal of Information Systems, 10*(2), 72-79.

Jalote, P. (2000). *CMM in practice: Processes for executing software projects at Infosys.* Reading, MA: Addison-Wesley.

Kraut, R.E., & Streeter, L. (1995). Coordination in software development. *Communications of the ACM, 38*(3), 69-81.

Leonard, D., & Sensiper, S. (1998). The role of tacit knowledge in group innovation. *California Management Review, 40*(3), 112-132.

Liebowitz, J. & Beckman, T. (1998). *Knowledge organizations: What every manager should know.* Bacon Raton, FL: St. Lucie/CRC Press.

Maier, R., & Remus, U. (2001). Towards a framework for knowledge management strategies: Process orientation as strategic starting point. In *Proceedings of the 34th Hawaii International Conference on System Sciences.*

Massey, A.P., & Montoya-Weiss, M. (2002). Performance-centered design of knowledge intensive processes. *Journal of Management Information Systems, 18*(4), 37-58.

Massey, A.P., Montoya-Weiss, M., & Holcom, K. (2001). Re-engineering the customer relationship: Leveraging knowledge assets at IBM. *Decision Support Systems, 32* 155-170.

Massey, A.P., Montoya-Weiss, M., & O'Driscoll, T. (2202). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Moorman, C., & Rust, R.T. (1999). The role of marketing. *Journal of Marketing, 63*, 180-197.

O'Dell, C., & Grayson, C.J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154-174.

Paulk, M., Weber, C.W., Curtis, B., & Chrissis, M.B. (1995). *The capability maturity model for software: Guidelines for improving the software process.* Reading, MA: Addison-Wesley.

Peppers, D., Rogers, M., & Dorf, R. (1999). *The one-to-one fieldbook.* New York: Currency and Doubleday.

Radice, R.A., Roth, N.K., O'Hara, A.C., & Ciarfella, W.A. (1985). A programming process architecture. *IBM Systems Journal, 24*(2), 79-90.

Ramasubramanian, S., & Jagadeesan, G. (2002). Knowledge management at Infosys. *IEEE Software, 19*(3), 53-55.

Rosenberg, M. (1995). Performance technology, performance support, and the future of training. *Performance Improvement Quarterly, 8*(1), 12-20.

Rubenstein-Montano, B., et al. (2001). A systems thinking framework for knowledge management. *Decision Support Systems, 31*(1), 5-16.

Rummler, G., & Brache, A. (1992). Transforming organizations through human performance technology. In H.D. Stolovitch & E.J. Keeps (Eds.), *Handbook of human performance technology: A comprehensive guide for analyzing and solving performance problems in organizations* (pp. 32-49). San Francisco: Jossey-Bass.

Rus, I., & Lindvall, M (2002). Knowledge management in software engineering. *IEEE Software, 19*(3), 26-38.

Rus, I., Lindvall, M., & Sinha, S.S. (2001). *Knowledge management in software engineering. DACS State of the Art Report (SOAR).* Retrieved on April 10, 2005, from http: www.dacs.dtic.mil/techs/kmse/kmse.html

Senge, P.M. (1990). *The fifth discipline.* New York: Doubleday.

Soo, C., Devinney, T., Midgley, D., & Deering, A. (2002). Knowledge management: Philosophy, processes, and pitfalls. *California Management Review, 44*(4), 129-150.

Stewart, T. (2001). *The wealth of knowledge: Intellectual capital and the twenty-first century organization*. New York: Doubleday.

Stolovitch, H.D., & Keeps, E.J. (1999). What is human performance technology? In H.D. Stolovitch, & E.J. Keeps (Eds.), *Handbook of human performance technology: Improving individual and organizational performance worldwide* (pp. 3-23). San Francisco: Jossey-Bass.

Sviokla, J.J. (1996). Knowledge workers and radically new technology. *Sloan Management Review*, 25-40.

Teng, J.T.C., Grover, V., & Fiedler, K.D. (1994). Business process reengineering: Charting a strategic path for the information age. *California Management Review, 36*(3), 9-31.

Tsoukas, H. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal*, 17.

Ward, J., & Aurum, A. (2004). Knowledge management in software engineering: Describing the process. In *Proceedings of the 2004 Australian Software Engineering Conference*. IEEE Computer Society. Retrieved on April 10, 2005, from http://csdl.computer.org/comp/proceedings/aswec/2004/2089/00/20890137abs.htm

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Chapter 1.13
Taxonomies of Knowledge

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INTRODUCTION

Knowledge management has become a major application of information technology (IT) and a major focus of IT research. Thus, it becomes increasingly important to understand the nature of the knowledge object and knowledge engineering processes. The assumption underlying this article is that in order for knowledge to be managed by technological means, it must first be represented in the relevant technology. As Sowa (1999) puts it:

Knowledge engineering can…be defined as the branch of engineering that analyzes knowledge about some subject and transforms it to a computable form for some purpose.

The purpose assumed here is the management of knowledge for organizational aims. The other key term is "analyzes knowledge"; to analyze an object, one must first describe it, and taxonomies are intended to facilitate description and analysis. A useful analogy is that of taxonomies of living creatures which employ multiple characteristics such as size, number of legs, blood temperature, and many more to assign specimens to categories.

As different kinds of knowledge require different modes of representation, taxonomy becomes the central link between knowledge engineering and knowledge management. For example, accounting data are represented as data records; routine manipulation of the data is performed employing accounting knowledge embedded in programs. Organizational use of accounting data may be mediated by expert systems, which are generally realized as a special form of rule-based programs. Thus, in order to effectively design a knowledge management system, one must first classify the types of knowledge to be embedded in it. Hence the importance of a taxonomy of knowledge. A definition of knowledge is itself knowledge; thus, this article deals essentially with knowledge about knowledge—that is, meta-knowledge.

Knowledge is a highly multidimensional phenomenon and can be studied from many points of view. Thus, Sowa's (1999) book titled Knowledge Representation is subtitled Logical, Philosophical, and Computational Foundations. The approach taken here is largely a computational one, since knowledge management is generally discussed, though not necessarily in the context of computer-based systems. Given a computerized knowledge management system, questions also arise of eliciting the knowledge to be embedded in the system; some of these are also addressed here.

BACKGROUND

Attempting to understand the nature of knowledge has been a major theme of philosophical enquiry for thousands of years. Thus, Aristotle (384-322 BC) argued that knowledge objects are made accessible to thought by assigning them to categories. This approach still underlies much of knowledge management in specific areas. It applies especially to library classification systems—for example, The Dewey Decimal Classification (Dewey et al., 2003) for organizing all published knowledge. The classic Yahoo search engine was based on the same principle.

However, not all knowledge management relates to knowledge by content area; many other classifications are possible, and it is the purpose of this article to elaborate those. Because of the multidimensionality of knowledge, many taxonomies are possible. A well-known attempt to

Table 1. Knowledge taxonomies and examples (Alavi & Leidner, 2001)

Knowledge Types	**Definitions**	**Examples**
Tacit	Knowledge is rooted in actions, experience, and involvement in specific context	Best means of dealing with specific customer
Cognitive tacit:	Mental models	Individual's belief on cause- effect relationships
Technical tacit:	Know-how applicable to specific work	Surgery skills
Explicit	Articulated, generalized knowledge	Knowledge of major customers in a region
Individual	Created by and inherent in the individual	Insights gained from completed project
Social	Created by and inherent in collective actions of a group	Norms for inter-group communication
Declarative	Know-about	What drug is appropriate for an illness
Procedural	Know-how	How to administer a particular drug
Causal	Know-why	Understanding why the drug works
Conditional	Know-when	Understanding when to prescribe the drug
Relational	Know-with	Understanding how the drug interacts with other drugs
Pragmatic	Useful knowledge for an organization	Best practices, business frameworks, project experiences, engineering drawings, market reports

survey taxonomies of knowledge in the context of knowledge management systems is that of Alavi and Leidner (2001); they present 10 categories of knowledge gleaned from the knowledge management literature; their summary is cited as Table 1. This article uses the Alavi and Leidner (2001) categories as a basis, while extending and rationalizing them.

In general, taxonomies of knowledge may be ordered by their degree of generality; one may deal with knowledge at the highest level of abstraction, as Sowa (2000) does, while at the other extreme there are taxonomies of knowledge within specific fields (i.e., subsets of the general scheme of classification by content). The approach taken here is something of an amalgam of these two extremes. As it is impossible within the confines of an encyclopedia article to cover the entire gamut of types of knowledge, the emphasis here is on some higher level categories that we consider most relevant to practical knowledge management.

THE FOCUS: DIMENSIONS OF KNOWLEDGE

In discussing types of knowledge, one can think of the characteristics of knowledge items as unique points, each representing a class of knowledge. In this approach, for example, tacit and explicit knowledge are two different types. Most taxonomies to date have adopted this view. However, these two categories are also opposite poles of a single dimension along which there may well be types of knowledge that are combinations of the extreme points: for example, a given item of knowledge may be partly tacit and partly explicit. It therefore seems useful to think of the dimensions as having two extremes and to juxtapose those to depict characteristics of any given knowledge object.

The dimensions of knowledge discussed here are the tacit-explicit, individual-social, procedural-declarative, commonsense-expert, and task-contextual; three additional dimensions—true-false, certain-uncertain, and private-public are also briefly introduced. As the reader will note, there is considerable, but not complete, overlap with the Alavi and Leidner (2001) typology. The dimensions are also consistent with, but broader than, Nichols' (2000) identification of tacit, explicit, declarative, and procedural knowledge.

Given the multidimensional nature of knowledge, the ontology of an item of knowledge must refer to its location on all relevant dimensions in order to provide a complete specification. Such a specification should provide guidance in building systems to manage knowledge.

The Tacit-Explicit Knowledge Dimension

Tacit knowledge is knowledge that is possessed by an individual, but which he or she is unable to express verbally. At the other extreme of this dimension is explicit knowledge—knowledge that can be fully verbalized and so is available to any enquirer. An extreme statement of the tacit knowledge problem is that of Wittgenstein (1922): "The limits of my language are the limits of my mind. All I know is what I have words for." This might seem to imply that there can be no tacit knowledge. If we cannot put things into words, we cannot know them. "Whereof one cannot speak, thereof one must be silent" (Wittgenstein, 1922). This position, however, does not consider the possibility of assistance to explicate tacit knowledge, and it seems likely that there are varying degrees on the tacit/explicit dimension.

One of the best known philosophical treatments of tacit knowledge is that of Polanyi (1983), who distinguishes between tacit and "focal" knowledge. Polanyi characterizes tacit knowledge in the statement, similar to Wittgenstein's, that "…we can know more than we can tell." But knowledge that "we cannot tell" can sometimes be elucidated with appropriate help; for example, Police Identikits aid witnesses to crimes to concretely describe physiognomies of persons glimpsed under poor conditions and which they cannot describe verbally. However, some deeper level still remains unfathomable. This might derive from the fact that words cannot express all the detail of a physical entity or concept—a problem of granularity of language.

We may regard Polanyi's tacit knowledge as inchoate cognitive sensations for which we have not yet found words. In that case, this is knowledge about "whereof one cannot speak." However, with assistance, one may be able to find the words and so make the knowledge explicit. That would render much tacit knowledge potentially explicable. Thus, in principle, there is nothing we know that we cannot tell; practically, however, there may be things we know that we have not yet developed the ability to tell.

Tacit knowledge is, among other things, the knowledge of experts who intuitively know what to do in performing their duties, but find it difficult to express. Such knowledge is frequently based on intuitive evaluations of sensory inputs or gestalts of smell, taste, feel, sound, or appearance. Eliciting such knowledge was a major problem in early attempts to automate production processes such as brewing beer, manufacturing paper, or making wine, which were traditionally managed by master craftsmen who acquired their knowledge from long apprenticeship and experience. Eliciting such knowledge can be a major obstacle in attempts to build expert systems, as will be elaborated in discussing the commonsense-expert dimension.

The Individual-Social Knowledge Dimension

The process of converting tacit knowledge into explicit knowledge has been dealt with in great depth by Nonaka (1995). The emphasis there is on explicating tacit individual knowledge and converting it into social knowledge at ever higher levels. Alavi and Leidner (2001) include individual and social knowledge as separate categories in their list of taxonomies; Nonaka, however, sees a continuum from individual knowledge through group, organizational, and inter-organizational levels. He envisions the process as a spiral in which the expansion of explicit knowledge permits the creation of knowledge at higher levels of organization: "A spiral emerges when the interaction between tacit and explicit knowledge is elevated dynamically from a lower ontological level to higher levels" (Nonaka, 1995, p. 57).

This dimension is well nigh synonymous with what has also been referred to as the objective artifact-socially constructed perception (Davenport & Prusac 1998): this view relates to the manner in which knowledge is attained—whether through personal experience or by social interaction.

The Procedural-Declarative Knowledge Dimension

Declarative knowledge consists of facts and figures. Procedural knowledge is knowledge about means for achieving goals. At first blush, it might not seem clear why the two are considered poles of a single dimension. There are, however, a number of reasons for this juxtaposition.

Psychologists have studied the interaction in humans between declarative and procedural knowledge for some time. There is disagreement over whether procedural knowledge develops from declarative knowledge (Anderson, 1996), or whether declarative knowledge plays a role in the development of procedural knowledge but does not evolve into procedures (Nichols, 2000). In any case, some procedures (e.g., facial recognition) are developed without recourse to declarative intervention.

Beginning with human knowledge, in many cases there is a tradeoff between knowing facts and knowing how to compute those facts. Thus, one may learn the multiplication table by heart, or one may compute a multiplication when needed. In fact, most people know the multiplication table for relatively small numbers, but must compute the outcomes for larger numbers. One may remember telephone numbers as facts, or one may have a procedure for recovering them from a repository of such numbers.

From the computer point of view, declarative knowledge (data) and procedures (programs) are indistinguishable. Both reside in digital memory in the same format and possibly intermingled. In some programming languages (e.g., LISP), programs are themselves data that can be manipulated by the program itself. As with humans, computer resident knowledge may be stored as the facts themselves, or as procedures for computing the facts. However, the degree of flexibility in deciding which form of representation to adopt is much greater for machine resident knowledge because of the far greater computing power of the machine. For example, it would be impractical to re-compute account balances for every access required to manually maintained bank records. However, a strategy of re-computation might be adopted in machine maintained accounts if the tradeoff between maintaining balances digitally and re-computing them is in favor of the latter.

Furthermore, declarative and procedural knowledge are increasingly intertwined in modern information systems. Thus, markup documents (HTML, XML, etc.) contain both declarative knowledge (the content) and procedural knowledge (the controls) that dictate the presentation of the declaratives. Spreadsheet cells may contain declarative knowledge or procedures that compute and display the declarative values.

The conclusion from this discussion is that design of a knowledge management system must take into consideration whether any knowledge item is optimally represented declaratively, procedurally, or both.

The Commonsense-Expert Knowledge Dimension

Commonsense knowledge is what every member of a society is expected to know. This includes socially approved behavior, how to conduct simple commercial transactions (Ein-Dor & Ginzberg 1989), and naïve physics (Hayes, 1978, 1979). Expert knowledge is that which imbues recognized experts with their status. Implicit in the recognition of experts is the understanding that their number is severely limited. When experts' knowledge is diffused to the population at large, it becomes commonsense knowledge. One example of this is driving automobiles; when they first appeared, automobiles were driven by professional drivers who were considered experts. Eventually, the majority of people in advanced economies learned to drive and that knowledge is now close to commonsense. Another example is writing, once the domain of expert scribes; with the advent of universal education, knowing how to write has become commonsense. The examples of driving and writing also exemplify the existence of a continuum between commonsense and expert knowledge.

This dimension of knowledge is one which poses severe problems for knowledge management (Buchanan et al., 1983; Feigenbaum, 1993), often related to the fact that expert knowledge is frequently tacit in nature. Expert systems are embodiments of expert knowledge. One of the reasons that expert systems have not realized the potential once projected for them is that it has proven extremely difficult, in many cases, to elicit the requisite knowledge from the relevant experts. Feigenbaum (1993) gives this as one of the reasons for the delay in expert systems achieving the expectations from them. Furthermore, once the knowledge has been elicited, it may be difficult to represent in digital form. The representation is usually as a set of rules determining the action to be taken for a given input set.

As for commonsense knowledge, one might first ask why is it necessary to represent such knowledge, given that it is possessed by all? There are several reasons to digitally represent commonsense knowledge. First, if it is desired to automatically process natural language texts—for example, newspaper items, professional reports, or voice recordings—commonsense knowledge is necessary in order to interpret the texts. Second, commonsense knowledge is common to a culture, but not necessarily outside that culture; much has been written, for example, concerning the different negotiating styles of Western and Asian businessmen and the difficulties this can cause. Such problems increase in intensity with the spread of globalization. Formal representation of the commonsense of cultures might help alleviate these problems.

Unfortunately, representing commonsense knowledge is an extremely difficult undertaking. There are numerous reasons for this (see Ein-Dor & Ginzberg, 1989). In spite of great efforts, much work still remains to compile a general commonsense knowledge base. One consolation is the presumption that once such a knowledge base has been compiled, it should be useable by all, with adaptation required perhaps to specific cases. A large project, known as Cyc, with the objective of building a commonsense knowledge base has been underway since 1984 (see Cycorp, 2004; Guha, Lenat, Pittman, Pratt, & Shepherd, 1990; Lenat & Guha, 1990; Lenat, 1995).

The Task-Context Knowledge Dimension

Organizational knowledge is generally utilized to perform tasks of various kinds from the most routine to the highest level strategic decision making. Many of these tasks, however, require some context for their performance (Pomerol & Brézillon, 2001). That context may be intra-organizational or external. Building on this definition, what we refer to here as "task knowledge" is also called "organizational knowledge."

The knowledge to perform a given organizational task may be exclusively internal to the organization (e.g., where to store inventory items) or it may require much contextual knowledge (e.g., devising a marketing program). Note however that while the low-level task of storing inventory may be dictated by organizational procedures, those procedures may themselves be influenced by contextual knowledge concerning the frequency of and size of requests for items.

Thus, the knowledge for performing a given task may vary from high to low task-context combinations. The import of this fact for knowledge management is that task information is internal to the organization and is relatively easier to acquire and maintain. But note the discussion of expert knowledge above, which suggests that even internal knowledge may be difficult to manage, partly because of the contextualization required. Van Leijen and Baets (2004) discuss the way business processes are affected by the contextual knowledge patterns of the individuals responsible for their execution.

Contextual knowledge external to the organization poses severe acquisition problems, as sources need to be identified and the organization's environment changes constantly, requiring that the knowledge be constantly updated. Such contextual knowledge is either commonsense or expert in nature and is consequently subject to the problems discussed for the commonsense-expert dimension.

Additional Dimensions of Knowledge

As noted, the dimensions of knowledge outlined above are those considered particularly relevant to knowledge management. However, some additional dimensions of knowledge have been identified, beyond those discussed above. These may be relevant to some knowledge management systems and are here noted very briefly.

- True-False: Certain things we know are true; others things we think we know are probably false. Much knowledge lies between the extremes of truth and untruth and may be closer to one extreme or the other. Thus, in recording knowledge, knowledge items will be of varying degrees of veracity. For example, respondents to a survey may give their exact years of experience, slightly overstate or understate it, or exaggerate wildly. A computerized knowledge management system cannot evaluate veracity, except perhaps by triangulation of different representations of the same knowledge item or by logical inference from a number of items. Thus, evaluating veracity is a function primarily of those who collect and use the knowledge.
- Certain-Uncertain: Things can be known with different degrees of certainty from accurately measured physical properties to estimations of an opponent's intentions based on evaluation of relevant facts, which may themselves be subject to high uncertainty and low veracity. Again, a computerized knowledge management system cannot evaluate degrees of certainty unless programmed to do so, with the quality of the determination depending both on the accuracy of the data and the correctness of the evaluation parameters. Thus, controlling for certainty is again the responsibility of the knowledge collector and user.
- Private and Individual-Public and Shared Dimension (Aarons, 2005): This dimension is linked to the objective artifact-socially constructed perception above. The latter deals with the way in which knowledge is constructed, the former with the current state of construction.

FUTURE TRENDS

Managing knowledge efficiently and effectively requires a deep understanding of the nature of knowledge and its embedding in computerized systems. Thus, it is reasonable to assume that greater efforts will be invested in research to improve our understanding of knowledge. In the context of this article, that presumes a full mapping of all the dimensions of knowledge and establishing relationships between knowledge, as mapped on these dimensions, and the technological implications for the management of that knowledge. Understanding knowledge, studied in the past primarily by philosophers and psychologists, is an area in which the Information Systems field might make a profound contribution.

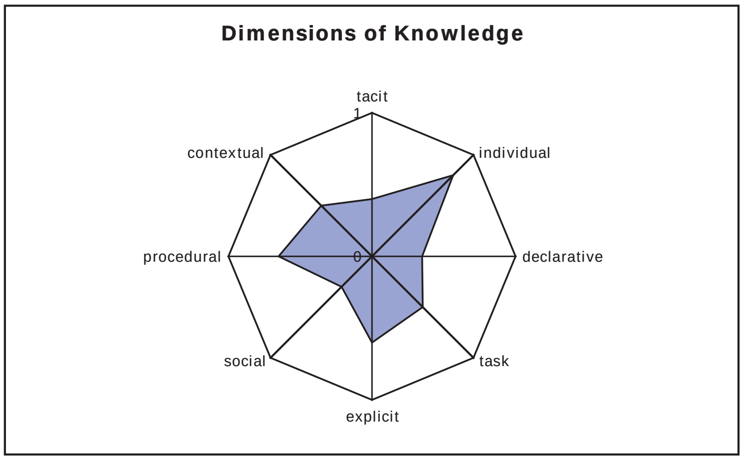
CONCLUSION

Knowledge is a multidimensional artifact, and cognizance of the various dimensions is useful for understanding the nature of a body of knowledge and is required in order to completely specify an item of knowledge. The principal dimensions of knowledge recognized here are tacit/explicit, individual/social, declarative/procedural, and task/context. The categorizations of a knowledge item may be graphically displayed as in the example in Figure 1.

Additional dimensions have been suggested—for example, the categories recognized in Alavi and Leidner (2001) as conditional, relational, and pragmatic; these are not included here because, while they may describe certain aspects of knowledge items, they are not generally recognized as basic dimensions of knowledge. The specification of knowledge to be represented computationally is important in choosing the computational solution to be employed.

A major conclusion from the multidimensional view of knowledge presented here is that the distinctions usually made in the IS literature

Figure 1. Example of dimensions of knowledge for a hypothetical knowledge item



between data, information, and knowledge are largely irrelevant (Ein-Dor, 1986). A data item in an organization's information systems is simply a piece of knowledge that is generally explicit, declarative, social, and organizational. A manager's knowledge of an aspect of the marketplace is probably to a large extent implicit, individual, declaratively and procedurally mixed, and contextual. Any knowledge item may be classified on these dimensions as a basis for analysis and implementation. This view can lead to greater integration of the various kinds of knowledge embedded in information systems.

REFERENCES

Aarons, J. (2005). The relationship between epistemology and knowledge management. In D.G. Schwartz (Ed.), *Encyclopedia of knowledge management.* Hershey, PA: Idea Group Publishing.

Anderson, JR. (1996). ACT: A simple theory of complex cognition. *American Psychologist, 51*, 355-365. Retrieved July 14, 2004, from http://act-r.psy.cmu.edu/publications/pubinfo?id=97

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Buchanan, B.G., Barstow, D., Bechtal, R., Bennett, J., Clancey, W., Kulikowski, C., Mitchell, T., & Waterman, D.A. (1983). Constructing an expert system. Chapter 5 in F. Hayes-Roth, D.A. Waterman, & D.B. Lenat (Eds.), *Building expert systems* (pp. 127-167). Reading, MA: Addison-Wesley.

Cycorp. (2004). Retrieved July 14, 2004, from http://www.cyc.com/cyc

Davenport, T., & Prusac, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dewey, M., Mitchell, J.S., Beall, J., Martin, G., Matthews, W.E., & New, G.R. (2003). *Dewey Decimal Classification and Relative Index* (22nd ed.). Retrieved October 4, 2004, from http://www.oclc.org/dewey/

Ein-Dor, P., & Ginzberg, Y. (1989). Representing commonsense business: An initial implementation. In L.F. Pau, J. Motiwalla, J.Y.H. Pao, & H.H. Teh (Eds.), *Expert systems in economics, banking, and management* (pp. 417-426). Amsterdam: North-Holland.

Ein-Dor, P. (1986). An epistemological approach to the theory of information systems. *Proceedings of the 18th Annual Meeting Proceedings of the Decision Sciences Institute* (pp. 563-363), Honolulu, Hawaii.

Feigenbaum, E.A. (1993). *Tiger in a cage: Applications of knowledge-based systems.* Stanford: University Video Communications.

Guha, R.V., Lenat, D.B., Pittman, K., Pratt, D., & Shepherd, M. (1990). Cyc: Toward programs with common sense. *Communications of the ACM*, *33*(8), 30-49.

Hayes, P.J. (1978). *Naïve physics 1: Ontology for liquids.* Working Paper, University of Essex, UK.

Hayes, P.J. (1979). The naïve physics manifesto. In D. Michie (Ed.), *Expert systems in the micro electronic age* (pp. 242-270). Edinburgh: Edinburgh University Press.

Lenat, D.B., & Guha, R.V. (1990). *Building large knowledge-based systems.* Reading, MA: Addison Wesley.

Lenat, D.B. (1995). Cyc: A large-scale investment in knowledge infrastructure. *Communications of the ACM, 38*(11), 33-38.

Nichols, F.W. (2000). The knowledge in knowledge management. In J.W. Cortada & J.A. Woods (Eds.), *The knowledge management yearbook 2000-2001* (pp. 12-21). Boston: Butterworth-Heinemann. Retrieved July 11, 2004, from http://home.att.net/~OPSINC/knowledge_in_ KM.pdf

Nonaka, I. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press.

Polanyi, M. (1983). *The tacit dimension.* Gloucester, MA: Peter Smith reprint.

Pomerol, J.-C., & Brézillon, P. (2001, July 27-30). About some relationships between knowledge and context. *Proceedings of the 3rd International and Interdisciplinary Conference (CONTEXT)*, Dundee, UK.

Sowa, J.F. (2000). *Knowledge representation: Logical, philosophical, and computational foundations.* Pacific Grove, CA: Brooks Cole. Actual publication date: August 16, 1999.

van Leijen, H., & Baets, W. (2004). Process standardization and contextual knowledge. *Proceedings of the 5th European Conference on Organizational Learning, Knowledge, and Capabilities (OLKC),* Innsbruck, Austria. Retrieved July 13, 2004, from http://www.ofenhandwerk.com/oklc/menu.html

Wittgenstein, L. (1922). *Tractatus logico philosophicus.* New York.

Chapter 1.14
Understanding Organizational Memory

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INTRODUCTION

It is generally recognized that Walsh and Ungson (1991) "provided the first integrative framework for thinking about organizational memory" (Olivera, 2000, p. 813). Within the field of knowledge management (KM), there has been interest in a variety of issues surrounding organizational memory (OM), which is understood to involve processes of storage and retrieval of organizational knowledge of the past for use in both the present and the future. The recognition of the importance of OM has implications for practice. For example, Argote, Beckman, and Epple (1990) suggest that the effective use of OM can protect an organization from some of the negative effects of staff loss, while Stein (1995, p. 19) asserts that an appreciation of OM can facilitate the solution of problems associated with the retention and utilization of knowledge within organizations.

Although the need to preserve knowledge in organizations is now recognized, organizational theorists still disagree on a number of issues relating to OM. Existing literature exhibits contradictory arguments regarding OM which can make the relevance and application of OM concepts to KM difficult to understand. This article describes some of the disagreements surrounding OM in order to provide a deeper understanding of how OM might help to manage knowledge.

BACKGROUND

The topic of OM has received a great deal of attention from researchers across a wide range of disciplines, most notably organization theory, psychology, sociology, communication theory, and information systems. In a detailed exploration of OM, Stein (1995, p. 17) suggests that "there are three major reasons to explore this concept in more detail: (1) memory is a rich metaphor that provides insight into organizational life; (2) OM is embedded in other management theories; (3) OM is relevant to management practice."

Most of the literature on OM tends to focus on definitions of the term, the content and types of OM, its location, and the processes associated with the acquisition, storage, retrieval, and maintenance of memory (Walsh & Ungson, 1991; Stein & Zwass, 1995; Casey, 1997). Walsh and Ungson (1991, p. 61) provide an overall definition of OM as "stored information from an organization's history that can be brought to bear on present decisions." This corresponds closely with the definition given by Stein (1995), who regards OM as the way in which organizational knowledge from the past is brought to bear on present activities.

Some studies have addressed the role of information technology in developing OM systems (OMS) which support OM processes (Sherif, 2002). Several researchers have highlighted the barriers to the implementation of OMS, the ways in which they might be overcome (Sherif, 2002), and the influence of OM on organizational effectiveness (Olivera, 2000).

OM occupies a significant place within management literature. However, Walsh and Ungson (1991, p. 57) argue that "the extant representations of the concept of OM are fragmented and underdeveloped." Examination of the existing literature reveals frequent divergence of understanding of the notion of OM (Corbett, 1997). Indeed, earlier researchers (most notably Ungson, Braunstein, & Hall, 1981; Argyris & Schon, 1978) denied the existence of OM. Generally, organizational theorists disagree about a variety of issues surrounding OM. Ackerman and Halverson (1998, cited by Schwartz, Divitini, & Brasethvik, 2000, p. 3) are concerned that a clear and universally accepted definition of what an OM should do appears to be lacking:

After nearly 10 years of research, the term organizational memory has become overworked and confused. It is time for a re-examination. The term is burdened with the practical wish to reuse organizational experience, leading researchers to ignore critical functions of an organization's memory and consider only some forms of augmenting memory.

CONTROVERSIES IN OM

The field of OM exhibits many controversies in which researchers seem unable to agree about fairly fundamental features. The literature regarding these issues tends to be somewhat sparse and inconclusive. Some of the most notable of these issues, on which we focus in subsequent sections, are:

- Can organizations be said to have memories, or is OM essentially anthropomorphism?
- What is the relationship between the research fields of OM and KM?
- Does OM reside in the minds of individual organizational members, or elsewhere?
- Is OM appropriately modeled in terms of static storage bins, or should it be treated as a dynamic socially constructed process?
- How are OM systems operationalized?
- Is OM functional or dysfunctional in terms of organizational performance and effectiveness?

IS OM ANTHROPOMORPHISM?

Some researchers question whether OM can truly exist at all. They argue that, unlike an individual human being, an organization cannot be said to have a memory. Walsh and Ungson (1991) suggest that the idea of OM raises possible problems of anthropomorphism: Attributing characteristics that may be uniquely human to organizations may be an everyday convenience, but may obscure rather than clarify research issues. Argyris and Schon (1978), for example, contend that organizations cannot memorize knowledge of the past. Others, however, argue the contrary. Weick (1979, p. 206), for instance, asserts that organizational memory is implicated in the production of organizational personality, and that organizations must accept and live with their memories.

WHAT IS THE RELATIONSHIP BETWEEN OM AND KM?

The relationship between OM and KM is another issue of contention. Knowledge management encompasses the management of organizational knowledge to enhance competitive advantage and implies an integrated approach to identifying, capturing, preserving, and retrieving the knowledge associated with the activities of an organization. Davenport and Prusak (1998), for example, define KM as the process of capturing, preserving, and distributing organizational knowledge. But are OM and KM fundamentally distinct fields of enquiry, or do they possess substantial commonality? This question is unresolved. Recent KM literature has either identified OM as an element of KM or appears to have used the terms, whether by accident or design, interchangeably. Unfortunately, however, there has been little attempt to systematically address the nature of the differences and similarities between them. There is little agreement as to what, if indeed anything, distinguishes OM from KM.

OM and KM seem to have evolved, at least, into close partners (Schwartz et al., 2000). Most researchers, including Kuhn and Abecker (1998), view OM as an important component of the KM perspective. The argument is that OM, being concerned with the preservation of knowledge for present and future use, must be integrated with KM. Similarly, Randall, Hughes, O'Brien, Rounefield, and Tomie (2001) consider OM to be a sister concept to KM, and the two are in practice used interchangeably. Hoog and Spek (1997, p. v) acknowledge the close relationship between OM and KM when they state that an important problem in KM is "insufficient use of knowledge possibly stored in badly organised corporate memories."

However, some researchers hold the view that OM and KM are not the same and should not be confused. Marsh and Morris (2001), for example, draw attention to temporality, arguing that KM is of the present, while OM is of the past. They regard KM as relating to the management of knowledge that is currently in use, while OM is concerned with the storage of past knowledge for future use.

Given that a central aspect of KM is the preservation and retrieval of organizational knowledge and that OM is the mechanism by which knowledge from the past is brought to bear on the present and future, it seems legitimate to regard OM as a constituent of KM. The two terms are not synonymous: KM, which addresses the entire issue of managing organizational knowledge, is a far broader area than OM. The storage and retrieval of organizational knowledge is just a part, albeit a crucial part, of the whole job.

WHERE DOES MEMORY RESIDE?

The memories held by an organization constitute a record of its past that may contain a vast amount of knowledge. The literature recognizes a variety of types of devices that may store knowledge (Table 1).

Where organizational memory resides, however, is controversial. The traditional view is that organizational knowledge is brought into being by people within the organization, and that it is located within the human mind (El Sawy, Gomes,

Table 1. Knowledge storage devices

Knowledge storage devices
Formal and informal behavioral routines, procedures, and scripts (Nelson & Winter, 1982)
Standard routine procedures (Stein, 1995)
Managerial technical systems and capabilities (Leonard-Barton, 1992)
Individuals (El Sawy et al., 1986)
Culture (Cook & Yanov, 1992)
Products (Olivera & Argote, 1999)
Physical artefacts of an organization (Campbell-Kelly, 1996)
Computer-based information systems (Stein & Zwass, 1995)

Table 2. A storage bin model of organizational memory (Walsh & Ungson, 1991)

Storage bins
<u>Internal retention bins:</u>
1. Individuals (and their own memory aids, such as files);
2. Culture;
3. Transformations (procedures, rules, and systems that guide the transformations of inputs into outputs);
4. Structures (in particular, organizational roles);
5. Ecology (the physical structure of the workplace); and
<u>External bin:</u>
6. External bin (external archives).

& Gonzalez, 1986; Olivera, 2000). Others place it in the organization itself (Galbraith, 1977). Walsh and Ungson (1991) suggest that memory resides in many different organizational locations, and adopt a "storage bin" analogy, in which OM is structured in six bins which underpin processes of knowledge acquisition and retention (Table 2).

SHOULD OM BE VIEWED AS A SOCIALLY CONSTRUCTED PROCESS?

The storage bin model of OM is typical of a perspective that regards OM as centered around "sets of knowledge retention devices, such as people and documents, that collect, store, and provide access to the organization's experience" (Olivera, 2000, p.

815). However, this is not a universal perspective. The typology of OM constructed by Nissley and Casey (2002) contrasts the storage bin view with that of OM as a socially constructed process, and this is an approach adopted by many researchers (Conklin & Star, 1991; Randall, O'Brien, Rounefield, & Hughes, 1996; Casey, 1997; Randall et al., 2001; Nissley & Casey, 2002; Ackermann & Halveson, 1998). For example, Nissley and Casey (2001) regard collective memory as a socially constructed shared interpretation of the past, and Randall et al. (1996) suggest that considerations of memory should acknowledge "social context," which is relevant not only to retention and transfer of knowledge but also to how it becomes useful to people in the course of their work.

Similarly, Conklin and Star (1991) regard OM as a facilitator of organizational learning. OM is more than the aggregate of the memories of the members of the organization—it is a social phenomenon. Randall et al. (1996, p. 29) emphasize that:

OM should be seen as a collection of socially organized activities done by persons in organizations; that is, remembering as a feasible achievement verb. To put it another way, the 'organizational memory' metaphor fails to distinguish the kinds of social remembering that might take place in organizational life, and provides few examples of the 'remembering how,' 'remembering who,' and 'remembering what' that we are interested in.

HOW ARE OM SYSTEMS OPERATIONALIZED?

Existing literature tends to either neglect the operationalization of OM systems, taking them for granted, or describe it in the context of a technology-based or a people-focused approach. Technologies do indeed play an important role in how organizations preserve their knowledge. Anand, Manz, and Glick (1998) consider technology-based OM systems to fully acknowledge technologies as forms of OM, and several researchers (e.g., El Sawy et al., 1986; Te'eni & Weinberger, 2003) conceptualize IT-supported OM.

Computer-mediated IT, such as Lotus Notes, databases, and Intranets, provide mechanisms for retaining and accessing electronic archives. Stein and Zwass (1995) stress the role of technology in actualizing OM and provide a model for an OM system, of which information systems are a vital component. Meanwhile, some researchers recognize the importance of non-IT-based processes in operationalization of OMS (Walsh & Ungson, 1991). Organizational members may be the most effective means to operationalize storage and retrieval of knowledge.

IS OM FUNCTIONAL OR DYSFUNCTIONAL?

It is perhaps surprising that there are arguments not only for, but also against, the desirability of making the knowledge of the past available in knowledge storage repositories (Paper & Johnson, 1996). Some do indeed argue that OM is functional (Walsh & Ungson, 1991; Stein 1995). Walsh and Ungson (1991, pp. 73-74), for instance, identify three important organizational roles occupied by OM: (1) an informational role; (2) a control function; and (3) a political role. Other benefits that have been identified include increased organizational learning (Te'eni & Weinberger, 2003), improved coordination (Yates, 1989), rapid product development (Moorman & Miner, 1997), and the facilitation of knowledge sharing (Te'eni & Weinberger, 2003). Stein (1995, pp. 31-32) contends that OM can benefit organizations in several ways, including strengthening its identity and providing new personnel with access to the expertise of their predecessors.

However, some authorities (e.g., Walsh & Ungson, 1991; Stein & Zwass, 1995) have pointed to dysfunctionalities. In their view, organizations should discard old practices and develop new ones. Argote (1999) provides evidence which indicates the significance of such policies. Stein (1995) argues that organizational memory is not necessarily a good thing for individuals or organizations, and that, at the other extreme, it can become a constraint that threatens organizational viability.

FUTURE TRENDS

This discussion of OM has focused on a number of key controversies in the field. The contention of the authors of this article is that exploration of these controversies will be valuable to the development of OM theory and practice, and that resolving and accommodating the disagreements will lead to substantial advance. Some research has been directed at such resolution and accommodation, and it is in this direction, the authors consider, that the future lies.

OM, as currently depicted, describes the ways in which organizations can learn and memorize knowledge of their past, through their members, by means of both mental and structural artefacts. As such, OM may be seen as a significant element of KM (Schwartz et al., 2000): KM addresses organizational knowledge holistically, while OM focuses on the storage of past or current knowledge for present and future use. The article presents divergent perspectives—static storage bin or dynamic socially constructed process—on an appropriate model of OM, with the bulk of the literature apparently favoring the former. In the future, we may expect to see some integration of these perspectives, perhaps moving toward a "dynamic socially-constructed storage bin" model which captures valuable aspects of both.

In parallel to this, the technological view of OM that many adopt has been challenged by some researchers. Anand et al. (1998) argue that in order to implement KM initiatives and to manage OM in particular, it will be crucial to understand the nature of the relationships between technology and other organizational features and, in particular, people. We can expect to see more even-handed approaches to human and technical elements in future OM developments.

Although the arguments pointing to the dysfunctionality of OM, potential or otherwise, should not be ignored, we would suggest that the Markovian organization—the organization with no memory—is a foolhardy goal. Indeed, we suggest it might be an impossible one and that organizations need to address the issue of OM, if for no other reason than managed memory is likely to be more functional (or, to put it more pessimistically, less dysfunctional) than unmanaged memory. The functionality of OM lies in the contribution it can make to the effective management of the future of the organization—to organizational decision-making. However, it is essential to ensure that the knowledge available in the repositories of OM is relevant to that activity.

CONCLUSION

Organizational memory is the function of the organization in which organizational knowledge is stored and retrieved for present and future use, and thus contributes importantly to the processes of designing and creating the future of the organization. Although it has interested researchers for several years, many aspects remain unclear and contradictory. The authors hope that this article has provided insight into these aspects and recommend a pluralistic stance to them.

REFERENCES

Ackerman, M.S., & Halverson, C. (1998). Considering an organization's memory. *Proceedings of CSCW '98*. Washington, (pp. 39-48).

Anand, V., Manz, C., & Glick. W.H. (1998). An organizational memory approach to information management. *Academy of Management Review, 23*(4), 796-809.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge*. Norwell, MA: Kluwer Academic Publishers.

Argote, L., Beckman, S.L., & Epple, D. (1990). The persistence and transfer of learning in industrial settings. *Management Science, 36(*2), 140-154.

Argyris, C., & Schon, D. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison-Wesley.

Campbell-Kelly, M. (1996). Information technology and organizational change in the British census, 1981-1911. *Information Research Systems, 7*(1), 22-36.

Casey, A. (1997). Collective memory in organizations. *Advances in Strategic Management, 14*, 111-146.

Conklin, E.J., & Star, S. (1991). Panel on organization memory. *ECSCW'91.*

Cook, S.D.N., & Yanov, D. (1993). Culture and organizational learning. *Journal of Management Inquiry, 2*, 373-90.

Corbett, J.M. (1997). Towards a sociological model of organizational memory. *Proceedings of the 30th Annual Hawaii International Conference on System Sciences, 2,* (pp. 252-261).

Davenport , T.H., & Prusak L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

El Sawy, O.A., Gomes, G.M., & Gonzalez, M.V. (1986). Preserving institutional memory: The management of history as an organizational resource. *Academy of Management Best Paper Proceedings, 37,* 118-122.

Galbraith, J.R. (1977). *Organizational design*. Reading, MA: Addison-Wesley.

Hoog, R.D., & Spek, R.v.d. (1997). Knowledge management: Hope or hype? *Expert Systems with Applications, 13*(1), v-vi.

Kuhn, O., & Abecker, A. (1998). In U.M. Borghoff & R. Pareschi (Eds.), *Corporate memories for knowledge management in industrial practice: Prospects and challenges* (pp. 183-206). Berlin: Springer.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal, 13*(Summer), 111-125.

Marsh, C.H.,& Morris E.C. (2001, October 24-27). Corporate memory and technical communicators: A relationship with a new urgency. *IEEE on Communication Dimensions Proceedings.* IEEE International.

Moorman, C., & Miner, A.S. (1997). The impact of organizational memory on new product performance and creativity. *Journal of Marketing Research, 34* (February), 91-106.

Nelson, R.R., & Winter, S.G.. (1982). *An evolutionary theory of economic change.* Cambridge, MA: The Belkman Press.

Nissley, N., & Casey, A. (2001). The politics of the exhibition: Viewing corporate museums through the paradigmatic lens of organizational memory. *British Journal of Management, 13,* 35-45.

Olivera, F. (2000). Memory systems in organizations: An empirical investigation of mechanisms for knowledge collection, storage and access. *Journal of Management Studies, 37*(6), 811-32.

Olivera, F., & Argote, L. (1999). *Organizational learning and CORE processes in new product development.* In L. Thompson, L. Levine, & D. Messick (Eds.) (pp. 297-326). NJ: Laurence Erlbaum Associates.

Paper, D.J., & Johnson J.J. (1996). A theoretical framework linking creativity, empowerment, and organizational memory. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences* (pp. 20-29).

Randall, D., Hughes, J., O'Brien, J., Rounefield, M., & Tomie, P. (2001) Memories are made of this: Explicating organisational knowledge and memory. *European Journal of Information Systems, 10*, 113-21.

Randall, D., O'Brien, J., Rounefield, M., & Hughes, J.A. (1996). Organizational memory and CSCW: Supporting the "Mavis Phenomenon." *Proceedings of 6th Australian Conference on Computer-Human Interaction.*

Schwartz, D.G., Divitini, M., & Brasethvik, T. (2000). *Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Sherif, K. (2002). *Barriers to adoption of organizational memories: Lessons from industry.* In Stuart Barnes (Ed.) (pp. 210-221). London: Thompson Learning.

Stein, E.W., & Zwass, V. (1995). Analyzing organizational memory with information systems. *Information Systems Research, 6*, 285-314.

Stein, E.W. (1995). Organizational memory: Review of concepts and recommendations for management. *International Journal of Information Management, 15*(2), 17-32.

Te'eni, D., & Weinberger, H. (2003). *Systems development of organizational memory: A literature survey.* Center for Global Knowledge Management, Bar-Ilan University. Retrieved from www.Biu.ac.il

Ungson, G.R., Braunstein, D.N., & Hall, P.D. (1981). Managerial information processing: A research review. *Administrative Science Quarterly, 26*, 116-134.

Walsh, J.P., & Ungson, G.R. (1991) Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Weick, K.E. (1979). *The social psychology of organizing.* Reading, MA: Addison-Wesley.

Yates, J. (1989) *Control through communications: The rise of system in American management.* Baltimore: John Hopkins Press.

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Chapter 1.15
Inquiring Organizations

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INTRODUCTION

In order to manage knowledge and operate successfully in today's information-intensive business environments, various organizational forms have emerged (e.g., Mintzberg, 1979; Nonaka, 1994; Nonaka & Takeuchi, 1995). The form that an organization takes has consequences for communication and dissemination of information, and thereby the ability to engage in organizational learning. Some of these forms compress knowledge at the root level of the organization, while others facilitate the search for useful knowledge within the organization. Other forms are capable of supporting organizational members who must synthesize knowledge from diverse sources. If a firm begins to reconfirm that knowledge management and core competencies are at the heart of organizational performance, the demand on organizations to develop core competencies and to create and manage knowledge intensifies. Even after realizing the critical role of knowledge in the present competitive environments, firms are struggling with managing and creating knowledge.

Growing interest in a firm's intellectual capital and collective knowledge have led to ways in which organizations improve knowledge (organizational learning), store knowledge (organizational memory), and share knowledge (knowledge transfer). Although often discussed separately, these three concepts are tightly interwoven, and all must be considered when an organization strives to move toward a knowledge-based competency. These aspects fall under the broad and complex umbrella of knowledge management. In a review of knowledge management literature, Schultze and Leidner (2002, p. 218) suggest a definition of knowledge management as being the "generation, representation, storage, transfer, transformation, application, embedding, and protecting of organizational knowledge." While their definition is not the only one, nor may all researchers or practitioners agree with its appropriateness, it does demonstrate the incredible complexity that knowledge management presents. The authors note that research in knowledge management is a complex interdependency of collaboration (both in knowledge/information sharing and work), organizational memory, and organizational learning.

An organization striving toward knowledge management competency may be best served by incorporating an organizational form that facilitates learning and thus the expansion of organizational memory. However, choosing one form may not be supportive of the multiple types of learning required by such an organization. These organizations should adopt the form of an inquiring organization (Courtney, Croasdell, & Paradice, 1998) and use it to structure flexible subforms that facilitate the learning process.

This article describes inquiring organizations and considers the appropriateness of applying philosophical perspective to organizational form. The next section provides a background to inquiring organizations. The latter part of the article focuses on how inquiring organizations can take on multiple forms. The article concludes with a discussion of areas for future investigation.

BACKGROUND: INQUIRING SYSTEMS, INQUIRING ORGANIZATIONS AND LEARNING

Inquiring systems are characterized by properties described by Churchman (1971), who develops five inquirers based on the writings of five Western philosophers Leibniz, Locke, Kant, Hegel, and Singer. While an in-depth discussion of the inquirers is not within the scope of this article, each of the inquirers is briefly introduced in the following sections on inquiring organization subforms.

Inquiring systems create and manage knowledge, and provide a component called a guarantor that promotes accuracy and reduces redundancy in organizational memory (Hall, Paradice, & Courtney, 2003). They can provide the basis for a knowledge-oriented organization by facilitating the creation of new organizational knowledge and the adaptation of existing knowledge in wickedly changing situations (Hall et al., 2003). Inquiring organizations are based on inquiring systems (Courtney et al., 1998).

Inquiring organizations and learning organizations are terms that are often used interchangeably; however, there is one critical difference between the two. To be an inquiring organization, the organization's philosophical foundation must be laid on the principles of inquiring systems as discussed by Churchman (1971). Both the learning organization and the inquiring organization aspire to learn. Learning organizations primarily engage in double-loop learning (e.g., reacting to a problem by both fixing the problem (single-loop learning) and making changes to underlying norms that may have contributed to the problem) (Argyris & Schön, 1996) and often approach knowledge management in a reactive manner rather than the proactive process of the inquiring organization. However, an inquiring organization inquires—that is, it continuously searches and investigates its environment and engages in behavior that examines the learning process itself with an end goal of increasing learning efficiency (triple-loop learning). In this manner, the organization challenges the assumptions on which its behavior is based, effectively examining not the most effective means to an end, but examining the foundation of means themselves (Isaacs, 1993). This provides the capacity to routinely check organizational memory for inaccuracies, redundancies, or information that is no longer relevant (Hall et al., 2003).

Given the complexity of any organization moving toward knowledge competency, one can see that its support needs go beyond managerial style, technology, or process design. A knowledge-based organization must be considered in its entirety; however, providing an adequate foundation that can support such an organization is not easy. Churchman's (1971) inquirers, and the inquiring organization in particular, provide a basis for that foundation.

THE MAIN FOCUS: THE INQUIRING ORGANIZATION

The inquiring organization is a mesh of integrated inquiring systems that operate singly or together depending on the complexity of the environment in which the organizational unit finds itself operating. Each of the inquirers discussed by Churchman (1971) has specific strengths that allow it to operate efficiently in specific contexts, and together the inquirers have the ability to handle the complexity and the chaotic environment in which many modern organizations operate. Each of the inquirers is suited to a particular organizational form and environment. For instance, the Leibnizian inquirer is suited to a hierarchical form where knowledge is pushed throughout the organization. Lockean inquiry is more suited to a network form where information is pulled into the network; knowledge is created specifically for that network's context.

Inquirers in the Churchmanian tradition embody different organizational subforms, but integration of the forms into the inquiring organizational metaform allows homeostasis to survive against the elements, and in doing so, supports the characteristics of an inquiring organization. We therefore define the inquiring organizational metaform as a complex structure of multiple organizational subforms working together for the benefit of the organization. We now discuss the subforms in terms of their architecture and learning characteristics.

The Leibnizian Subform

The Leibnizian inquirer is the most basic of the inquirers and provides the inquiring organization with its initial set of facts (fact nets) and axioms derived from formulas that comprise the foundation of organizational memory. These fact nets are created by identifying and testing a hypothesis using basic axioms stored in the system (Churchman, 1971). This inquirer is considered a closed system; that is, it functions within a limited set of relationships. Learning that is attributed to the Leibnizian inquirer is primarily based in the theory of autopoiesis which is the ability to self-perpetuate and produce through a series of relationships in a closed, stable environment. Organizations or organizational units that exist in an environment of stability and routine do well to adopt the Leibnizian inquirer as their organizational form.

This structured environment requires adherence to rules and regulations; learning within the organization is a push rather than pull process. Learning occurs at the top of the organization and is pushed downward throughout the organization by processes such as demonstration workshops. Because of the explicit nature of the information being passed downward throughout the organization, teaching is not generally a necessary means of information dissemination; the printed rules and handbooks of the organization serve the function well.

The Lockean Subform

The Lockean inquirer is a well-suited system for a relatively stable, but highly social environment. This inquirer is founded on principles of agreement embedded in classification of observations. The Lockean inquirer's members share a common belief and vision, culminating in shared mental models of the organization's environment, tasks, and strategies. Learning is a group effort and does not occur without consensus. Thus, relationships and communication are integral facets of this inquirer (Churchman, 1971).

The learning here is both a push process (e.g., guidelines) and an assimilation process (e.g., the collective observation of senior sales personnel). Rather than demonstrate techniques, formal teaching is likely to involve storytelling by top producers, combined with tried-and-true heuristics generated by those experts to react to specific situations, such as an irate customer.

The new salesperson will strive to assimilate actions and processes that are observed to have favorable outcomes for senior sales personnel. This pull process is encouraged through informal indoctrination and by extrinsic motivation factors such as commission percentages.

The Kantian Subform

The Kantian inquirer is designed to incorporate both multiple perspectives and facts to determine models that are appropriate for the situation. Using Leibnizian fact nets to support its data analysis, this inquirer performs modeling techniques to detect causal relationships between perspectives. After a model is chosen as being most appropriate for the particular context through a process known as best-fit analysis, the Kantian inquirer performs an analysis to determine whether that model continues to produce satisfying results; when a model fails to satisfy, it is removed from consideration (Churchman, 1971). This form is most suitable in environments where there is some structure and some ability to formally analyze data, but where a clear solution may not be evident or possible.

Learning in this inquirer is a combination of theoretical and empirical analysis, and is disseminated through the organization via the group members. The nature of the knowledge will affect whether formal or informal teaching applies. Learning may take place in the explicit form (e.g., a change in a process) that would likely be disseminated through a push process as well as being represented in the organization's memory. A new goal, mission, or cultural change may be disseminated less formally through narrative indoctrination.

The Hegelian Subform

The Hegelian inquirer is a more advanced form that seeks to create knowledge through a dialectic process (Churchman, 1971). At its foundation are opposing Leibnizian fact nets that contain the thesis and antithesis perspectives of the question under consideration. Each of these perspectives is examined for their underlying assumptions; these are then paired (one from each side) and examined. As each pair is examined, the assumption with the most applicability to the situation at hand is synthesized into a new perspective that draws on the strength of each of the underlying perspectives (Churchman, 1971). Communication is critical in this form where learning occurs during the synthesis process and a greater understanding of the context is obtained.

Learning in this form is the outcome of the dialectic. Lessons are disseminated throughout the form itself by communication among the members. Little formal teaching or observing is required because members of these organizations are active in the learning process; however, when this form interacts with other forms, the teaching process would be selected in accordance with the receiving form (e.g., formal workshops for the Leibnizian form).

The Singerian Subform

The Singerian inquirer is the most complex of Churchman's (1971) inquirers. Its primary purpose is to seek out inconsistencies throughout the organization and resolve the inconsistencies through a process of measuring, partitioning, and refining. During this process, the Singerian inquirer "sweeps in" variables and perspectives from as many stakeholders as possible, sometimes using the other inquirers for support. When there are no problems to be solved, the Singerian inquirer challenges the status quo and again enters the measurement process. A subcomponent of the inquirer reruns the models associated with the measurement process to ensure replication throughout the system. This inquirer is appropriate for all environments, but is most appropriate for tumulus environments where fast, efficient action is required and little experience with the problem context is available.

The learning associated with this inquirer is complex in both breadth and depth, and is designed to enlarge the "natural image" with multiple perspectives, partitions, and refinements that allow an organization and its members to engage in a wider variety of innovative and creative tasks. The Singerian organizational form produces knowledge on all levels, and therefore all of the aforementioned learning approaches may be appropriate.

MULTIPLE APPROACHES: THE INQUIRING ORGANIZATIONAL METAFORM

The subforms described above are contained within the inquiring organizational metaform. Rarely does an organization consist of a homogenous set of processes, individuals, cultures, or environments. One common thread that does run throughout the organization, however, is the need for an accurate and dynamic organizational memory. As contributions from any organizational member or unit are stored in organizational memory, other organizational components, such as knowledge discovery components, may develop relationships between the new information and existing information that will be beneficial to another, possibly unrelated, unit, thereby facilitating organizational learning. Growth of organizational memory may be further enhanced in this organizational metaform by the use of a system designed to discover and distribute information, particularly from the external environment. Organizational memory may then be used within the organization to facilitate new or innovative knowledge creation.

Just as the components of an organization may differ vastly, so too may the tasks, environment, and decision-making strategies of different units. These characteristics play an important role in determining an appropriate organizational form to adopt. Because the focus of the inquiring organization is learning and the accompanying growth of organizational memory, care must be taken to structure each organizational unit in a way that provides appropriate structure for the task and environment, but does not limit learning potential. The following examples help clarify how the inquiring organizational metaform may translate into its subforms, all working together to provide proper support to the organization.

Manufacturing firms provide an example that illustrates the existence of varying organizational forms in inquiring organizations. Factory floor workers following standard operating procedures and highly routinized tasks are representative of the Leibnizian form. Team members working together to analyze and reengineer business processes to improve efficiencies and productivity represent the Lockean form. Matching product development and production to market needs and developing strategy to meet consumer needs require model fits typified by the Kantian form of inquiry. Labor talks and negotiated contracts are representative functions of the Hegelian form. Finally, organizational metrics that are used to inform productivity measures, assign performance bonuses, or modify existing practices would be typical of the Singerian inquirer. New knowledge from these process (e.g., new consumer needs strategy or new productivity measures) are added to organizational memory.

Another organizational form that can be considered is the academic community that exists in higher education. Each form of organizational inquiry exists within the community. Staff members within a given area function at the Leibnizian level using formal mechanisms and routines. The academic work environment is typically stable, and relatively few administrators carry out centralized high-level decision making. Researchers working together through the processes of research and publication are functioning in Lockean communities; committee and service commitments are also Lockean in nature. Kantian forms of inquiry are active when decisions such as budgeting or admissions standards are considered. These tasks are moderately formal, more complicated in nature, and typically include more autonomy in the decision-making process. Hegelian forms of inquiry may exist between students and faculty, and between faculty and the board of trustees. The tenure and promotion process would be typical of Singer inquiry, with the emphasis on measuring output by the number and quality of publications, student evaluation metrics, and quantified contributions to the referent discipline. Individuals go through a process of refining "research" to a specific number of publications, journal quality, contribution matrices, and so forth. These measures may vary by department. The newly created knowledge that arises from this decision scenario may consist of new journal rankings, new productivity measures, and new ratios of service to research. Again, these are added to organizational memory.

Five organizational subforms have been presented in this article. Discussion has included how each of the subforms may be implemented by or within a given organization, and exemplified how they may work together within an organization under the inquiring organization metaform. Each of the subforms has strengths in particular environments or contexts, but as the metaform, they support the underlying philosophy of the inquiring organization. Managers considering these perspectives can apply the basic principles of each subform as appropriate. Table 1 summarizes the discussion.

FUTURE TRENDS FOR INQUIRING ORGANIZATIONS

Over the last several years, researchers have searched for a unifying theory for knowledge management and the complexities it presents. Clearly, such a theory must support adaptability, flexibility, and the construction of social processes. Two often suggested for the task are Open Systems Theory and Weick's ESR model.

Adaptability is a goal of open systems theory (OST) (Morgan, 1997; von Bertalanffy, 1950, 1968). OST examines an organization for its ability to look beyond its boundaries for information and material, making changes in response to environmental input and learning. These changes are based not only on what it has experienced, but also by combining new information with human experiential knowledge as in an inquiring organization. Weick's (1979, 1995, 2001) Enactment-Selection-Retention (ESR) model of organizing is also concerned with flexibility and

Table 1. Organizational structure of Churchman's (1971) inquirers

Form C	Characteristics P	Primary Learning Style
Leibnizian and Lockean	Formal, routine tasks, stable environment	Top-down dissemination (Leibnizian) Observant assimilation (Lockean)
Kantian	Moderately formal, more complicated tasks, moderately stable environment	Lateral dissemination
Hegelian and Singerian	Informal and often temporary, complicated tasks, turbulent environment	Dialectic (Hegelian) Any of the above (Singerian)

information sharing. One of the main premises of ESR is that an adaptive organization is a collective action, and that influence comes not from positional individuals, but from the pattern of communication and relationships inherent in any social organization.

Churchman's (1971) inquirers, OST, and the ESR model each stress the need for communication and information sharing, and propose that an effective organization is a product of its environment, enacts on its environment, and ultimately shapes its environment. Thus, each of these systems is suitable for both stable and unstable environments, and is a potential knowledge management foundation theory. The inquiring organizational metaform described herein goes a step beyond OST and ESR by facilitating knowledge creation within a framework of multiple perspectives.

It is likely that research into a foundational theory for knowledge management will continue. Further development and testing of organizational structures and technologies developed on the foundation of Churchman's (1971) inquiring theory may provide insight into the applicability of this theory as a foundational one. Churchman's (1971) theory has been used as a foundation for organization memory systems and knowledge management systems. Chae, Hall, and Guo (2001) suggest that using Churchman's (1971) inquirers as a foundation for an organizational memory information system can support Huber's (1991) four assumptions about organizational learning: existence, breadth, elaborateness, and thoroughness.

One conceptualized knowledge management system founded on the principles of Churchman's (1971) inquiring systems is proposed to enable organizations to create, manage, and store reliable information that may then be used to support decision making (Hall et al., 2003). This system not only provides technological and social support for an inquiring organization, but places particular emphasis on information acquisition and discovery, a requirement for organizations embroiled in a fast-paced environment. This model was later found to be applicable to Mintzberg, Raisinghani, and Theoret's (1976) seven-stage systems approach to decision making (Hall & Paradice, 2005).

Future research opportunities into inquiring organizations exist in further development and testing of this knowledge management system and its decision-making components. Further, this system was developed using the design theory espoused by Walls, Widmeyer, and El Sawy (1992), which provides yet another research opportunity. For instance, one may ask what advantages and disadvantages exist when a comprehensive theory such as the inquiring systems theory is overlaid on a framework designed to work with focused theories.

To our knowledge, the metaform discussed in this article is unique in the research realm. Thus, many opportunities exist for researchers interested in organizational form. For instance, can heuristics be generally developed to indicate when an organizational unit should invoke a particular subform? Should the lesser subforms be eliminated in favor of the Hegelian and Singerian forms? Is the learning style of a given subform as effective as another? If new and innovative organizational forms are not routinely considered, developed, and tested, will knowledge management fail to reach its full potential?

CONCLUSION

A flexible organizational form such as that underlying an inquiring organization will provide organizations with the ability to withstand tumulus environments and succeed in establishing themselves as knowledge-based systems. The form that supports inquiring organizations allows them to confront different domains, contexts, and environments with an appropriate form, supports knowledge creation and social processes when appropriate, and provides support for quick action.

Organizations adopting this flexible and comprehensive form will achieve better advancement toward their knowledge-based goals.

We propose that no one form, process, or system will transform an organization into one with a knowledge orientation. Careful examination of social and technological processes, including the importance of a dynamic organizational memory accessible to all organizational members, is critical. This foundation for viewing the whole organization as a knowledge manager contributes to the future of knowledge management.

REFERENCES

Argyris, C., & Schön, D.A. (1996). *Organizational learning II.* Reading, MA: Addison-Wesley.

Chae, B., Hall, D., & Guo, Y. (2001, August 3-5). A framework for organizational memory and organizational memory information system: Insights from Churchman's five inquirers. *Proceedings of the Americas Conference on Information Systems,* Boston.

Churchman, C.W. (1971). *The design of inquiring systems: Basic concepts of systems and organizations.* New York: Basic Books.

Courtney, J.F., Croasdell, D.T., & Paradice, D.B. (1998). Inquiring organizations. *Australian Journal of Information Systems, 6*(1), 3-15.

Hall, D.J., & Paradice, D.B. (2003). Philosophical foundations for a learning-oriented knowledge management system for decision support. *Decision Support Systems 39*(3), 445-461.

Hall, D.J., Paradice, D.B., & Courtney, J.F. (2003). Building a theoretical foundation for a learning-oriented knowledge management system. *Journal of Information Technology Theory and Application (JITTA), 5*(2), 63-89.

Huber, G.P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Isaacs, W.N. (1993). Taking flight: Dialogue, collective thinking, and organizational learning. *Organizational Dynamics, 22*(2), 24-39.

Mintzberg, H. (1979). *The structuring of organizations: A synthesis of the research*. Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H., Raisinghani, D., & Theoret, A. (1976). The structure of 'unstructured' decision processes. *Administrative Science Quarterly, 21,* 246-275.

Morgan, G. (1997). *Images of organizations* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How the Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly, 26*(3), 213-242.

von Bertalanffy, L. (1950). The theory of open systems in physics and biology. *Science, 3,* 23-29.

von Bertalanffy, L. (1968). *General systems theory: Foundations, development, applications.* New York: Braziller.

Walls, J.G., Widmeyer, G.R., & El Sawy, O.A. (1992). Building an information system design theory for vigilant EIS. *Information Systems Research, 3*(1), 36-59.

Weick, K.E. (1979). *The social psychology of organizing* (2nd ed.). New York: Random House.

Weick, K. E. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publications.

Weick, K.E. (2001). *Making Sense of the organization.* Oxford: Blackwell Publishers.

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Chapter 1.16
Quality of Knowledge in Virtual Entities

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INTRODUCTION

The work done by some authors in the fields of computer science, artificial intelligence, and multi-agent systems foresees an approximation of these disciplines and those of the social sciences, namely, in the areas of anthropology, sociology, and psychology. Much of this work has been done in terms of the humanization of the behavior of virtual entities by expressing human-like feelings and emotions.

Some authors (e.g., Ortony, Clore & Collins, 1988; Picard, 1997) suggest lines of action considering ways to assign emotions to machines. Attitudes like cooperation, competition, socialization, and trust are explored in many different areas (Arthur, 1994; Challet & Zhang, 1998; Novais et al., 2004). Other authors (e.g., Bazzan et al., 2000; Castelfranchi, Rosis & Falcone, 1997) recognize the importance of modeling virtual entity mental states in an anthropopathic way.

Indeed, an important motivation to the development of this project comes from the author's work with artificial intelligence in the area of knowledge representation and reasoning, in terms of an extension to the language of logic programming, that is, the Extended Logic Programming (Alferes, Pereira & Przymusinski, 1998; Neves, 1984). On the other hand, the use of null values to deal with imperfect knowledge (Gelfond, 1994; Traylor & Gelfond, 1993) and the enforcement of exceptions to characterize the behavior of intelligent systems (Analide, 2004) is another justification for the adoption of these formalisms in this knowledge arena.

Knowledge representation, as a way to describe the real world based on mechanical, logical, or other means, will always be a function of the systems ability to describe the existent knowledge and their associated reasoning mechanisms. Indeed, in the conception of a knowledge representation system, it must be taken into attention different instances of knowledge:

- The Existent Knowledge: It will not be known in all its extension because it characterizes all the circumstances of the universe of discourse, known or unknown.
- The Observed Knowledge: Acquired by the experience, it must be noticed that it may depend upon the observer education, state of mind, and prejudices (to state a few).
- The Represented Knowledge: With respect to a certain objective, it may be irrelevant to represent a given set of data. This is the information that must be represented and understood.

In a classical logical theory, the proof of a question is made in terms of being true or false, or in terms of representing something about which one could not be conclusive. In spite of that, in a logic program, the answer to a question is only of two types: it can be true or false. This is due to the fact that a logic program shows some limitations in terms of knowledge representation. (It is not allowed explicit representation of negative information.) In addition, in terms of an operational semantics, it is applied the Closed World Assumption (CWA) to all the predicates.

The generality of the programs written in logic represents implicitly negative information, assuming the application of reasoning according to the CWA. An extension of a logic program may comprise negative information (Alferes et al., 1998; Neves, 1984), as well as directly describe the CWA for some predicates. Consequently, it is possible to distinguish three types of conclusions for a question: true, false or, when there is no information inferring one or another, the answer will be unknown.

In this work, the subject related with the qualitative knowledge is discussed behind the assumption that, when a system needs to reason about the real world, it must have the ability to infer upon imperfect knowledge. Hence, this knowledge imperfection may have an important role in the quality of the whole system when considered as a part of a wider community of virtual entities with a rich knowledge component, having sophisticated properties such as planning, reactivity, learning, cooperation, communication, and argumentation. Agent societies may mirror a great variety of human societies with emphasis on behavioral patterns and predefined roles of engagement and obligation.

PRELIMINARIES

Knowledge and belief are generally incomplete, contradictory, or error sensitive, being desirable to use formal tools to deal with the problems that arise from the use of incomplete, contradictory, ambiguous, imperfect, nebulous, or missing information. This work is supported by the developments in Analide (2004) where the representation of incomplete information and the reasoning based on partial assumptions is studied, using the representation of null values (Analide & Neves, 2000; Neves, 1984) to characterize abnormal or exceptional situations. The ELP language presents itself as a formal and flexible tool to obtain a solution for the problems just referred.

Null Values

The identification of null values emerges as a strategy for the enumeration of cases, for which one intends to distinguish between situations where the answers are known (true or false) or unknown (Analide & Neves, 2000; Traylor & Gelfond, 1993).

The representation of null values will be scoped by the ELP. In this work, two types of null values wil be considered: the first will allow the representation of unknown values, not necessarily from a given set of values, and the second will represent unknown values from a given set of possible values.

Consider the following as a case study to show some examples of how null values can be used to represent unknown situations. Consider the implementation of a time table to express the departure of trains through the predicate:

connect: City × Time

where the first argument denotes the city of departure and the second represents the time of arrival (e.g., connect(guimarães,17:00) denotes that the Guimarães's coming train is expect to arrive at 17 o'clock, Program 1).

Program 1

Extension of the predicate that describes arrivals at the train station:

connect(guimarães,17:00)
¬connect(C,T) ←
    not connect(C,T)

In Program 1, the symbol ¬ denotes the strong negation, denoting what should be interpreted as false, and the term not designates negation by failure.

Unknown

Following the example given by Program 1, one can admit that the connection from Oporto has not yet arrived. This situation will be represented by a null value of the type unknown that should allow the conclusion that the connection exists but to which it is not possible to be affirmative with respect to the arrival time (Program 2).

Program 2

Information about Oporto connection with an unknown delay:

connect(guimarães,17:00)
connect(oporto,⊥)
¬connect(C,T) ←
    not connect(C,T) ∧ not exception(connect(C,T))
exception(connect(C,T)) ←
    connect(C, ⊥)

Symbol ⊥ represents a null value of an undefined type, in the sense that it is a representation that assumes that any value is a potential solution but without given the clue to conclude about which value one is speaking about. Computationally, it is not possible to determine from the positive information, the arrival time of the Oporto's connection; by the description of the exception situation (fourth clause from Program 2, the closure of predicate connect), the possibility to be assumed as false any question on the specific time of arrival of that connection is discarded.

Unknown but Enumerated

Consider now the example in which the time of arrival of Lisbon's connection is foreseen as 18 o'clock but is 15 minutes delayed. It is not possible to be affirmative regarding the arrival at 18:00 or at 18:01 or even at 18:15. However, it is false that the train will arrive at 16:16 or at 17:59. This example suggests that the lack of knowledge may only be associated to an enumerated set of possible values.

Program 3

Representation of the connection with a 15-minute delay:

connect(guimarães,17:00)
connect(oporto,⊥)
¬connect(C,T) ←
    not connect(C,T) ∧ not exception(connect(C,T))
exception(connect(C,T)) ←
    connect(C, ⊥)
exception (connect(lisbon,T)) ←
    T ≥ 18:00 ∧ T ≤ 18:15

The exception occurs to the time interval 18:00…18:15. It is unknown that Lisbon's connection will arrive at 18:05 or at 18:10; it is false that it will arrive at 17:55 or at 18:20.

Interpretation of Null Values

To reason about the body of knowledge presented in a particular knowledge, set on the base of the formalism referred to above, let us consider a procedure given in terms of the extension of a predicate called demo, using ELP as the logic programming language. Given a question, it returns a solution based on a set of assumptions. This meta-predicate will be defined as:

demo: Question × Answer

where Question denotes a theorem to be proved, and Answer denotes a truth value: True (T), False (F), or Unknown (U) (Program 4).

Program 4

Extension of meta-predicate demo:

demo(Q, T)   ← Q
demo(Q, F)   ← ¬Q
demo(Q, U)   ← not Q ∧ not ¬Q

The first clause of Program 4 sets a question to be answered with appeal to the knowledge base positive information; the second clause denotes the question is proved to be false with appeal to the negative information presented at the knowledge base level; the third clause stands for itself.

COMPUTING THE QUALITY OF KNOWLEDGE

Based on the assumptions presented previously, it is possible to establish mechanisms to analyze and process the information available in a way that turns feasible the study of the behavior of virtual entities in terms of its personification. Situations involving forgetfulness, remembrance, learning, or trust can be analyzed in the way proposed in this work; that is, the description of abnormal situations, declared as exceptions to a predicate extension, made one's goals possible.

Characterization of a Problem

Consider the following example, built up to illustrate the practical application of what is the main contribution of this work.

Program 5

Excerpt of an extended logic program, representing knowledge at a time ti:

parent(carlos,joão)
¬parent(P,S) ←
    not parent(P,S) ∧ not exception(parent (P,S))

In Program 5, there is an axiom stating that Carlos is a parent of João. Assuming that this is all the knowledge available at instant ti, the second clause of Program 5 enforces that all other situations where there is a lack of information and that are not being treated as exceptions must be considered false.

Suppose that, an instant later, tj, the knowledge evolves in such a way that it may be represented as shown in Program 6.

Program 6

Knowledge base excerpt at instant tj:

¬parent(P,S) ←
not parent(P,S) ∧ not exception(parent (P,S))
exception(parent(carlos,joão))
exception(parent(luís,joão))
exception(parent(pedro,joão))

At a third instant of time, tk, the knowledge base is shown as Program 7.

Program 7

Excerpt of the program that shows how the knowledge base evolves between instants tj and tk:

parent(⊥,joão)
¬parent(P,S) ←
not parent(P,S) ∧ not exception(parent(P,S))
exception(parent(P,S)) ←
parent(⊥,S)

Looking to the way the knowledge base evolved, between instants tj to tk, one may say that the information has been losing specificity. In the beginning, it was known that Carlos was a parent of João (ti); after that, it was only known that the parent of João was Carlos, Luís, or Pedro (tj); finally, in a third instant, the system only knows that João has a parent but cannot be conclusive about who such a person is; it is also not possible to state that João does not have a father.

Consequently, in terms of the temporal axis ti → tj → tk, one may say that the knowledge evolution has taken a form of forgetfulness, leading to the emptying of the knowledge base knowledge. However, taking the knowledge evolution the other way around, that is, tk → tj → ti, a similar analysis leads to the conclusion that the knowledge base learned something, showing that the knowledge base evolves in a way that secures its information.

The System Semantics

Last but not least, it is now possible to pay some attention to the human-like attributes to be represented at a system level, considering the ELP as the language to describe its knowledge bases or theories. Consequently, the objective here is to define those mechanisms that will allow the advent of computational agents at the system level with human-like properties and behaviors, making the way to a certain kind of personification of those computational entities.

Let us consider Program 5, referred to above, that describes the state of the system at instant ti, where who is João's parent is questioned. In terms of the demo meta-predicate, one may have:

i. "(P): demo(parent(P,joão),T)?
∠ successful
"(P): demo(parent(P,joão),F)?
∠ unsuccessful
"(P): demo(parent(P,joão),U)?
∠ unsuccessful

This question is answered in terms of the knowledge base positive information that states that Carlos is João's parent. It is now possible to determine the amount and quality of the information that was used in this round. In other words, one intends to find the set of all the solutions that could contribute to solve the question referred to above, namely:

ii. "(P,S): findall(P,demo(parent(P,joão),T),S)?
∠ S = [carlos]

Let us now consider Program 6, referred to above, and in this context, endorse the same question as in (i). One may have:

iii. "(P): demo(parent(P,joão),T)?
∠ unsuccessful
"(P): demo(parent(P,joão),F)?
∠ unsuccessful
"(P): demo(parent(P,joão),U)?
∠ successful

That is, the question is solved but the answer is vague. This means that endorsing the question as in (ii) will give rise to an empty set of solutions when invoked in terms of the meta-predicate demo. One may have:

iv. "(P,S): findall(P,demo(parent(P,joão),U),S)?
∠ S = [ ]

This situation denotes there are clauses defined as exceptions to the extension of predicate parent, allowing the solution to be unknown, U. One may now turn to the exceptions in order to evaluate the answer. One may have:

v. "(P,S): findall(P,exception(parent(P,joão)),S)?
∠ S = [carlos, luís, pedro]
"(S,N): length(S,N)?
∠ N = 3

In this case, attending to the fact that there are three exceptions to the predicate extension, the vagueness of the data is set to 1/3.

Finally, let us consider the case described by Program 7, referred to above. By the application of the same procedures as in (i), one may have:

vi. "(P): demo(parent(P,joão),T)?
∠ unsuccessful
"(P): demo(parent(P,joão),F)?
∠ unsuccessful
"(P): demo(parent(P,joão),U)?
∠ successful

That is, the solution to the question is undefined. In this case, acting as in (ii), one is presented with a specific result:

vii. "(P,S): findall(P,demo(parent(P,joão),U),S)?
∠ S = [⊥]
"(S,N): lenght(S,N)?
∠ N = ∞

That is, the evaluation of the truth value to assign to the solution falls back upon a mechanism that starts from an unlimited set of possible solutions. It is to be understood that the cardinality of such a set tends to be infinite.

CONCLUSION

The dissemination of computational systems with the ability to live in a virtual community is an open subject for discussion, attaining increasing relevance when the debate relates to the assessment of human-like attitudes and behaviors to virtual entities. The ability to represent and infer upon an entity body of knowledge built around the need to manage imperfect information is an advantage and a virtue explored in this work. This benefit is used to reason about the quality of the information that characterizes such body of knowledge. ELP proved to be an adequate tool for knowledge representation and reasoning, in particular, when one intends to endorse situations where the information is vague, imperfect, or incomplete, which is the case when representing properties and attitudes at the agent's level, only found in humans. The use of these techniques, in particular, in intelligent systems, are flexible to endorse problems where the knowledge of several agents has to be diffused and integrated, and the agents reason about the knowledge or the behavior of their peers in a competitive and/or collaborative way.

REFERENCES

Alferes, J., Pereira, L., & Przymusinski, T. (1998). Classical negation in nonmonotonic reasoning and logic programming. *Journal of Automated Reasoning, 20,* 107-142.

Analide, C. (2004). *Anthropopathy in virtual entities.* PhD Thesis, University of Minho, Department of Informatics.

Analide, C., & Neves, J. (2000, October). Representing incomplete knowledge. *Proceedings of the 1st CAPSI, Conference of the Portuguese Association of Information Systems,* University of Minho, Guimarães, Portugal.

Arthur, W. (1994). Inductive reasoning and bounded rationality (The El Farol Bar Problem). *Proceedings of the American Economics Review,* 84 (p. 406).

Bazzan, A., Bordini, R., Vicari, R., & Wahle, J. (2000, November 19-22). Evolving populations of agents with personalities in the minority game. *Proceedings of the International Joint Conference: 7th IBERAMIA and 15th SBIA, Atibaia-SP,* Brazil.

Castelfranchi, C., Rosis, F., & Falcone, R. (1997, November 8-10). Social attitudes and personalities. In *Proceedings of the Agents, Socially Intelligent Agents, AAAI Fall Symposium Series,* MIT, Cambridge, Massachusetts.

Challet, D., & Zhang, Y. (1998). On the minority game: Analytical and numerical studies. *Physica A, 256*, 514.

Gelfond, M. (1994). Logic programming and reasoning with incomplete information. *Annals of Mathematics and Artificial Intelligence, 12,* 89-116.

Neves, J. (1984). A logic interpreter to handle time and negation in logic data bases. In R. L. muller and J. J. Pottmyer (Eds), *Proceedings of ACM'84 Annual Conference, The 5th Generation Challenge* (pp. 50-54).

Novais, P., Analide, C., Machado, J., & Neves, J. (2004, July). Reputation and trust in the context of logic based argumentation. *Proceedings of the ICKEDS 2004, 1st International Conference on Knowledge Engineering and Decision Support,* Oporto, Portugal.

Ortony, A., Clore, G. L., & Collins, A. (1988). *The cognitive structure of emotions.* Cambridge, UK: Cambridge University Press.

Picard, R. (1997). *Affective computing.* Cambridge, MA: MIT Press.

Traylor, B., & Gelfond, M. (1993). Representing null values in logic programming. *Proceedings of the ILPS'93 Workshop on Logic Programming with Incomplete Information* (pp. 35-47). Vancouver, Canada.

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Chapter 1.17
Knowledge Management, Communities of Practice, and the Role of Technology:
Lessons Learned from the Past and Implications for the Future

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ABSTRACT

This chapter reviews the current work in knowledge management (KM) and attempts to draw lessons from research work in situated cognition about the nature of knowledge which can be useful to the field of KM. The role of technologies and the issues of literacy in technology are discussed in the context of communities of practice (CoPs) and the KM framework with some examples described for K-12 settings. Implications are drawn in terms of how teachers and students can be a community of learners-practitioners through technologies which support their work and learning processes.

INTRODUCTION

As countries in the world compete globally in a knowledge and technology-driven environment where national and global business boundaries continue to dissolve at an unprecedented rate, education is seen as one of the key strategies in meeting the challenges ahead. Educating citizens with attributes such as innovation, creativity, and enterprise has become the rallying call of many governments to make their economies competitive. In order for K-12 schools to produce citizens with such attributes to meet the challenges ahead, school leaders and teachers must be able to fully exploit and share critical pedagogical knowledge with one another. Knowledge management (KM) is a key enabler of a successful school today. In this chapter, KM is discussed in the context of teachers sharing knowledge as a community of practitioners, and when such a community can be facilitated through technologies, the technology literacy levels of teachers are developed in the process. This chapter will begin with a discussion of KM and how lessons from situated cognition can be drawn to inform the field of KM and the issues of CoPs, and technology literacy in K-12 schools are drawn as implications to KM as found in the later parts of this chapter. As the field of KM may be new to many readers of this book, a relatively large section of this chapter will be devoted to the discussion of KM.

In essence, KM is an attempt to understand what works in organizations and institutions such as K-12 schools—their best educational practices, expert practitioners' thinking, and other processes that seem obvious to the experienced school leaders and teachers, but would be alien to beginning teachers. In the past, knowledge management practices focused primarily on the management of data and information. But, more recently, KM practices increasingly revolve around facilitating dialogue and forming collaborative groups within the organization that leverage on innovative information technology (IT) tools to create, capture, and use that information to facilitate communication among individuals to meet organizational goals (Duffy, 2000; Petrides & Guiney, 2002). Thus, the appropriate adoption of technologies in KM in schools should increase the technology literacy levels of teachers. Much of the difficulty in KM for schools lies in the fact that these KM processes may be very much hidden as tacit or implicit knowledge. The difficulty with tacit knowledge is that there is only an extent through which that knowledge can be made explicit. Take for example the case of riding a bicycle. If someone were to ask you to describe the process of riding a bicycle (or how to ride it), you would probably begin to tell about how to balance, how to position the steering, how to pedal, and so forth. However, this merely describes the how-to procedure of bicycle riding. You would probably agree that there is more to riding than the procedure of how-to. Even if we could articulate all about our experiences of riding a bicycle, it is still not the same as the actual skill of riding one. There is a fundamental difference between descriptions of experiences and the actual experience. In other words, tacit knowledge may not necessarily be fully described in explicit terms. The irony is that even if one can fully describe the tacit knowledge, you would not know if what is articulated is the fullest description ever possible.

Tacit knowledge about teaching and learning processes is thus the knowledge gained through experience of managing K-12 schools and designing appropriate learning opportunities for students. Expert teachers and school leaders gain a whole wealth of tacit knowledge as they encounter numerous cases and problem-solving experiences during the course of their work. In the past decade, artificial intelligence (AI) attempted to create expert systems such as intelligent tutoring systems by trying to make explicit the tacit knowledge of expert teachers through codifying this knowledge in the form of computer programs. Two decades of research yielded the fact that expert systems (containing the rules of expert thinking) are not isomorphic or equivalent to experts. Polyani (1964) stressed that we know much more than we can say. Expert teachers and school leaders, in others words, know much more than they can tell or articulate what they know. For example, reading a book written by a successful school leader in turning around a poorly performing school is still miles apart from what the person actually knows from the wealth of his personal experiences in turning around such a school.

KM is an attempt to make explicit what is implicit. Of course, not all implicit or tacit knowledge is useful to a school. A school's tacit knowledge is probably better known as the collective wisdom of the school (c.f., Choo, 2001). Taking a corporate example, "…what HP knows which it cannot even describe as best practice and transfer these processes" to another HP plant (Brown & Duguid, 2000). The explicit knowledge of a school would include, among other things, routines, rules, standard operating procedures, strategic planning documents, and curricular-related materials such as schemes of work and syllabuses. In essence, KM's intent should be to make the school a more effective educational organization by attempting to make explicit as much of what "works best" in terms of practices and processes, and to consciously formulate them, either into documentations and/or through imparting the knowledge to others by explicit sharing.

APPROACHES TO KNOWLEDGE MANAGEMENT

This chapter explores the application of the situated cognition concepts and principles (Lave & Wenger, 1991) to KM within a K-12 school context. It highlights fundamental issues on translating the tacit to explicit and institutional knowledge in a school context. It is important to appreciate that not all tacit knowledge about educational practices and processes can be made explicit. In developing KM within a school, there should be a consideration of context (the work environment or learning environment in relation to persons, tasks, functions, and others) to understand the limit to which there is meaningful translation of tacit knowledge to explicit knowledge—that is, to be mindful of the socio-cultural perspective. While it may not always be possible to fully extract out the tacit knowledge residing in an expert teacher or school leader, it should be possible to engineer processes within a school that could eventually lead to the distillation of key tacit knowledge for the purpose of either "training" (codified knowledge—explicit or established knowledge) or improving educational practices. We suggest that there are two approaches that could be adopted in KM within a school context:

- Approach 1: In situations where the tacit knowledge could be understood and clarified, it should be, as far as possible, be made explicit through the process of externalization such as dialogue, reflection, abstraction, and so forth. This extracted knowledge could be improved upon through appropriate re-packaging with the aim of 'imparting' them to practitioners. This 'imparting' process could be through training, documented in descriptions such as books, or reified into the form of artifacts (Choo, 2002, 2003).
- Approach 2: In situations where the tacit knowledge is difficult to codify (or made objective), the alternative approach is to design a social setting or environment for apprenticeship (imitation and modeling) where experts and novices could interact and where novices could be mentored. Through such a process, tacit knowledge is "internalized" (both tacit and explicit) through enculturation. Through such an enculturation process, members interact on the basis of problems encountered, stories or narratives of situations and cases experienced, and the co-production of artifacts (Brown & Duguid, 2000).

As not all dimensions of tacit knowledge within a school context could be fully understood objectively, we can never be certain that the first approach is always the better approach. We suggest that KM (in its current state of understanding as a field) move towards the second approach of "designing for knowledge stealing" (as it were), and in the process of communities of practice (CoPs) engage in a systematic process of understanding the known processes (first stance). The two stances can be adopted in tandem. Before we elaborate on the two approaches, we reiterate that Approaches 1 and 2 can be adopted for any generic model of training and learning where technology literacy is a topical issue that teachers and students need to address explicitly or whether CoPs can be fostered around issues of literacy where tacit knowledge is negotiated. If technology literacy is not the subject-context or content, teachers and students could be engaged in issues of concern through the facilitation of technologies, and as a consequence, heighten their technology literacy levels in K-12 contexts.

Approach 1 is commonly known as the objectivist worldview, where the assumption is that knowledge is objective and that there is a one version of truth in reality out there. The entire thrust would be to try to find out scientifically what is the truth (in the form of explicit knowledge) and represent it in some codified form. The worldview assumes that there is a singular perspective to "truth" or reality and thus could be represented into forms of language—albeit through multimodal means.

From an expert system point of view, AI has, in the past, attempted to distil or make explicit in the form of programmable rules and language the behavior, skills, and thinking of experts. By and large, much of this knowledge is well-structured knowledge, whereas what is considered as ill-structured remains difficult to make explicit. In a sense, one can say that attempts at understanding the well structured or well defined is noteworthy. By doing so, we could improve educational practices by "automating" what is well understood through, for example, off-loading what is well defined from teachers and letting them concentrate on what are more ill-structured demands in the classroom. This approach would make them more efficient.

The situated cognition view taken in Approach 2 above differs from the objectivist worldview. The situated view espouses that knowledge is deeply contextualized, and any attempt to decontextualize knowledge from either the person or context makes that knowledge meaningless. Such a deep interwovenness of context to knowledge makes the argument of abstraction problematic. In addition, the situated cognition view claims that because knowledge is contextualized, all knowledge is deeply influenced by one's interpretation of a reality or phenomena, giving rise to multiple perspectives (of which all perspectives are valid). In other words, even in KM's attempt to codify knowledge, this codified knowledge is via a perspective—the perspective prevalently held by the interpreters of the phenomena. Hence, the situated view is "against" notions or attempts at over-representing knowledge; rather it favors the perspective of designing situated contexts where improvement in educational practices occurs between teachers in schools through interactions such as negotiations of meanings, apprenticeship, and other methods espoused by social-cultural psychology.

Importance of Product and Process in KM

There is much that KM can learn from the lessons of the last two decades—the work of AI arising from the objectivist view, and the subsequent attempts by situated cognition. Our sense is that clearly both views (Approaches 1 and 2) are at the two ends of the knowledge continuum—one espousing that there is one singular objective view, and the other where multiple views exist—and that all these views may be equally valid. On one end, all attempts made are to codify knowledge as products, and on the other end, knowledge codification is not emphasized, but rather process-interactions are.

Both product and process are important. KM's attempts at putting structures in place within organizations to promote sharing and collaborations, and rewarding process-oriented activities are noteworthy. Such a perspective is very much aligned with the situated cognition view. In addition to facilitating sharing, KM could focus on the design of learning environments or rather the design of workplace environments to facilitate apprenticeship forms of learning and social interactions. The examples of studies done on Xerox engineers by Julian Orr (1996) and others are good examples of such design. John Seely Brown relates the example of how the coffee brewer, once fresh coffee is made, sends a signal to all staff via the Web, and members in the organization flock to the coffee corner (space for informal interactions) where informal knowledge is transacted. However, all these interactions assume that knowledge remains in the organization, as they are held by the individuals and processes within the community. But when these 'experts' leave, the collective knowledge held by these teams within the organizations would most likely be leaked out of the organization as well.

Problem Formulation for KM

Hence, the key issue for schools would be to adopt certain KM practices or processes to ensure that knowledge of best educational practices and tacit knowledge about teaching and learning are retained within the school as far as possible. With an understanding of these practices, knowledge can then be institutionalized (in the form of cultural knowledge) and formalized procedures can then be made explicit. However, when educational contexts change, these institutional norms/practices would have to change accordingly. The challenge for any school is really to know when and how to change.

In summary, the problem of KM can be formulated as an attempt to: (a) understand practice through putting structures in place for knowledge sharing and interactions (still largely explicit knowledge made overt); (b) improve practice by knowing what it knows, retaining as much of what it knows, and by changing what it knows based on changing demands and contexts (establishing and adjusting cultural knowledge); and (c) design community interactions that would facilitate members to appropriate or "steal" knowledge (particularly tacit knowledge).

For this chapter, we would like to concentrate on point (c) that is concerned with the design of community interactions. Based on KM literature, we recognize that this is one significant area of which the literature on situated cognition and the work in education and learning can inform the field of knowledge management (Choo, 2001, 2002, 2003).

DESIGNING COMMUNITY INTERACTIONS

The concept of communities is not new (Vygotsky, 1978). The earliest communities were tribal in nature, where people form societies underpinned by traditions and beliefs of varied orientations. Communities include all kinds of professional practices, religious communities, networks of people, and so forth. More recently the concept of communities of practice (CoPs) is a prevalent concept that has dominated the field of learning, education, and business management. CoPs arise based on professional practices such as the scientific, mathematics, engineering, law, or accounting practices. CoPs are a community of people who practice a profession oriented towards a code of conduct, ethics, history, and peculiar culture. This community of people shares similar concerns and passions, allowing them to collectively evolve the necessary structures and processes to deepen their expertise and knowledge through engaging one another on an ongoing basis (Barab & Duffy, 2000). So, when we try to model the concepts and strategies of CoPs into schools and learning contexts, we have "CoLs" or communities of learners. Similar to CoPs and CoLs is the concept of schools as learning organizations. Within this concept, Fullan (1999) suggests collaborative organizations to: (a) value diversity, (b) bring conflicts into the open, (c) value the quality of relationships as being central to success, (d) accept emotional responses as a complement to rationality and logic, and (e) recognize the value of quality ideas. These tenets are in the same vein as the kinds of orientations CoPs aim to foster.

Principles for Growing and Sustaining Communities

Four principles are observed to be necessary for growing and sustaining communities. These principles, derived from CoPs, would have to find their counterpart-principle in a community of learners.

First, within CoPs there ought to be mutuality, where members share overlapping histories, values, and beliefs. Because of mutual benefits to one another, interdependence of actions is crucial to sustain activities within the CoP.

Second, the community has to, over time, develop a repertoire of artifacts for mutual enterprise. These artifacts represent the knowledge and skills of the members in that community. Over time, the CoP develops increasingly efficient and innovative mechanisms of production and reproduction, giving rise to common practices.

Third, the CoP has to be organized in ways where there would be plenty of opportunities for interactions, active participation, and meaningful relationships to arise. Within these relationships, respect for diverse perspectives and views would be necessary. In other words, CoPs are connected by intricate, socially constructed webs of beliefs and ways of thinking. The authentic activities arising from CoPs are framed by their culture and demands—usually mooted by society needs. Meanings are socially constructed within CoPs through negotiations among present and past members.

Lastly, within CoPs, there has to be a growth and renewal process of new members with past and present persons within the community. Throughout the history of CoPs, one important phenomena observed is new members joining as legitimate peripheral participants (Lave & Wenger, 1991) where they act as novices elbowing experts (or older members) of the CoP. This process begins with peripheral participants (as novices) appropriating an identity through observing masters at work. After extended opportunities of practicing the trades of the community, these novices begin to behave and think like the experts in the community of practice (Wertsch & Rupert, 1993). Lave and Wenger (1991) espoused that by exposing a newcomer to the practices of a community and providing him or her with the opportunities to engage in those practices, the newcomer would move from peripheral participation to a more central participation. In other words, there are levels of participation and contribution through which members in a community make advancements over time. The hypothesis is that, through each advancement, members appropriate a fuller identity similar to the central participants of that particular community of practice. Gradually, over time, these members become significant members in the community and take on central participation within these CoPs.

To summarize the principles underpinning CoPs, Brown and Duguid (2000) characterize learning to be: (a) demand driven, as CoPs create needs of mutual interdependency and outcomes; (b) a social act, as members interact and relate to one another with specific roles and functions in order to achieve the CoP's goals; and (c) an identity formation, where members develop "ways of seeing" meanings, beliefs, and ethics according to the professional practice, for example, mathematicians see patterns in numbers.

The Role of Technology in a CoP Framework

First, within the CoP framework as articulated above, we believe technology can play a crucial role in enhancing learning in the context of relationship-building—that is, technology as a collaborative tool (not just for task collaboration, but socializations). The basic question to ask is how technology can bridge the mutual enterprise of members within the CoPs that involves interdependency of engaging in joint tasks and projects for learning among one another. A key question for research in technology is how to develop scaffolds and structures in collaborative applications where it would help members to co-develop mutual interdependency with one another. Today we have examples of online communities which capitalize on the Internet to establish environments where members are always dependent on each other. One such example is the "Tapped In" Community (http://tappedin.org/tappedin/), a community of education professionals established since 1997. This community is an online forum where groups of teachers are brought together to engage one another based on their specific needs and demands. Professionals participate in sites such as "Tapped In" because there is a rather quick way of receiving some (personal) benefit such as having some query answered by someone, somewhere in the Internet world. Members bother to answer questions, and when their answers are unique and "stand out" from others, these "experts" rise to fame and indirectly receive consultancies and celebrity. It all works on the principles of mutual gain and benefit. Within these thriving online communities, members begin to adopt an online identity and sense of belonging to this community of like-minded people with similar interests and passion. Learning occurs as a consequence of participation in these online communities.

Second, a significant use of technology within the community context is what we are all familiar with—technology as a productivity tool. We are all familiar with how technology enables us to maximize our outputs and production of resources and artifacts for teaching, to communicate with one another either synchronously or asynchronously, to search for information, and to automate our administrative tasks. There is no need to further elaborate on this point.

Thirdly, technology can be used to support a learning community by assisting learners in seeing meanings and concepts without which it would be difficult. Here, we have technology as a (collaborative and individual) sense-making tool. In science, the microscope is an example of a technology which enables learners and scientists to see cells beyond the naked eye. When learners are engaged in meaningful discovery of concepts, technology can open up new vistas of concept visualizations. Computer graphics today can simulate phenomena which traditional media of 2-D charts are unable to do. Chemical bonds and molecular structures can be visualized through appropriate simulations. Simulations are also useful in dangerous or very expensive situations where actual use of equipment may prove unwise.

Thus far, the examples mentioned above described the role of technology in communities. Communities can be formed around teachers who are interested in its use for enhancing their professional practices. In order to leverage on such professional communities to enhance learning, there would be a need to adapt the KM approach to capturing, understanding, and retaining the knowledge and insights gained from the interactions arising from within these communities.

For example, in an ongoing professional development program for Heads of Department for Information Technology (HoDs in IT) in Singapore schools, we had a group of HoDs (IT) who became interested in knowledge-building pedagogies (Hung, Tan, Hedberg, & Koh, 2005; see Scardamalia, 2002 for knowledge-building pedagogies) using computer-supported collaborative learning (CSCL) systems, and who decided to collaborate and support one another in the implementation of knowledge-building activities in their respective schools. One of the HoDs (IT) who was initially observed to be rather passive both during face-to-face sessions and online sessions (when these teachers were attending a heads of department course at the National Institute of

Education) developed into an active participant at the end of the program. She mentioned in an interview that she was the least knowledgeable of the three members in her knowledge-building team in terms of the use of CSCL systems for teaching and learning. She described how the other members in the group, more experienced in knowledge-building activities and CSCL systems, supported her during the planning and implementation stages, sharing ideas with her and helping her solve technical problems. Through this enculturation process, she developed from being a peripheral participant (Lave & Wenger, 1991) at the beginning of the program into a more central participant. She has since presented in two sharing sessions to other HoDs (IT), an ICT conference, as well as a school cluster (a group of schools within a particular district) sharing session. She has plans to implement this knowledge-building concept to more levels in her school and tried to tie up with other schools in implementing knowledge-building activities using CSCL systems.

In this example, we could see the development of this HoD (IT) in identity formation, from a peripheral participant at the beginning of the program to a central participant after one year into the program. This process of transformation is facilitated by the use of online discussion tools, used at the beginning of the program for the members to raise issues on teaching and learning using technology, and using e-mail for discussion when the HoDs (IT) were back in school during the implementation period. Such identity formation in a community arose from uncertainty in the use of technology for innovative use of technology in teaching and learning. The KM approach, had it been adapted for use in the above example, would have yielded more useful learning that could be used to grow and sustain other similar communities.

The above roles of technology are not exhaustive, but indicative of technology as an enabler to facilitate learning interactions within communities of learners. We emphasize that educational technology is a means to an end, and not an end in itself. They can be used effectively to enhance social relationships in learning, assist learners in their projects, and help learners explore and deepen their conceptual understanding through simulations and visualizations.

A summary of the role of technology in forming and sustaining communities discussed thus far is provided in Table 1. From Table 1, it is obvious that there is a lack of technology tools for identity formations such as the learning or enculturation of beliefs and shared values.

The ability of members such as teachers within a CoP to adopt technology in the above ways

Table 1. Synthesizing CoP principles with technology tools

CoP-CoL Principles	3 principles of Learning	Technology Tools
Shared Beliefs and History	Learning is an identity formation	*Gap area*
Mutual enterprise & production of joint artifacts	Learning is demand-driven (based on needs to understand); Learning is a social act	Technology as a productivity tool; Technology as a sense-making tool Technology as a collaborative tool
Interactions, activities, and relationships-building (mutual trust)	Learning is a social act	Technology as a collaborative tool
Cycle of renewal—new members joining the community	Learning is a social act; Learning is an identity formation	Technology as a collaborative tool *Gap area*

enhances their literacy levels with regards to: (1) using language, symbols, and text for knowledge creation and dialogue; (2) interacting between their knowledge-understanding and the information they receive from others and elsewhere; and (3) adopting different technology tools whenever they need to achieve goals at hand (Istance, 2003).

FUTURE DIRECTIONS FOR KM: INVOLVING THE LARGER COMMUNITY

The approach taken by the CoP framework is clearly more process than product oriented from the KM perspective. So, what's next? Knowledge from Polanyi's perspective is largely tied to context and the person. In other words, knowledge differs from "information" because when information is applied to a context, it becomes contextualized, and the person applying that knowledge gained personal experiences and knowledge. If that person leaves the community (or organization), knowledge leaves with that person(s). We offer one recommendation to KM: invest heavily on person and context-process development. There is a need to form networks of teams across organizations and communities, and expand the global process of knowledge management. Technology today can mediate and connect people and expertise (not just information), and knowledge can still be managed across networks of people. We recommend a community of communities suggestion.

Academia serves as a good example of these community of communities networks. In academia, professors and practitioners belong to different universities and organizations, but generally many are affiliated to societies and professional bodies. Yearly, many of these societies organize activities such as conferences where expertise is being shared. In addition, many of these societies have dissemination means such as Web sites, e-mail communications, journals, and others. The unique part of universities in terms of their rewarding mechanisms to their faculty members is that academics are rewarded when they contribute to new knowledge to the larger community (and not just to the university). And this recognition mechanism is common across most universities. Thus knowledge leaks (as it were, when individuals move out of these respective institutions or organizations) are contained to within the larger communities and mediated by societies and communication means (such as journals). Importantly, in academia, the reward criteria for academics are relatively consistent across universities. These networks of networks represent the non-linearity of interactions that are needed for knowledge creation and management—denoting "complex forms of negotiation and interaction between people, some of whom will offer different kinds of knowledge" (Southworth, 2000, p. 290).

Technologies have in the past supported attempts at codifying knowledge, and these efforts can be seen in databases being created to manage information. More recently, technologies that support processes of knowledge creation and sharing include computer-supported collaborative environments and computer-supported communication tools. These technologies support the process rather than the product-oriented views of knowledge. Similarly, authoring or constructive tools enable individuals to engage in the process of knowledge creation and meaning making rather than receiving knowledge. Increasing, technology must now support the process of story creation or narrative creation as we recognize that storytelling is one effective tool in KM. Moreover, how can technologies support the social construction process of story creation, refining, and reconstruction—the process of which enables individuals to construct a coherent understanding of "what they are doing in practice"? The commonly told accounts of Xerox's technicians constructing stories of the machine problems they encounter, by relating to one another pieces of troubleshooting data, account for their experimentations on certain problems, getting more data to support their conjectures and co-constructing their "story," attempting to being coherent to their "story," and defending that their stories are all part of the social construction process.

CONCLUSION

The fundamental issue of KM is to understand the "ways things work," improve on them, establish and formulate processes, and possibly scale up and sustain these so-called good practices. Within this whole process of attempting to understand practice, we expect dimensions of tacit, explicit, and cultural (or institutional) knowledge to be interwoven and to manifest in various forms. Moving from "if only an organization knows what it knew" to "knowing as much of what it knows and setting processes to sustain its better processes" and "knowing when to change its processes when needed" seem to be what the business of KM is all about. All these attempts presume the assumption that we tease out as much of the tacit (individual and organizational levels) to the explicit (individual and organizational), and formulate cultural knowledge (organizational level) to improve ways of thinking and doing.

We need to recognize that there is a limit to what KM can achieve. Social relations, cultural and contextual underpinnings (or overpinnings), and knowledge as tied to persons are part of the capital of what distinguishes one organization-individual from another. The key lies in striking a balance between codifying knowledge and creating the processes which support knowledge creation, sharing, and transfer. Technology can only facilitate the processes enabled for both and enhance the KM efforts. The CoP frameworks are efforts to create such process-oriented KM processes, but as in any approach, there would be advantages and disadvantages. Certainly, we recognize that both process- and product-oriented KM is necessary, and we see both as dialectically informing each other. We envisage that in the near future, this concept of CoPs will pervade the teaching profession and educational community as its popularity increases (Gee, 2000; Hung et al., 2005). Technology will inevitably be an integral part of CoPs—both as a content-issue to be dialogued upon by members of the CoPs and thus heighten technology literacy, and as a means through which members engage in interactions within CoPs and across disciplines through knowledge brokering. As a result of such adoptions, teachers will become more technology competent both in terms of its awareness and in terms of its use as a tool. Issues in the adoption of technology in learning are dialogued upon as a "product" and adopted as a tool in the "process" of being members in CoPs. CoPs and the concepts of KM can transform our traditional notions of pedagogy and radically shift our mindsets from transmission notions of learning to transformative possibilities where knowledge for the learner (both students and teachers) is not only an entity-product to be absorbed, but as an emerging-process to be constructed and understood both individually and socially.

Schools can no longer afford to be structured in entrenched hierarchical structures, but must be able to respond quickly to the external environment in order to meet the increasingly competitive demands of the global society. Fostering members into CoPs, where every member contributes to others and receives from others within a KM framework, would enable knowledge to flow dynamically within a school (or across schools) (Wenger, McDermott, & Snyder, 2002). In this way, members of CoPs need to assume increased responsibility, ownership, and accountability to the school organization and to knowledge. Inevitably, we believe that schools would have to be "transformed" into dynamic communities and sub-communities. Information technologies would be an integral part of the knowledge flow processes, and as a consequence, literacy levels rise in tandem. Through such a transformative stance, schools become "knowledge-creating schools" (Hargreaves, 1999) where learning is understood as a collaborative effort, and in the process, artifacts are developed within a KM framework which could be knowledge-products, practices, and ideas—both conceptual and material (Paavola, Lipponen, & Hakkarainen, 2004).

Finally, summarizing the entire chapter, we recognize that (as we think through the issues of KM, CoPs, CoLs, and the related underlying theoretical foundations of situated cognition) CoPs and/or CoLs can be seen as ways of organizing teachers (or professionals) for continuous (organizational) learning and for propagating good professional practices. The tools of CoPs/CoLs are frameworks or strategies available to facilitate interactions among members in some structured manner to give focus and to achieve goals and results. KM is a product and process methodology that captures and retains the knowledge and insights gained for future mining to minimize possible mistakes (which were done in the past) and lower the entry of learning needed to participate in the community (that is, to speed up the process of learning within the community—from novice to expert). Technologies (including AI) are enablers to facilitate KM, CoPs/CoLs, and the implementation of derived framework-strategies to facilitate interactions and processes more conveniently.

REFERENCES

Barab, S., & Duffy, T. (2000). From practice fields to communities of practice. In D. Jonassen & S. Land (Eds.), *Theoretical foundations of learning environments*. Mahwah, NJ: Lawrence Erlbaum.

Brown, J., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Press.

Choo, C. W. (2001). Knowledge management. In J. R. Schement (Ed.), *Encyclopedia of communication and information*. New York: Macmillan Reference.

Choo, C. W. (2002). *Sensemaking, knowledge creation, and decision making: Organizational knowing as emergent strategy. Strategic management of intellectual capital and organizational knowledge*. New York: Oxford University Press.

Choo, C. W. (2003). Perspectives on managing knowledge in organizations. In N.J. Williamson & C. Beghtol (Eds.), *Knowledge organization and classification in international information retrieval*. Binghamton, NY: Haworth Press.

Duffy, J. (2000). Knowledge management: To be or not to be? *Information Management Journal*, *34*(1), 64-67.

Fullan, M. (1999). *Change forces: The sequel*. London: Cassell.

Gee, J.P. (2000). Communities of practice in the new capitalism. *Journal of the Learning Sciences, 9*(4), 515-523.

Hargreaves, D. (1999). The knowledge-creating school. *British Journal of Educational Studies, 47*(2), 122-144.

Hung, D., Tan, S. C., Hedberg, J., & Koh, T. S. (2005). A framework for fostering a community of practice: Scaffolding learners through an evolving continuum. *British Journal of Educational Technology, 36*(2), 159-176.

Istance, D. (2003). Schooling and lifelong learning: Insights from OECD analyses. *European Journal of Education, 38*(1), 85-98.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Orr, J. (1996). *Talking about machines: An ethnography of a modern job*. Ithaca, NY: IRL Press.

Paavola, S., Lipponen, L., & Hakkarainen, K. (2004). Models of innovative knowledge communities and three metaphors of learning. *Review of educational research, 74*(4), 557-576.

Petrides, L., & Guiney, S. (2002). Knowledge management for school leaders: An ecological framework for thinking schools. *Teachers College Record, 104*(8), 1702-1717.

Polanyi, M. (1964). *Personal knowledge: Towards a post-critical philosophy.* New York: Harper & Row.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in the knowledge society* (pp. 67-98). Chicago: Open Court.

Southworth, G. (2000). How primary schools learn. *Research Papers in Education, 15*(3), 275-291.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes.* Cambridge: Harvard University Press.

Weber, S. (2003). Boundary-crossing in the context of intercultural learning. In T. Tuomi-Grohn & Y. Engestrom (Eds.), *Between school and work: New perspectives on transfer and boundary-crossing* (pp. 157-177). The Netherlands: Elsevier Science.

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice*. Boston: Harvard Business Press.

Wertsch, J. V., & Rupert, L. J. (1993). The authority of cultural tools in a sociocultural approach to mediated agency. *Cognition and Instruction, 11*(3&4), 227-239.

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Chapter 1.18
Customer Knowledge Management

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INTRODUCTION

As companies begin to develop competence in managing internal knowledge and applying it towards achieving organizational goals, they are setting their sights on new sources of knowledge that are not necessarily found within the boundaries of the firm. Customer knowledge management comprises the processes that are concerned with the identification, acquisition, and utilization of knowledge from beyond a firm's external boundary in order to create value for an organization. Companies can utilize this knowledge in many different forms of organizational improvement and change, but it is especially valuable for innovation and the new product development function.

The notion of working with partners to share information was first discussed in 1966 where the possibility of transferring information between a company and its suppliers and customers was identified. Kaufman (1966) describes the advantages to a business that include reduced order costs, reduced delivery time, and increased customer "confidence and goodwill" (p. 148).

Organizations have since been viewed as interpretation systems that must find ways of knowing their environment (Daft & Weick, 1984). Through this environmental learning, a firm's ability to innovate can improve by going beyond a firm's boundaries to expand the knowledge available for creating new and successful products. Some organizations conduct ongoing, active searches of the environment to seek new and vital information. Such organizations become the key innovators within an industry. Other, more passive organizations accept whatever information the environment presents and avoid the processes of testing new ideas and innovation. Marketing literature refers to this concept as market orientation (Kohli & Jaworski, 1990; Slater & Narver, 1995).

More recently, many organizations have realized the value of information about their customers through customer relationship management and data mining strategies, and have used this information to tailor their marketing efforts (Berson, Smith, & Thearling, 2003; Blattberg, Getz, & Thomas, 2001; Davenport, Harris, & Kohli, 2001). The idea of using information from suppliers to accurately manage inventory levels within the supply chain (Lin, Huang, & Lin, 2002) also reflects this notion. However, what is missing from these theories and strategies is the realization of the value of knowledge residing within customers, and not information about customers.

Iansiti and Levien (2004) describe an organization's environment as an ecosystem, where networked organizations rely on the strength of others for survival. Within this ecology, they identify certain "keystone organizations" that "simplify the complex task of connecting network participants to one another or by making the creation of new products by third parties more efficient" (p. 73). This increase in overall ecosystem productivity is accomplished though the incorporation of technological innovations and niche creation through innovative technologies. Through recognizing customer knowledge as a key component to a firm's ability to innovate, and actively searching for sources of knowledge within the business environment, a firm is able to augment its innovation capabilities and position themselves as a keystone organization.

BACKGROUND

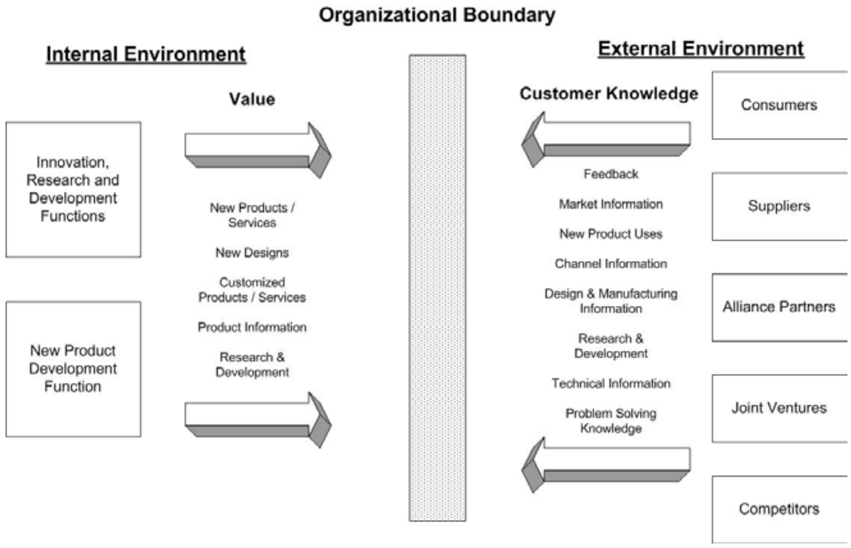
In examining the role of external knowledge in an organization's internal processes, customer is broadly defined as an organization's stakeholders such as consumers, suppliers, partners, joint ventures and alliances, and competitors. In some cases, a customer may not have a current relationship with the organization, but one is likely to develop in the future. Knowledge in this context refers to the model presented by Cook and Brown (1999), where it can be explicit or tacit, and individual or group knowledge. Explicit knowledge is easily codified, transferred, and understood by multiple individuals, where tacit knowledge requires experience and practice in order to flow from one individual to another. Both of these forms of knowledge can reside at the individual level, or be created and transferred between different groups.

Knowledge derived from these relationships through an interactive and mutually beneficial process is referred to as customer knowledge. Customer knowledge can be composed of a combination of consumer knowledge, supply chain knowledge, joint venture specific knowledge, and so forth. This knowledge is created within a two-way flow of knowledge which creates value for both parties. It goes beyond information identifying and classifying customers, to knowledge that is resident within the external organization that has been developed through industry and market experience. Examples can be consumer preferences of new product features, newly recognized uses for current products, knowledge derived from joint research and development, design improvements from suppliers intended to reduce the cost of manufacturing, and knowledge regarding trends within the business environment.

An important aspect of customer knowledge is that it is knowledge not owned by the firm, but by others who may or may not be willing to share such knowledge. The processes that a firm employs to manage the identification, acquisition, and internal utilization of customer knowledge are collectively referred to as customer knowledge management. It is within these processes that an organization and its customers collectively work together to combine their existing knowledge to create new knowledge. This new knowledge is a key input into a company's ability to innovate, which is reflected in their research and development function. Furthermore, the ability to design and improve new products is also impacted by the level of customer knowledge flows. A depiction of customer knowledge flows is shown in Figure 1.

Many studies have used customer knowledge and customer information interchangeably, causing confusion between the two terms. Blosch (2000) states that understanding "how each customer interacts with business processes is to gain

Figure 1. Summary of customer knowledge



knowledge about that customer" (p. 266). Gibbert, Leibold, and Probst (2002) would describe this only as customer information, as it is knowledge about the customer and is gained without a predetermined close interaction or partnership. Dennis, Marsland, and Cockett (2001) also examine the use of customer information within a retail environment, and look at how data mining can contribute to an organization's understanding of the customer. Once again, the emphasis is on acquiring information about the customer, without interaction or joint knowledge creation.

Davenport et al. (2001) begin to argue that knowledge about the customer is only the first step, and organizations should create processes to better manage the relationships they discover with this information to create profitable interactions. The focus they present remains with learning about the customer's needs through different channels. However, the customer's involvement in the knowledge process is still passive, and not participatory.

Recently, an emphasis on customers as partners in the knowledge creation process has been presented (Sawhney & Prandelli, 2000). Customers co-create knowledge with an organization in order to create value for both parties by sharing knowledge residing within customers in order to create better products. Here, the two entities work together with a shared goal in mind, and the customer becomes an active and key participant in the knowledge creation process. Gibbert et al. (2002) examined a set of organizations that have implemented this idea into their customer relationship strategy, and described the types of CKM they observed.

CUSTOMER KNOWLEDGE AND INNOVATION

Henry Chesbrough (2003) states that most innovations fail when brought to the marketplace. However, if companies do not continually innovate, they die. This is in part due to the key role innovation plays in value creation and profitable growth (Prahalad & Ramaswamy, 2003). Innovation creates advantages in the marketplace over competitors, leads to and supports other competitive advantages such as cost savings, and differentiates the organization in the marketplace through the eyes of its customers.

Innovation relies on the creation of new knowledge by the organization, and this is derived from many sources. Companies can identify new and usable knowledge within their employees (Bontis, Crossan, & Hulland, 2002; Leonard & Sensiper, 1998), convert this existing tacit knowledge to easily shared explicit knowledge (Nonaka & Takeuchi, 1995), purchase or acquire knowledge from other organizations, or look to the external environment for new sources of knowledge such as their customers. This is where customer knowledge can significantly contribute to a firm's ability to innovate.

An organization is continually challenged to create new knowledge, and transform this knowledge (i.e., into solutions to problems, new products, etc.) through the integration of knowledge from different sources (Carlile & Rebentisch, 2003). Firms are constantly striving to identify valuable information and disseminate it to the appropriate areas of the organization in order to make informed decisions and create a competitive advantage. More and more, firms are looking beyond external boundaries for new sources of knowledge, and in many cases this points them towards their customers. An organization will be able to stimulate its new product development process and create well-received products if it can collaborate via a knowledge sharing strategy with its customers. A successful knowledge partnership with the most valuable and important customers can not only strengthen these business relationships, but also create a competitive advantage that is difficult for the competition to duplicate.

Customer knowledge can establish a competitive advantage for the organization through increased organizational learning and innovation. The competitive advantage gained through knowledge acquisition can either be temporary, as other competitors will follow and learn the new skills, processes, products, and so forth, or it can be more permanent if the competition is prevented from gaining this knowledge. Customer knowledge can be a barrier to knowledge acquisition for the competition by building a close relationship with the customer that cannot be duplicated. This barrier is strengthened if the customer perceives an intrinsic benefit that cannot be duplicated by other competitors. For example, as Amazon.com learns a customer's buying preferences and is able to offer valuable recommendations, that customer will be reluctant to switch retailers and begin the learning process over. In some cases this is referred to as customer learning (Stewart, 1997), where the two-way exchange of knowledge allows the customer to gain new knowledge and use this to his or her benefit. The knowledge sharing partnership acts both as a facilitator of knowledge transfer and sharing, and a barrier to the competition.

Types of Customer Knowledge

Customers can provide unique knowledge that allows an organization to learn and acquire knowledge to improve its internal operations, including innovation. In turn, the organization provides to the customer knowledge of its products and services which improves the functionality to the customer. This two-way flow of knowledge provides the basis for a competitive advantage through a strong relationship or partnership. Gibbert et al. (2002) discuss the five basic forms of customer knowledge which are prosumerism, team based co-learning, mutual innovation, communities of creation, and joint intellectual property development (Table 1). Each form of customer knowledge originates from a relationship between the organization and a customer source, and can be derived from multiple sources.

The first version of customer knowledge is prosumerism, a term derived from Toffler's (1980) 'prosumer', which describes a customer filling the dual role of consumer and producer. In this

Table 1. Summary of the five forms of customer knowledge

Knowledge Form (Gibbert et al., 2002)	**Typical Relationship Form**
Prosumerism	Firm—Producer/Manufacturer
Team-Based Co-Learning	Firm—Consumer/Joint Venture
Mutual Innovation	Firm—Supplier/Joint Venture
Communities of Creation	Firm—Consumer/Joint Venture
Joint Intellectual Property	Firm—Consumer

instance, knowledge co-production is generated from role patterns and interactivity. For example, Bosch develops engine management systems with Mercedes-Benz who then creates and assembles the finished product, a car. Bosch's customer, Mercedes-Benz, is allowed to share value-creating ideas and facilitates the development of new initiatives and products.

The second form of customer knowledge management is team-based co-learning. This involves intense interactions with the customer to gain their knowledge on processes and systems to facilitate systematic change. A prominent example of this is Amazon.com. By restructuring their organization from being an online book retailer to a seller of many varieties of goods, they accomplished many co-learning interactions with their customers (i.e., suppliers) to design a new value chain. Amazon.com uses this value chain as a competitive advantage against other online retailers, as it allows for quick movement of goods at competitive prices. This strategy has the added value of creating an even closer relationship with their suppliers that other online retailers will not be able to duplicate. A second illustration is Toyota, who has created knowledge-sharing networks with its suppliers, with the common goal of learning through combining each other's knowledge to create efficiencies in the production process (Dyer & Nobeoka, 2000). Toyota and a supplier will create a team, co-populated with employees from each organization who together study organizational processes and create new customer knowledge.

Mutual innovation was initially identified by von Hippel (1988), who discussed that most product innovations come from the end-users of the product, as they have specific product knowledge derived from use and their own needs. Mutual innovation is more than just asking for future requirements, but constructing knowledge that comes from closely integrated innovation practices. Rider Logistics developed complex and extensive logistical solutions for its customers through close examination of their manufacturing operations and supply chain strategies, then designed services that fit and added value to these processes. This may convert Rider from a basic trucking company towards a logistics solutions provider (Gibbert et al., 2002).

Communities of creation occur when companies organize their customers into groups holding similar expert knowledge and encourage interaction in order to generate new knowledge. These groups are characterized by working together over a long period of time, sharing a common interest, and wanting to create and share valuable knowledge. Unlike traditional communities of practice (Wenger, 1998), these groups span organizational boundaries and develop value for multiple organizations. Microsoft beta testing with customers is an example where groups of targeted customers test products together with the Microsoft product development engineers to jointly create a product that provides value for Microsoft and its participating customer organizations. These communities also form through informal relationships which are capable of producing valuable knowledge.

The final form of CKM is joint intellectual property, which may be the most intense form of cooperation between a company and its customers. Here, the company takes the view that it is owned by its customers and they have ownership in product development. This notion goes beyond normal customer relationships and co-creates new businesses based on customer education and co-development. Skandia Insurance is an example where a company and its valued consumers created new businesses owned by both. They have proven this strategy especially successful in emerging markets where the company initially lacks customer knowledge, yet gains a great deal from its local customers.

Challenges for Customer Knowledge Management

Many of the discussions on internal knowledge transfer deal with the challenges of sharing knowledge at the individual, group, or organizational level. These challenges remain true for sharing customer knowledge across an external boundary. Initially, firms may experience a cultural challenge of perceiving customers as a source of knowledge, not just revenue. This is reflected in the 'not invented here' concept, which demonstrates an organization's unwillingness to accept externally generated ideas. Other companies fear showing internal processes to customers such as suppliers or alliance partners in case a poor perception develops. It is common for heavily brand-based companies who want to control what the customer sees to be afraid of giving away strategic secrets to the marketplace (Gibbert et al., 2002). A further case is resistance to sharing proprietary knowledge with suppliers. Questions of how to control the flow of this knowledge to competitors arise, and the effectiveness of confidentiality agreements are doubted when a firm must reveal or share proprietary technology that is part of a firm's competitive advantage (Ragatz, Handfield et al., 1997).

Besides cultural influences, a firm may not have the competency required to absorb and utilize the external knowledge. Cohen and Levinthal (1990) state that a firm's absorptive capacity, or its ability to absorb new knowledge, is a function of the firm's prior knowledge that allows it to recognize and synthesize new knowledge. Also, information systems may not be able to handle the transfer of knowledge from external sources, as most knowledge sharing support systems are only designed for internal use. Organizations can be quite reluctant to open up these systems, as technical challenges occur without a universal integration and security mechanism that interfaces with both parties' systems. Control of content may be lost, as external knowledge transfer can push the locus of control beyond a firm's boundaries which for some may cause apprehension (Gibbert et al., 2002).

A further obstacle exists when the customer can solely derive innovations from their knowledge and the need for a partner becomes insignificant. Von Hippel (1988) argues that innovators must have a poor ability to gain from their knowledge regarding innovations in order to share this information with others, or else they would capitalize on their knowledge independently and realize higher revenues. Factors such as manufacturing capability, geography, market knowledge, or supply chain requirements can increase an innovator's ability to bring their development to market, and prevent the opportunity for a formalized knowledge sharing alliance.

A key question an organization may ask is how do they know the customer is supplying correct information or that it is representative of the entire market? Although some knowledge sharing partnerships may only be able to encompass the knowledge of one customer, market researchers have techniques to ensure enough customers were consulted to recognize trends or significant findings. However, customer knowledge management still depends on the assumption that an environment exists where useful knowledge can be provided to the company. This may indicate that the potential value to be realized by a customer knowledge management initiative is equal to the ability of the external environment to provide such knowledge, and customer knowledge management may be more effective in some industries over others.

To further this point, companies should realize the limitations of focusing on their current customers and markets, and look beyond their range to products that cannot be foreseen or their value realized by current customers. These new ideas, sometimes called disruptive technologies (Christensen, 2000), go against the axiom of staying close to your customer (Prahalad & Ramaswamy, 2000) and encourage innovators to develop innovative ideas that disrupt a customer's process and patterns to introduce new products that leap the product lifecycle and replace current paradigms and technologies. They may even target new markets that do not exist or satisfy customers' needs today, and therefore cannot be currently used to gain customer knowledge, but possibly will in the future.

FUTURE TRENDS

The concept of customer knowledge is relatively new to the field of knowledge management, yet it continues to develop as more organizations embrace the idea and put it into practice. It is becoming quite common to observe knowledge-sharing agreements between separate firms, and in some cases joint ventures for the specific purpose of creating new knowledge.

As competency in utilizing customer knowledge increases, more companies will conduct new product development through a web of businesses capable of enhancing the process with their unique core competencies. By working as a team, each firm's internal knowledge will contribute to the creation of a new set of shared knowledge. This new knowledge will be the driver for innovative product ideas and advancements. Developing the ability to learn from external organizations will become a key objective in organizational knowledge management strategies. Firms will take the best practices of sharing knowledge over external boundaries, and apply these skills towards improving internal knowledge transfer between different teams, departments, units, and subsidiaries. A cyclical learning cycle of improving knowledge management practices by learning through internal and external knowledge transfer only strengthens a firm's knowledge management abilities.

The definition of customer can be broadened even further to include those entities that may not have a transactional relationship with the firm, yet contain pertinent knowledge of an organization's business environment. Lobby groups, government organizations, legal entities, activist groups such as environmental awareness associations, professional associations, and standards boards all influence the business environment and a firm's ability to operate within it. Each should be considered a valuable source of external knowledge a firm requires to not only understand the environment, but flourish in it (Paquette, 2004). Expanding the range of sources providing customer knowledge will transform this knowledge set into external knowledge management, encompassing all stakeholders' knowledge available to the firm.

CONCLUSION

Facilitating knowledge sharing between internal individuals and groups can be a daunting task for any organization. The challenges of this endeavor multiply when the knowledge sharing involves an external entity possessing knowledge that is not owned by the firm.

However, the benefits of creating social structures, business processes, and technologies to facilitate customer knowledge flows can have a substantial impact on the performance of the organization, and in particular its ability to innovate. By actively involving customers in creating a two-way flow of knowledge that supports innovation, an organization leverages a new source of knowledge which can improve its standing in the marketplace. Determining the correct combination of valuable customer knowledge sources and customer knowledge management forms can create a sustainable competitive advantage through the introduction of products that satisfy a market's latent needs. A firm's acknowledgement of the importance of customer knowledge will encourage the expansion of its current knowledge management practices to beyond the organizational boundary. This creates an improved ability to identify, acquire, and utilize valuable knowledge that an organization requires to be successful.

REFERENCES

Berson, A., Smith, S., & Thearling, K. (2003). Customer acquisition. *Building Data Mining Applications for CRM* (p. 7). New York.

Blattberg, R.C., Getz, G., & Thomas, J.S. (2001). *Customer equity: Building and managing relationships as valuable assets* (1st ed.). Boston: Harvard Business School Press.

Blosch, M. (2000). Customer knowledge. *Knowledge and Process Management, 7*(4), 265-268.

Bontis, N., Crossan, M.M., & Hulland, J. (2002). Managing an organizational learning system by aligning stocks and flows. *Journal of Management Studies, 39*(4).

Carlile, P., & Rebentisch, E.S. (2003). Into the black box: The knowledge transformation cycle. *Management Science, 49*(9), 1180-1195.

Chesbrough, H.W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Boston: Harvard Business School Press.

Christensen, C.M. (2000). *The innovator's dilemma* (revised ed.). New York: HarperCollins.

Cook, S.D.N., & Brown, J.S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 10*(4), 381-400.

Daft, R.L., & Weick, K.E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9*(2), 284-295.

Davenport, T.H., Harris, J.G., & Kohli, A.K. (2001). How do they know their customers so well? *MIT Sloan Management Review,* (Winter), 63-73.

Dennis, C., Marsland, D., & Cockett, T. (2001). Data mining for shopping centers: Customer knowledge management framework. *Journal of Knowledge Management, 5*(4), 368-374.

Dyer, J.H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal, 21*, 345-367.

Gibbert, M., Leibold, M., & Probst, G. (2002). Five styles of customer knowledge management, and how smart companies use them to create value. *European Management Journal, 20*(5), 459-469.

Iansiti, M., & Levien, R. (2004). Strategy as ecology. *Harvard Business Review,* (March), 68-78.

Kaufman, F. (1966). Data systems that cross corporate boundaries. *Harvard Business Review,* (January-February), 141-155.

Kohli, A.K., & Jaworski, B.J. (1990). Market orientation: The construct, research propositions, and managerial implications. *Journal of Marketing, 54*(2), 1-18.

Leonard, D., & Sensiper, S. (1998). The role of tacit knowledge in group innovation. *California Management Review, 40*(3), 112-132.

Lin, F.-R., Huang, S.-H., & Lin, S.-C. (2002). Effects of information sharing on supply chain performance in electronic commerce. *IEEE Transactions on Engineering Management, 49*(3), 258-268.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. New York: Oxford University Press.

Paquette, S. (2004, May 14-16). Customer knowledge management systems supporting innovation. *Proceedings of the 9th Annual Great Lakes Information Sciences Conference*, Toronto, Canada.

Prahalad, C.K., & Ramaswamy, V. (2000). Co-opting customer competence. *Harvard Business Review*, 79-87.

Prahalad, C.K., & Ramaswamy, V. (2003). The new frontier of experience innovation. *Sloan Management Review,* (Summer), 12-18.

Ragatz, G.L., Handfield, R.B., & Scannell, T.V. (1997). Success factors for integrating suppliers into new product development. *Journal of Product Innovation Management*, (14), 190-202.

Sawhney, M., & Prandelli, E. (2000). Beyond customer knowledge management: Customers as knowledge co-creators. In Y. Malhtora (Ed.), *Knowledge management and virtual organizations* (pp. 258-281). Hershey, PA: Idea Group Publishing.

Slater, S.F., & Narver, J.C. (1995). Market orientation and the learning organization. *Journal of Marketing*, *59*(3), 63-74.

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations* (2nd ed., vol. 1). New York: Doubleday.

Toffler, A. (1980). *The third wave*. New York: Morrow.

von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.

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Chapter 1.19
A Survey of Internet Support for Knowledge Management/ Organizational Memory Systems

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ABSTRACT

Studies of organizational memory/ knowledge management, OM/KM, systems have found that using a common infrastructure to facilitate access to and utilization of knowledge and memory increases the usability and success of these systems. The solution to this is for organizations to have an integrated network. This paper discusses using the Internet as the integrated network. Several systems are described that use the Internet for the OM/KM infrastructure. Theoretical support from case study research for using the Internet as a common knowledge infrastructure is provided through DeLone and McLean's IS Success Model modified and analyzed for knowledge/memory based systems.

INTRODUCTION

Organizations are building and maintaining systems for managing organizational knowledge and memory. Users of these systems may not be at the same location. In many cases, they are distributed across large geographical distances and multiple offices. Key to this task is developing an infrastructure that facilitates distributed access and utilization of the retained knowledge and memory. Connectivity and easy-to-use interfaces are main concerns. Jennex (2000) found that using the Internet as a common communications platform (either as an Intranet or an Extranet) and web browsers as an interface is a viable, low cost solution. Newell et al. (1999) found that Intranets not only supported distributed knowledge processes, but also enhanced users' abilities to capture and control knowledge. Stenmark (2002) proposes that using a multiple perspective of the Internet—information, awareness, and communication—allows developers to build successful Internet-based Knowledge Management Systems, KMS. The purpose of this paper is to illustrate how the Internet can be effectively used as an infrastructure for Knowledge Management/ Organizational Memory Systems, KMS/OMS. This is based on an intensive analysis of a KMS/OMS, an action research study of a KMS, and a literature review of KMS/OMS studies. For simplicity, this paper assumes that knowledge is a subset of Organizational Memory, OM, and the term OMS includes KMS, however, the term KMS will be used to generically refer to a KMS/OMS. This relationship will be illustrated later.

The paper begins by defining concepts used in the paper. This is followed by a discussion on the two types of KMS and the presentation of an assessment model based on DeLone and McLean's (1992) IS Success Model. The presented assessment model is used to assess the success of Internet-based KMS. This is followed by a discussion on enabling factors for a KMS and other tools and research for building an Internet-based KMS. This culminates in the presentation of examples of Internet-based KMS's followed by conclusions and limitations.

BACKGROUND

Organizational Learning

Organizational Learning, OL, is identified as a quantifiable improvement in activities, increased available knowledge for decision-making, or sustainable competitive advantage (Cavaleri, 1994; Dodgson, 1993; Easterby-Smith, 1997; Miller, 1996). Another definition refers to OL as the process of detection and correction of errors, Malhotra (1996). In this view, organizations learn through individuals acting as agents for them. Individual learning activities are seen as being facilitated or inhibited by an ecological system of factors that may be called an organizational learning system. Learning in this perspective is based on Kolb's (1984) model of experiential learning, where individuals learn by doing.

An organization can also learn if, through its processing of information, its potential behaviors are changed, Huber et al. (1998). This incorporates the concept of OM into OL (Huysman et al., 1994; Walsh, Ungson, 1991). In this view, OM is the process by which experience is used to modify current and future actions.

Organizational Memory and Knowledge

Organizational Memory is variously viewed as abstract or unstructured concepts and information that can be partially represented by concrete/physical memory aids, such as databases, and as concrete or structured concepts and information that can be exactly represented by computerized records and files. This paper views OM as a combination of abstract and concrete, where the concrete is the history and trend data collected in the memory and the abstract is the experience gained by the organizational member over time. Definitions by Stein and Zwass (1995) and Walsh and Ungson (1991) support this. Additionally, all agree that OM can include everything within the organization that is retrievable, including the set of documents and artifacts that forms the corporate record and the collection of shared and stored understandings and beliefs that forms the basis for organizational sense-making and social construction of reality.

OM has two principle goals: to integrate information across organizational boundaries and to control current activities and, thus, avoid past mistakes. OM functions are perception, acquisition, abstraction, recording, storage, retrieval, interpretation, and transmission of organizational knowledge (Stein, Zwass, 1995). OM retention facilities are individuals, transformations, structure, ecology, and culture (Walsh, Ungson, 1991).

Davenport and Prusak (1998) view knowledge as an evolving mix of framed experience, values, contextual information and expert insight that provides a framework for evaluating and incorporating new experiences and information. They found that in organizations knowledge often becomes embedded in documents or repositories and in the organizational routines, processes, practices, and norms. Nonaka (1995) expands this definition by stating that knowledge is about meaning in the sense that it is context-specific.

This paper considers OM and knowledge to be constructs and attributes of organizational learning. Also, knowledge is a subset of OM and the acquisition and use of OM includes the acquisition and use of knowledge.

Knowledge Management

Knowledge Management, KM, as a discipline has not been clearly agreed upon. KM is defined as that process established to capture and use knowledge in an organization for the purpose of improving organizational performance (Malhotra, 1998). Organization refers to any acknowledged business group, from a small team to the total enterprise. Also, this process is not restricted to the IS/IT organization and is better done in the organizations that create and use the knowledge. Personnel performing these functions are referred to as Knowledge Workers.

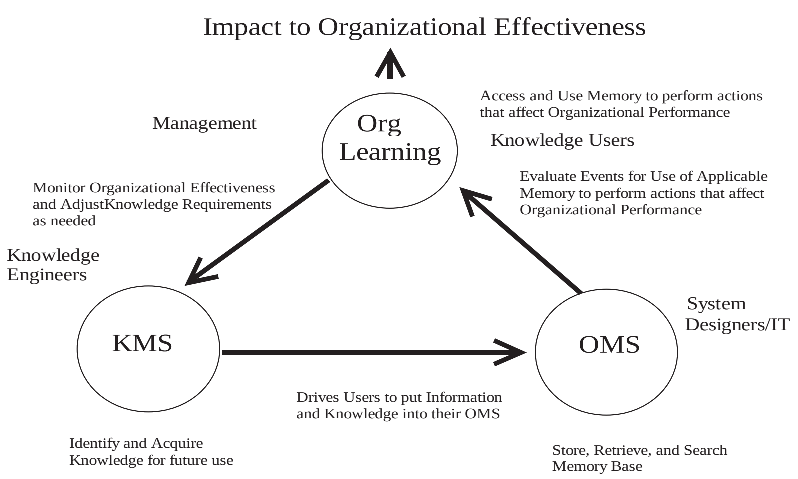
Organizational Memory and Knowledge Management Systems

The OMS is the processes and IS components used to capture, store, search, retrieve, display, and manipulate OM. The KMS consists of the tools and processes used by knowledge workers to identify and transmit knowledge to the knowledge base contained in the OM. Knowledge is managed and used through a combination of the KMS and OMS. Jennex and Olfman (2002) presented the KMS-OMS model in Figure 1 as a model illustrating the relationships between OM, KM, and OL. As mentioned earlier, to simplify terms, the rest of the paper will refer to these combined systems as a KMS.

Types of Knowledge Management Systems

There are two approaches to building a KMS as discussed by Hansen et al. (1999) and Stenmark (2002). These can be described as a project/pro-

Figure 1. The KMS-OMS model



cess/task-based approach, henceforth referred to as the project-based approach, and an infrastructure/generic system based approach, henceforth referred to as the infrastructure-based approach. The project-based approach focuses on the use of OM by participants in a process, task or project in order to improve the effectiveness of that process, task or project. This approach identifies information and knowledge needs, where they are located, and who needs them. The KMS is designed to capture OM unobtrusively and to make OM available upon demand to whoever needs it. Many Y2K projects used project-based KMS.

The infrastructure-based approach focuses on building a base system to capture and distribute OM for use throughout the organization. Concern is with the technical details needed to provide good mnemonic functions associated with the identification, retrieval, and use of OM. The approach focuses on network capacity, database structure and organization, and information and knowledge classification. Context is captured with the knowledge. The key difference is that the project-based approach has known users with a common context of understanding, while the infrastructure-based approach does not.

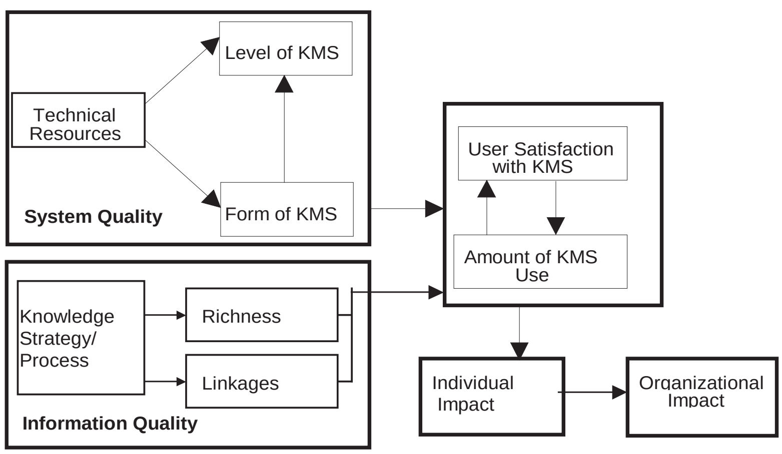
It is hypothesized that both approaches are necessary to create a complete organization-wide OM and KMS. Morrison and Weiser (1996) support the dual approach concept by suggesting that an organizational KMS be designed to combine an organization's various project/task/process-based KMSs into a single environment and integrated system.

Assessing KMS Success

Jennex and Olfman (2002) generalized assessment of KMS success by adapting DeLone and McLean's (1992) IS Success Model to a KMS. The DeLone and McLean model is based on a review and integration of 180 research studies that used some form of system success as a dependent variable. It identifies six system success constructs and shows how they are related. Figure 2 is the model adapted for KMS. The model is a block-recursive one that includes five blocks. Block descriptions are as follows:

System Quality – is defined by the technical characteristics of the KMS as described by three constructs: the technical resources of the organization, the form of the KMS, and the level of the

Figure 2. The KMS modified IS success model



KMS. Technical resources define the capability of an organization to develop and maintain a KMS. The form of KMS refers to the extent to which it is computerized and integrated, explicitly, how much of the accessible information/knowledge is on-line and available through a single interface. The level of the KMS refers to its ability to bring past information to bear upon current activities. Given the effectiveness of information technology to provide timely information, it is expected that a more fully computerized system utilizing network and data warehouse technologies will result in the highest levels of system quality.

Information Quality – Davenport and Prusak (1998) discuss two primary types of knowledge, links to experts who serve as sources of knowledge and rich, detailed knowledge. Jennex and Olfman (2002) found that KMS users new to an organization utilized knowledge linkages more than any other aspect of the KMS, while more experienced members of the organization relied on retrieving detailed, accurate, and timely information. The third construct, KM Strategy and Process, reflects that the knowledge needs of the KMS users change over time. KM Strategy is needed to determine what information/ knowledge should be in the knowledge base, where it is located, and how it is to be acquired. The KM Process ensures that knowledge requirements are reviewed on an ongoing basis.

Use - Information/knowledge use refers to the utilization of the outputs of the system. This construct is most applicable as a success measure when use is required. User satisfaction measures perceptions of the users. It is considered a good surrogate for measuring system use when use is voluntary. Jennex and Olfman (2002) used a perceived benefit model adapted from Thompson, Higgins, and Howell (1991) to measure user satisfaction and predict continued use of the KMS. This measure was found to work well and is included in the user satisfaction construct.

Individual and Organizational Impact – An individual's use of a system will produce an impact on that person's performance. DeLone and McLean (1992) note that an individual 'impact' could also be an indication that an information system has given the user a better understanding of the decision context, has improved his or her decision-making productivity, has produced a change in user activity, or has changed the decision maker's perception of the importance or usefulness of the information system. Each individual impact will, in turn, have an effect on the performance of the whole organization. Organizational impacts are typically not the summation of individual impacts, so the association between individual and organizational impacts is often difficult to draw.

Enabling Factors for KMS/OMS

Jennex and Olfman (2001) developed a set of design recommendations for enabling KM/OM in systems. The recommendations, Table 1, are based on the research previously discussed and on the blocks of the KM/OM modified IS Success Model. It should again be noted that the model is recursive and that enhancing one factor enhances succeeding factors. System Quality recommendations call for use of a common infrastructure. The Internet is suggested for this due to its widespread availability, open architecture, and developed interfaces. This also assists in standardizing software across the organization through the use of browsers and web applications. Information Quality recommendations include one for security. This topic is not discussed in this paper due to length considerations, not lack of importance.

The Internet meets several of these recommendations. It provides a common network that is global. Use of common browsers aids in standardizing software. Ease of use of browsers and in building and maintaining Internet-based systems empowers users (Newell et al., 1999) and simplifies incorporating the KMS into everyday processes. Ease in handling unstructured data,

Table 1. KMS enabling recommendations

Factor	Recommendation
System Quality	Use a common network structure, such as the Internet.
	Add KM/OM skills to the tech support skill set
	Use high end PCs and/or clients.
	Standardize hardware and software across the organization.
System and Information Quality	Incorporate the KMS into everyday processes and IS
	Use an Enterprise wide data dictionary to design knowledge base
	Allocate maintenance resources for KMS
	Train users on use and content of the KMS
Information Quality	Create and Implement a KM Strategy/Process for identifying/ maintaining the knowledge base
	Expand system models/life cycles to include the Knowledge process
	Assess system/process changes for impact to the KMS.
	Automate data capture.
	Design security into the knowledge base
Use	Incorporate KM into personnel evaluation processes
	Implement KMS use/satisfaction metrics
	Identify organizational culture concerns that could inhibit KMS usage.

as well as databases, simplifies knowledge representation, capture, and dissemination. Tools and research that expand the ability of the Internet to serve as the infrastructure for a KMS are discussed in the next section.

Other Tools/Research

Although there is strong support for using the Internet as a Knowledge infrastructure, there are concerns. Chief among these concerns is the difficulty in organizing and searching for knowledge. Ezingeard et al. (2000) points out that Ernst & Young UK in the beginning of 2000 had in excess of one million documents in its KMS. Another concern is the tendency to not use the system. Cross (2000) discusses this tendency, but comes to the conclusion that repositories are essential. Jennex and Olfman (2002) found that voluntary use is enhanced if the system provides near and long-term job benefits, is not too complex, and the organization's culture supports sharing and using knowledge and the system. Stenmark (2002) found that if the Internet is visualized as a system for increasing awareness of knowledge and the KMS as a system for retaining and sharing knowledge, and as a system for enhancing communication and collaboration between teams and knowledge experts and users, then it should be successful as a KMS.

Newman and Conrad (2000) propose a framework for characterizing KM methods, practices, and technologies. This framework looks at how tools can impact the flow of knowledge within an organization, its role in manipulating knowledge artifacts, and the organizational behavior most likely to be affected. The framework also looks at the part of the KM process the tool works in. The activity phase looks at the utilization, transfer, retention, and creation of Knowledge. This framework can be used to show that Internet and browser-based KMS tools are effective.

Gandon et al. (2000) propose using XML to encode memory and knowledge, and suggest using a multi-agent system that can exploit this technology. The proposed system would have improved search capabilities and would improve the disorganization and poor search capability normally associated with Internet systems. Chamberlin et al. (2001) and Robie et al. (1998) discuss using XML query language to search and retrieve XML encoded documents.

Dunlop (2000) proposes using clustering techniques to group people around critical knowledge links. As individual links go dead due to people leaving the organization, the clustered links will provide a linkage to people who are familiar with the knowledge of the departed employee. This technique would improve the reliability of the links to the knowledge called for in Figure 2. Lindgren (2002) proposes the use of Competence Visualizer to track skills and competencies of teams and organizations.

Te'eni and Feldman (2001) propose using task-adapted websites to facilitate searches. This approach requires the site be used specifically for a KMS. Research has shown that some tailored sites, such as ones dedicated to products or communities, have been highly effective. This approach is incorporated in the examples in this paper with the exception of the use of dynamic adaptation.

Eppler (2001), Smolnik and Nastansky (2002), and Abramowicz et al. (2002) discuss the use of knowledge maps to graphically display knowledge architecture. This technique uses an Intranet hypertext-clickable map to visually display the architecture of a knowledge domain. Knowledge maps are also known as Topic Maps and Skill Maps. Knowledge maps are useful, as they create an easy-to-use standard graphical interface for the Intranet users and an easily understandable directory to the knowledge.

The use of ontologies and taxonomies to classify and organize knowledge domains is growing. Zhou et al. (2002) propose the use of ROD, Rapid Ontology Development, as a means of developing an ontology for an undeveloped knowledge domain.

EXAMPLES OF INTERNET KMS

Jennex (2000) discussed an intranet-based KMS used to manage knowledge for a virtual Y2K project team. This KMS used two different site designs over the life of the project. The purpose of the initial site was to facilitate project formation by generating awareness and providing basic information on issues the project was designed to solve. The design of this site was based on Jennex and Olfman (2002), who suggested that a structure providing linkages to expertise and lessons learned was the knowledge needed by knowledge workers. This was accomplished by providing hot links to sites that contained Y2K knowledge, a project team roster that indicated the areas of expertise for each of the project team members and additional entries for individuals with expertise important to the project, and some basic answers to frequently asked questions. This site was accessed from the corporate Intranet site through the special projects section of the IT division page. This made the site hard to find for those who did not know where to look, forcing the project team leadership to provide direction to the site through e-mail directions. The site did not contain guidelines and accumulated knowledge as reflected in test plans, test results, inventories of assets referenced to the division who owned them, and general project knowledge, such as project performance data, meeting minutes and decisions, presentations, and other project documentation. This information had not been generated at the time the site was implemented. Once generated, this information was stored on network servers with shared access to acknowledged project team members. This was done due to a lack of resources allocated to the initial site. No dedicated personnel or special technologies were allocated for the design or maintenance of the site. This site was in effect from early 1998 through mid 1998.

As the project team formed and began to perform its tasks, the requirements for the Intranet site changed from generating awareness to supporting knowledge sharing. The site was redesigned and expanded to include detailed, frequently asked questions (FAQs), example documents, templates, meeting minutes, an asset database, guidelines for specific functions that included lessons learned, etc. The knowledge content of the site was distributed to the other components of the site and persons were identified as being responsible for the information and knowledge content of their responsible areas. Additionally, access to the site was enhanced by the addition of a hot link to the Y2K site placed and prominently displayed on the Corporate Intranet home page. The basic layout of the site provided for access to seven specific sub-sites: Major Initiatives, Contacts, Documents, What's New, Hot Links, Issues and Questions, and Y2K MIS.

Access to this site was granted to all the employees, however, several of the sub-sites were password protected for restricted use. Most of the knowledge contained on the site was contained in these protected sub-sites. The knowledge from the initial site was rolled over into the Hot Links and Contacts sub-sites. Additionally, information that had been previously stored on network servers was left on those sites, but access was provided through the Intranet site. The network structure was expanded to include more sub-structures for storing more documents, information, and knowledge.

The effectiveness of the two sites was considered good. The first site was successful in generating interest and starting the project. The second site succeeded in taking a project that was performing in the bottom third of all projects, to being a leading project within six months after its release. Effectiveness of the sites was established using the model in Figure 2 and by ensuring the Information Quality was high and the System Quality, especially the search, retrieval, and infrastructure, was good. Use of both sites was established by ensuring the sites met the needs of the project team and the company.

The second example is the Extranet site used by the utility industry for Y2K (Jennex, 2000). Its purpose was to facilitate information/knowledge sharing between industry members. It initially provided documents, procedures, and guidelines for getting projects started. It also provided an electronic forum for questions and answers. As projects progressed, more test data became available and this information was posted. Finally, this site provided links to other important sites and sources of information.

The effectiveness of the site was limited. A great deal of knowledge was stored on the site, but searching was difficult and time consuming, reducing system quality. The consensus of the Nuclear and Non-Nuclear Generation Y2K project personnel was that the site provided little benefit, as many companies did not post test results, thus reducing information quality. The Substation Controls Y2K project personnel also found it limited, except they did use the knowledge to put together a statistically valid test sample as requested by the North American Electric Reliability Council (NERC). Industry consensus was that the site had limited knowledge value. A redesign of the site with more emphasis on knowledge search and retrieval was not available until after most projects were complete. It was anticipated the new site would be available for the expected onslaught of lawsuits following the roll over to 2000 which, of course, did not happen. A further inhibitor to effectiveness was that the member companies did not categorize equipment and system information in the same format. This lack of a shared ontology contributed to the search and retrieval difficulties and made understanding the posted information and knowledge more difficult for users from other companies.

The third example, from Cross (2000), is an Intranet site built by Andersen Consulting. Consulting firms have had a long tradition of brokering their knowledge into business. In the early 1990s, Andersen Consulting began to produce global best practices CDs for distribution to project personnel. This evolved into the development of a Intranet site called KnowledgeSpace that provided consultants with various forms of knowledge, including methodologies and tools, best practices, reports from previous like engagements, and marketing presentations. Support was also provided for online communications for online communities of practice and virtual project teams. The site was effective for personnel with access to the Internet and adequate bandwidth. It should be noted that current modem technology and improved dial-in access, as well as the proliferation of cable modems and digital subscriber lines, DSL, have made sites such as this much more effective for field or remote personnel.

The last examples come from Eppler (2001). There are five types of knowledge maps: source, asset, structure, application, and development. A multimedia company Intranet site is used to illustrate a knowledge source map. This site provides graphical buttons representing individuals with specific expertise, color-coded to indicate the expert's office location. The Knowledge Asset map provides a visual balance sheet of an organization's capabilities of a skills directory or core competency tree. Colors are used to indicate knowledge domains, while the size of symbols indicates level of expertise. Knowledge Structure maps divides knowledge domains into logical blocks that are then broken into specific knowledge areas. The Knowledge Application map breaks an organization's value chain into its components parts and then indicates what knowledge, tools, or techniques are needed to implement the component part. The last example is a Knowledge Development map. This map is used to plot the activities needed to acquire the indicated knowledge competence. Clicking on the displayed competence displays the steps needed to develop the competence. Effectiveness of these maps has only been determined for the Knowledge Asset map. This map, developed for a telecommunications consultant firm, was found to be very useful for the planning of training activities and for identifying experts quickly when required during an emergency. It should be noted that knowledge maps enhance the linkage aspects of information quality.

CONCLUSIONS

The conclusion is that the Internet is an effective infrastructure for a KMS. However, there are issues associated with using the Internet that KMS designers need to be aware of. Chief among these are knowledge representation and search. Several tools, such as Knowledge Maps, XML, adaptive websites, clustering, and examples of effective Internet based KMSs, were discussed that addressed these issues. However, as knowledge bases grow, designers need to be aware of increasing search times, as well as a variety of knowledge artifacts. This is perhaps the most important area for future research. Developing ontologies and taxonomies to aid in classifying and structuring knowledge domains is critical.

Maintaining a site is critical. User, organizational, and/or project needs for knowledge change over time, requiring the KMS to change its knowledge content. Also, knowledge has a life cycle and eventually reaches a point where it is no longer useful. Organizations must allocate resources to update and maintain every KMS.

Securing the KMS is also critical, as knowledge is valuable. This paper did not address security issues or technologies, but KMS designers need to ensure the security of captured knowledge. This may be the greatest impediment to the development of Internet-based KMSs.

The final issue is the tendency of people not to use the computer portion of a KMS. Jennex and Olfman (2002) found that this is a tendency of new members and suggest that this is a matter of context. New members do not understand the context under which the knowledge was created and stored, so they don't know how to retrieve and use the knowledge. As these members gain experience, they gain context and rely more upon the computer and less upon their peers.

Browsers are not discussed in the paper, except that the mentioned sites were designed to work with Internet Explorer and Netscape. Use of a browser is mandatory for the Jennex (2000) examples with the inference that effectiveness of these sites supports the use of browsers. A potential issue for KMS designers is deciding which browsers to support. Knowledge representation can include rich context information and documents designed to store this information may not display or function properly on all browsers.

LIMITATIONS

The examples used in this paper are limited in number and scope. They may not be indicative of the actual effectiveness of the Internet when used to develop a KMS. Insufficient research has been performed to verify that the Internet is the best approach for a KMS infrastructure. However, sufficient evidence exists to suggest this may be the case. The external validity is limited and is left to the reader to determine if sufficient evidence exists to warrant the claims of this paper.

The examples have limitations as discussed in the references. In general, all used reliable methods to reach their conclusions.

REFERENCES

Abramowicz, W., Kowalkiewicz, M., & Zawadzki, P. (2002). Tell me what you know or I'll tell you what you know: Skill map ontology for information technology courseware. *Proceedings of the 2002 Information Resources Management Association International Conference.*

Cavaleri, S. (1994). Soft systems thinking: A pre-condition for organizational learning. *Human Systems Management, 13*(4), 259-267.

Chamberlin, D., Clark, J., Florescu, D., Simon, J., Robie, J., & Stofancscu, M. (2001). *Xquery 1.0: An XML query language.* WSC Working Draft 2001. Retrieved from www.w3.org/TR/xquery/

Cross, R. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3).

Davenport, T. H., & Prusak, L. (1998). *Working knowledge.* Harvard Business School Press.

DeLone, W. H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research*, 3.

Dodgson, M. (1993). Organizational learning: A review of some literatures. *Organization Studies, 14*(3), 375-394.

Dunlop, M. D. (2000). Development and evaluation of clustering techniques for finding people. *Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Easterby-Smith, M. (1997). Disciplines of organizational learning: Contributions and critiques. *Human Relations, 50*(9), 1085-1113.

Eppler, M. J. (2001). Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. *Proceedings of the Thirty-fourth Hawaii International Conference on System Sciences.* IEEE Computer Society.

Ezingeard, J.-N., Leigh, S., & Chandler-Wilde, R. (2000). Knowledge management at Ernst & Young UK: Getting value through knowledge flows. *Teaching Case,* pp. 807-822.

Gandon, F., Dieng, R., Corby, O., & Giboin, A. (2000). A multi-agent system to support exploiting an XML-based corporate memory. *Proceedings of the Third International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March-April). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science,* 2.

Huber, G. P., Davenport, T. H., & King, D. (1998). *Some perspectives on organizational memory.* Unpublished Working Paper for the Task Force on Organizational Memory. F. Burstein, G. Huber, M., Mandviwalla, J. Morrison, & L. Olfman (Eds.), Presented at the 31st Annual Hawaii International Conference on System Sciences.

Huysman, M. H., Fischer, S. J., & Heng, M. S. H. (1994). An organizational learning perspective on information systems planning. *Journal of Strategic Information Systems, 3*(3).

Jennex, M. E. (2000). *Using an intranet to manage knowledge for a virtual project team. Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Jennex, M. E., & Olfman, L. (2001). Development recommendations for knowledge management/ organizational memory systems. *Contemporary Trends in IS Development.* Kluwer.

Jennex, M. E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity; A longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Jennex, M. E., Olfman, L., Pituma, P., & Yong-Tae, P. (1998). An organizational memory information systems success model: An extension of DeLone and McLean's I/S success model. *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Kolb, D. (1984). *Experimental learning.* Prentice-Hall.

Lindgren, R. (2002). Competence visualizer: Generating competence patterns of organizational groups. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Malhotra, Y. (1996). *Organizational learning and learning organizations: An overview.* Retrieved from www.brint.com/papers/orglrng.htm

Malhotra, Y. (1998). *Knowledge management for the new world of business.* Retrieved from www.brint.com/km/whatis.htm

Miller, D. (1996). A preliminary typology of organizational learning: Synthesizing the literature. *Journal of Management, 22*(3), 485-505.

Morrison, J., & Weiser, M. (1996). A research framework for empirical studies in organizational memory. *Proceedings of the Twenty-Ninth Annual Hawaii International Conference on System Sciences.* IEEE Computer Society Press.

Newell, S., Scarbrough, H., Swan, J., & Hislop, D. (1999). Intranets and knowledge management: Complex processes and ironic outcomes. *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Newman, B., & Conrad, K. (2000). A framework for characterizing knowledge management methods, practices, and technologies. *Proceedings of the Third International Conference on*

Practical Aspects of Knowledge Management, PAKM2000.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14-37.

Robie, J., Lapp, J., & Schach, D. (1998). *XML query language (XQL). WWW The Query Language Workshop (QL).*

Smolnik, S., & Nastansky, L. (2002). K-discovery: Using topic maps to identify distributed knowledge structures in groupware-based organizational memories. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Stein, E. W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research*, *6*(2).

Stenmark, D. (2002). Information vs. knowledge: The role of intranets in knowledge management. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Te'eni, D., & Feldman, R. (2001). Performance and satisfaction in adaptive websites: An experiment on searches within a task-adapted website. *Journal of the Association for Information Systems, 2*(3).

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991, March). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly.*

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1).

Zhou, L., Booker, Q.E., & Zhang, D. (2002). ROD – Toward rapid ontology development for underdeveloped domains. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Chapter 1.20
Information Technology Assessment for Knowledge Management

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ABSTRACT

New technologies, increasingly demanding customers, new aggressive competitors, and innovations in products and value now characterize our current competitive environment. Organizations of the 21st century have no choice but to invest in new technologies, especially knowledge management tools to enhance their services and products in order to meet the demands of today's information-driven, globally competitive marketplace. Knowledge embedded in systems, brains and technology has always been the key to economic development. However, knowledge management is increasingly being viewed as a strategy to leverage a firm's knowledge and best practices to serve customers and to be competitive. Several organizations have already started experimenting with knowledge management initiatives to capture and capitalize on knowledge assets and thereby claim the enormous benefits afforded by such endeavors, including improved profitability and transformation of their businesses into new generation businesses. This chapter develops a technology assessment model for knowledge management indicating what kinds of computing and communication systems any organization needs in order for it to have a sound knowledge management approach.

INTRODUCTION

Any 21st century organization faces a dynamic, new competitive environment consisting of numerous opportunities, possibilities and challenges.

As economies are becoming more knowledge-based, consumers' expectations are rising day by day. While new technologies threaten to make present systems and networks obsolete, new competitors threaten to upset existing markets and infrastructures. Global deregulation, allowing new competitors to enter previously guarded national monopolies, and hyper-competition are forcing organizations to offer services and products as a one-stop solution to meet customers' increasingly demanding expectations (Housel & Bell, 2001). To tackle such a global competitive environment, organizations have to invest in new technologies such as knowledge management tools that can contribute to enhance services and products that are offered in information technology-driven marketplaces.

The rules of business are undergoing radical change and these impact the competitive strategies of many businesses. The old laws of production, distribution, and consumption are evolving into new theories of e-businesses. Many organizations have an abundance of data and information but they starve for knowledge (Dean, 2001). Global markets are expanding rapidly, thus capturing new customers and retaining existing ones are becoming daunting tasks for organizations. Organizations are becoming more knowledge intensive in order to learn from past experiences and from others to reshape themselves and to change in order to survive and prosper (Brown & Duguid, 2000). New Web-based technologies have the capabilities to prepare organizations for knowledge management. The recently published report Knowledge Management Software Market Forecast and Analysis 2000/2004 estimated that the total KM software market would reach $5.4 billion by 2004 (Duffy, 2000). While extensive literature exists to describe the developments in the knowledge management area, little work has been done on the assessment of IT for knowledge management. This chapter endeavors to address this void by developing an IT assessment model for knowledge management. Concisely stated, IT assessment means focusing on the availability and capability of computing and communication resources. Specifically, our model will enable organizations to answer such questions as: What kinds of computing and communication systems does our organization need for knowledge management to be successful? Such questions are critical for organizations as they try to incorporate knowledge management and move to become knowledge-based enterprises.

KNOWLEDGE MANAGEMENT (KM)

Arguably, the most valuable resource available to any organization today is its knowledge that is stored in patents, copyrights, corporate data warehouses, employees' brains, processes and information systems (Duffy, 2001). Knowledge management focuses on how to identify, manage, share, and leverage all information assets, such as databases, policies and procedures, content, and staff and members' expertise and experience to serve the organization (Shepard, 2000). These knowledge assets or repositories are stored in unstructured data formats (i.e., document and content management, groupware, e-mail and other forms of interpersonal communication) and structured data formats (i.e., data warehousing, databases, etc.). KM is the process of creating value from an organization's intangible assets. Organizations are realizing that their human capital (people power) and structural capital (databases, patents, intellectual property and related items) are the distinguishing elements of their organizations (Liebowitz, 2000). KM consists of systems, information and processes that take information and turn it into structured knowledge to support specific and general business purposes. Early attempts at KM included the use of data warehouses and data marts to help to predict future patterns in form of data mining, but now the KM domain is recognized to be much more than mere data warehousing and data mining (Srikantaiah & Koeing, 2000).

KM's major objective is to connect people with people and stimulate collaboration (Lee, 2000). Knowledge management benefits significantly from real-time communication between individuals that encompasses information exchange and provides a shared workspace (e.g., application sharing and videoconferencing). Such communication accommodates shared creation of work products — documents, group decision support, networked virtual meetings, etc. — and provides the ability to link immediately to experts if they are online (Alavi & Leidner, 2001). To support both explicit and tacit knowledge, KM solutions are built with content and collaboration technologies. Data technologies are structured and typically numerically oriented; knowledge technologies deal most often with text. Knowledge technologies need more human interactions than data technologies.

FACILITATING FOR E-COMMERCE AND INTELLIGENT ENTERPRISES

E-business and e-commerce is growing fast and becoming the popular way of doing business. E-business mandates that organizations use new technological tools, have new sharing cultures, incorporate new sets of values and new strategies appropriate for the new knowledge-based economy (Brown & Duguid, 2000). Many experts today believe that e-business is one of the three pillars of the new economy, along with knowledge management and partnering strategies (Moore, 2000). Today, organizations want to know more about their customers, partners and suppliers. Companies are willing to invest in technologies that enable them to track patterns in customers and other partners' transactions (Davenport et al., 2001). Companies are interested in creating an integrated data repository about customers, policies, procedures, suppliers and partners so that the concerned user in one location can learn everything about a customer, procedure or suppliers by accessing information with one click (Davenport et al., 2001).

Knowledge management is becoming a key determinant of value in the marketplace, of an organization's success, and a competitive edge in this e-commerce era. Many organizations leverage the efficient flow and transfer of knowledge across the organization (Silver, 2000) for enhancing markets, revenues and growth opportunities for e-business. Today, many companies compete not only on the basis of product, service and operational superiority, but also through KM assets to drive their competitive edge.

In this e-business era, organizations that offer e-business solutions have a number of automated systems that generate valuable data. But many of these automated systems are disparate systems that do not integrate and relate the stored data, leaving the consolidation and analysis of the data to the end-user (Hammond, 2001). Despite their strength, these systems do not help end-users to make better business decisions. End-users need business intelligence (BI) derived from the systems that provide the in-depth analytical capabilities to analyze the situations and prepare strategies accordingly to compete in a global environment (Hammond, 2001). The growth of Web technologies provides an opportunity to build portal-type applications that integrate a firm's knowledge in the form of KM assets and can be accessed from anywhere through dynamic, end-user-driven querying tools for report distribution and data analysis (McMillin, 2000). Such features of a portal will add value to an enterprise's strategy by improving analysis of interdepartmental data by delivering relevant enterprise data to a greater number of knowledge consumers. Furthermore, such a KM infrastructure would help organizations to improve customer service and partner relationships and to create marketable knowledge products from an enterprise's own internal data (Hammond, 2001). Organizations can allow their customers to view dynamic reports displaying their purchasing habits and identifying areas where they can consolidate purchases from different suppliers to take advantage of volume discounts. Another indirect benefit of implementing a KM solution exists in the capability of an enterprise to package and resell its own internal data to other companies.

Knowledge management is an intelligent process by which raw data is gathered and transformed into information elements. These information elements are assembled and organized into context-relevant structures that represent knowledge (Onge, 2001). It has become necessary for organizations to have their business information stored in databases, file servers, Web pages, e-mails, ERP (enterprise resource planning), and CRM (customer relationship management) systems integrated into a repository which can be accessed by various users. These integrated repositories, which act as knowledge management systems, can cut the time wasted on searching for particular data and allowing better business decisions. Having such knowledge management systems can turn a company into an intelligent enterprise (Hammond, 2001).

A knowledge-based view of the firm identifies knowledge as the organizational asset that enables a sustainable competitive advantage, especially in hyper-competitive environments (Alavi, 1999; Davenport & Prusak, 1998; Kanter, 1999) or in environments experiencing radical discontinuous change (Malhotra, 2000). This is attributed to the fact that barriers exist regarding the transfer and replication of knowledge (Alavi, 1999). Knowledge and knowledge management have strategic significance (Kanter, 1999). Knowledge management addresses the generation, representation, storage, transfer and transformation of knowledge. Therefore, knowledge architecture, designed to capture knowledge and, thereby, enable the knowledge management processes to be efficient and effective (Wickramasinghe & Mills, 2000).

Underlying the knowledge architecture is the recognition of the binary nature of knowledge, namely its objective and subjective components. Knowledge can exist as an object in essentially two forms: explicit or factual knowledge and tacit or "know how" (Polyani, 1958; Polyani, 1966). It is well established that while both types of knowledge are important, tacit knowledge is more difficult to identify and thus manage (Nonaka, 1994). Furthermore, objective knowledge can be located at various levels, e.g., the individual, group or organization (Kanter, 1999). Of equal importance, though perhaps less well defined, knowledge also has a subjective component and can be viewed as an ongoing phenomenon, being shaped by social practices of communities (Boland et al., 1995). The objective elements of knowledge can be thought of as primarily having an impact on process while the subjective elements typically impact innovation. Both effective and efficient processes as well as the functions of supporting and fostering innovation are key concerns of knowledge management.

The knowledge architecture recognizes these two different yet key aspects of knowledge and provides the blueprint for an all-encompassing KMS. Clearly, the knowledge architecture is defining a KMS that supports both objective and subjective attributes of knowledge. Thus, we have an interesting duality in knowledge management that draws upon two distinct philosophical perspectives, namely, the Lockean/Leibnitzian stream and the Heglian/Kantian stream (Wickramasinghe & Mills, 2001). This duality can be best captured in the Yin-Yang of knowledge management (refer to Figure 1) (ibid). The principle of Yin-Yang is at the very roots of Chinese thinking and is centered around the notion of polarity, not to be confused with the ideas of opposition or conflict, thereby making it most apt for describing these two sides of knowledge management because both are necessary in order for knowledge management to truly flourish (ibid).

Models of convergence and compliance that make up one side are grounded in a Lockean/Leibnitzian tradition (Wickramasinghe & Mills, 2001). These models are essential to provide the information processing aspects of knowledge management, most notably by enabling efficiencies of scale and scope and thus supporting the objective view of knowledge management. In contrast, the other side provides agility and flexibility in the tradition of a Hegelian/Kantian perspective (ibid). Such models recognize the importance of divergence of meaning which is essential to support the "sense-making," subjective view of knowledge management. Figure 1 depicts this Yin-Yang view of knowledge management. This figure shows that, given a radical change to an environment or given a highly competitive environment, an organization needs knowledge to survive. From this Yin-Yang depiction of knowledge management we see that knowledge is required for the organization to be effective and efficient, but new knowledge and knowledge renewal is also necessary. The ultimate challenge for KMS is to support both these components of knowledge management. The pivotal function underlined by the knowledge architecture is the flow of knowledge. The flow of knowledge is fundamentally enabled (or not) by the knowledge management tools adopted.

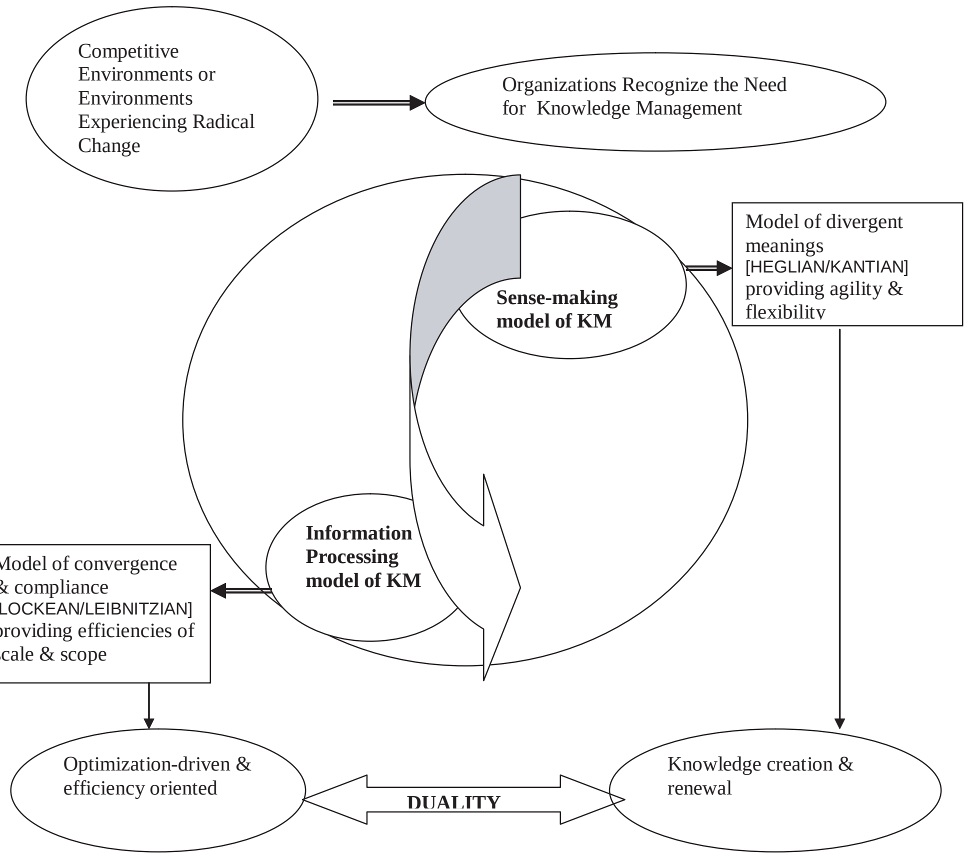
TECHNOLOGY ASSESSMENT MODEL FOR KNOWLEDGE MANAGEMENT

Today's organizations offer e-commerce and conduct business on a 24-hour-seven-day-a-week basis through their own offices as well as with the help of their business partners located geographically in dispersed locations worldwide. Organizations have their databases, people, and technology infrastructure dispersed in many different locations. Organizations need a single database and e-commerce systems of all their activities that allows their customers, staff and business partners to have real-time information for their use (Shepard, 2000). Furthermore, organizations need knowledge by integrating all data stored in these disparate systems. Organizations typically have various systems such as database systems, intranets, groupware, document management, data warehousing, e-mail and ERP systems. The first step in actualizing the knowledge management systems architecture is concerned with integrating all these systems so that these various formats can be integrated to create a uniform format for users (Nissen et al., 2000).

The first major step needed for embracing KM often includes overcoming hierarchies and building environments in which knowledge sharing and collaboration become a routine way of doing business. This requires a technology infrastructure that encourages collaboration and facilitates knowledge capture and access (Duffy, 2001) as well as changes in business rules, procedures and policies. While organizations generate much data during transactional phases, its systems do not document much of the generated data. The undocumented data potentially could be quite useful for generating business intelligence. Therefore, one of the biggest problems faced by an organization is the need to bring disparate enterprise data sources into a cohesive data warehouse. Data abstraction from databases of enterprises of data storage requires skills to map the actual database fields and tables into the intuitive query tools that end-users will eventually see on their desktops for extracting intelligence or knowledge. This is just one of many instances where a technology assessment model would be beneficial.

The technology assessment model can be divided into five layers (Duffy, 2000) or groups

Figure 1. Yin-Yang model of KM



in the typical enterprise systems architecture model. The layers and their purpose are shown in Figures 2, 3 and 4.

Communication Systems Layer

The basic foundation layer for knowledge management is the communication systems layer that represents all the communication systems involved. There are varieties of communication systems such as local area network (LAN) or intranet, extranet and World Wide Web or Internet. The organizations would have connectivity to Internet service providers (ISPs) through various "last-mile technologies" options. The communications systems are used for communicating across or exchanging information through various groupware systems for the creation of knowledge. Organizations should have their communication systems in place before they opt for knowledge management. It is required that communication systems should support appropriate bandwidths for effective information exchange. It has been experienced that many times organizations have low bandwidth links that restrict effective groupware applications supports.

The next major wave of communication systems would be to deliver the information and experience on demand, in the right form, at the right time and at the right price to fixed or mobile

Figure 2. Technology assessment model for knowledge management

Layers	Domain
End User Application Layer	Represents the user interface into the applications and data used regularly
Middleware Layer	Integrates the internal knowledge to easy to user interface.
Knowledge Repository layer	Consists of repositories for unstructured data (i.e., document and content management) and structured data (i.e., data warehousing, generation, and management), groupware for supporting the collaboration needed for knowledge sharing as well as e-mail and other forms of interpersonal communication required for the efficient, time and location-independent exchange of information
Enterprise Data Source layer	Consists of databases, file servers, Web pages, e-mails, ERP (enterprise resource planning), and CRM (customer relationship management) systems
Communication Systems layer	Made up of local area network, Intranet, extranet and Internet Systems

terminals anywhere. Bandwidth, distance and time will ultimately no longer be significant. Service and access will become the dominant features of the changing demands and knowledge-focused society.

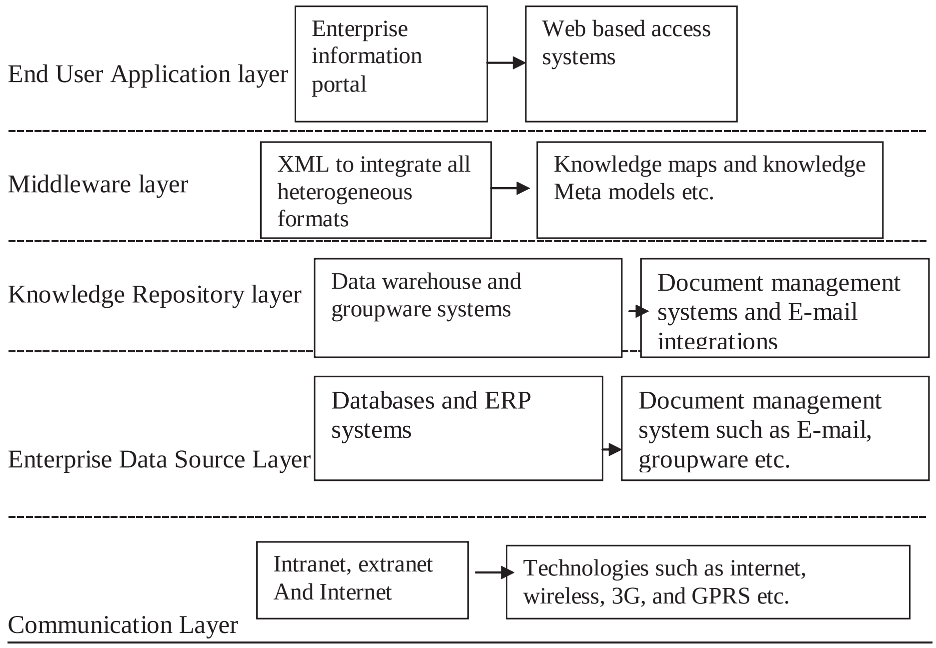
Using communication systems would ensure more information and more transparency for customers, suppliers and users. In the world of knowledge management, everybody will know everybody else's business. Advances in communications technology are being driven by the relentless spread of e-commerce. The latest developments in communications technology promise that it will soon be possible to receive up-to-the-second information about the flow of goods from manufacturer to customer with a small and compact handheld device. And in the next two years, developers are promising communications devices that are small and light enough to be worn as jewelry or clothing. Much is riding on the next generation of networks, the so-called "third generation" (3G), which will allow moving pictures and data to be transmitted much more easily to handheld devices.

Network and handset operators are also pinning their hopes on another variant of transmission technology, which allows a mobile device to be continually connected to a network. The technology is known as general packet radio service (GPRS). Today's mobile devices have to dial into a central server and download electronic information and translate it into a voice or digital message. Devices that use GPRS are known as "always on" because they do not need to be switched on and off.

Enterprise Data Source Layer

The enterprise data source layer provides the base or platform upon which KM solutions are built. It consists of repositories for unstructured data (i.e., document and content management)

Figure 3. Components of each layer of KM solutions



and structured data (i.e., databases, e-mail) and groupware, etc. (Duffy, 2001). Companies use databases and ERP systems for structured data and varieties of document management systems for unstructured data.

This layer acts as a foundation for KM solutions. At this layer data is captured in various databases or document management systems. The technological tools used include relational database management systems, document management systems, messaging technologies (like e-mails systems), groupware, and work flow systems.

The enterprise data source layer represents different types of data (textual data, video, and audio) stored in databases, file servers, Web pages, e-mails, ERP (enterprise resource planning), and CRM (customer relationship management) systems. Enterprise data sources can be fileservers, database servers, groupware servers, document management systems, e-mail servers or web sites. Each repository's structure will depend on the content or knowledge it stores and manages. Although each is a separate physical repository, together they form a single, virtual knowledge repository (Duffy, 2000).

Knowledge Repository Layer

The knowledge repository layer consists of a data warehouse for structured data and document content management and a groupware system for unstructured data. The knowledge repository layer mainly consists of repositories for unstructured data (i.e., document and content management), structured data (i.e., data warehousing, generation, and management), and groupware for supporting the collaboration needed for knowledge (Duffy, 2001).

The knowledge stored may be either created inside an organization or acquired from external sources and then added to the enterprise's knowl-

Figure 4. Technologies and systems of knowledge management

Layer	Tools and Technologies
End User Application Layer	Enterprise information portal (EIP) and web based access system
Middleware layer	XML technology and various routing and retrieval algorithms
Knowledge Repository layer	Data warehouse, data marts, document management systems, groupware applications
Enterprise Data Source layer	Databases, ERP, Groupware, document management systems, and E-Mail etc.
Communication Systems Layer	Systems: LAN, Intranet, Extranet and internet Technologies: Internet, 3G, GPRS, Bluetooth etc.

edge base. There are a variety of tools needed to capture the knowledge at the knowledge repository layer. Traditional tools for capturing knowledge include word processing, spreadsheets, e-mail, and presentation software. Increasingly, newer technologies such as voice recognition, shared workspaces, and video conferencing are also used to support the knowledge-capture process.

This layer is also known as the data abstraction layer and represents the processes through which data is extracted from the enterprise data source layer or operational form of data layer and converted into summarized data. Data abstraction involves suppression of irrelevant data. The relevancy depends on the task and the use of information, thus it changes with the context. There are six main abstraction mechanisms used such as classification, generalization, aggregation, contextualization, materialization and normalization.

Data Warehouse and Data Marts

The data warehouse is the main component of KM infrastructure. Organizations store data in a number of databases. The data warehousing process extracts data captured by multiple business applications and organizes it in a way that is meaningful to the business for any future references in the form of knowledge (Duffy, 2001).

The data warehouse process has two components of data warehousing software to support KM. One component transfers operational data to the warehouse (i.e., data extraction, cleansing, transformation, loading, and administration) and the second component supports warehouse management or utilities for supporting data mining (Shaw et al., 2001).

Collaborative Applications

Collaborative applications' core functions include e-mail, group calendaring and scheduling, shared folders/databases, threaded discussions, and custom application development. Collaborative applications provide the capabilities needed for identifying subject matter experts who can give answers to knowledge seekers (Skyrme, 1999). Collaborative applications systems are the major component of KM systems because it is through these systems that an interaction of experts and users take place.

Content Management

Content management software represents the convergence of full-text retrieval, document management, and publishing applications. It supports the unstructured data management requirements of KM initiatives through a process that involves capture, storage, access, selection, and document publication. Content management tools enable users to organize information at an object level rather than in binary large objects or full documents. The information is broken down by topical area and usually tagged via extensible markup language (XML). Both capabilities dramatically increase the opportunity for re-use.

Middleware Layer

The middleware integrates the applications of the knowledge repository and enterprise information portals. Middleware supports intelligent message routing, business rules that control information flow, security, and system management and administration.

Users like to have information or knowledge without getting into complexities of how knowledge is stored or structured. Thus, there is a need for the middleware layer which can keep the complexities of knowledge repositories hidden from users who want easy access to knowledge. Some authors refer to this layer as the "knowledge about the knowledge" layer (Duffy, 2001) that represents the entire collection of knowledge objects, regardless of category or location, and helps to identify the links between existing islands of information. This layer has two components, i.e., knowledge maps and knowledge meta-model. Thus, the middleware layer is the heart of a knowledge management system. The information about each knowledge object in the repository includes such items as the identity of the person who created the knowledge and the time it was created, the knowledge object's format and media, the knowledge object's purpose, actions and sequences of events surrounding its existence, and linkages with other knowledge objects. The knowledge map (K-map) is the navigational system that enables users to navigate to find the answers they seek (Duffy, 2001). The K-map is the front end of an integrated knowledge management system and helps to create an interactive user interface.

KM uses XML technology as a standard for middleware. Knowledge management technologies have to follow open standards so that they can support a heterogeneous environment on the Internet and foster interoperability among various operating systems and software applications. These standards will promote a common platform that simplifies integration and furthers connectivity between diverse sources of information. XML (extensible markup language) is emerging as a fundamental enabling technology for content management and application integration. XML is a set of rules for defining data structures, thus making it possible for key elements in a document to be categorized according to meaning.

End-User Application Layer

The end-user application layer represents the user interface into the applications and knowledge. Because the Web is used as a medium for interface, it uses Web-based interactive tools to access knowledge from knowledge management systems. In many instances, portals similar to those used to access the Internet (e.g., Yahoo!, Lycos, Excite, or Plumtree) represent the user interface layer (Duffy, 2001). A user interface should be easy to use, interactive and valuable to the users. It should hide all the internal complexities of KM architecture and should respond to users' requests through easy-to-use features.

The end-user application layer has two components, enterprise information portal and Web-based access systems. These two components are supported by varieties of various other tools such as presentation, distribution and Web-mining tools.

Enterprise Information Portals

Enterprise information portals (EIPs) are evolving as a single source of knowledge-based systems (Silver, 2000). They integrate access to knowledge and applications. EIPs provide a single point of entry to all the disparate sources of knowledge and information both within and outside an organization, usually through the Internet or a company intranet (Ruppel & Harrington, 2001). EIPs have to be fully integrated with legacy systems of the organization. Through these EIPs, companies serve their customers, interact with business partners and suppliers, and offer employees access to online tools and the right content and knowledge for decision making. EIP functionality ranges from access to structured data used in classifying and searching unstructured data to supporting collaborative processes. EIPs are poised to integrated access to heterogeneous types of data (Morris, 2000).

Web-Based Access System

The Web has created a noble opportunity for easy access to data from any geographic location. KM supports Web-based access system having thin client architecture for end-user applications. Thin client architecture requires no software installation on the client end.

The KM Web-based access system uses many tools like Text and Web Mining Tools for Query system (Duffy, 2001). Text mining is used to automatically find, extract, filter, categorize and evaluate the desired information and resources. Text mining applies to Web content mining, which is the automatic retrieval of information and resources, filtering and categorization. End-user query and reporting tools are designed specifically to support ad hoc data access and report building by even the most novice users.

Information extraction utility pulls information from texts in heterogeneous formats — such as PDF files, e-mails, and Web pages — and converts it to a single homogeneous form. In functional terms, this converts the Web into a database that end-users can search or organize into taxonomies (Adams, 2001).

CONCLUSION

As we move into the 21st century, the need for rapid access to relevant knowledge has never been greater. The business world is becoming increasingly competitive, and the demand for innovative products and services is growing. Organizations that compete in such an intense competitive environment need to leverage their knowledge assets so that they do not lose markets, revenues and growth opportunities. The importance of KM technology and the role it will play in organizational success cannot be over emphasized. This chapter has discussed a myriad of technologies and tools for knowledge management that are at the disposal of organizations. The importance of addressing both the subjective and objective perspective of KM as well as outlining the significance of the knowledge architecture was highlighted. Necessary technology components that need to be considered by any organization as part of the sound knowledge architecture were discussed. The proposed knowledge assessment model will provide organizations with a useful framework in order for them to successfully embrace KM.

REFERENCES

Adams, K. C. (2001). The Web as a database: New extraction technologies & content management. *Online*, *25*(2), 27-32.

Alavi, M. (1999). *Managing organizational knowledge*. Working Paper.

Alavi, M. & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly*, *25*(1), 107-136.

Boland, R., & Tenkasi, R. (1995). Perspective making, perspective taking. *Organization Science*, *6*, 350-372.

Brown, J. S., & Duguid, P. (2000). KM's future in the e-world. *Information World Review, 158*, 18.

Davenport, T. H., & Prusak, L. (1998). *Working lnowledge*. Harvard Business School.

Davenport, T. H., Harris, J. G., & Kohli, A. K. (2001). How do they know their customers so well? *MIT Sloan Management Review, 42*(2), 63-73.

Dean, J. (2001). Turning data into knowledge. *Government Executive, 33*(4), 76-78.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal, 34*(2), 62-66.

Duffy, J. (2001). The tools and technologies needed for knowledge management. Information *Management Journal, 35*(1), 64-67.

Hammond, C. (2001). The intelligent enterprise. *InfoWorld, 23*(6), 45-46.

Housel, T., & Bell, A. H. (2001). *Measuring and managing knowledge*. Irwin: McGraw Hill.

James, L., Sr. (2000). Knowledge management: The intellectual revolution. *IIE Solutions, 32*(10), 34-37.

Kanter, J. (1999, Fall). Knowledge management practically speaking. *Information Systems Management*, 7-15.

Liebowitz, J. (2000). *Building organizational intelligence: A knowledge management primer.* CRC Press.

Malhotra, Y. (2000). Knowledge management & new organizational forms. In E. Y. Malhotra (Ed.), *Knowledge management and virtual organizations.* Hershey, PA: Idea Group Publishing.

McMillin, K. (2000). Knowledge management lessons aiding e-commerce growth. *Oil & Gas Journal*, 2-3.

Moore, K. (2000). The e-volving organization. *Ivey Business Journal, 65*(2), 25-28.

Nissen, M. E., Kamel, M. N., & Sengupta, K. C. (2000). A framework for integrating knowledge process and system design. *Information Strategy, 16*(4), 17-26.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*, 14-37.

Onge, A. S. (2001). Knowledge management and warehousing. *Modern Materials Handling, 56*(3), 33.

Polyani, M. (1958). *Personal knowledge: Towards a post-critical philosophy.* Chicago: The University Press Chicago.

Polyani, M. (1966). *The tacit dimension*. London: Routledge & Kegan.

Ruppel, C. P., & Harrington, S. J. (2001). Sharing knowledge through intranets: A study of organizational culture and intranet implementation. *IEEE Transactions on Professional Communication, 44*(1), 37-52.

Shaw, M. J., Subramaniam, C., Tan, G. W. & Welge, M. E. (2001). Knowledge management and data mining for marketing. *Decision Support Systems, 31*(1), 127-137.

Shepard, E. (2000). Transforming knowledge into professional power. *Association Management, 52*(13), 16.

Silver, C. A. (2000). Where technology and knowledge meet. *The Journal of Business Strategy, 21*(6), 28-33.

Skyrme, D. J. (1999). *Knowledge networking: Creating the collaborative enterprise*. Butterworth Heinemann.

Srikantaiah, T. K., & Koenig, M. E. D. (2000). ASIS Monograph Series. *Information Today*.

Wickramasinghe, N., & Mills, G. (2001). Integrating e-commerce and knowledge management — What does the Kaiser experience really tell us. Forthcoming article in *International Journal of Accounting Information Systems.*

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Chapter 1.21
Practice-Based Knowledge Integration

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INTRODUCTION

For organisations, the tension between integration and specialisation has become a key issue as the knowledge of work is becoming increasingly fragmented through specialisation (Becker, 2002; Grant, 1996; Kogut & Zander, 1992). Specialisation, as knowing more about less, distributes the overall accomplishment of work on several entities (Aanestad, Mørk, Grisot, Hanseth, & Syvertsen, 2003; Becker; Berg, 1997; Hutchins, 1995) with the consequent need for the integration of different competencies and types of expertise. Becker (p. 3) provides the following definition of knowledge integration:

By knowledge integration we mean solving problems raised by specialisation: Specialisation leads to a dispersion of specialised bodies of knowledge that are held by different specialists...Knowledge integration refers to how this drawing on different bodies of specialised knowledge is organised.

The capability of relying upon specialisation and the ability to integrate specialised knowledge have been identified as critical factors in the competitiveness of an organisation (Grant, 1996; Kogut & Zander, 1992). Because of this, integration has become a theme for numerous research efforts.

A first line of research looks at knowledge integration as the transferring of knowledge to where it is supposed to be used (Berends, Debackere, Garud, & Weggeman, 2004). By transferring knowledge to someone who is able to use it and combine it with his or her own work practice, knowledge is integrated. If we are able to capture and model the content of knowledge, we can disseminate it and make it usable across contexts. As an integration mechanism, transfer is problematic because "it is costly and counters the necessary specialisation of organisation members" (Berends et al., p. 4). Moreover, the notion of knowledge as something that can be externalised and combined is problematic in itself (Blackler, 1995; Walsham 2001, 2004).

Current discourse on knowledge is filled with ambiguities and varying conceptualisations (see, e.g., Alvesson, 2001; Blackler; Boland & Tenkasi, 1995; Carlsen, Klev, & von Krogh, 2004; Cook & Brown, 1999; Davenport & Prusak, 1998; Fitzpatrick, 2003; Gherardi, 2000; Walsham, 2001), and a detailed discussion of this issue is beyond the scope of this article. For this article, we will recall that the underlying tenet grounding most of the existing views is a distinction between explicit and tacit knowledge. Explicit knowledge refers to knowledge that is movable and easy to convey, while tacit knowledge is intimately connected to our identity and is thus hard to formalize (Polanyi, 1966). Nonaka and Takeuchi (1995, p. 61) claim that the conversion between tacit and explicit knowledge is "a 'social' process between individuals and not confined within an individual." While popular, their view on tacit knowledge as something to be externalised and combined has been criticized (see, e.g., Blackler, 1995; Walsham 2001, 2004). As human interaction is always mediated by representations, our experiences and the way we perceive the world can never be replicated perfectly. Hence, Walsham (2001) argues that the knowledge-management discourse in general, and knowledge-management systems in particular, should pay closer attention to the contextual sides of knowledge.

This different understanding of knowledge leads to a second line of research on knowledge integration: one that is first and foremost paying attention to the relational and situated nature of knowledge (Brown & Duguid, 1991; Lave & Wenger, 1991; Suchman, 1987). Rather than trying to single out the knowledge entities and how they could merge, the focus is on understanding how knowledge is deeply embedded in situated practices and closely connected to people's ability to act (see, e.g., Carlsen et al., 2004; Cook & Brown, 1999). In this article, we discuss research in this direction. In particular, we elaborate on the practice-based perspective on knowledge integration to understand better the role of artefacts. In our opinion, it is not enough to look at the practice in terms of human interaction; we also need to look at the overall system where integration takes place. Our perspective is illustrated with an example from the health care domain. We will look in particular at the patient list, an A4 format template created by nurses to support their everyday activities and used in different settings in the hospital ward. We illustrate how the patient list serves various functions within the ward and how it, along with other actors, helps the integration of different aspects of work. For the ongoing efforts of introducing information technology in health care, understanding the implicit roles of existing material arrangements is essential as it helps us identify how technology might be better designed.

The article is organised as follows. In the next section we discuss research on knowledge integration and the relevance of adopting a practice-based perspective, paying attention to the artefacts used within practices. The section after introduces health care as a relevant domain to study integration and presents a concrete example on how the patient list integrates different aspects of work. The last section sums up the contribution of this article.

KNOWLEDGE INTEGRATION

While the literature abounds in diverse classifications on how to coordinate the efforts of specialists (see, e.g., Becker, 2002; Berends et al., 2004; Ditillo, 2002; Willem & Scarbrough, 2002), we remain at their common reference point: the work of Grant (1996). Grant identifies four different organising mechanisms for integrating knowledge: (a) rules and directives, (b) sequencing, (c) routines, and (d) group problem solving. Rules and directives are standards that regulate interaction between workers (e.g., policies and rules). These standards or artefacts can be said to accumulate knowledge. In health care, for example, the transition from paper-based to electronic health records (EPR) has imposed new rules and directives on how to handle EPRs (e.g., security and privacy). Sequencing is a mechanism for coordinating efforts across time and space. For instance, a procedure is a sequence of actions that should be undertaken to do a certain task. In terms of work, sequencing can be said to be a mechanism for minimising communication and maximising specialisation. In health care there are diverse types of procedures ranging from clinical (e.g., how to perform an operation) to administrative (e.g., how to refer a patient to a specialist). Routines are habitual procedures embedded in work practices. They are beneficial in that they enable complex interaction in the absence of other coordinating mechanisms. For example, experienced surgeons do not search for a procedure before performing a standard operation as it has become an embodied routine. Group problem solving is different from the previous three mechanisms in that it requires personal and communication-intensive forms of integration. In this sense, group work in itself is a mechanism for integrating knowledge.

Of the four mechanisms, the latter (group) has been recognised as fundamental for knowledge creation (see, e.g., Becker, 2002; Ditillo, 2002). Ditillo (p. 11), claiming that "knowledge integration is best achieved through direct involvement," suggests a group-based approach to knowledge integration. In a similar vein, Fitzpatrick (2003, p. 106) contends that "strategies to supporting knowledge sharing, even in large scale communities cannot discount for the interactional human-to-human processes through which it is nurtured in local settings or across settings." The fundamental view grounding these perspectives is that no individual can possess all knowledge, and thus a group or community, where knowledge is naturally distributed, becomes an effective mechanism for integration. In this sense, knowledge is not treated as a transferable entity, but rather knowledge integration is considered to be a collective and interactive process. Understanding integration thus implies unfolding human interaction.

A Practice-Based Perspective on Knowledge Integration

Based on the assumption that we know more than we can express, Polanyi (1966) points out that we sometimes act according to our feelings without being able to give rational explanations for our conduct. In this sense, the notion of tacit knowledge has become an important aspect of the way we understand work (Levin & Klev, 2002). Empirically assessing knowledge thus implies attending to the everyday practices constituting organisational performances. Practice implies doing and is the situation of all human action (Suchman, 1987).

In a practice-based perspective, emphasis is on the active and productive processes of knowledge (see, e.g., Carlsen et al., 2004; Cook & Brown, 1999). Practices are driven by, but not limited to, tacit knowledge; they are improvised, spontaneous, and hallmarked by responses to changing and unpredictable environments (Brown & Duguid, 2000). Emphasis is on communities of practice (CoPs) in which knowledge sharing and integration takes place rather than on individuals, methods, or particular systems. In this sense, the traditional view on knowledge integration needs elaboration. Boland and Tenkasi (1995, p. 359) provide an interesting perspective:

...the problem of integration of knowledge...is not a problem of simply combining, sharing or making data commonly available. It is a problem of perspective taking in which the unique thought worlds of different communities of knowing are made visible and accessible to others.

Our experiences and the way we perceive the world can never be replicated perfectly, but to be able to make visible different world views, we need common denominators: that is, entities that are interpreted differently in different social worlds, but still remain common enough to be recognisable (Star & Griesemer, 1989). These entities are what Star and Griesemer call boundary objects. In a practice perspective, these boundary objects are means of representing, learning about, and transforming knowledge (Carlile, 2002). They enable collaborative work across social worlds (i.e., different CoPs).

We would like to emphasise that these social worlds consist of both people and artefacts. Knowledge is distributed among actors, and no actor has the complete picture of the collaborative work process (Berg, 1997; Hutchins, 1995).

Activating the Artefacts

Practice, then, as knowing in action, implies unfolding the joint activity performed by interrelated elements. In this perspective, activity does not take place solely in people's heads. Hutchins (1995) would contend that it is the system that knows. Looking at the practice of navigating ships, Hutchins develops a methodological and analytical framework for understanding how cognitive achievements can be conceptualised as a joint accomplishment. Hutchins maintains equality between people and artefacts in structuring practice. One expects to find a system that can dynamically configure itself to bring subsystems into coordination to accomplish various functions (Hollan, Hutchins, & Kirsh, 2000). Thus, the centre of attention in work activities is the interdependencies between people, and between people and artefacts.

In the same way, Berg (1996, 1997) illustrates each minute part of a work process aiming at documenting a hospital patient's fluid balance, which is a sum of what fluid goes in and what comes out. In observing and recording each minute detail of a particular process, the separate elements are identified. This hybrid comprises everything that is needed for the activity to proceed including several people, various artefacts, routines, and experiences. The formal tools come to life only as part of the real-life activity. In Berg's (1996) and Hutchins' (1995) terminology, integration implies looking at how work is distributed, delegated, coordinated, and communicated across time and space (Ellingsen & Monteiro, 2003).

In this article, artefacts are provided an active role in integrating knowledge. Artefacts not only mediate human action, but rather, they play an active role in shaping that same action. Furthermore, there is a relational interaction between artefacts and humans. Knowledge, then, is not a group of entities that can be merged, but rather a distributed system of cognitive elements whose integrative potential lies in the collective ability to perform.

INTEGRATION IN PRACTICE: AN EXAMPLE FROM HEALTH CARE

Below we provide a short example on how an artefact, the patient list, is produced and used in a hospital ward. By going beyond the concrete representational aspects of the list, other aspects of work become visible, for instance, the informal and implicit coordination and interaction among the people that populate the ward. The description and analysis of the patient list described below is based on observations from a 4-week stay at a hospital ward working as a nursing assistant.

The Patient List

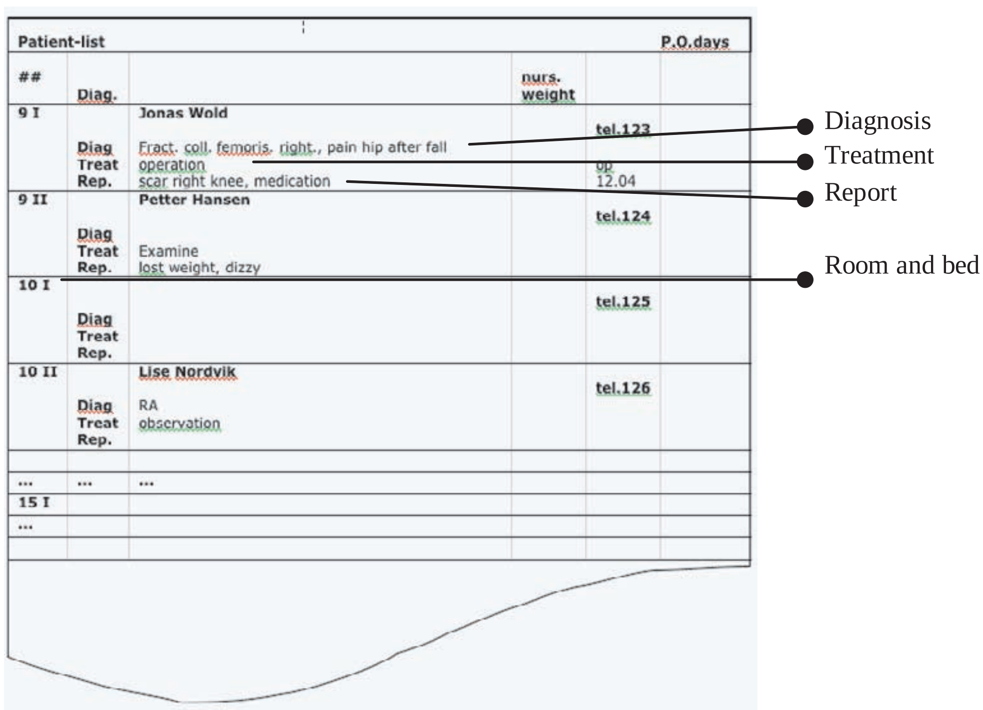
Medical records take many forms. Information from the electronic patient record, clinical-specific systems, and other systems are often printed out on paper and copied to become usable in everyday work. Representations of patients are found on walls, in circulation, in copies, in annotated copies, on computers, in people's heads, in letters, on Post-It notes, in pockets, and so forth. In this article, we analyse one of these artefacts: the patient list. The patient list is a sheet of A4 paper listing all admitted patients, arranged after which room they are lying in. Every nurse on watch carries a copy of the list. The patient list summarizes information about the patient's diagnosis, type of treatment, and report, that is, recent information that might be relevant for nurses (as shown in Figure 1). It is a tool for planning, coordinating, distributing, delegating, and communicating.

A new list is assembled during each night watch. A fresh copy of the patient list is given to all nurses starting a new watch. During their watch, the nurses use the patient list to record information regarding things that happen. Upon change of watch, in order to hand over tasks and information, a briefing meeting is held with the nurses ending their watch and those starting a new watch. Nurses actively use the patient list during these meetings (sometimes supported by other documents). Nurses finishing the watch use their personal patient list as a reference. Nurses starting their watch take notes on their own blank copy while listening to the brief. All the patients at the ward are reported on, and at the end of the brief, all nurses have information about the patients. Moreover, they all have written down the distribution of responsibility on the patient list. Afterward, they go about doing their duties in the ward with the patient list nicely folded into their pockets. Frequently during the watch, they pick up the list to make sure that they are on schedule. Furthermore, the list is used as a reference point during discussions, meetings, and so on.

Constructing Knowledge by Interplaying, Tinkering, and Enacting

The patient list itself seems like a rather poor representation of patients. It is assembled from

Figure 1. A section of the patient list (fabricated for visualisation purposes only)



a myriad of different, richer representations. What, then, makes its way from these richer representations into the patient list? During the night watch, a software program assembles the list. This program delegates the task of providing information to the nurses. It determines what information the nurses are expected to provide. Still, it presents a limited number of fields to fill. Once the nurses have provided the software with the required information, the patient list is assembled. Knowledge is in this sense distributed between the nurses, the software, and the patient list. What is it then that decides what information is extracted from the different representations? Is it the fields provided by the software? Is it the nurses who determine what goes into these fields? There is an interplay between the nurses and the software: in effect, an integration process. In deciding what should go into the different fields, the nurses fluctuate between glimpsing into the patient record, asking colleagues, and memorising. In this sense, filling out the form is a process of tinkering (searching, combining, reducing, and writing down). Furthermore, what eventually becomes engraved into the patient list is based on a process of enactment based on different knowledge representations. According to Ellingsen and Monteiro (2003), in rendering knowledge credible, relevant, and trustworthy, knowledge representations have to be enacted.

Reconstructing Meaning by Telling Stories and Circulating

In the briefing meeting, the reporting nurses (accompanied by the patient list) are themselves highlighting certain parts of what has happened during their watch. The report takes form as a story, structured by the list and told by the nurse. Stories, the patient lists remade by the nurse, act as repositories of accumulated wisdom, and it allows people to keep track of the sequence of behaviour and their wisdom (Brown & Duguid, 1991; Orr, 1996). Storytelling thus serves as a mechanism for integrating knowledge. Furthermore, the stories are not only shared in the briefing meeting, but they circulate, partly by means of the patient list, partly by means of nurses' encounters and so forth.

Circulation can also be seen as the way the patient list travels as a template among the nurses. The list is easy to replicate and thus easy to circulate. In this way, knowledge about nursing, as manifested in the patient list, can circulate and spread. Furthermore, the list has an organising effect, having the power to organise a large number of workers (see Turnbull, 1993).

Knowing as a Sociotechnical Interaction

In the latter part of this analysis, we look closer into the details of the list (see Figure 1). What does the patient list know? By taking a brief look at it, the list can tell nurses which rooms and bed are available. In the figure, the list tells us that Bed 1 in Room Number 10 is available. Furthermore, the list does not give Petter any diagnosis, but tells us that the he is waiting for an examination. For Lise Nordvik, the situation is more clear-cut: The list tells us of a diagnosis and that the patient is admitted to the hospital for observation.

The way that the nurse interacts with the patient list regulates and coordinates the action that can be taken. For example, a new patient should be admitted to Bed 1 in Room 10. The list tells nothing about Petter's diagnosis. The nurse might want to consult a physician before giving him any medication. The patient list tells nurses that Lise has been here before and that this patient knows her way around, but that the nurses must keep an eye on her regularly. All three cases illustrate that interaction does not solely take place between people mediated by artefacts. Rather, interaction can often be identified as something happening between humans and artefacts. Artefacts and humans have knowledge about different aspects of the ward and its patients, and it is in the interaction that this knowledge becomes usable. Action is the result between the social and the material, and the integration is not observable in itself, only the resulting practice.

CONCLUSION

This article has addressed the concept of knowledge integration. We have described how a practice-based perspective provides an extension of the seminal work on knowledge integration by Grant (1996). In our practice-based approach, we have emphasised the role of artefacts not only as mediators of human action, but as active participants in shaping that same action. By providing an example from health care—the patient list, an A 4-format template created by nurses and used in different settings at a hospital ward—we have highlighted the relational interplay between artefacts and humans in work performance. Tinkering, enacting, storytelling, circulation, and sociotechnical interaction have been identified as mechanisms for integrating knowledge.

The main contribution of this article is the proposal for a practice-based perspective on knowledge integration where specialisation, as traditionally being located only within humans, is challenged. We have emphasised the need to look beyond the pure representational aspects and also attend to the interactive roles of tangible arrangements (e.g., paper). This makes it imperative to be explicit on the role of artefacts in work performance because it plays such an important part in our understanding of collaboration and work. As we have demonstrated, the patient list plays an active role in structuring and coordinating work (see also Fitzpatrick, 2000). Furthermore, paper in itself provides rich support for collaborative work: It can help us gain knowledge of how technology might be better designed (Sellen & Harper, 2002). In health care, for instance, any move to introduce IT impacts the very nature of that care, so if we do not have a profound understanding of the richness and complexity in the accomplishment of that work, we will not be able to design effective systems that will fit with the work (Fitzpatrick, 2000).

Traditionally, when specifying requirements for knowledge management systems, conventional interview techniques are employed to portray existing work arrangements. In other words, work is specified as presented by the human workers. The problem then is that they (the human workers) are not consciously aware of the interactive role artefacts play in performing work. As artefacts do not talk back, conventional interview techniques need to be supplemented with additional ethnographic techniques to enable technology designers to look beyond the pure representational aspects of tangible arrangements. However, technology designers do not have the professional competence of ethnographers, so there is a need to provide them with guidelines to simplify the effort needed.

Another issue that naturally comes out of this article is the understanding of how users themselves actually design their own work practices in the usage of artefacts. For instance, in health care, organisational decisions on what kind of general types of information systems to implement have already been made (e.g., the electronic patient record, picture archive and communication system, etc.). Thus, future research needs to attend to the domestication of technology, that is, how to effectively integrate it into different work environments. This implies not only an understanding of how technology needs to be designed, but also of how existing work arrangements need to be adjusted.

REFERENCES

Aanestad, M., Mørk, B. E., Grisot, M., Hanseth, O., & Syvertsen, C. M. (2003). Knowledge as a barrier to learning: A case study from medical R&D. *Proceedings of the 4th European Confer-*

ence on Organisational Knowledge, Learning and Capabilities, Barcelona, Spain.

Alvesson, M. (2001). Knowledge work: Ambiguity, image and identity. *Human Relations, 54*(7), 863-886.

Becker, M. C. (2002). *Towards a consistent analytical framework for studying knowledge integration: Communities of practice, interaction, and recurrent interaction patterns*. Paper presented at the 3rd European Conference on Organizational Learning, Knowledge and Capabilities, Athens, Greece.

Berends, J. J., Debackere, K., Garud, R., & Weggeman, M. C. D. P. (2004). *Knowledge integration by thinking along* (Working Paper No. 04.05). Netherlands: Eindhoven Centre for Innovation Studies.

Berg, M. (1996). *Practices of reading and writing: The constitutive role of the patient record in medical work*. Sociology of Health and Illness, 18, 499-524.

Berg, M. (1997). On distribution, drift and the electronic medical record: Some tools for a sociology of the formal. *Proceedings of the 5th European Conference on Computer-Supported Cooperative Work, ECSCW'97*, 141-156.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies*, *16*(6), 1021-1046.

Boland, R. J., Jr., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Brown, J. S., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Publishing.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science, 13*(4), 442-455.

Carlsen, A., Klev, R., & von Krogh, G. (2004). *Living knowledge: The dynamics of professional service work*. New York: Palgrave Macmillan.

Cook, S. D. N., & Brown, J. S. (1999). Bridging epistemologies: The generative dance between organisational knowledge and organisational knowing. *Organization Science, 10*(4), 381-400.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Ditillo, A. (2002). *The relevance of information flows in knowledge-intensive firms* (Working Paper No. 74). SDA Bocconi.

Ellingsen, G., & Monteiro, E. (2003). Mechanisms for producing a working knowledge: Enacting, orchestrating and organizing. *Information and Organization, 13*, 203-229.

Fitzpatrick, G. (2000). Understanding the paper health record in practice: Implications for EHRs. *Proceedings of HIC: Integrated Information for Health Care*.

Fitzpatrick, G. (2003). Emergent expertise sharing in a community. In M. Ackerman, V. Pipek, & V. Wulf (Eds.), *Sharing expertise: Beyond knowledge management* (pp. 81-110). Cambridge, MA: MIT Press.

Gherardi, S. (2000). Practice-based theorizing on learning and knowing in organisations. *Organization*, *7*(2), 211-223.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*, 109-122.

Hollan, J., Hutchins, E., & Kirsh, D. (2000). Distributed cognition: Toward a new foundation of human-computer interaction research. *ACM*

Transactions on Computer-Human Interaction, 7(2), 174-196.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

Levin, M., & Klev, R. (2002). *Forandring som praksis: Læring og utvikling i organisasjoner.* Bergen, Norway: Fagbokforlaget

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford, UK: Oxford University Press.

Orr, J. (1996). *Talking about machines: An ethnography of a modern job.* Cornell, CA: Cornell University Press.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Sellen, A. J., & Harper, R. H. R. (2002). *The myth of the paperless office.* Cambridge, MA: MIT Press.

Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, translations, and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology. *Social Studies of Science*, 19, 1907-1939.

Suchman, L. A. (1987). *Plans and situated actions: The problem of human-computer communication*. Cambridge, MA: Cambridge University Press.

Turnbull, D. (1993). The ad hoc collective work of building Gothic cathedrals with templates, string and geometry. *Science, Technology and Human Values, 18*(3), 315-340.

Walsham, G. (2001). Knowledge management: The benefits and limitations of computer systems. *European Management Journal, 19*(6), 599-608.

Walsham, G. (2004). Knowledge management systems: Action and representation. *Proceedings of Action in Language, Organisations and Information Systems (ALOIS2004).*

Willem, A., & Scarbrough, H. (2002). Structural effects on inter-unit knowledge sharing: The role of coordination under different knowledge sharing needs. *Proceedings of the 3rd European Conference on Organisational Knowledge, Learning and Capabilities,* Athens, Greece.

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Chapter 1.22
Knowledge Representation

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INTRODUCTION

In 1982, Allen Newell introduced the "knowledge level" principle (Newell, 1982) and revolutionized the traditional way of conceiving the relationships between knowledge management and computer science. According to this principle, the knowledge level represents the highest level in the description of any structured system: Situated above and independent from the "symbol level," it describes the observed behaviour of the system as a function of the knowledge employed, and independently of the way this knowledge is eventually represented/implemented at the symbol level. "The knowledge level permits predicting and understanding behaviour without having an operational model of the processing that is actually being done by the agent" (Newell, 1982, p. 108). An arbitrary system is then interpreted as a rational agent that interacts with its environment in order to attain, according to the knowledge it owns, a given goal in the best way; from a strict knowledge level point of view, this system is then considered as a sort of "black box" to be modeled on the basis of its input/output behaviour, without making any hypothesis on its internal structure. To sum up, the knowledge level principle emphasises the why (i.e., the goals), and the what (i.e., the different tasks to be accomplished and the domain knowledge) more than the how (i.e., the way of implementing these tasks and of putting this domain knowledge to use).

BACKGROUND

The emergence of the knowledge principle produced a shift of emphasis, in the (computerized) knowledge management domain, from a pure "representational" attitude to a "modeling" one, that is, a shift from the production of tools for implementing the knowledge a system will use to that of tools for building up models of the behaviour of the system in terms of that knowledge. An example of this is the Knowledge Acquisition and Design Structuring (KADS) methodology (Schreiber, Wielinga, & Breuker, 1993; Schreiber, Akkermans, Anjewierden, de Hoog, Shadbolt, Van de Velde, & Wielinga, 1999). A fundamental step in the KADS approach is, in fact, the set up of a general "conceptual model" of the system, which an observer (a knowledge engineer) creates by abstracting from the problem-solving behaviour of some experts. According to the knowledge principle, the conceptual model does not include any detailed constraint about the implementation level. This last function is assigned to the "design model," which corresponds to the (high level) specifications of the final knowledge-based system (KBS), and which represents the transformations to be executed on the conceptual model when we take into account the external requirements (e.g., specialised interfaces, explanation modules, etc.). The conceptual model is built up according to a four-layer structured approach: Each successive layer interprets the description given at the lower layer. A first layer concerns the "static domain knowledge," that is, the domain concepts and their attributes, the domain facts, the structures representing complex relations, and so forth. The static knowledge can be viewed as a declarative theory of the domain. A second type of knowledge concerns the "knowledge sources" and the "metaclasses." A knowledge source is defined as an elementary step in the reasoning process (an inference) that derives new information from the existing one; KADS presupposes the existence of a set of canonical inferences such as "abstraction, association, refinement, transformation, selection, computation." Metaclasses describe the role that a group of concepts plays in the reasoning process (e.g., observable, hypothesis, solution, etc.). The third layer contains knowledge describing how inferences can be combined to fulfill a certain goal, that is, how to achieve operations on metaclasses. The most important type of knowledge in this category is the "task": A task is a description of a problem-solving goal or subgoal, as "diagnose a patient with these particular symptoms." The fourth category of knowledge is the "strategic knowledge," which settles the general goals that are relevant to solve a particular problem; how each goal can be achieved is determined by the task knowledge.

One of the main attractions of this structured, analytical approach to the automation of knowledge management resides in the fact that all the methodologies based implicitly or explicitly on the knowledge level principle embrace the idea that the set up of KBSs can be facilitated by the development of libraries of reusable components. These pertain mainly to two different classes, (1) reusable "ontologies" (see also Zarri, "RDF and OWL" in this Volume) and (2) reusable problem-solving methods, which define classes of operations for problem-solving. Chandrasekaran (1990) is one of the first to suggest the development of reusable components under the form of "generic tasks," where a generic task defines both a class of application tasks with common features, and a method for performing these tasks.

An additional manifestation of this general tendency toward generalisation, abstraction, and reuse in the knowledge management domain are the activities aimed at the construction of general and reusable "corporate memories," (see van Heijst, van der Spek, & Kruizinga, 1996; Brooking, 1998; Beckett, 2000). Knowledge has been recognised as one of the most important assets of an enterprise and a possible success factor for any industrial organization, on the condition that it can be controlled, shared, and reused in an effective way. Accordingly, the core of the organization can then be conceived under the form of a general and shared organizational memory, that is, of an online, computer-based storehouse of expertise, experience, and documentation about all the strategic aspects of the organization. The construction and practical use of corporate memories becomes then the main activity in the knowledge management of a company, a focal point where several computer science and artificial intelligence disciplines converge: knowledge acquisition (and learning), data warehouses, database management, information retrieval, data mining, case-based reasoning, decision support systems, querying (and natural language querying) techniques, and so forth.

A clear discrimination between "knowledge" and "symbol" level is often not so easy to attain. For example, some methodologies that make reference to the knowledge level principle go in reality against Newell's approach because the structure they impose on the knowledge is a function of how a specific class of applications is implemented and dealt with, and the models they produce are then valid only in a very specific context. On a more pragmatic level, reuse can be very difficult to obtain, because there is often a significant semantic gap between some abstract, general method, and a particular application task. Moreover, discovering and formalising a set of elementary tasks independently from any specific application domain is a particularly hard endeavour which meets all sort of embarrassing problems, ranging from the difficulties in defining the building blocks in a sufficiently general way to the ambiguities concerning which aspects (the model or the code) of the blocks can really be reused. This explains why a (not trivial) number of "pure" knowledge-level proposals are still theoretical proposals, characterised by a limited implementation effort.

Indiscriminate use of the "modeling" approach risks forgetting that the basic technological support for implementing effective knowledge management is nevertheless provided by the knowledge representation (and processing) techniques. The building blocks, the generic tasks, the reusable modules, the shareable ontologies, and so forth must be formalised using one or more of the ordinary knowledge representation techniques developed in the last 50 years such as rules, logic, or frames. In this article, knowledge management will then be seen essentially as an application of the usual knowledge representation (and processing) techniques: creating and using, for example, large corporate memories requires that, first off all, the knowledge be represented, store,d and computer-managed in a realistic and efficient way.

TYPES OF KNOWLEDGE REPRESENTATION SYSTEMS

"Knowledge is power!" according to the well-known slogan spread abroad by Edward Feigenbaum—more precisely, Feigenbaum stated that: "...the power...does not reside in the inference method; almost any inference method will do. The power resides in the knowledge" (Feigenbaum, 1984, p. 101). Reviewing the different solutions for representing knowledge proposed in these last 50 years, we can isolate two main groups:

- The "symbolic" approach. This is characterised by (1) the existence of a well-defined, one-to-one (bijective) correspondence between all the entities of the domain to be modeled (and their relationships) and the symbols used in the knowledge representation language, and (2) by the fact that the knowledge manipulation algorithms (inferences) take explicitly into account this correspondence.
- The "soft programming" approach. Here, only the input and output values have an explicit, bijective correspondence with the entities of a given problem to be modeled. For the other elements and factors of the problem, (1) it is often impossible to establish a local correspondence between the symbols of the knowledge representation system and such elements and factors; (2) the resolution processes are not grounded on any explicit correspondence notion; (3) statistical and probabilistic methods play an important part in these resolution processes.

Given the present popularity of "ontologies" (a sort of symbolic approach) in all the domains requiring the concrete application of knowledge representation tools—including the knowledge management context, (e.g., Staab, Studer, Schnurr, & Sure, 2001)—it is very likely that knowledge management specialists will have to make use of symbolic (ontological) tools in the practice of their discipline. On the other hand, (1) information about soft systems is, apparently, less omnipresent than its symbolic counterpart in the knowledge management literature, and (2) bio-inspired intelligent information systems are broadly seen as one of the next frontiers of computer science. We will then supply here some (very limited) information about soft systems and an essential bibliography. For an in-depth discussion of the symbolic approach (see Bertino, Catania, & Zarri, 2001, p. 105-170; Zarri, "RDF and OWL" in this Volume).

THE SOFT PROGRAMMING PARADIGM

Neural Networks

Neural networks represent probably the most well-known example of soft programming paradigm. As genetic algorithms, their inner model can be considered as (loosely) "biologically inspired." More than on a loose analogy with the organisation of the brain—in this contest, only the (very simplified) concepts of "neuron" and "synapse" have been preserved—the biological foundations of neural networks reside in the self-organising principles that are characteristic of living systems. When a threshold number of interconnections (synapses) have been established between a set of neurons—and if the network has been carefully "programmed"—a form of self-organising activity appears that allows an external observer to affirm that the network "learns": it learns, for example, to associate a pattern with another, to synthesise a common pattern from the set of examples, to differentiate among input patterns and so forth where "pattern" must be understood here according to its more general meaning.

A neural network is made up of several "layers," where any number of neurons (processing units) can be present in each of the layers. Each neuron maps the inputs received from all the other neurons situated in a lower layer (or some external stimuli) to a one-dimensional output. This last is a function, among other things, of the "weights" associated with the connections (synapses) between the neurons in layer n and neurons in layer n-1, that is, of the "strength" of these connections. "Learning" is normally implemented by modifying the weights of the connections: For example, the "backpropagation method" consists in adjusting the weights making use of the difference, for a given distribution of input values, between the desired output values of the network and the values really obtained. Using then a training set made up of couples of input-output patterns, the weights are cyclically modified so that the differences are eventually minimised according, for example, to a least-squares sense. See Wasserman (1989) and Anderson (1995) for a detailed account of neural networks' theory.

Neural networks are particularly useful for capturing associations or discovering regularities within a set of patterns, especially when (1) the number of variables or the diversity of data is very great, and (2) the relationships between the variables are not well understood and, therefore, are difficult to describe using traditional (symbolic) methods. Accordingly, "classical" applications of neural networks concern banking (credit scoring, recovery scoring, forecasting the behaviour of new costumers, identifying "good risks"), financing (predicting share prices and volatilities, portfolio and asset management), industry (predicting demand for a product or a service, servo-control for machines or chemical reactors), marketing (marketing and mailing targeting, turnover prediction, data mining), public administration (analysis and prediction of crime, tax fraud detection, economic forecasting), and so forth. In these domains, neural network present, with respect to the corresponding "symbolic solutions," the fundamental advantage of freeing the knowledge engineer from the necessity of constructing a faithful "model" of the situation at hand, and of formatting correspondingly the data: with neural networks, the model is already there, even if it must be appropriately tuned (learning). Moreover, at the difference of many symbolic solutions, neural networks are relatively insensible to missing or erroneous values. On the other hand, neural networks—because of the lack of a one-to-one correspondence between entities to be modeled and symbols—are "black boxes" that do not explain their decisions. Moreover, their possible domains of applications are surely limited in number with respect to those where a symbolic approach can be appropriate.

Genetic Algorithms

Darwinian evolution—based on the principle of the "only the strongest survive strategy"—characterises the biological metaphor that is behind the creation of the genetic algorithms (GAs). According to this strategy, individuals compete in nature for food, water, and refuge, and for attracting a partner: The most successful individuals survive and have a relatively large number of offsprings. Their (outstanding) genetic material will then be transmitted to an increasing number of individuals in each successive generation; the combination of such outstanding characteristics ("chromosomes" or "genotypes") will be able to produce individuals whose suitability ("fitness") to the environment will sometimes transcend that of their parents. In this way, species can evolve—John Holland (Holland, 1975) and his colleagues of the University of Michigan are unanimously recognized as the first researchers to have envisaged the utilization of this strategy to solve the usual computer science problems.

The first step in the utilisation of the GAs approach consists then in the creation of a "population" of individuals (from a few tens to a few hundreds) that are represented by "chromosomes" (sometimes called "genotypes"). From the point of view of the problem to be solved, each chromosome represents a set (list) of parameters that constitutes a potential solution for the problem: for example, in a problem requiring a numerical solution, a chromosome may represent a string of digits; in a scheduling problem, it may represent a list of tasks; in a cryptographic problem, a string of letters, and so forth. Each item of the list is called a "gene." Traditionally, the parameters (genes) are coded using some sort of binary alphabet (i.e., a chromosome takes the form of a string of n binary digits).

The initial population is then modified and "improved" making use of two genetic operators, "crossover" and "mutation." Crossover takes two selected individuals, the "parents," and cuts their gene strings at some randomly (at least in principle) chosen position, producing two "head" and two "tail" substrings. The tail substrings are then switched, giving rise to two new individuals called "offsprings," which inherit some genes from each of the parents: The offsprings are then created through the exchange of genetic material. Mutation is applied to the offsprings after crossover, and consists into a random modification of the genes with a certain probability (normally a small one, e.g., 0.0001) called the "mutation rate." Note that mutation—that can be conceived, in biological terms, as an error in the reproduction process—is the only way to create truly new individuals (crossover makes use of already existent genetic material).

Genetic algorithms are part of a wider family of biologically inspired methods called in general "evolutionary algorithms," which are search and optimisation procedures all based on the Darwinian evolution paradigm evoked here, and consisting then in the simulation of the evolution of particular individuals through the application of processes of selection, reproduction, and mutation. Apart from GAs, other evolutionary methodologies are known under the name of “Evolution Strategies,” “Evolutionary Programming,” “Classifier Systems,” and “Genetic Programming.” Genetic Programming domain has emerged in these last years as particularly important. Genetic Programming can be seen as a variation of GAs where the evolving individuals are computer programs instead of chromosomes formed of fixed-length bit strings; when executed, the programs supply then a solution of the given problem (see Koza, 1992). In Genetic Programming, programs are not represented as lines of ordinary code, but rather as “parse trees” corresponding to a coding syntax in prefix form, analogous to that of LISP. The nodes of the parse trees correspond then to predefined functions (“function set”) that are supposed to be appropriate for solving problems in general in a given domain of interest, and the leaves (i.e., the terminal symbols) correspond to the variables and constants (“terminal set”) that are proper to the problem under consideration. Crossover is then implemented by swapping randomly selected sub-trees among programs; mutation, normally, is not implemented.

The classical reference in the GAs field is still Goldberg (1989); a good introductory book is Mitchell (1998).

Fuzzy Knowledge Representation Techniques

The fuzzy logic paradigm also is based on some sort of biologically inspired approach, even if the analogy looks less evident. It is related to the fact that fuzzy logic intends to simulate the way humans operate in ordinary life, that is, on a continuum, and not according a crisp “nothing-or-all” Aristotelian logic. Humans use some forms of gradually evolving linguistic expressions to indicate that, with respect to a given thermal environment, they are “comfortable,” “cold,” or “freezing.” Fuzzy logic allows to quantify such “fuzzy” concepts, and to represent then our sensations about temperature making use of numeric values in the range of 0 (e.g., “comfortable”) to 1 (e.g., “freezing,” with 0.7 representing then “cold”).

More precisely, according to the “fuzzy sets” theory—this theory, introduced by Zadeh (1965) makes up the core of the fuzzy logic paradigm (see also, in this context, Zimmerman, 1991; Kosko, 1992)—every linguistic term expressing degrees of qualitative judgements, like “tall, warm, fast, sharp, close to,” and so forth corresponds to a specific fuzzy set. The elements of the set represent then different “degrees of membership,” able to supply a numeric measure of the congruence of a given variable (e.g., temperature) with the fuzzy concept represented by the linguistic term.

Knowledge representation according to the fuzzy logic approach consists then in the computation, for a collection of input values, of their degree of membership with respect to a group of fuzzy sets. For a fuzzy application dealing with a temperature regulation system, the fuzzy sets to be considered for the variable “temperature” will be “cold,” “cool,” “comfortable,” “warm,” and “hot.” The process allowing us to determine, for each of the inputs, the corresponding degree of membership with respect to each one of the defined sets is called “fuzzification”; the degrees are calculated making use of appropriate “membership functions” that characterise each one of the sets. In this way, an input value of 83° F will be translated into two fuzzy values, 0.2 which represents the degree of membership with respect to the fuzzy set “hot,” and 0.8 representing the degree of membership with respect to the fuzzy set “warm,” (see Viot, 1993 for the technical details). Imprecise, approximate concepts like “warm” and “hot” are then translated into computationally effective, smooth, and continuous terms.

The fuzzy logic paradigm is widely used in industrial applications, especially for systems without a precise mathematical model and characterised by a high level of uncertainty. These applications range from household appliances such as dishwashers and washing machines that make use of fuzzy logic to find out the optimal amount of soap and the correct water pressure, to self-focusing cameras and embedded micro-controllers. Fuzzy logic also is used in special kinds of expert systems like decision support systems and meteorological forecast systems.

The Symbolic Paradigm

Knowledge representation systems that follow the symbolic approach range between two possible basic forms (as usual, mixed forms are possible):

- Pure rule-based representations supporting inference techniques that can be assimilated to first order logic procedures (inference by resolution). Within this first pole, is at least pragmatically useful to distinguish between the systems developed in a logic programming context and the simplest Expert Systems based on the standard production rules paradigm.
- Pure frame- or object-based representations supporting inference by inheritance, and also admitting defaults and procedural attachment. A particular class of inheritance-based systems that are today particularly fashionable are the ontology-based systems and their formal counterpart, the description logics (terminological logics) systems.

The Rule-Based Approach

Expression (a) below represents a so-called “Horn clause” (named after Alfred Horn, who first investigated their properties), that is, a kind of well-formed formula (wff) of the first-order predicate calculus characterised by the fact of having at most one positive “literal,” ‘A.’ Horn clauses are particularly important in artificial intelligence because they represent the basis of the logic programming paradigm and constitute the formal framework of programming languages like PROLOG and DATALOG.

$$A \vee \neg B1 \vee \neg B2 \ldots \vee \neg Bn \qquad n \geq 0 \qquad (a)$$

Applying to (a) a series of logical transformations based, inter alia, on the well-known de Morgan’s laws, formula (a) can be transformed into (b)—(see Bertino, Catania, & Zarri, 2001, pp. 112-113)—where ‘∧’ represents now the “conjunction” or “logical and” symbol, and ‘⊃’ is the “implication” symbol.

$$(B1 \wedge B2 \ldots \wedge Bn) \supset A \quad n \geq 0 \qquad (b)$$

Making use of the standard notation for representing implication, we can write (b) as (c), where the arrow ‘→’ is the connective “if” representing the implication and a “comma” still represents a “logical and”:

$$B1, B2, \ldots Bn \rightarrow A \qquad n \geq 0 \qquad (c)$$

In (c), B1 … Bn is now the “antecedent,” or the “conditions,” of the implication, and A is the “consequent” or the “conclusion.” Therefore, formula (c) states that, if the different conditions B1, B2, …, Bn are all verified (TRUE), they imply the conclusion A; we can write (c) succinctly as:

If B Then A. (d)

Formula (d) corresponds to the well-known notation used for the “production rules” that still constitute one of the basic operational tools used in all sort of artificial intelligence, cognitive science, knowledge management and Semantic Web applications. Their derivation from “classical” first order logic sketchily outlined is very important, given that the theory of production rule can then be easily brought back to the well-known formal context proper to theorem proving (resolution principle) and logic programming, (see Bertino, Catania, & Zarri, 2001, p. 107-122). Note, however, that production rule systems can only implement a reduced subset of the full first order logic.

The functioning of a typical "expert system" (ES) that makes use of production rules can be described as follows:

- The system includes a "rule base," that is, an unordered collection of production rules having the format of (c). We give now to the Bi the meaning of "conditions" (facts) that must be satisfied, and to A the meaning of the "action/actions" that must be performed if the conditions are satisfied. The Bi represent the "left-hand side" (LHS) of the rule r, A the "right-hand side" (RHS).
- The system also includes a "working memory" (WM) where the facts submitted are stored as input to the system or automatically inferred during its functioning.
- During its functioning, the system repeatedly performs a "recognise-act" cycle, which can be characterised as follows in the case of "condition-driven" or "forward-chaining" ESs:
    - In the "selection phase," for each rule r of the rule base, the system: (1) determines whether LHS(r) is satisfied by the current WM contents, that is, if LHS(r) matches the facts stored in the WM ("match subphase") and, if so, (2) it adds the rule r to a particular rule subset called the "conflict set" (CS) ("addition subphase"). When all the LHS are false, the system halts.
    - In the "conflict resolution phase," a rule of the CS is selected for execution. If it is impossible to select a rule, the system halts.
    - In the "act phase," the actions included in RHS(r) are executed by the interpreter—this is often called "firing a rule." Firing a rule will normally change the content of WM and, possibly, the CS. To avoid cycling, the set of facts ("instantiation") that has instantiated the LHS variables of the fired rule becomes ineligible to provoke again the firing of the same rule, which, of course, can fire again if instantiated with different facts.

A way of schematising the recognise-act cycle is represented in Figure 1. The name of "conflict set" is due to the fact that, amongst all the competing selected rules that are in agreement with the current state of WM, it is necessary to choose the only rule to be executed by the interpreter in the current cycle—choosing and executing multiple rules is possible, but more complex. The specific procedures to be implemented for performing the resolution of the conflicts depend on the application, and can be very complicated, given that the execution of a rule may lead other rules to "fire," or on the contrary, prevent their firing and so forth. It is then possible to make use of user-defined priorities: The user is allowed to choose a particular strategy, such as giving preference to rules that operate on the most recent information added to WM, or that match the highest number of items, or the most specific rule, the one with the most detailed LHS that matches the current state of WM. It is also possible to make use of predefined criteria for ordering the rules, which may be static (i.e., a priority ordering is assigned to the rules when they are first created) or dynamic.

Production systems can be classified into two different categories according to the way rules are compared with data of WM. When the comparison is between LHS(r) and WM as illustrated in Figure 1, we have the "condition-driven" or "forward-chaining" systems). But it is also possible to compare RHS(r) with WM ("action-driven," or "backward-chaining" systems). An example of a backward-chaining system is given by MYCIN, a software designed to perform medical diagnosis (prescribe antibiotic therapy) in the field of bacterial infections that represents one of the best known and historically important expert system (see Shortliffe, 1976). More details can be found in Bertino, Catania, & Zarri (2001, p. 125-131).

The Inheritance-Based Approach

Inheritance is one of the most popular and powerful concepts used in the artificial intelligence and knowledge representation domains. It represents, at the same time:

- Static: A static structuring principle that allows to group together similar notions in classes, and to economise in the description of some attributes of the entities of the low-level classes because these descriptions can be inherited from the entities of the high-level classes;
- Dynamic: A dynamic inferencing principle that allows to make deductions about the properties (attributes) of the low-level entities that are a priori unknown because these properties can be deduced from those that characterise the high-level entities—with the well-known problems linked with the fact that, for example, "penguins" and "ostriches" pertain to the class "birds," but they cannot inherit from the description of this general class the property "can_fly";
- Generative principle: A generative principle that allows to define new classes as variants of the existing ones: The new class inherits, in fact, the general properties and behaviours of the parent class, and the system builder must only specify how the new class is different.

The inheritance principle is normally used to set up hierarchies of "concepts"—"ontologies" or "taxonomies," where the first are differentiated from the second because they add to the plain description of the hierarchical links among the concepts also an explicit definition/description of these concepts. Ontologies/taxonomies are then structured as inheritance hierarchies making use of the well-known IsA link—also called AKindOf (Ako), SuperC, and so forth (see Figure 2). A relatively unchallenged—see however, Brachman,

Figure 1. The "recognise-act" cycle

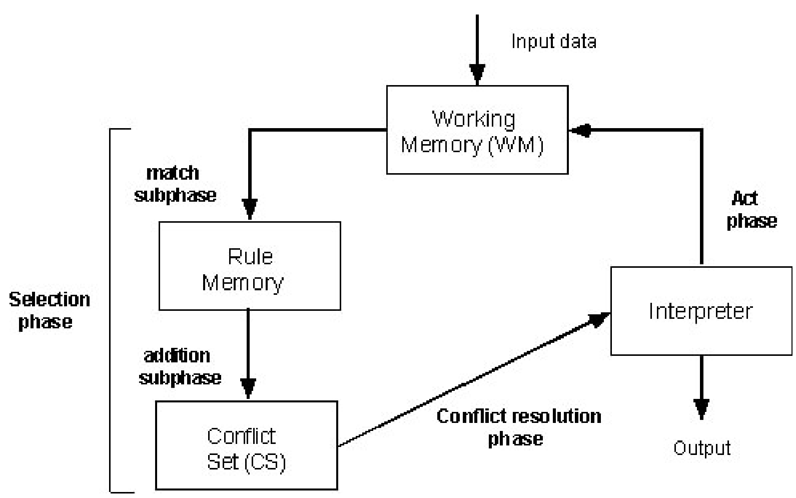
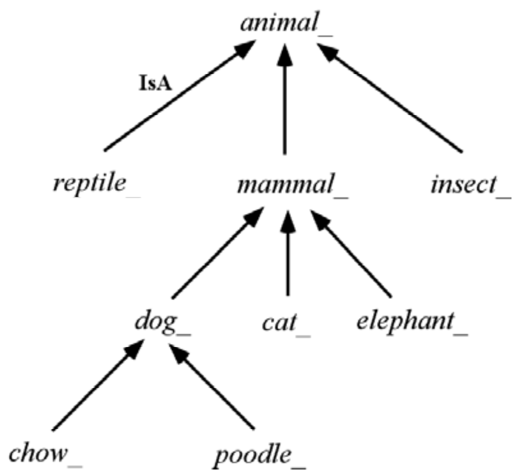


Figure 2. A simple inheritance hierarchy



(1983)—semantic interpretation of IsA states of this relationship among concepts, when noted as (IsA B A), means that concept B is a specialisation of the more general concept A. In other terms, A subsumes B. This assertion can be expressed in logical form as:

$\forall x\ (B(x) \rightarrow A(x))$; (e)

(e) says that, if any elephant_ (B) IsA mammal_ (A), and if clyde_ is an elephant_, then clyde_ is also a mammal_—as usual, the concepts_ are written down in italics, and their instances_ (e.g., clyde_, an "individual") in roman characters. When (e) is interpreted strictly, it also implies that a given concept B and all its instances must inherit all the features (properties) and their values of all the concepts Ci in the hierarchy that have B as a specialization; we speak in this case of "strict inheritance." Note that, under the strict inheritance hypothesis, totally new properties can be added to B to differentiate it (specialize it) with respect to its parents.

Relation IsA is transitive: This means that, for example, having both $\forall x\ (C(x) \rightarrow B(x))$ and $\forall x\ (B(x) \rightarrow A(x))$, we can deduce from this that $\forall x\ (C(x) \rightarrow A(x))$. This property is particularly important because it allows, in an inheritance hierarchy like that of Figure 2, to represent explicitly only the IsA relationships that associate directly two nodes (i.e., without the presence of intermediary nodes). All the residual IsA relationships are then explicitly derived only when needed: For example, from Figure 2 and from the transitive property of IsA, we can explicitly assert that (IsA chow_ mammal_).

The necessary complement of IsA for the construction of well-formed hierarchies concerns some form of InstanceOf link, used to introduce the "instances" (concrete examples) of the general notions represented by the concepts. The difference between (IsA B A) and (InstanceOf C B) is normally explained in terms of the difference between the two options of (1) considering B as a subclass of A in the first case, operator '$\subset$', and (2) considering C as a member of the class B in the second, operator '$\in$'. Unfortunately, this is not sufficient to eliminate any ambiguity about the notion of instance, which is much more controversial than that of concept. Problems about the definition of instances concern: (1) the possibility of accepting that concepts (to the exclusion of the root) could also be considered as "instances" of their generic concepts; (2) the possibility of admitting several levels of instances, that is, instances of an instance. For a discussion about these problems and the possible solutions, see Bertino, Catania, and Zarri (2001, p. 138).

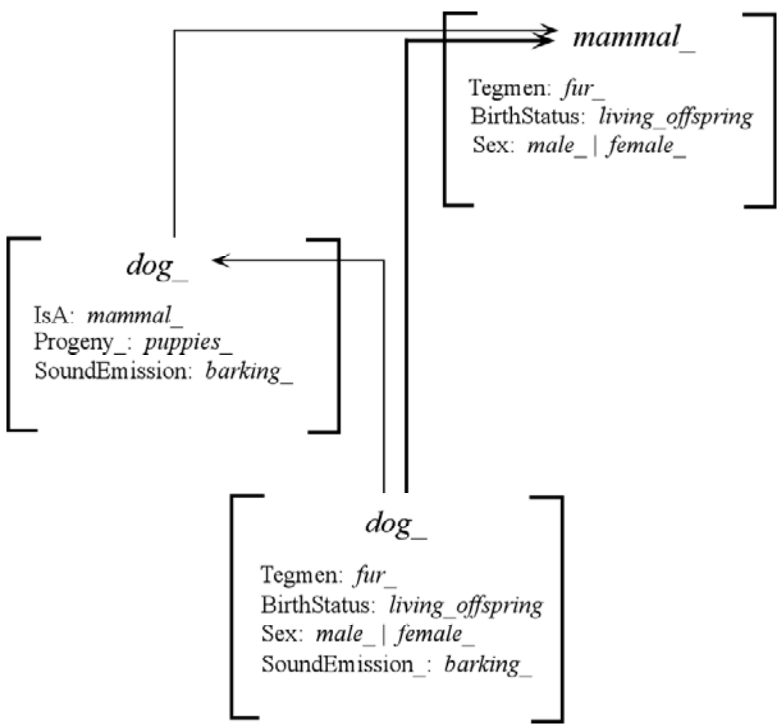
We can now associate to any concept a "structure" (a "frame") to reflect the knowledge human beings have about (1) the intrinsic properties of these concepts and (2) the network of relationships, other than the hierarchical one, the concepts have each other. As already stated, we are now totally in the "ontological" domain, and this sort of frame-based ontologies can be equated to the well-known "semantic networks" (see Lehmann, 1992).

Basically, a "frame" is a set of properties, with associated classes of admitted values, that is linked to the nodes representing the concepts. Introducing a frame corresponds then to establishing a new sort of relationship between the concept Ci to be defined and some of the other concepts of the ontology. The relationship concerns the fact that the concepts C1, C2 … Cn used in the frame defining Ci indicate now the "class of fillers" (specific concepts or instances) that can be associated with the "slots" of this frame, the slots denoting the main properties (attributes, qualities, etc.) of Ci. There is normally no fixed number of slots, nor a particular order imposed on them; slots can be accessed by their names.

Figure 3 (an "ontology") reproduces a fragment of Figure 2 (a "taxonomy") where the concepts are now associated with their (highly schematized) defining frames—note that the two fillers male_ | female_ also could have been replaced by their subsuming concept sex_. This figure makes explicit what "inheritance of properties/attributes" means: Supposing that the frame for mammal_ is already defined, and supposing now to tell the system that the concept dog_ is characterised by the two specific properties Progeny and SoundEmission, what the frame dog_ really includes is represented in the lower part of Figure 3.

Even if, under the influence of the Semantic Web work (see Zarri, "RDF and OWL" in this Volume), the "classic" frame paradigm sketched here is moving toward more formalized, logic-based (and XML/RDF-based) types of representation, nevertheless this paradigm still constitutes the foundation for the setup of a large majority of knowledge repositories all over the world;

Figure 3. A simple example explaining the "inheritance of properties/attributes"



often, a knowledge base is nothing more than a "big" ontology formed of concepts/individuals represented under the form of frames. The most well-known tool for the setup of large knowledge bases making use of the frame model is Protégé-2000, developed for many years at the Medical Informatics Laboratory of the Stanford University (California, USA) (e.g., Noy, Fergerson, & Musen, 2000; Noy, Sintek, Decker, Crubezy, Fergerson, & Musen, 2001). Protégé-2000 represents today a sort of standard in the frame-based ontological domain.

FUTURE TRENDS

Knowledge representation systems that follow the "soft programming" paradigm are expected to evolve into the new "bio-inspired intelligent information systems." These are systems capable of extracting meaning associated to complex patterns of sensor stimuli and of generating well coordinated sequences of elementary actions complying with a set of higher level goals. The systems should show autonomous growth in perceptual, motor, and cognitive abilities. Examples can concern the construction (1) of hardware/software "artifacts that live and grow" (ALGs), that is, artifacts that self-adapt and evolve beyond pure programming, and (2) of perception-response systems (PRSs) inspired by the sophistication of solutions adopted by living systems, where "perception" refers to the sensorial, cognitive, and control aspects (covering vision, hearing, or any other modalities) used by the biological organisms to interact with the environment.

With respect now to the "symbolic approach," the most up-to-date rule-based systems are those used in a Semantic Web context (see Zarri, "RDF and OWL" in this Volume). In the inheritance- and frame-based domain, Protégé-2000 is still the de facto standard; on a more theoretical level—and thanks at least partly, once again, to the success of the Semantic Web research—description logics (DLs) have gained particular importance in these last years. DLs (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2002) are an axiomatized, inheritance-based system characterised by the presence of a mechanism for the automatic classification of concepts as its main reasoning component. One of the main reasons for the introduction of DLs has been the wish to offer a formal and logically-sound foundation for frame-based systems (see Minker & Grant in this Volume).

CONCLUSION

In this article, we started with the fundamental revolution in the relationships between knowledge management and computer science that followed the introduction of the "knowledge level" principle, and of the new emphasis on the "modeling" principles that resulted from that. Notwithstanding the corresponding, indisputable progresses at the theoretical and methodological level, we have then shown that the adoption of the knowledge level principle does not eliminate the need—when creating and using, for example, large organizational memories—for making certain that the required "knowledge" be represented, stored, and computer-managed in a realistic and efficient way. Knowledge representation represents then one of the key, enabling factors for knowledge management.

Confronted with the choice of selecting specific knowledge representation tools, we must choose between two conflicting paradigms, the "symbolic" approach—where there is a precise, one-to-one correspondence between the entities of the domain to be dealt with and the symbol intended to represent them – and the "soft programming" approach, where this correspondence is totally blurred. In a knowledge management context, the symbolic paradigm ("ontologies") seems to be, presently, the predominant one; given, however, the importance that the new "bio-inspired intelligent information systems"—an evolution of the "soft programming" approach—should have in the future, the soft programming techniques (neural networks, genetic algorithms, and fuzzy logic) are of growing importance.

REFERENCES

Anderson, J.A. (1995). *An introduction to neural networks.* Cambridge, MA: MIT Press.

Baader, F., Calvanese, D., McGuinness, D., Nardi, D., & Patel-Schneider, P.F. (Eds.) (2002). *The description logic handbook: Theory, implementation and applications.* Cambridge: University Press.

Beckett, R.C. (2000). A characterization of corporate memory as a knowledge system. *Journal of Knowledge Management*, *4*(4), 311-319.

Bertino, E., Catania, B., & Zarri, G.P. (2001). *Intelligent database systems.* London: Addison-Wesley and ACM Press.

Brachman, R.J. (1983). What IS-A is and isn't: An analysis of taxonomic links in semantic network. *IEEE Computer*, *16*(10), 30-36.

Brooking, A. (1998). *Corporate memory: Strategies for knowledge management.* London: Thomson Business Press.

Chandrasekaran, B. (1990). Design problem solving: A task analysis. *AI Magazine*, *11*(4), 59-71.

Fegenbaum, E.A. (1984). Knowledge engineering: The applied side of artificial intelligence. In *Annals of the New York Academy of Sciences, 246,* 91-107.

Goldberg, D.E. (1989). *Genetic algorithms in search, optimization, and machine learning.* Reading, MA: Addison-Wesley.

Holland, J.H. (1975). *Adaptation in natural and artificial systems.* Ann Arbor, MI: University of Michigan Press.

Kosko, B. (1992). *Neural networks and fuzzy systems: A dynamical systems approach to machine intelligence*. Englewood Cliffs, NJ: Prentice Hall.

Koza, J. (1992). *Genetic programming.* Cambridge, MA: The MIT Press.

Lehmann, F. (Ed.). (1992). *Semantic networks in artificial intelligence.* Oxford: Pergamon Press.

Mitchell, M. (1998). *An introduction to genetic algorithms.* Cambridge, MA: The MIT Press.

Newell, A. (1982). The Knowledge Level. *Artificial Intelligence, 18,* 87-127.

Noy, F.N., Fergerson, R.W., & Musen, M.A. (2000). The knowledge model of Protégé-2000: Combining interoperability and flexibility. In *Knowledge Acquisition, Modeling, and Management. Proceedings of the European Knowledge Acquisition Conference*, *EKAW'2000*. Berlin: Springer-Verlag.

Noy, N.F., Sintek, M., Decker, S., Crubezy, M., Fergerson, R.W., & Musen, M.A. (2001). Creating Semantic Web contents with Protégé-2000. *IEEE Intelligent Systems, 16*(2), 60-71.

Schreiber, G., Akkermans, H., Anjewierden, A., de Hoog, R., Shadbolt, N., Van de Velde, W., & Wielinga, B. (1999). *Knowledge engineering and management: The CommonKADS Methodology.* Cambridge, MA: The MIT Press.

Schreiber, G., Wielinga, B., & Breuker, J. (1993). *KADS: A principled approach in knowledge-based system developments.* London: Academic Press.

Shortliffe, E.H. (1976). *Computer-based medical consultations: MYCIN.* New York: American-Elsevier Publications.

Staab, S., Studer, R., Schnurr, H.-P., & Sure, Y. (2001). Knowledge processes and ontologies. *IEEE Intelligent Systems, 16*(1), 26-34.

van Heijst, G., van der Spek, R., & Kruizinga, E. (1996). Organizing corporate memories. In B.R. Gaines & M. Musen (Eds.), *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop*, Calgary: Department of Computer Science of the University.

Viot, G. (1993). Fuzzy logic: Concepts to constructs. *AI Expert 8*(11), 26-33.

Wasserman, P.D. (1989). *Neural computing: Theory and practice.* New York: Van Nostrand Reinhold.

Zadeh, L.A. (1965). Fuzzy sets. *Information and Control, 8*, 338-353.

Zimmermann, H.J. (1991). *Fuzzy set theory and its applications* (2nd Ed.). Norwell, MA: Kluwer.

Chapter 1.23
External Knowledge Integration

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INTRODUCTION

As an academic field, knowledge management has concentrated on the creation, storage, retrieval, transfer, and application of knowledge within organizations, while underexposing external knowledge (e.g., Alavi & Leidner, 2001). Although the importance of external knowledge is well recognized (e.g., Cohen & Levinthal, 1990), there remains a need for a better understanding of the organizational processes through which external knowledge is integrated (Grant, 1996; Ranft & Lord, 2002). In particular, we believe that a holistic view on knowledge integration (KI) is both important and lacking. In this article, we address this lacuna in the literature by proposing a process model of KI consisting of three stages—identification, acquisition, and utilization of external knowledge. Our objective is to propose a model consisting of modular subprocesses that parsimoniously reflect the variety of KI concepts in the literature. This model is useful to scholars and practitioners because it provides a better understanding of the various KI subprocesses by putting them together in a coherent way. Such understanding serves as bedrock for solving KI problems and for designing KI solutions (cf. Markus, Majchrzak, & Gasser, 2002).

BACKGROUND

In the current literature, the term KI is used for the integration of knowledge from individuals or departments within an organization (Becerra-Fernandez & Sabherwal, 2001; De Boer, Van den Bosch, & Volberda, 1999; Grant, 1996; Leonard-Barton, 1995; Okhuysen & Eisenhardt, 2002; Szulanski, 1996). Based on the meaning of the word integration ("to incorporate into a larger unit," Merriam Webster Online) we extend the term KI with three stages that model the incorporation of external knowledge. We call the processes associated with the term KI in the current literature utilization. Because external knowledge needs to be acquired before it can be utilized, we include a stage of acquisition in the model that precedes the utilization stage. Correspondingly, to acquire external knowledge it needs to be identified first. Acquisition is therefore preceded in our model by a stage of identification.

Although there is excellent research done on each of the KI stages, we found no contribution that covers them all. For their own reasons, scholars concentrate on one or two KI stages and disregard either identification (e.g., Almeida, 1996; Crossan, Lane, & White, 1999; Tsang, 2002), acquisition (e.g., Galunic & Rodan, 1998; Rosenkopf & Nerkar, 2001), or utilization (e.g., Leifer & Huber, 1977; McEvily, Das, & McCabe, 2000; Shenkar & Li, 1999). Other scholars regard KI as a black box or elaborate on explanatory models of successful KI (e.g., De Boer et al., 1999; Hamel, 1991; Hansen, 2002; Lane & Lubatkin, 1998; Mowery, Oxley, & Silverman, 1996; Szulanski, 1996; Zander & Kogut, 1995). As such, they provide an understanding of the outcome of KI but less so of the process. Holistic approaches are found in literature on knowledge transfer (e.g., Appleyard, 1996; Bhagat, 2002; Duncan, 1972; Gupta & Govindarajan, 2000; Kostova, 1999; Newell & Swan, 2000; Szulanski, 1996, 2000). In this article, however, networks and alliances are the objects of research, which limits its contribution to the understanding of the KI process in a single organization.

Though they do not provide a holistic model, these scholars provide us with all the necessary ingredients for a holistic KI model. In this article, we try to put the pieces of the KI puzzle together. We follow a pragmatic approach in which we borrow relevant concepts from literature and position them in the KI model: an approach similar to what Glaser called "transcending"—taking relevant variables from theories while trying to raise their conceptual level (1978, pp. 14-15).

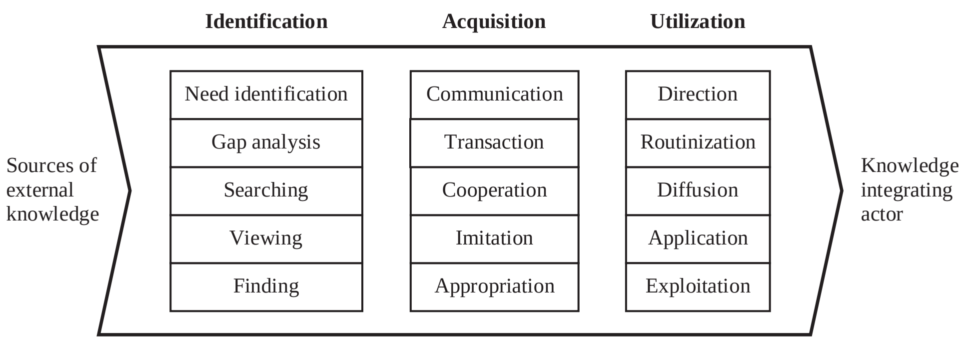
MAIN FOCUS: STAGE MODEL

Although there is no consensus on what constructs form the essential basis of a process model (Curtis, Kellner, & Over, 1992), we define a process as a configuration of connected subprocesses, performed by certain actors. Within this article, we suggest an ordered set of KI subprocesses (see Figure 1) and four views on actors that perform them. An elaboration on the configurations that can be created with these elements is left for future research.

Identification

All subprocesses between initiating a KI process and locating specific external knowledge are considered the identification stage. The apparent relevant theory for this stage is the theory on

Figure 1. Stages and subprocesses of knowledge integration



information seeking. Many information-seeking models follow the process of an information need followed by a successful or unsuccessful search (for an overview, see Case, 2002). These models, however, only partly cover the identification stage, because there are variations in how this stage is initiated. Some seekers start actively from a defined need, while others wait for useful information to appear. Knowledge sources and third parties also can initiate the KI process by pushing an organization to use certain knowledge. Aguilar (1967), Daft and Weick (1984) and Choo (2002) make these distinctions in their work on environmental scanning. At the heart of information-seeking models are information needs. Some authors (e.g., Ellis & Haugan, 1997; Leckie, Pettigrew, & Sylvain, 1996; Wilson, 1999) assume that these needs automatically follow a stimulus or goal. There is, however, substantial evidence that identifying needs is a core problem in information seeking (Choo, Detlor, & Turnbull, 2000; Dervin, 1992; Taylor, 1968). The first subprocess that we propose is therefore need identification, which is defined as finding out to a satisfying degree what knowledge an actor needs at a certain moment for a particular purpose. Closely related to need identification is gap analysis, which we define as finding out what knowledge an actor is lacking at a certain moment for a particular purpose. It can be beneficial to find out whether knowledge is available internally before looking outside since search costs are likely to be lower within an organization (cf. March, 1991; March & Simon, 1958) and in personal files (Taylor, 1968). If no additional external knowledge is needed, available knowledge can be exploited (which we consider part of the utilization stage). Once there are indications for what knowledge is needed, companies can search for it. Therefore, a third subprocess that we propose is searching, which is defined as intentionally striving to find knowledge or sources of knowledge. This definition suggests that searching is an intentional process regardless of its outcome (cf. Marchionini, 1995). Together, these three subprocesses reflect an information seeking procedure. However, knowledge also can be identified without a focused searching process by broadly scanning the environment. Daft and Weick (1984) call this viewing. Daft and Weick do not provide a definition, so we define it as monitoring the existing external knowledge base to detect relevant changes. A final subprocess proposed in the identification stage is finding, which we define as coming across knowledge or across sources of knowledge. Finding is an outcome that can occur without searching or viewing, for example, when knowledge is pushed by another organization.

Acquisition

Although there is a conceptual difference between identification and acquisition (Hansen, 1999), searching is often included in the acquisition process (e.g., Gold, Malhotra, & Segars, 2001; Zahra & George, 2002) or defined as the acquisition of information (Johnson, in Case, 2002). However, in our view, searching does not automatically imply acquisition. Since knowledge that crosses organizational borders implies interactions between two or more organizations, social systems theory is highly relevant for this stage. Kuhn and Beam describe three intersystem interactions that we include as subprocesses within the KI model. (Kuhn & Beam, 1982, p. 14)

- Communication: An interaction analyzed with respect to its information content
- Transaction: An interaction analyzed with respect to its value content
- Organization: An interaction analyzed with respect to its joint effectual content

We propose these three interactions as subprocesses in the KI model, but prefer the term “cooperation” above “organization” because of the broader meaning that is given to “organization” in management literature. The subprocesses differ in the way knowledge is transferred. For example, by communication, knowledge is acquired by talking to somebody; by transaction, it is acquired by buying a document; and by cooperation, it is acquired by working together on a project. These three acquisition subprocesses imply the involvement of both the source and the recipient of knowledge. However, knowledge also can be acquired without the involvement of the source. Disregarding illegal activities, such as stealing and spying, this is achieved by imitating a source's behavior or products (Zander & Kogut, 1995). We propose imitation as a fourth acquisition subprocess and define it as reproducing knowledge by copying objects or actions from another actor, with or without its assent. Imitation without the source's assent is also called "replication" (Nelson & Winter, 1982). Imitation is, however, also carried out with the assent of the source, for example, when a knowledge source demonstrates how to perform a certain task and the recipient imitates this behavior. Related to knowledge transfer is the transfer of a certain form of property rights, such as patents or copyrights. When one organization buys a document from another organization, this usually automatically involves the acquisition of property rights. In other cases, however, the transfer of property rights is not so natural and might even be problematic, for example, during cooperation (Liebeskind, 1996; Teece, 1998). It is important to include the acquisition of property rights in the KI model because they allow for different ways of utilization (Liebeskind, 1996). Some knowledge may only be used once in an unmodified form, while other knowledge may be fully modified and exploited. We propose appropriation as the final subprocess in the acquisition stage and define it as obtaining rights to utilize acquired knowledge in a certain way.

Utilization

As argued in the introduction, knowledge management scholars have extensively researched this KI stage. Researchers on organizational memory (Stein, 1995; Walsh & Ungson, 1991; Wijnhoven, 1999) have distinguished several "mnemonic" processes for utilizing knowledge within an organization. Subprocesses frequently included are acquisition, retention, search, retrieval, and maintenance (Stein, 1995; Walsh & Ungson, 1991). Since acquisition was regarded as a separate stage, we exclude it here.

Grant (1996) observed two primary internal KI "mechanisms"—direction and routinization—which we propose as subprocesses within this stage. Direction involves codifying tacit knowledge into explicit rules and instructions so that it can be communicated at low cost throughout the organization (Grant, 1996: 379). Routinization is the development of a fixed response to defined stimuli in order to simplify choice (March & Simon, 1958: 142). In dynamic environments, where there are few "defined stimuli," adaptation of the repertoire of these routines is crucial (Argyris & Schön, 1978; Levitt & March, 1988). Organizations can facilitate direction and routinization by a third utilization subprocess: diffusing knowledge throughout the organization. Using the image of a jigsaw puzzle, Galunic and Rodan distinguish two forms of diffusion: "A picture on a jigsaw puzzle is distributed when each person receives a photocopy of the picture. The same image would only be dispersed when each of the pieces is given to a different person" (1998: 1198). Like Boisot (1995), by diffusion we not only refer to the active dissemination of knowledge to persons in the organization, but also to the establishment of availability. Therefore, storage of knowledge is included in this subprocess. Unlike routinization, which includes application (Nelson & Winter, 1982), direction and diffusion do not imply that knowledge is applied. A fourth subprocess is therefore distinguished—application—which is defined as using knowledge for the purpose(s) for which it was acquired. Knowledge can be applied for other purposes than those for which it was acquired. Organizations might gain maximum advantage from knowledge by reusing it (Markus, 2001) and recombining it (Galunic & Rodan, 1998). Following March (1991) and Schumpeter (1934), we call this fifth and last subprocess in the utilization stage exploitation.

Actors

The occurrence and interrelationships of the 15 subprocesses will depend upon the roles that their actors play within the organization. Rather than providing specific roles, we discern four general views on the roles that individuals play within collectives.

The first view stems from the gatekeeper theory (Allen & Cohen, 1969; Tushman, 1977) in which individuals are representatives that identify and acquire knowledge for the organization. In the utilization stage, knowledge is elevated to a collective level by direction, routinization, and diffusion into the organizational memory. This view is also central in the information processing perspective (e.g. Daft & Lengel, 1984; Weick, 1979) in which a manager's task is to reduce equivocality within the organization. Although this view might reflect the usual situation in hierarchical organizations, a different situation might well exist in organizations of professionals (cf. Mintzberg, 1979). In such organizations, individuals are professionals that identify, acquire, and utilize knowledge themselves. In this second view, each of the subprocesses can be executed individually as well as collectives, such as by collaborative search, group decisions, and group work. Some researchers on collective mind (Weick & Roberts, 1993), organizational decision-making (Simon, 1997), and organizational learning (Argyris & Schön, 1978; Hedberg, 1981; Kim, 1993; March, 1991) emphasize the mutual influence of individuals and collectives. Collectives, like organizations, influence individual knowledge needs and KI processes, while individuals' knowledge and actions, in turn, influence the organization. This third view suggests that individuals are part of a collective. People can choose to keep knowledge at the individual level (in their head and personal filing systems) and not make it available to the collective, a central issue in knowledge sharing literature and practice. A fourth view emerges when considering that KI processes can cross business processes and organizational units. Knowledge that is identified, acquired, and applied in one business process or unit also can be used within another business process or unit. This occurs, for example, in new product development, where knowledge acquired and used by a production department also is used in the development of a new product by an R&D department. In this view, individuals are specialists that have different areas of expertise.

We believe the proposed stage-model of subprocesses and actors is the most comprehensive of its sort. It extends the most comprehensive existing model that we found (Schwartz, Divitini, & Brasethvik, 2000) with knowledge acquisition and application subprocesses and with an elaboration on the relation between individuals and collectives. The value of these extensions is that the model allows for a more complete analysis of KI than existing models do. This can provide practitioners with a better awareness of the KI process and with an instrument to solve KI problems in their organizations. For example, suppose a company's director notices that his information specialists find and acquire much external knowledge and successfully diffuse it by sending documents to the concerning people in the company. However, he receives many complaints from engineers that this knowledge is not applicable for them. Faced with this problem, the director can use the proposed model to analyze what is going wrong and what can be done to solve this. First, he will observe that application is done by different people than the other subprocesses, which suggests that the information specialists act as representatives of the engineers. Based on this observation, he might decide that it is better to treat the engineers as professionals that can and should identify and acquire the needed knowledge themselves. Second, he can observe that the knowledge is acquired and diffused by means of documents while alternative ways might lead to less loss of relevant details. The KI model makes him aware that imitation and routinization might be alternatives for respectively communication and diffusion. Thus, while the model is descriptive, it can facilitate normative decisions by pointing out alternatives for and relationships between KI subprocesses and roles of actors.

FUTURE TRENDS

In this article, we have proposed an ordered set of KI subprocesses and four views on the relation between individual and collective actors. Very important and still lacking are the KI configurations (combinations of subprocesses and roles of individuals) that can be created with them. We suspect that from the numerous theoretically possible configurations, only few appear in practice. It is a challenge to find out which they are and how they relate to organizational effectiveness. Future research should address these open questions, as well as test the completeness and validity of the proposed model. To this end, further decomposition and operationalization of the model into reliable and valid measurement instruments are challenging but necessary steps. Because of its formal approach, we expect the literature on workflow processes to be very useful to find interactions between subprocesses and to check the KI process on completeness (e.g., Van der Aalst, Ter Hofstede, Kiepuszewski, & Barros, 2003).

Considering the growing interconnectivity of organizations over the world, external knowledge becomes more and more important for them. Because of this growing importance for practitioners, we expect a growing attention to KI and KI-related concepts amongst KM researchers in the near and far future. Looking back at the last decade of KM research, we believe there is indeed a growing attention. We find it, however, hard to estimate whether this trend is merely numerical or whether it also reflects cumulativity of knowledge. Huber already remarked in 1991 on the lack of cumulative work and on the lack of synthesis of work from different research groups on organizational learning (Huber, 1991: 107). We have tried to make a step toward synthesis with respect to the integration of external knowledge. This complete volume shows to what extent the KM research community in general has achieved synthesis and also what research challenges there still are.

With the growing attention for interorganizational connectivity, we also expect research attention to shift from large organizations to small organizations and individuals. In networks of companies and individuals, the concept of organization becomes ambiguous. A revealing example is the development of Linux software (Lee & Cole, 2003). The emergence of such networks, where organizational borders and structures are blurred, has significant consequences for KM research and practice. It imposes unanswered questions on, for example, the remaining value of concepts like organizational learning and organizational memory. Because of the diverging meaning of the term organization, we have not committed ourselves to a single level of collectiveness in this article. Conversely, we have proposed perspectives on interactions of subprocesses on different levels of collectiveness. We believe these perspectives as well as the KI model remain relevant on the level of organizations, networks, and individuals.

CONCLUSION

We started our analysis with the observation that a comprehensive model of the KI process is both important and lacking. In this article, we have proposed a model that consists of 15 subprocesses ordered in three stages—identification, acquisition, and utilization. This model is comprehensive in its coverage of subprocesses that are involved in KI. However, the current model is like a box of LEGOs®—we have proposed bricks (subprocesses) and types of connections (roles of individuals within collectives), but not the designs (configurations) that can be created with them. Although substantial work still needs to be done, we believe the proposed model is a useful instrument for knowledge management practitioners and researchers because a thorough understanding of the KI process is essential to find and design KI solutions (cf. Keen & Scott Morton, 1978). As a process model, the proposed KI model serves as a kernel theory for design of information systems that are to support the KI process (cf. Markus et al., 2002).

REFERENCES

Aguilar, F.J. (1967). *Scanning the business environment.* New York; London: The MacMillan Company.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Allen, T.J., & Cohen, S.I. (1969). Information flow in research and development laboratories. *Administrative Science Quarterly, 14*(1), 12-19.

Almeida, P. (1996). Knowledge sourcing by foreign multinationals: Patent citation analysis in the U.S. semiconductor industry. *Strategic Management Journal, 17*(Winter), 155-165.

Appleyard, M.M. (1996). How does knowledge flow? Interfirm patterns in the semiconductor industry. *Strategic Management Journal, 17*(Winter), 137-154.

Argyris, C., & Schön, D.A. (1978). *Organizational learning: A theory of action perspective.* Reading, MA: Addison-Wesley.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Bhagat, R. S. e. a. (2002). Cultural variations in the cross-border transfer of organizational knowledge: An integrative framework. *Academy of Management Review, 27*(2), 204-221.

Boisot, M. (1995). *Information space: A framework for learning in organizations, institutions and culture.* London: Routledge.

Case, D.O. (2002). *Looking for information: A survey of research on information seeking, needs, and behavior.* San Diego: Academic Press.

Choo, C.W. (2002). *Information management for the intelligent organization: The art of scanning the environment.* Medford, NJ: Information Today, Inc.

Choo, C.W., Detlor, B., & Turnbull, D. (2000). *Web work: Information seeking and knowledge work on the World Wide Web.* Dordrecht, The Netherlands: Kluwer Academic Publishers.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Crossan, M.M., Lane, H.W., & White, R.E. (1999). An organizational learning framework: From intuition to institution. *Academy of Management Review, 24*(3), 522-537.

Curtis, B., Kellner, M.I., & Over, J. (1992). Process modeling. *Communications of the ACM, 35*(9), 75-90.

Daft, R.L., & Lengel, R.H. (1984). Information richness: A new approach to managerial behavior and organizational design. *Research in Organizational Behavior,* 191-233.

Daft, R.L., & Weick, K.E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9*(2), 284-295.

De Boer, M., Van den Bosch, F.A.J., & Volberda, H.W. (1999). Managing organizational knowledge integration in the emerging multimedia complex. *Journal of Management Studies, 36*(3), 379-398.

Dervin, B. (1992). From the mind's eye of the 'user': The sense-making qualitative-quantitative methodology. In *Qualitative Research in Information Management* (pp. 61-84). Englewood, CO: Libraries Unlimited.

Duncan, W.J. (1972). The knowledge utilization process in management and organization. *Academy of Management Journal, 15*(3), 273-287.

Ellis, D., & Haugan, M. (1997). Modeling the information seeking patterns of engineers and research scientists in an industrial environment. *Journal of Documentation, 53*(4), 384-403.

Galunic, D.C., & Rodan, S. (1998). Resource combinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management Journal, 19*, 1193-1201.

Glaser, B.G. (1978). *Theoretical sensitivity: Advances in the methodology of grounded theory*. Mill Valley, CA: The Sociology Press.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Grant, R.M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Gupta, A.K., & Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal, 21*, 473-496.

Hamel, G. (1991). Competition for competence and inter-partner learning within international strategic alliances. *Strategic Management Journal, 12*(Summer), 83-103.

Hansen, M.T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly, 44*, 82-111.

Hansen, M.T. (2002). Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Organization Science, 13*(3), 232-248.

Hedberg, B. (1981). How organizations learn and unlearn. In P. C. Nystrom & W. H. Starbuck (Eds.), *Handbook of organizational design* (Vol. 1, pp. 8-27). New York: Oxford University Press.

Huber, G.P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Keen, P.G.W., & Scott Morton, M.S. (1978). *Decision support systems: An organizational perspective*. Reading, MA..

Kim, D.H. (1993). The Link between individual and organizational learning. *Sloan Management Review, 35*(1), 37-50.

Kostova, T. (1999). Transnational transfer of strategic organizational practices: A contextual perspective. *Academy of Management Review, 24*(2), 308-324.

Kuhn, A., & Beam, R.D. (1982). *The logic of organization*. San Francisco: Jossey-Bass Inc.

Lane, P.J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*, 461-477.

Leckie, G.J., Pettigrew, K.E., & Sylvain, C. (1996). Modeling the information seeking of professionals: A general model derived from research on engineers, health care professionals and lawyers. *Library Quarterly, 66*, 161-193.

Lee, G.K., & Cole, R.E. (2003). From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organization Science, 14*(6), 633-649.

Leifer, R., & Huber, G.P. (1977). Relations among perceived environmental uncertainty, organization structure, and boundary-spanning behavior. *Administrative Science Quarterly, 22*(2), 235-247.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Levitt, B., & March, J.G. (1988). Organizational learning. *Annual Review of Sociology, 14*, 319-340.

Liebeskind, J.P. (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal, 17*(Winter), 93-107.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*(1), 71-87.

March, J.G., & Simon, H.A. (1958). *Organizations.* New York: John Wiley.

Marchionini, G. (1995). *Information seeking in electronic environments.* Cambridge, MA: Cambridge University Press.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Markus, M.L., Majchrzak, A., & Gasser, L. (2002). A design theory for systems that support emergent knowledge processes. *MIS Quarterly, 26*(3), 179-212.

McEvily, S.K., Das, S., & McCabe, K. (2000). Avoiding competence substitution through knowledge sharing. *Academy of Management Review, 25*(2), 294-311.

Mintzberg, H. (1979). *The structuring of organizations: A synthesis of the research*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Mowery, D.C., Oxley, J.E., & Silverman, B.S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal, 17*(Winter), 77-91.

Nelson, R.R., & Winter, S.G. (1982). *An evolutionary theory of economic change*. Cambridge, MA; London: The Belknap Press of Harvard University Press.

Newell, S., & Swan, J. (2000). Trust and interorganizational networking. *Human Relations, 53*(10), 1287-1328.

Okhuysen, G.A., & Eisenhardt, K.M. (2002). Integrating knowledge in groups: How formal interventions enable flexibility. *Organization Science, 13*(4), 370-386.

Ranft, A.L., & Lord, M.D. (2002). Acquiring new technologies and capabilities: A grounded model of acquisition implementation. *Organization Science, 13*(4), 420-441.

Rosenkopf, L., & Nerkar, A. (2001). Beyond local search: Boundary-spanning, exploration, and impact in the optical disk industry. *Strategic Management Journal, 22*, 287-306.

Schumpeter, J.A. (1934). *The theory of economic development.* Cambridge, MA: Harvard University Press.

Schwartz, D.G., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D.G. Schwartz, M. Divitini & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management.* Hershey, PA: IGP.

Shenkar, O., & Li, J. (1999). Knowledge search in international cooperative ventures. *Organization Science, 10*(2), 134-143.

Simon, H.A. (1997). *Administrative behavior: A study of decision-making processes in administrative organizations* (4th Ed.). New York: The Free Press.

Stein, E.W. (1995). Organizational memory: Review of concepts and recommendations for management. *International Journal of Information Management, 15*(1), 17-32.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*(Winter), 27-43.

Szulanski, G. (2000). The process of knowledge transfer: A diachronic analysis of stickiness. *Organizational Behavior and Human Decision Processes, 82*(1), 9-27.

Taylor, R.S. (1968). Question-negotiation and information seeking in libraries. *College and Research Libraries, 29*, 178-194.

Teece, D.J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review, 40*(3), 55-79.

Tsang, E.W. (2002). Acquiring knowledge by foreign partners from international joint ventures in a transition economy: Learning-by-doing and learning myopia. *Strategic Management Journal, 23*, 835-854.

Tushman, M.L. (1977). Special boundary roles in the innovation process. *Administrative Science Quarterly, 22*(4), 587-605.

Van der Aalst, W.M.P., Ter Hofstede, A.H.M., Kiepuszewski, B., & Barros, A.P. (2003). Workflow patterns. *Distributed and Parallel Databases, 14*(1), 5-51.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Weick, K.E. (1979). *The social psychology of organizing* (2nd ed.). Reading, MA: Addison-Wesley Publishing Company.

Weick, K.E., & Roberts, K.H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(3), 357-381.

Wijnhoven, F. (1999). *Managing dynamic organizational memories: Instruments for knowledge management*. Enschede: Twente University Press.

Wilson, T.D. (1999). Models in information behaviour research. *The Journal of Documentation*, *55*(3), 249-270.

Zahra, S.A., & George, G. (2002). Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review, 27*(2), 185-203.

Zander, U., & Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organization Science, 6*(1), 76-92.

Chapter 1.24
Understanding Innovation Processes

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INTRODUCTION

Knowledge integration is a process whereby several individuals share and combine their information to collectively create new knowledge (Okhuysen & Eisenhardt, 2002). Here we are interested in knowledge integration in the context of innovation project teams tasked with developing a new product or organizational practice. Knowledge integration is crucial in relation to innovation, since innovation depends on the generation of new ideas (new knowledge) that leads to the development of new products or organizational practices. Knowledge integration, rather than simply knowledge per se, is important for innovation because it is not simply the possession of new knowledge that will create success in terms of improved practice or new products, but rather, the ability to integrate knowledge across groups and organizations (Gibbons et al., 1994). This is especially the case in relation to radical innovation, which depends on involvement of an increasingly dispersed range of professional groups and organizations (Powell, Koput, & Smith-Doerr, 1996). For example, in the medical domain there are an increasing number of breakthroughs in scientific and technical knowledge that could drastically change medical practice. Achieving such breakthroughs, however, does not necessarily result in performance improvements in medical practice. Major pharmaceutical companies take, on average, 11 years and a minimum of one-third of $1 billion to bring a drug to market, and over 90% of development processes fail (CMR International, 2000). Similarly, in relation to major transformational IT innovation projects in organizations, many do not just fall short of meeting cost, functionality, and scheduling targets, but actually fail outright (Johnson, 1995).

While there are many reasons for such failure, one important reason relates to the problem of integrating knowledge, because breakthroughs leading to radical innovation are highly disruptive (Christensen, Bohmer, & Kenagy, 2000) and potentially “competency destroying” (Henderson, Orsenigo, & Pisano, 1999). For example, the development of the new drug or the new IT system will often cut across established institutionalized domains and structures for the production of knowledge, and therefore require radical shifts in relationships among professional and functional groups. New developments made possible by breakthroughs in science may not align well, for example, with existing professional regimes and medical practices (Christensen et al., 2000).

In this article then, we consider the issue of knowledge integration in the context of innovation projects and relate it to social capital, since understanding the process of knowledge integration involves exploring the "micro-social interactions among individuals" (Okhuysen & Eisenhardt, 2002). It is helpful to explore these micro-social interactions through the lens of social capital since social capital refers to the social networks and the assets that can be mobilized through these networks that enable social action generally and knowledge sharing more specifically (Nahapiet & Ghoshal, 1998). In other words, given that the development of new products and practices typically involves teams of people from different backgrounds (i.e., multi-disciplinary project teams) working together, exploring how individual team members share and combine their respective knowledge in order to generate new ideas to support innovation is important. Specifically, we will consider how different approaches to creating and using social capital leads to different levels of knowledge integration, which in turn influence the innovation achieved, which can be either incremental or radical.

BACKGROUND

The Concept of Knowledge Integration

To reiterate, in this article we are interested in how a project team, tasked with developing a new product or practice, shares and combines the information of the different team members and of other stakeholders who have relevant information in order to create new knowledge that supports innovation. While the Okhuysen and Eisenhardt definition (above) suggests that knowledge integration is a simple process, the reality is that sharing and combining information is often very difficult. This is because knowledge is dispersed (Tsoukas, 1996) and ambiguous (Dougherty, 1992), as well as being potentially competency destroying (Henderson et al., 1999) in the sense that new products or practices may make obsolete the knowledge of particular groups who may then resist involvement in the knowledge integration process and so limit progress.

Teams will differ in terms of what they achieve in relation to knowledge integration. To simplify this we can identify two extremes in the way that knowledge can be taken to be integrated in the context of a project team tasked with developing a new product or service—"mechanistic pooling" (Knights & Wilmott, 1997) versus "generative" (Cook & Brown, 1999) knowledge integration. Mechanistic pooling occurs when each project member works independently on a set of clearly defined tasks or processes with which he/she is familiar and uses his/her existing knowledge to consider the potential of the new scientific/technological breakthrough on the particular problem domain, be this a new drug to help treat cancer or a new IT system to support information integration within an organization. In such circumstances, the new drug or IT system is perceived as simply fitting independent pieces together, like a jigsaw puzzle. This mechanistic pooling of knowledge is likely to result in a new product or service that may have higher performance than current products or services, in which case it may replace what currently exists. However, the innovation is likely to be incremental and is unlikely to lead to any radical change in practice, because radical change is likely to require a more generative and interactive approach to knowledge integration (Newell, Huang, & Tansley, 2004).

Generative knowledge integration occurs when there is joint knowledge production achieved through the combination and exchange of knowledge (Nahapiet & Ghoshal, 1998) and experimentation (Rosenberg, 1982) between individuals from diverse backgrounds (Grant, 1996; Hitt, Nixon, Hoskisson, & Kochhar, 1999). Through this exchange and experimentation, new and novel ways of doing things are identified that could not have been predetermined by the independent parts (Cook & Brown, 1999). In other words, generative knowledge integration occurs when communication and exchange within a group or a team evokes novel associations, connections, and hunches such that new meanings and insights are generated. In this case, knowledge integration involves a process of social construction in which organizational members negotiate, achieve, and refine a shared understanding through interaction, sense-making, and collective learning (Ayas & Zeniuk, 2001; Boland & Tenkasi, 1995). It is this process that provides the basis for creativity, and it is precisely such creative, generative knowledge integration that is much more likely to lead to radical change—for example, radical changes in medicine that many declare is possible with new scientific/technological breakthroughs.

As indicated, exploring knowledge integration processes involves understanding the network relationships and social interactions within and across communities that support this activity (Okhuysen & Eisenhardt, 2002; Grant, 1996). Grant (1996) points out that there is a dearth of empirical research exploring these networking processes supporting knowledge integration. In the next section we consider how these micro-social processes are viewed through the lens of social capital.

The Concept of Social Capital

Effective knowledge integration during an innovation project depends on selecting project team members with an appropriate mix of knowledge, skills, and expertise (Teram, 1999). This will include both organizational and technical/scientific knowledge. This intellectual capital of the team comprises both human and social capital. The human capital of the team refers to the "knowledge and knowing capability of the collectivity" (Nahapiet & Ghoshal, 1998). While important, it is unlikely that team members will have all the relevant knowledge and expertise necessary. Thus, the development of a new drug or a new IT system requires the integration of an extremely broad base of knowledge, but the number of individuals that can be directly involved in the project is necessarily small because of communication and resource constraints (Grant, 1996). So the project team will need to network with others. In doing this they will be drawing upon their collective social capital. Social capital is derived from the network of relationships that connect people together and refers to the "goodwill that is engendered by the fabric of social relations and that can be mobilized to facilitate action" (Adler & Kwon, 2002, p. 17), here to access and integrate knowledge needed for innovation. Social capital would, therefore, appear to be highly relevant in understanding these processes of knowledge integration.

The concept of social capital has become very popular in Management literature, based on the recognition that social networks are useful in a variety of contexts (Coleman, 1988) and can influence a wide range of outcomes (Burt, 1997). Here, we are interested in the ways in which social capital influences knowledge integration during innovation projects. We focus on the antecedent conditions for social capital in such projects (Adler & Kwon, 2002). Thus, networks will vary in their quality and configuration. For example, networks will differ in terms of the extent to which actors' contacts are also connected (Coleman, 1988). They will also differ in the content of the network ties (Uzzi, 1996, 1999), for example the extent to which the connected actors share common knowledge (Nonaka, 1994) and/or beliefs and norms (Portes, 1998). This will influence the development of social relationships and influence the strength of the ties (Granovetter, 1973). As individuals interact with each other, social relationships are built, and goodwill develops (Dore, 1983). This can be drawn upon to gain benefits at some later point in time. While the terms of exchange are not clearly specified, there is a tacit understanding that a 'favor' will be repaid at some time and in some way. This repayment (the outcome of social capital) may be in the form of information, influence, and/or solidarity (Sandefur & Laumann, 1998).

While the concept of social capital is widely used, Adler and Kwon (2002) highlight one central distinction in the way the concept is defined, contrasting the "bridging" from the "bonding" view of social capital. The "bridging" view is focused externally, seeing social capital as a resource inhering in a social network that can be appropriated by a focal actor, based on relations with others in the network (Burt, 1997). Individuals who provide a "bridge" across divided communities are important, since they play a brokerage role. For example, Burt (1997) identifies how there are structural gaps within any given network—individuals and groups who are relatively disconnected from each other. He suggests that people who bridge across these gaps are particularly important to ensure that individuals and groups are not isolated from the larger network. The "bonding" view, by contrast, focuses on the collective relations between a defined group (Coleman, 1988). Social capital relates to the internal structure and relations within this collective. It ensures an internal cohesiveness that allows the collective to pursue shared goals. The source and effects of social capital are, therefore, viewed differently, depending on whether the focus is on bonding or bridging.

Adler and Kwon (2002) note that some definitions of social capital do not distinguish whether the focus is internal (bonding) or external (bridging). They argue that this is preferable because, in practice, both bridging and bonding will influence behavior in all situations, and because bridging and bonding are essentially interchangeable depending upon the unit of analysis considered. They argue against "bifurcating our social capital research into a strand focused on external, bridging social capital and a strand focused on internal, bonding, social capital" (Adler & Kwon, 2002, p. 35). They develop a definition of social capital that does indeed include both internal and external ties. Thus, social capital is "the goodwill available to individuals or groups. Its source lies in the structure and content of the actor's social relations. Its effects flow from the information, influence, and solidarity it makes available to the actor" (Adler & Kwon, 2002, p. 23).

However, given that in this article we are considering the project team as the unit of analysis, we can differentiate between internal bonding within the project team itself, as members collaborate and share and combine knowledge, and external bridging, as team members seek out or are provided with knowledge and information from others outside the project team. Thus, while we agree that in practice both forms of social capital are involved simultaneously in any social activity system and, therefore, adopt Adler and Kwon's definition, we argue that, in relation to innovation projects, it is helpful to maintain the distinction (Newell et al., 2004). This is because while project teams engage in both external bridging and internal bonding activities, they differ in how they undertake these two activities and this influences the way they approach knowledge integration. This article, then, explores how social capital, considered in terms of the bridging and bonding components, is an antecedent to knowledge integration within innovation project teams.

In summary, it is argued that knowledge integration is a key issue during an innovation project. The level of knowledge integration achieved will influence the extent to which the innovation is incremental and simply reinforces the status quo (mechanistic pooling) or is radical, with the potential to create transformational change in a product or a practice (generative knowledge integration). The level of knowledge integration actually achieved depends upon how social capital is used by the project team tasked with designing and implementing the new product or service.

MAIN FOCUS: THE LINK BETWEEN SOCIAL CAPITAL AND KNOWLEDGE INTEGRATION

Table 1 presents a summary of the suggested link between social capital and knowledge integration.

Starting with generative knowledge integration, it is argued that this is necessary for radical innovation, and requires the establishment of strong bonds within the team plus access to diverse stakeholders beyond the team (through bridging relationships). First, developing strong bonds within a project team appears to be critical to facilitate generative knowledge integration. Encouraging the development of strong ties (Granovetter, 1973) increases the closeness and reciprocity between project members who develop strong common or "consummatory" norms (Portes, 1998). Moreover, building a project team where members participate because they are interested in and knowledgeable about the project helps to ensure some 'knowledge redundancy' (Nonaka, 1994)—that is, overlapping knowledge within the team. The development of strong links, common understanding, and norms of trust and reciprocity (i.e., the structural, cognitive, and relational aspects of social capital; Nahapiet & Ghoshal, 1998) leads to high levels of cooperation (Gulati, 1998) that facilitates knowledge sharing and creativity. Team building to enhance the bonding aspect of social capital within the project team is, therefore, crucial for generative knowledge integration. The effect of this bonding is that it allows the team to subsequently share and integrate the dispersed knowledge that they gather during their bridging activities.

In relation to this bridging activity, as already discussed, a project team is unlikely to have all the knowledge necessary for developing the new product or service so that bridging activity with a wider stakeholder community is also important (Coleman, 1988). The ties between the project team members and the wider stakeholder community are likely to be much looser or weaker (Granovetter, 1973) than those ties developed within the project team itself. This is necessary since it will not be possible to develop the dense network, based on a strong sense of common purpose, across so many people. Thus, the network will be open and loose, with others getting involved with the project team for instrumental reasons—to ensure that they had some influence on the new product or service. Such weak ties are sufficient for such information access (Hansen, 1999, 2002). The effect of encouraging this wider involvement is that

Table 1. The link between social capital and knowledge integration

	Social Capital	
Knowledge Integration	**Bonding**	**Bridging**
Generative knowledge integration	Establishment of trust and redundant knowledge allows team to synergistically share and integrate unique knowledge and expertise	Involvement of multiple stakeholders with diverse and conflicting views—resolving conflicts and evaluating different views provides source of new ideas
Mechanistic pooling	Each team member works independently to design his or her part of the new product or service based on existing knowledge and expertise	Minimal involvement of stakeholders, thus restricting access to different views

the team will have access to broader knowledge from across the stakeholder community, which will mean that different perspectives will be surfaced. These differences will need to be discussed in order to develop new products or practices that people will buy-in to. Radical innovation, based on generative knowledge integration, depends on cultivating extensive social networking between the project team and other stakeholders, in order to foster opportunities for the transformation of a product or a practice.

To achieve mechanistic pooling of knowledge, adequate for more incremental innovation, is simpler so that bonding within the team can be weaker and bridging to other stakeholders more limited. This is because incremental innovation does not depend on breakthrough knowledge but rather builds on existing knowledge. For incremental innovation, team members can work independently of each other, and knowledge sharing can be limited because the interfaces between the knowledge domains are already established. Moreover, there is less need to bridge extensively to a diversity of stakeholders because there is no need to identify new knowledge trajectories that may be relevant, nor will stakeholders be required to radically change their existing practices. They do not, therefore, need to be involved in the innovation project in order to ensure that their commitment is built. This mechanistic approach to knowledge integration is therefore more economical and facilitates the introduction of a new product or practice more quickly with limited disruptive change, albeit the new product or practice only improves what currently exists.

The point of making this distinction is that there are some contexts in which a mechanistic approach to knowledge integration to support innovation is likely to be more effective, while there are other contexts in which a more generative approach will be more beneficial. For example, mechanistic pooling will be most efficient where a new product or practice, for example a new medical treatment or a new IT system, simply replaces an existing product or practice. Similarly, mechanistic pooling will be more efficient where there is little need for interaction across professional or functional domains in developing the new product or practice. On the other hand, generative knowledge integration will be necessary where the development of the new product or practice depends upon interactions between professional groups who have not worked together previously or where the innovation results in radical changes to a product or a practice so that the buy-in of stakeholders requires cultivation. In other words, a contingency approach is suggested, which specifies that for incremental innovation, where a mechanistic approach is appropriate, social networking both within the project team and between the project team and the wider stakeholder community can be minimized. Under conditions where a generative approach to knowledge integration is necessary, team bonding and bridging will need to be more intensive and extensive because of the need to engage in the "generative dance" (Cook & Brown, 1999) of sharing and integrating knowledge that underpins innovation processes that lead to radical changes in products or practices.

FUTURE TRENDS

It is likely that radical innovation, requiring a lot of interactivity across professional and disciplinary groups, will become more important as competition intensifies in most industries (Gibbons et al., 1994). This suggests that the need for generative knowledge integration will increase in the future. Below we consider the implications of this for the management and organization of project teams tasked with creating radical new products and practices. More specifically we consider a number of aspects of a project team that will be differentially affected depending upon whether the focus is radical or incremental innovation. It is likely that the aspects that foster radical innovation through generative knowledge integration will become more important:

1. Team Building: Where generative knowledge integration is necessary to foster radical innovation, it will be important to nurture a strong and cohesive project team through, for example, team-building exercises. Where mechanistic pooling is sufficient, there is less need for such team building.
2. Division of Tasks: Where mechanistic pooling is adequate, tasks can be divided up into independent activities that are assigned to different people, since as Becker (2001) identifies, one strategy for dealing with the dispersion of knowledge is to decompose organizational units into smaller ones so that each unit (in this case each individual) is responsible for one part of the larger problem. As Becker notes, this strategy of specialization reduces the opaqueness of complex problems. Where the resulting 'pieces' of work can be put together easily because interfaces between the 'pieces' are pre-established, this is very efficient. For generative knowledge integration, however, this is problematic because these interfaces are not pre-established, since different groups are involved, which have not previously worked together. In this case, tasks are more effectively divided up so that there is considerable overlap and inter-dependency built in.
3. Allocation of Tasks: Where the mechanistic pooling of knowledge is sufficient, it is most efficient to allocate only specialists to tasks. However, where generative knowledge integration is required, the allocation of specialists may not be appropriate because these specialists are likely to have preconceived ideas about how activities should be completed and so will not think about alternative processes that could be supported by the new scientific/technological breakthroughs. As Meacham (1983) states:

   Each new domain of knowledge appears simple from the distance of ignorance. The more we learn about a particular domain, the greater the number of uncertainties, doubts, questions, and complexities. Each bit of knowledge serves as the thesis from which additional questions or antithesis arise. (p. 120)

   The point is that specialists may not get past their "distance of ignorance" because they believe that they already have the solution. Involving non-expert individuals may therefore help in generative knowledge integration because such individuals are more likely to ask the questions that could identify the complexities of the situation and the alternative opportunities afforded by the breakthroughs.
4. Knowledge Redundancy: Generative knowledge integration also requires significant common understanding within the project team where mechanistic pooling does not require this to the same extent because, as already indicated, the interfaces between the different parts of the project are already well established. Bruner (1983) described creativity as "figuring out how to use what you already know in order to go beyond what you currently think" (p. 183). This implies that an important impetus to creativity is knowledge about the issue you are dealing with. So, while existing knowledge can be a barrier to creative thinking, it is also the case that without knowledge there can be no creativity. Without this effort to understand broader issues across different disciplines, individuals will rely on their existing knowledge and so a more mechanistic orientation to knowledge integration is likely to result.

In the future it will be increasingly important for those involved in radical innovation projects to have a broad inter-disciplinary understanding.

5. Stakeholder Involvement: Another important issue relates to the extent of bridging activity. Limiting bridging activity means that the diversity of opinion that exists across the wider stakeholder community will not be voiced. This may be efficient in contexts where incremental innovation is the goal. Yet, as Leonard-Barton (1995) reminds us, bringing together individuals with different views and backgrounds can lead to "creative abrasion" that results in new and innovative approaches being considered. Creative abrasion is necessary to achieve generative knowledge integration. User involvement is likely to be especially important in this respect. Involving users can help to encourage commitment to the project. Additionally, users can be a source of creativity if they are given the opportunity to voice their ideas about alternative processes and practices. Discussion with users may lead to conflicting suggestions, as expected in such novel situations; nevertheless they can also provide a significant source of ideas.

CONCLUSION

In conclusion, there are significant differences in the knowledge integration challenge of a project team that is tasked with developing a radical innovation compared to a team tasked with some kind of incremental innovation. These differences in the knowledge integration challenge have implications for the way the team will need to create and use its social capital. It is suggested that where the focus is on radical innovation, it is important for project teams to develop strong internal ties and develop a sense of a shared purpose to foster generative knowledge integration. The focus is thus on team bonding and the development of a closed network. This allows team members to develop some common or redundant knowledge that is crucial for generative knowledge integration. This team building creates a sense of shared destiny and understanding among the project members, which leads to a normative commitment to the project. However, where the focus is on more incremental innovation, knowledge integration within the team can be more mechanistic. The social capital bonding requirements for the team are then much simpler because within the team, bonds do not need to be as strong since individuals can work more independently.

For generative knowledge integration, once the core project team has developed a shared sense of purpose—a "collective mind" (Weick & Roberts, 1993)—they can begin to bring in ideas and information from individuals across the wider network of stakeholders who will be affected by the innovation. In doing this they are using their bridging social capital to gather information needed for the project. External parties provide the needed information because they can see an instrumental return in doing this. The provision of this information gives the project team an understanding of the likely sources of resistance to the change in practice and so can begin the process of building user commitment to the change. The network focus is on bridging activity, and it is helpful if the network structure is more open to facilitate wider information flow. However, for more incremental innovation projects, the project team can work in a more isolated way from potential users and other stakeholders, with a more restricted network, since there is less need to capture the diversity of views and ideas. Working in this way, the project team will probably be unchallenged by creative abrasion, but this is efficient where the goal is incremental innovation.

Where project teams work towards a common goal in a very mechanistic way, the extent of transformational change that they can anticipate from the new product or practice they develop is likely to be limited. But there are situations in which this is highly appropriate. Where project teams work more collaboratively, this will encourage interaction and the sharing of knowledge more synergistically and creatively so that they are more likely to be able to generate products and practices that can encourage more transformational change. Which approach to knowledge integration is appropriate will depend on the unique circumstances of each innovation project.

REFERENCES

Adler, P., & Kwon, S.-W. (2002) Social capital: Prospects for a new concept. *Academy of Management Review, 27*(1), 17-40.

Ayas, K., & Zeniuk, N. (2001). Project-based learning: Building communities of reflective practitioners. *Management Learning, 32*(1), 61-76.

Becker, M. (2001). Managing dispersed knowledge: Organizational problems, managerial strategies and their effectiveness. *Journal of Management Studies, 38*(7), 1037-1051.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Burt, R. (1997). The contingent value of social capital. *Administrative Science Quarterly, 42*, 339-365.

Bruner, J. (1983). *In search of mind*. New York: Harper.

Christensen, C., Bohmer, R., & Kenagy, J. (2000). Will disruptive innovations cure health care? *Harvard Business Review,* (September/October), 102-112.

CMR International. (2000). *R&D Briefing*, (26).

Coleman, J. (1988). Social capital in the creation of human capital. *American Journal of Sociology, 94,* S95-S120.

Cook, S.D.N., & Brown, J.S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 190,* 381-400.

Dore, R. (1983). Goodwill and the spirit of market capitalism. *British Journal of Sociology, 34*, 459-482.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization Science, 3,* 179-202

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. London: Sage Publications.

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology, 78,* 1360-1380.

Grant, R. (1996). Prospering in dynamically competitive environment: Organizational capability as knowledge integration. *Organization Science, 7,* 375-387.

Gulati, R. (1998). Alliances and networks. *Strategic Management Journal, 19*(April), 293-317.

Hansen, M. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits. *Administrative Science Quarterly, 44,* 82-111.

Hansen, M. (2002). Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Organization Science, 13*(3), 232-248.

Henderson, R., Orsenigo, L., & Pisano, G. (1999). The pharmaceutical industry and the revolution in molecular biology: Interactions among scientific, institutional, and organizational change.

In D. Mowery & R. Nelson (Eds.), *Sources of industrial leadership* (pp. 267-311). Cambridge, MA: Cambridge University Press.

Hitt, M., Nixon, R., Hoskisson, R., & Kochhar, R. (1999). Corporate entrepreneurship and cross-functional fertilization: Activation, process and disintegration of a new product design team. *Entrepreneurship Theory and Practice, 24,* 145-167.

Johnson, J. (1995). Chaos: The dollar drain of IT project failures. *Application Development Trends*, (January), 41-47.

Knights, D., & Wilmott, H. (1997). The hype and hope of interdisciplinary management studies. *British Journal of Management, 8*(9), 9-22.

Leonard Barton, D. (1995). *The wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Meacham, J. (1983). Wisdom and the context of knowledge. In D. Kuhn & J. Meacham (Eds.), *Contributions in human development* (vol. 8, pp. 111-134). Basel: Karger.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*, 242-266.

Newell, S., Huang, J., & Tansley, C. (2004). Social capital and knowledge integration in an ERP project team: The importance of bridging AND bonding. *British Journal of Management, 15,* 43-57.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5,* 14-37.

Okhuysen, G., & Eisenhardt, K. (2002). Integrating knowledge in groups: How formal interventions enable flexibility. *Organization Science, 13*(4), 370-386.

Portes, A. (1998). Social capital: Its origins and applications in modern sociology. *Annual Review of Sociology, 24,* 1-24.

Powell, W., Koput, W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116-130.

Rosenberg, N. (1982). *Inside the black box*. Cambridge, MA: Cambridge University Press.

Sandefur, R., & Laumann, E. (1998). A paradigm for social capital. *Rationality and Society, 10,* 481-501.

Teram, E. (1999). A case against making the control of clients a negotiable contingency for interdisciplinary teams. *Human Relations, 52,* 263-278.

Tsoukas, H. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal, 17,* 11-25.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review, 61*, 674-698.

Uzzi, B. (1999). Embeddedness in the making of financial capital: How social relations and networks benefit firms seeking finance. *American Sociological Review, 64*(4), 481-505.

Weick, K., & Roberts, K. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*(3), 357-282.

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Chapter 1.25
Knowledge Management System Success Factors

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INTRODUCTION

What does it take to build a successful knowledge management system (KMS)? Knowing the essential success factors is useful as it provides researchers and practitioners with the basic requirements for building a successful KMS. Also, if we take a Churchman (1979) view of systems, it can be argued that determining KMS success factors will also help us determine KM initiative success factors as Churchman found it difficult to separate the system from the process requiring the system. However, what is KM or KMS success? The literature does not provide a consensus on this, although two concepts of success can be identified. The first considers KM or KMS a success if knowledge use through the initiative or system improves the organization's ability to compete. The second considers KM or KMS a success if the KM processes implemented through the KMS (discussed later) are implemented effectively. Both success concepts imply that the KMS has to be used. Therefore, KM and KMS success factors are those factors that encourage or help users to use the KMS to effectively perform KM functions.

What is a KMS? Alavi and Leidner (2001, p. 114) define KMSs as "IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application." They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT system that supports the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, access, search, and application. Stein and Zwass (1995) define an organizational memory information system (OMIS) as the processes and IT components necessary to capture, store, and bring to bear knowledge created in the past on decisions currently being made. Jennex and Olfman (2004) expanded this definition by incorporating the OMIS into the KMS and adding strategy and service components to the KMS.

This article uses a literature review to identify these success factors. Studies looking at KM, KMS, OM, and OMS or OMIS were reviewed and the success factors extracted. KM studies were included as a Churchman (1979) view of a KMS can be defined to include the KM initiative driving the implementation of a KMS (also, the same logic can be applied for including OM with OMS studies). OM and OMS studies are included with KM and KMS as Jennex and Olfman (2002) found that KM and OM are essentially the same with the difference being the players. End users tend to use KM where KM is concerned with the identification and capture of key knowledge. Information systems personnel tend to be concerned with OM where OM is the storage, search, retrieval, manipulation, and presentation of knowledge. KMS and OMS are the systems built to support KM and OM, and are essentially systems designed to manage organizational knowledge.

The literature review identified many KMS success factors that are summarized below. To make sense of these factors, they were analyzed for key words and concepts and combined into generic success factors. Definitions for the generic success factors were generated by combining and simplifying the concepts included in the base success factors. The generic success factors are also presented and discussed. The generic success factors were ranked based on the number of articles the base success factors appeared in. The article concludes with a ranked list of KMS success factors.

KMS SUCCESS FACTORS

A successful KMS should perform well the functions of knowledge creation, storage and retrieval, transfer, and application. However, other factors can influence KMS success. Mandviwalla, Eulgem, Mould, and Rao (1998) summarized the state of the research and described several strategy issues affecting the design of a KMS. These include the focus of the KMS (who are the users), the quantity of knowledge to be captured and in what formats, who filters what is captured, and what reliance and/or limitations are placed on the use of individual memories. Additional technical issues affecting KMS design include knowledge storage and repository considerations, how information and knowledge is organized so that it can be searched and linked to appropriate events and use, and processes for integrating the various repositories and for reintegrating information and knowledge extracted from specific events. Some management issues include how long the knowledge is useful, access locations as users rarely access the KMS from a single location (leads to network needs and security concerns), and the work activities and processes that utilize the KMS.

Ackerman (1994) studied six organizations that had implemented his Answer Garden system. Answer Garden is a system designed to grow organizational memory in the context of help-desk situations. Only one organization had a successful implementation because expectations of the capabilities of the system exceeded the actual capabilities. Ackerman and Mandel (1996) found that a smaller task-based system was more effective on the suborganization level because of its narrower expectations. They refer to this narrower system as "memory in the small."

Jennex and Olfman (2000) studied three KM projects to identify design recommendations for building a successful KMS. These recommendations include the following:

- Develop a good technical infrastructure by using a common network structure, adding KM skills to the technology support skill set, using high-end PCs (personal computers),

integrating databases, and standardizing hardware and software across the organization.
- Incorporate the KMS into everyday processes and IS by automating knowledge capture.
- Have an enterprise-wide knowledge structure.
- Have senior management support.
- Allocate maintenance resources for the OMS.
- Train users on the use and content of the OMS.
- Create and implement a KM strategy or process for identifying and maintaining the knowledge base.
- Expand system models and life cycles to include the KMS, and assess system and process changes for impact on the KMS.
- Design security into the KMS.
- Build motivation and commitment by incorporating KMS usage into personnel evaluation processes, implementing KMS use and satisfaction metrics, and identifying organizational culture concerns that could inhibit KMS usage.

Additionally, Jennex and Olfman (2002) performed a longitudinal study of KM on one of these organizations and found that new members of an organization do not use the computerized KMS due to a lack of context for understanding the knowledge and the KMS. They found that these users needed pointers to knowledge more than codified knowledge.

Jennex, Olfman, and Addo (2003) investigated the need for having an organizational KM strategy to ensure that knowledge benefits gained from projects are captured for use in the organization by surveying year 2000 (Y2K) project leaders. They found that benefits from Y2K projects were not being captured because the parent organizations did not have a KM strategy or process. Their conclusion was that KM in projects can exist and can assist projects in utilizing knowledge during the project.

Davenport, DeLong, and Beers (1998) studied 31 projects in 24 companies. Eighteen projects were determined to be successful, five were considered failures, and eight were too new to be rated. Eight factors were identified that were common in successful KM projects. These factors are as follow:

- Senior management support.
- Clearly communicated KMS purposes and goals.
- Linkages to economic performance.
- Multiple channels for knowledge transfer.
- Motivational incentives for KM users.
- A knowledge-friendly culture.
- A solid technical and organizational infrastructure.
- A standard, flexible knowledge structure.

Malhotra and Galletta (2003) identified the critical importance of user commitment and motivation through a survey study of users of a KMS being implemented in a healthcare organization. They found that using incentives did not guarantee a successful KMS. They created an instrument for measuring user commitment and motivation that is similar to Thompson, Higgins, and Howell's (1991) perceived-benefit model, but is based on the self-determination theory that uses the perceived locus of causality.

Ginsberg and Kambil (1999) explored issues in the design and implementation of an effective KMS by building a KMS based on issues identified in the literature and then experimentally implementing the KMS in a field setting. They found knowledge representation, storage, search, retrieval, visualization, and quality control to be key technical issues, and incentives to share and use knowledge to be the key organizational issues.

Alavi and Leidner (1999) surveyed executive participants in an executive development program with respect to what was needed for a successful KMS. They found organizational and cultural issues associated with user motivation to share and use knowledge to be the most significant. They also found it important to measure the benefits of the KMS and to have an integrated and integrative technology architecture that supports database, communication, and search and retrieval functions.

Holsapple and Joshi (2000) investigated factors that influenced the management of knowledge in organizations through the use of a Delphi panel consisting of 31 recognized KM researchers and practitioners. They found leadership and top management commitment and support to be crucial. Resource influences such as having sufficient financial support, a high skill level of employees, and identified knowledge sources are also important.

Koskinen (2001) investigated tacit knowledge as a promoter of success in technology firms by studying 10 small technology firms. Key to the success of a KMS was the ability to identify, capture, and transfer critical tacit knowledge. A significant finding was that new members take a long time to learn critical tacit knowledge, and a good KMS facilitates the transference of this tacit knowledge to new members.

Barna (2003) studied six KM projects with various levels of success (three were successful, two failed, and one was an initial failure turned into a success) and identified two groups of factors important to a successful KMS. The main managerial success factor is creating and promoting a culture of knowledge sharing within the organization by articulating a corporate KM vision, rewarding employees for knowledge sharing, creating communities of practice, and creating a best-practices repository. Other managerial success factors include obtaining senior management support, creating a learning organization, providing KMS training, and precisely defining KMS project objectives.

Design and construction success factors include approaching the problem as an organizational problem and not a technical one; creating a standard knowledge submission process; having methodologies and processes for the codification, documentation, and storage of knowledge; and having processes for capturing and converting individual tacit knowledge into organizational knowledge. Also, organizations should create relevant and easily accessible knowledge-sharing databases and knowledge maps.

Cross and Baird (2000) propose that KM would not improve business performance simply by using technology to capture and share the lessons of experience. It was postulated that for KM to improve business performance, it had to increase organizational learning through the creation of organizational memory. To investigate this, 22 projects were examined. The conclusion was that improving organizational learning improved the likelihood of KM success. Factors that improved organizational learning include the following:

- Supporting personal relationships between experts and knowledge users.
- Providing incentives to motivate users to learn from experience and to use the KMS.
- Providing distributed databases to store knowledge and pointers to knowledge.
- Providing work processes for users to convert personal experience into organizational learning.
- Providing direction to what knowledge the organization needs to capture and learn from.

Sage and Rouse (1999) reflected on the history of innovation and technology and identified the following issues:

- Modeling processes to identify knowledge needs and sources.

- A KMS strategy for the identification of knowledge to capture and use, and of who will use it.
- Incentives and motivation to use the KMS.
- An infrastructure for capturing, searching, retrieving, and displaying knowledge.
- An understood enterprise knowledge structure
- Clear goals for the KMS.
- The measurement and evaluation of the effectiveness of the KMS.

Yu, Kim, and Kim (2004) explored the linkage of organizational culture to knowledge manage-

Table 1. KMS success factor summary

ID	Success Factor	Source
SF1	An integrated technical infrastructure including networks, databases/repositories, computers, software, KMS experts	Alavi and Leidner (1999), Barna (2002), Cross and Baird (2000), Davenport et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Mandviwalla et al. (1998), Sage and Rouse (1999), Yu et al. (2004)
SF2	A knowledge strategy that identifies users, user experience-level needs, sources, processes, storage strategies, knowledge, and links to knowledge for the KMS	Barna (2002), Ginsberg and Kambil (1999), Holsapple and Joshi (2000), Jennex et al. (2003), Koskinen (2001), Mandviwalla et al. (1998), Sage and Rouse (1999), Yu et al. (2004)
SF3	A common enterprise-wide knowledge structure that is clearly articulated and easily understood	Barna (2002), Cross and Baird (2000), Davenport et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Mandviwalla et al. (1998), Sage and Rouse (1999)
SF4	Motivation and commitment of users including incentives and training	Alavi and Leidner (1999), Barna (2002), Cross and Baird (2000), Davenport et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Malhotra and Galletta (2003), Yu et al. (2004)
SF5	An organizational culture that supports learning and the sharing and use of knowledge	Alavi and Leidner (1999), Barna (2002), Davenport et al. (1998), Jennex and Olfman (2000), Sage and Rouse (1999), Yu et al. (2004)
SF6	Senior management support including the allocation of resources, leadership, and providing training	Barna (2002), Davenport et al. (1998), Holsapple and Joshi (2000), Jennex and Olfman (2000), Yu et al. (2004)
SF7	Measures established to assess the impacts of the KMS and the use of knowledge, as well as to verify that the right knowledge is being captured	Alavi and Leidner (1999), Davenport et al. (1998), Jennex and Olfman (2000), Sage and Rouse (1999)
SF8	A clear goal and purpose for the KMS	Ackerman (1994), Barna (2002), Cross and Baird (2000), Davenport et al. (1998)
SF9	A learning organization	Barna (2002), Cross and Baird (2000), Sage and Rouse (1999), Yu et al. (2004)
SF10	Easy knowledge use supported by the search, retrieval, and visualization functions of the KMS	Alavi and Leidner (1999), Ginsberg and Kambil (1999), Mandviwalla et al. (1998)
SF11	Work processes designed to incorporate knowledge capture and use	Barna (2002), Cross and Baird (2000), Jennex and Olfman (2000)
SF12	The security/protection of knowledge	Jennex and Olfman (2000), Sage and Rouse (1999)

ment success. They found that KM drivers such as a learning culture, knowledge-sharing intention, KMS quality, rewards, and KM team activities significantly affected KM performance. These conclusions were reached through a survey of 66 Korean firms.

DISCUSSION

These studies provide several success factors. To summarize them, they have been reviewed and paraphrased into a set of ranked success factors where the ranking is based on the number of sources citing them. Table 1 lists the final set of success factors in their rank order. Additionally, success factors SF1 through SF4 are considered the key success factors as they were mentioned by at least half of the success factor studies.

FUTURE RESEARCH TRENDS

Many of the above KMS success factors were identified through qualitative research with their importance established through bibliographical analysis. Future research needs to consolidate these factors into a single KMS success-factor model. To be useful, the generated KMS success model needs to be quantitatively validated against a variety of organizations. This will improve the validity and general application of the model.

CONCLUSION

Many studies have been performed that have identified KM success factors. The summary of Table 1 is a useful summary of success factors and their importance, and is useful for researchers and practitioners. However, more research into KM and KMS success is needed. The success factors presented in this article were generated from a literature survey. The studies used for this literature survey utilized a variety of methods including surveys, case studies, Delphi studies, and experimentation. A total of 78 projects or organizations were investigated using case studies, and approximately 100 organizations were surveyed. Overall, in addition to the case studies mentioned, four surveys were administered and one Delphi study and experiment were performed. However, this is not sufficient research to definitively state that all KM success factors have been identified and their importance determined. Only a few of the sources were able to conduct any kind of statistical analysis or hypothesis testing, leaving a qualitative analysis basis for most of these success factors. This leaves an opportunity for researchers.

REFERENCES

Ackerman, M. (1994). Definitional and contextual issues in organizational and group memories. *Proceedings of the 27th Annual Hawaii International Conference on System Sciences* (pp. 191-200).

Ackerman, M., & Mandel, E. (1996). Memory in the small: An application to provide task-based organizational memory for a scientific community. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences* (pp. 323-332).

Alavi, M., & Leidner, D. E. (1999). Knowledge management systems: Emerging views and practices from the field. *Proceedings of the 32nd Hawaii International Conference on System Sciences.*

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Barna, Z. (2003). *Knowledge management: A critical e-business strategic factor.* Unpublished master's thesis, San Diego State University, San Diego.

Churchman, C. W. (1979). *The systems approach* (Rev. ed.). New York: Dell Publishing.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 41-54.

Davenport, T. H., DeLong, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Ginsberg, M., & Kambil, A. (1999). Annotate: A Web-based knowledge management support system for document collections. *Proceedings of the 32nd Hawaii International Conference on System Sciences.*

Holsapple, C. W., & Joshi, K. D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information Systems, 9,* 235-261.

Jennex, M. E., & Olfman, L. (2000). Development recommendations for knowledge management/ organizational memory systems. *Proceedings of the Information Systems Development Conference 2000.*

Jennex, M. E., Olfman, L., & Addo, T. B. A. (2003). The need for an organizational knowledge management strategy. *Proceedings of the 36th Hawaii International Conference on System Sciences, HICSS36.*

Jennex, M. E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. *Proceedings of the 35th Hawaii International Conference on System Sciences, HICSS35.*

Koskinen, K. U. (2001). Tacit knowledge as a promoter of success in technology firms. *Proceedings of the 34th Hawaii International Conference on System Sciences.*

Malhotra, Y., & Galletta, D. (2003). Role of commitment and motivation as antecedents of knowledge management systems implementation. *Proceedings of the 36th Hawaii International Conference on System Sciences.*

Mandviwalla, M., Eulgem, S., Mould, C., & Rao, S. V. (1998). *Organizational memory systems design*. Unpublished working paper for the Task Force on Organizational Memory presented at the 31st Annual Hawaii International Conference on System Sciences.

Sage, A. P., & Rouse, W. B. (1999). Information systems frontiers in knowledge management. *Information Systems Frontiers, 1*(3), 205-219.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Yu, S.-H., Kim, Y.-G., & Kim, M.-Y. (2004). Linking organizational knowledge management drivers to knowledge management performance: An exploratory study. *Proceedings of the 37th Hawaii International Conference on System Sciences, HICSS36.*

Chapter 1.26
Knowledge Management Systems Acceptance

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INTRODUCTION

Knowledge management is a set of systematic actions that organizations can take to obtain the greatest value from the knowledge available to it (Davenport & Prusak, 1998). Systematic means that knowledge management is made up of intentional actions in an organizational context. Value means that knowledge management is measured according to how knowledge management projects contribute to increased organizational ability (see for example Prieto & Gutiérrez, 2001; see Goldkuhl & Braf, 2002, on the subject of organizational ability). The motivation for knowledge management is that the key to competitive advantage for organizations in today's business world is organizations' ability to manage knowledge (Nonaka & Takeuchi, 1995; Davenport & Prusak, 1998). Knowledge management as an intentional and value-adding action is not easy to accomplish in practice (Scarbrough & Swan, 1999). Scarbrough and Swan (1999) present several case studies in knowledge management, successful and unsuccessful in their respective knowledge management projects. A major point and lessons learned from the case studies is that prevalent approaches in knowledge management overstate technology and understate how technology is implemented and applied.

To succeed with knowledge management, encompassing development of information technology-based information system, some requirements have to be fulfilled. An important aspect in the development process is system acceptance. Implementation is at large a process of acceptance. Implementation is the process where the system becomes an integrated part of the users' or workers' work practice. Therefore implementation is essential to make a knowledge management project successful in order attain an increased organizational ability and to succeed with knowledge management.

ISSUES OF KNOWLEDGE MANAGEMENT—SYSTEMS AND ACCEPTANCE

In this section we provide broad definitions and discussion of the topics to support our positions on the topics of knowledge management and systems acceptance.

Managing Knowledge

Work in knowledge management has a tendency to omit social or technological aspects by taking on one of two perspectives on knowledge management, the anthropocentric or the technocratic view (Sveiby, 2001; Swan, 1999). The anthropocentric and the technocratic views represent two contradictory views on knowledge management and can be summarized as technology can or technology cannot. The gap between the anthropocentric and technocratic view depends on a difference of opinions concerning the notion of knowledge. The technocratic view conceives knowledge to be some organized collection of data and information, and the anthropocentric view conceives knowledge to reside in humans, not in the collection (Churchman, 1971; Meredith & Burstein, 2000). Our conception of knowledge is that of the anthropocentric view. Taking on an anthropocentric view on knowledge management does not mean that we discard knowledge management technologies; we rather take on a balanced view on the subject. Information technology can support knowledge management in an organization through a number of different technological components, for example intranets, extranets, data warehouses, and database management systems (Borghoff & Pareschi, 1998; Tiwana, 2000; Ericsson & Avdic, 2002). The point in taking on an anthropocentric view of knowledge management is not to lose sight of the knower who gives meaning to the information and data found in IT-based knowledge management systems.

Knowledge Management Systems

Information systems can include either operative or directive and decision support information (Langefors, 1966; Yourdon, 1989). Operative systems provide system users with information necessary in workers' daily work, while directive and decision support systems provide system users with information that improves the quality of decisions workers make in daily work. Knowledge managements systems are systems developed to manage knowledge directly or indirectly to give support for an improved quality of a decision made in workers daily work, and as an extension, an increased organizational ability. A knowledge management system typically includes directive information, for example in guiding a user's choice in a specific work situation. Such systems are often optional in the sense that users can deliberately refrain from using the system and/or refrain from taking the directed action. Accordingly, user acceptance is crucial for the degree of usage of knowledge management systems.

Acceptance of Technological Systems

Technology acceptance has been subject of research by, for example, Davis, Bagozzi, and Warshav (1989), who developed the well-known Technology Acceptance Model (TAM) and later a revised version of the original model, TAM2 (Venkatesh & Davis, 2000). TAM is an explanative model explaining user behavior of computer technologies by focusing on perceived ease of use, perceived usefulness, attitude towards use, and behavioral intentions as determinants of user behavior. TAM2 is an extension of the original model including external factors related to perceived usefulness.

The framework for system acceptance, Requirements of Acceptance Model (RAM) have some resemblances with TAM and the later TAM2.

RAM is in comparison with TAM descriptive in nature. Workers' work practice is treated as an integrated element of RAM, compared with not being treated as a determinant of system use in the original TAM and as an external factor in TAM2. Further, RAM covers acceptance of knowledge management systems, and TAM/TAM2 cover a broad range of computer technologies. RAM systematically acknowledges factors important in implementation of knowledge management systems to gain acceptance of such systems.

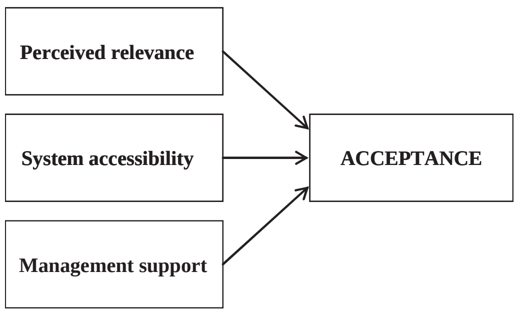
REQUIREMENTS OF THE ACCEPTANCE MODEL

We perceive acceptance to be a function of perceived relevance, systems accessibility, and management support. Together these elements constitute our framework RAM. In this section we present the requirements of acceptance in RAM. The Requirements of Acceptance Model is illustrated in Figure 1.

Perceived Relevance

The workers, who are to use the system, must perceive the knowledge management system as relevant. Since it is possible for workers to work without using the system, it has to be obvious

Figure 1. Requirements of Acceptance Model (Ericsson & Avdic, 2003)



that usage of the system implies adding value to the work result. An additional aspect of relevance related to perceived relevance is how the system should be integrated in running work, that is, to make the system an integrated part of the workers' work practice.

In summary, perceived relevance is about workers, who are to use the system, perceiving the system as (Ericsson & Avdic, 2003)

- adding value to the work results; and
- being integrated in running work.

Accessibility

To obtain acceptance of knowledge management systems, accessibility has to be satisfactory. It must be accessible to the workers who are to use the system. Accessibility is a question of who is to be the user (type of workers concerning organizational position), what action and work the system is to support (daily work, product development, innovation, etc.), where users get access to the system (the physical access), when the system is ready to use, and how the system's interface fulfills the goal of the system.

In summary, systems accessibility is about (Ericsson & Avdic, 2003):

- knowing who the user is;
- systematizing the actions workers perform in the work practice the system is to support;
- deciding the system's physical access;
- securing a certain degree of usage before the system is put into operation; and
- ensuring the system's design meets the goals of the system.

Management Support

Management support is vital according to many models on information systems development, especially when the system is a directive/decision support system (Yourdon, 1989). Knowledge management systems are typically directive systems, and workers have a choice in deciding whether to use the system or not. Management support is important to stress the value for workers to use the system and to make conditions for workers to do so.

Development is a Process of Acceptance

There must be a fit between workers' work practice and technology to get acceptance of knowledge management systems. The technology used to create a knowledge management system must fit the actions workers perform in their work practice. On an overall level there must be a fit between technology and actions performed by individual workers, and between individual workers and the organization as a whole, thus forming a coherent whole. It is in the development of knowledge management systems that the requirements of acceptance are fulfilled. A common conception concerning information systems development is that it constitutes analysis, design, construction, and implementation of information systems (Hirschheim, Klein & Lyytinen, 1996).

The groundwork for acceptance is made during the design, but foremost when implementing the system. Workers who are to use the system should be engaged at an early stage of the development process. The point of including workers at an early stage is to acquaint users with the system and the purpose of the system. Further, this is an opportunity for workers to influence the system's design and content. The most prominent aspect addressed when involving workers at an early stage is that of choosing and determining the meaning of crucial concepts managed by the system. Crucial concepts managed by the system are the knowledge represented in the system, and by determining concepts, knowledge represented in the system takes on a systematized character. Further, by involving the workers in the process of choosing and determining the meaning of crucial concepts managed by the system, the knowledge represented in the system does not lose its origin or meaning. The point is to keep the knowledge represented in the system within a frame of understanding or meaning, as perceived by workers. A knowledge management systems should be seen as a tool developed to support workers in learning and acquiring knowledge about actions taking place at work. This requires closeness between how concepts are perceived by workers and how such concepts are represented in a system.

FUTURE TRENDS

Research on technology acceptance (i.e., Davis et al., 1989; Venkatesh & Davis, 2000) has focused on user behavior of computer technologies. RAM is developed for and is used to assess acceptance of knowledge management systems. Acceptance has not been a crucial issue within the knowledge management area. A problem with knowledge management systems is that they work in theory, but seldom in practice (Wickramasinghe, 2003). A contributing factor to that picture may very well be that of having overlooked usage-related problems connected to knowledge management systems. In that sense, knowledge management systems acceptance can be expected to be an area for further research in the future.

CONCLUSION

Acceptance of knowledge management systems is a function of perceived relevance, systems accessibility, and management support. Together these elements constitute our framework RAM. RAM is summarized in Table 1.

The Requirements of Acceptance Model point towards several important aspects concerning relevance, accessibility, and support. The groundwork for system acceptance is the development process. Development is very much a process of

Table 1. Summary of RAM (Ericsson & Avdic, 2003)

Perceived relevance—Workers, who are to use the system, have to perceive the system as:

- Adding value to work results
- Being integrated in running work

Systems accessibility—System accessibility is about:

- Knowing who the user is
- Systematizing actions workers perform in the work practice the system is to support
- Deciding the physical location where users get physical access to the system
- Securing usage of the system before it is put into operation
- The systems' design must meet up to the goals of the system

Management support—Fundamental because management authorizes development of systems

acceptance as a process of developing the system itself. Through requirements of acceptance, knowledge management systems can remain and continue to be a contributing factor for the organization's ability to do business.

REFERENCES

Borghoff, U.M. & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management.* Berlin, Heidelberg: Springer-Verlag.

Churchman, C.W. (1971). *The design of enquiring systems: Basic concepts of systems and organization.* New York: Basic Books.

Davenport, T. & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School.

Davis, F.F., Bagozzi, R.P. & Warshaw, P.R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Ericsson, F. & Avdic, A. (2002). Information technology and knowledge acquisition in manufacturing companies: A Scandinavian perspective. In E. Coakes, D. Willis & S. Clarke (Eds.), *knowledge management in the socio-technical world. The grafitti continues.* London: Springer-Verlag.

Ericsson, F. & Avdic, A. (2003). Knowledge management systems acceptance. In E. Coakes (Ed.), *Knowledge management: Current issues & challenges* (pp. 39-51). Hershey, PA: Idea Group Publishing.

Goldkuhl, G. & Braf, E. (2002). Organisational ability: Constituents and congruencies. In E. Coakes, D. Willis & S. Clarke (Eds.), *Knowledge management in the socio-technical world. The grafitti continues* (pp. 30-42). London: Springer-Verlag.

Hirschheim, R., Klein, H.K. & Lyytinen, K. (1996). Exploring the intellectual structures of information systems development: A social action theoretic analysis. *Accounting, Management & Information Technology, 6*(1/2), 1-64.

Langefors, B. (1966). *Theoretical analysis of information systems.* Lund: Studentlitteratur.

Meredith, R. & Burstein, F. (2000). Getting the message across with communicative knowledge management. *Proceedings of the Australian Conference on Knowledge Management and Intelligent Decision Support (ACKMID'2000)* (pp. 43-55). Melbourne: Australian Scholarly Publishers.

Nonaka, I. & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Prieto, I.M. & Gutiérrez, E.R. (2001). A contingency perspective of learning and knowledge management in organizations. In D. Remenyi (Ed.), *Proceedings of the 2nd European Conference on Knowledge Management* (pp. 487-502). Slovenia: Bled School of Management.

Scarbrough, J. & Swan, J. (Eds.). (1999). *Case studies in knowledge management.* London: Institute of Personnel and Development.

Sveiby, K.-E. (2001, April). *What is knowledge management?* Retrieved June 28, 2002, from www.sveiby.com.au.

Swan, J. (1999). Introduction. In J. Scarbrough & J. Swan (Eds.), *Case studies in knowledge management.* London: Institute of Personnel and Development.

Tiwana, A. (2000). *The knowledge management toolkit. Practical techniques for building a knowledge management system*. Upper Saddle River, NJ: Prentice-Hall.

Venkatesh, V. & Davis, F.D. (2000). A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science, 46*, 86-204.

Yordon, E. (1989). *Modern structured analysis.* Englewood Cliffs, NJ: Prentice-Hall.

Wickramasinghe, N. (2003). Do we practice what we preach? Are knowledge management systems in practice truly reflective of knowledge management systems in theory? *Business Process Management Journal*, *9*(3), 295-316.

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Chapter 1.27
Knowledge Synthesis Framework

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INTRODUCTION

The last decade of the 20th century saw explosive growth in discussions about knowledge—knowledge work, knowledge management, knowledge-based organizations, and the knowledge economy (Cortada & Woods, 2000). At the center of such discussions are the two notions of process and knowledge. The former represents not only the organization's operations characterized by clearly defined inputs, outputs, and flows, but also management practices which give the organization its depth and means for handling change and turbulence. The latter is represented by a range of complexity and intellectual richness, from Plato's "justified true belief" (Nonaka & Takeuchi, 1995) to a more mundane "the capacity to act" (Sveiby, 1997). How knowledge is characterized, used, and even created within an organization is a very complicated process. Nevertheless, we believe that each member of an organization has his or her own knowledge space, which is subject to some level of description, and thus may be architected, integrated, and designed into an organization (Davenport & Prusak, 1998; Levine, 2001). As the source of wealth shifts from capital to knowledge (Drucker, 1992), it is clear that organizations that actively seek to create their own communal knowledge space from that, which exists among its members, will have a decided advantage over those who do not. One working definition of knowledge is hereby interpreted in terms of its potential for action and its ability to change context and goals—the rules of relevance and adaptation. Yet, what is the means by which a communal knowledge space may be built? And how would an organization use it for advantage? To answer these questions, this article is divided into five sections: The Background of Knowledge Synthesis; Pursuing the Ideal of a Learning Organization; Scaffolding the Knowledge Framework; Future Trends of IS Design for Knowledge Sharing; and Conclusion.

The first provides the foundations on understanding the knowledge phenomenon as it is happening in many an organization today. The second serves as a digest in capturing some basic ideas of the learning organization. The third brings forth our conception of an actionable framework of knowledge synthesis, applicable to the Internet-based development of present-day organizations. The fourth discusses some of the challenges in information systems (IS) design for knowledge work. The fifth concludes the article by reiterating the challenges in doing organizational knowledge synthesis.

The theme of this article is to investigate strategies to enhance knowledge sharing through the idea of a learning organization. Its aim is to conceive appropriate design of IS support so as to expand an organization's capacity to adapt to future challenges.

THE BACKGROUND OF KNOWLEDGE SYNTHESIS

To situate our discussions about knowledge work in an organization, we first resort to the classification scheme of knowledge tasks from Charles Perrow (1970) on the basis of their analyzability (the degree to which search activity is needed to solve a problem) and variability (the number of exceptions—new or unexpected—encountered while performing a task). There are four task subtypes: craft, routine, engineering, and non-routine. Routine tasks are characterized by the combination of low variability and high analyzability. Namely, few exceptions are encountered in the work process, and when an exception does occur, little search behavior is required to handle it. Craft tasks are characterized by the combination of low variability and low analyzability. This means only a narrow range of exceptions being encountered, but a high level of search activity is needed to find a solution to problems. Engineering tasks are characterized by the combination of high variability and high analyzability. Namely, the number or variety of exceptions that workers may encounter in the task is high, but finding a solution is relatively easy because well-understood standard procedures should have been established to handle the exceptions. Finally, non-routine tasks are characterized by the combination of high variability and low analyzability. It is the most complex and least routine of the four tasks in Perrow's classification. These tasks are complex because not only is the number of unexpected situations large, but search activity is high: Each new situation creates a need to expend resources to deal with it. A key goal of management is to analyze and refine what have been craft and non-routine tasks, and transform them into routine and engineering tasks. They constantly seek to reduce the ambiguity and uncertainty by routinizing work and the business rules governing that work. Nonetheless, organizational tasks are increasingly being craft and non-routine. Such knowledge work is not easily subject to process explicitness (clearly defined specifications). As tasks become more unanalyzable (i.e., craft, non-routine), the level of ambiguity increases and requires people with relatively more experience and tacit knowledge, and a certain level of rich information. Similarly, as tasks become more variable (i.e., engineering and non-routine), the level of uncertainty increases thereby requiring people with more training, formal education, explicit knowledge, and high quantities of information. Obviously, such is the backdrop behind which many an enterprise today has been developing their contexts for organizational knowledge synthesis.

In order to develop a communal knowledge space—one that develops new forms of knowledge from that which exists among its members—we must describe how and with what an organization performs its work, say, in terms of its core capabilities (i.e., strategic processes) and core competencies (i.e., knowledge areas applied to capabilities) (Stalk, Evans, & Shulman, 1992). Oftentimes the alignment context is expressed in terms of the dynamics of the people-process-system issue. Namely, we need to design suitable information systems to help people with knowledge to perform the processes involved to produce results of value to the organization. In fact, Zuboff (1988) has written extensively on the interaction of people and information technology (IT), and the all-important shift in management thinking from automating to informating. In practice, automating typically refers to the use of IT during process change to substitute the deployment of humans. Automating serves to lower uncertainty and increase management control. Informating, in contrast, refers to the effect IT may have on the understanding and transparency of a process. Informating makes people more productive through their use of and process integration with IT. It serves to increase the capacity of people to understand the entire value-adding business process. Thus, informating concerns itself with the connection people have with their specific tasks as well as the whole flow of work. Certainly, the notion of knowledge must be incorporated. While informating concerns IT and task integration, the idea of knowledging (Savage, 1996) refers to individual and organizational learning, and is characterized by the process of knowledge creation and the active involvement of the individual with his or her work. Knowledging includes a dynamic interaction between the known (explicit) and the vision (tacit) forms of knowledge. In fact, each context from automating to informating to knowledging may be thought of as a stage, a progression requiring additional alignment threads and trade-off. In particular, the trade-off between individualism and community may impact the movement from informating to knowledging. Individualism drives individual knowledge and rewards, and thus encourages informating, while a community emphasizes sharing and is more closely associated with knowledging, including the interaction of computers, people, lateral relations, business processes, and organizational learning (including knowledge creation). Thereby, in order to create a communal knowledge space for the organization, each successive organizational transformation, from automating to informating to knowledging, requires higher levels of process abstraction and a broad range of process integration and alignment threads.

PURSUING THE IDEAL OF A LEARNING ORGANIZATION

Nowadays, enterprises including educational institutes are challenged to do things faster, better, and more cost effectively in order to remain competitive in an increasingly global economy. There is a strong need to share knowledge in a way that makes it easier for individuals, teams, and enterprises to work together to effectively contribute to an organization's success. This idea of knowledge sharing has well been exemplified in the notion of a learning organization (LO) (Garvin, 1993; King, 1996; Levine, 2001; Senge, 1990; Vat, 2001). Basically, a learning organization could be considered as an organization that focuses on developing and using its information and knowledge capabilities in order to create higher-value information and knowledge, to modify behaviors to reflect new knowledge and insights, and to improve bottom-line results. Based on this characterization of LO, there are many possible IS instances that could be incorporated into a learning organization. The acronym "LOIS" (Learning Organization Information System) (Vat, 2003; Williamson & Lliopoulos, 2001) as applied to an organization is often used as a collective term representing the conglomeration of various information systems, each of which, being a functionally defined subsystem of the enterprise LOIS, is distinguished through the services it renders. For example, if a LOIS could support structured and unstructured dialogue and negotiation among the organizational members, then the LOIS subsystems might need to support reflection and creative synthesis of information and knowledge, and thus integrate working and learning. They should also help document information and knowledge as it builds up, say, by electronic journals. Or, they have to make recorded information and knowledge retrievable, and individuals with information and knowledge accessible. Collectively, a LOIS can be considered as a scheme to improve the organization's chances for success and survival by continuously adapting to the external environment. Consequently, we stand a better chance of increasing social participation and shared understanding within the enterprise, and thus foster better learning. Although we believe that this positioning of LOIS represents a significant vision of a future generation of information systems, there are serious questions to be addressed in connection with knowledge capture and transformation, as well as intellectual asset management within the enterprise. All these have consequences for organization transformation in such areas as strategies, structures, processes, systems, and people. More importantly, the philosophy underlying the LOIS design should recognize that our knowledge is the amassed thought and experience of innumerable minds, and the LOIS helps capture and reuse those experiences and insights in the enterprise. The notion that emerges strongly resembles the classical history paradigm of learning from past events, necessitating the collection of data and repeated re-interpretation of its meaning, significance, and impact for next generations. That is also the idea of organizational learning (Senge et al., 1994), supported by an organizational memory (Conklin, 1996)—the means by which knowledge from the past is continuously brought to bear on present activities. It should possibly result in higher or lower levels of organizational effectiveness (Stein, 1992) in terms of the decision making, organizing, leading, designing, controlling, communicating, planning, and motivating functions of the management process. The cultivation of a communal knowledge space based on the organizational memory is fundamental to enterprises that intend to establish, grow, and nurture a digital learning organization (Hackbarth & Groven, 1999), where individuals grow intellectually and expand their knowledge by unlearning inaccurate information and relearning new information. Oftentimes, there is the essential difference between doing it the way we always did it (single-loop learning) and arriving at an innovative solution that establishes new patterns and relationships (double-loop learning) (Argyris, 1992; Senge et al., 1994).

SCAFFOLDING THE KNOWLEDGE FRAMEWORK

In order to create the communal knowledge space for the entire organization, an organization needs a vision that orients the entire organization to the kind of knowledge it must acquire, and wins spontaneous commitment by the individuals and groups involved in knowledge creation (Dierkes, Marz, & Teele, 2001; Stopford, 2001). It is top management's role to articulate this knowledge vision and communicate it throughout the organization. A knowledge vision should define what kind of knowledge the organization should create in what domains. It helps determine how an organization and its knowledge base will evolve in the long run (Leonard-Barton, 1995; Nonaka & Takeuchi, 1995). On the other hand, the central requirement for organizational knowledge synthesis is to provide the organization with a strategic ability to acquire, create, exploit, and accumulate new knowledge continuously and repeatedly in a circular process. To meet this requirement, we need an actionable framework, which could facilitate the installation of this strategic ability. It is believed that there are at least three major elements constituting the knowledge framework of a learning organization, including the knowledge architecture, the knowledge synthesis process, and the technical knowledge infrastructure. The first, being a component of the overall organizational architecture, is responsible for generating an ever-growing body of organizational knowledge. The second provides the formal methodology for collecting, integrating, and disseminating knowledge. The third, increasingly being virtualized over the Internet in every organization, should allow every individual to gain access to knowledge wherever and whenever it is needed.

The Knowledge Architecture

Following the idea of a learning organization, we suggest the creation of a number of architectural components in the knowledge architecture (Vat, 2001, 2003), which are intended to facilitate learning, and the creation, acquisition, plus distribution of knowledge among organizational members.

- The IL-component: The individual learning (IL) (Kim, 1993) component serves to provide training and education for individuals through the institution of workshops, apprenticeship programs, and the establishment of informal mentoring programs. Typically, an IL component provides free use of the organization's IS infrastructure to access unstructured material in order to pursue an explicit educational path, and to access structured learning material purposely designed for online self-learning. The organization that adopts the IL component in pursuit of a learning organization is betting on its people; namely, enhanced individual learning will translate into improved organizational behaviors and performance.
- The OL-component: The organizational learning (OL) (Grant, 1996; Probst & Buchel, 1997) component focuses on the use of a communities of practice approach, leading to the formation of collaborative groups composed of professionals who share experience, knowledge, and best practices for the purposes of collective growth. The conceptual basis is that group-based organizational competencies and capacities can be developed, refined, and enhanced to enable the organization to adapt to changing circumstances and demands, through such ideas as teamwork, empowerment, case management, or development-centered career paths.
- The IPM-component: This component deals with the issue of intellectual property management (IPM) (Stewart, 1997; Sveiby, 1997; Wiig, 1997) underlying the activities that are involved in leveraging existing codified knowledge assets in the form of patents, brands, copyrights, research reports, and other explicit intellectual properties of the organization. The organization that pursues the IPM component in support of a learning organization may devise a financial incentive that allows individuals and groups to be rewarded for the creation and leveraging of intellectual properties.
- The KM-component: The knowledge management (KM) (O'Leary, 1998) component focuses on the acquisition, explication, and communication of mission-specific professional expertise that is largely tacit in nature to organizational participants in a manner that is focused, relevant, and timely (Grant, 1996; King 1999; van der Spek & De Hoog, 1995; Wiig, 1993). The conceptual basis is that an organization's tacit knowledge can, in part, be made explicit, and leveraged through the operation of KM-related processes and systems developed for knowledge sharing.

The Knowledge Synthesis Process

Knowledge synthesis is a social as well as an individual process. Sharing tacit knowledge requires individuals to share their personal beliefs about a situation with others. At that point of sharing, justification becomes public. Each individual is faced with the tremendous challenge of justifying his or her beliefs in front of others—and it is this need for justification, explanation, persuasion, and human connection that makes knowledge synthesis a highly fragile process. To bring personal knowledge into a social context, within which it can be amplified or further synthesized, it is necessary to have a field that provides a place in which individual perspectives are articulated and conflicts are resolved in the formation of higher-level concepts. In a typical organization, the field for interaction is often provided in the form of an autonomous, self-directed work team, made up of members from different functional units. It is a critical matter for an organization to decide when and how to establish such a team of interaction in which individuals can meet and interact. This team triggers organization knowledge synthesis through several steps. First, it facilitates the building of mutual trust among members, and accelerates creation of an implicit perspective shared by members as tacit knowledge. Second, the shared implicit perspective is conceptualized through continuous dialogue among members. Tacit field-specific perspectives are converted into explicit concepts that can be shared beyond the boundary of the team. It is a process in which one builds concepts in cooperation with others. It provides the opportunity for one's hypothesis or assumption to be tested. As Markova and Foppa (1990) argue, social intercourse is one of the most powerful media for verifying one's own ideas.

Next comes the step of justification, which determines the extent to which the knowledge created within the team is truly worthwhile for the organization. Typically, an individual justifies the truthfulness of his or her beliefs based on observations of the situation; these observations, in turn, depend on a unique viewpoint, personal sensibility, and individual experience. Accordingly, when someone creates knowledge, he or she makes sense out of a new situation by holding justified beliefs and committing to them. Indeed, the creation of knowledge is not simply a compilation of facts, but a uniquely human process that cannot be reduced or easily replicated. It can involve feelings and belief systems of which we may not even be conscious. Nevertheless, justification must involve the evaluation standards for judging truthfulness. There might also be value premises that transcend factual or pragmatic considerations. Finally, we arrive at the stage of cross-leveling knowledge (Nonaka, Toyama, & Konno, 2002). During this stage, the concept that has been created and justified is integrated into the knowledge base of the organization, which comprises a whole network of organizational knowledge.

The Knowledge Infrastructure

The knowledge infrastructure supporting the idea of a learning organization is based on a simple philosophy; namely, various knowledge services, in support of a specific LOIS context (say, the creation of a communal knowledge space), must be interpreted as the essential means to realize the particular synthesis processes for organizational knowledge transfer. And such services could be made available to their users in the form of different distributed Web-based applications, which are each designed and tested incrementally and iteratively according to the purposeful activities of the organizational scenarios. The challenge is how to design the infrastructure to enable spontaneous knowledge capture and transfer so as to turn the scattered, diverse knowledge of individual knowledge workers into well-structured knowledge assets ready for reuse in the organization (De Hoog, Benus, Vogler, & Metselaar, 1996). Accordingly, adoption of a three-tiered configuration—composed of respectively the front-end KM services (KMS), the middle-layer KM architecture (KMA), and the back-end organizational memory (OM)—is suggested (Vat, 2000, 2002).

- The knowledge management services (KMSs): The design of front-end KM services is an attempt to recognize the human assets within the minds of individuals, and to leverage them as organizational assets that can be accessed and used by a broader set of individuals on whose decisions the organization depends. According to Nonaka and Takeuchi (1995), organizational knowledge can be created through the interactions between tacit and explicit knowledge based on the SECI (socialization, externalization, combination, and internalization) process. Consequently, our KM services can be devised based on these four modes of interactions. The 'knowledge socialization' process usually occurs in the form of informal communication when someone raises a question for discussion or an issue that requires a response. The 'knowledge internalization' process occurs when we are actively searching for methods or lessons learned to solve problems at hand. We internalize knowledge by doing, and also by observing what other people have done in a similar context and by example. The 'knowledge externalization' process is aimed at structuring knowledge and making it available to other users. It involves concept mapping, tacit knowledge categorization, and representation. The 'knowledge combination' process involves various knowledge sharing and decision coordination.

- The knowledge management architecture (KMA): The KMA acts as the middle layer supporting the front-end KMS through the back-end OM. Its logical requirements are to satisfy the KM concerns to create, retain, share, and leverage knowledge from the personal level to the team level, the organizational level, and even the inter-organizational level. Its development is conceived from two architectural perspectives: the business architecture and the technology architecture. The former involves the development of management solutions that are related to modeling the business functionality of the organization—namely, business strategies, processes, and structures that enhance and facilitate organization-wide knowledge leveraging. The latter involves the development of information and communications technology (ICT) components within an intranet-based knowledge medium to translate the organization's business vision into effective electronic applications that support the intra- and inter-organizational KM services.
- The organizational memory (OM): The KM processes involved in organizational learning often require iterations of references and modification of the components developed in the business and the technology architectures of the KMA. This requirement implies the importance of a reusable asset repository for storing various business-specific and technology-related components in the form of tacit and explicit knowledge items. The OM could be designed to fulfill this specific requirement. For example, it could be structured into the business repository and the technology repository. Typically the business repository stores knowledge items we can use to standardize definitions of organizational and process models. And we can archive existing process components, which can then be recalled later by coworkers in other departments to be reused or modified for new process models. Similarly, the technology repository stores technology resources such as 'business objects', pre-built and purchased components, developer documentation, and numerous other technology standards.

FUTURE TRENDS OF IS DESIGN FOR KNOWLEDGE SHARING

According to Checkland and Holwell (1995), the main role of an information system is that of a support function. The IS function is to support people taking purposeful action by indicating that the purposeful action can itself be expressed via some activity models, which are called the "human activity systems" (HAS) models from the perspective of soft systems methodology—SSM

(Checkland & Scholes, 1990). The job of providing IS support can then be thought about as entailing a pair of systems, one a system which is served (the people taking the action), and the other a system which does the serving. Thereby, whenever a system serves or supports another, it is a very basic principle of SSM (Checkland, 1983) that the necessary features of the serving system can be worked out only on the basis of a prior account of the system served. This is because the nature of the system served—the way it is thought about—will dictate what counts as service, and hence what functions the system which provides that service must contain (Checkland, 1981, p. 237). Thus, an IS strategy concerning support to an organization, such as a LOIS, can be coherently designed and set up only on the basis of a clear concept of the knowledge sharing context. This is true not only for the IS strategy of the learning organization as a whole, but also for the thinking concerning each detailed system created within that strategy. Consequently, the process of IS development needs to start not with attention quickly focused on data and technology, but with a focus on the actions served by the intended organizational system. Once the actions to be supported have been determined and described (using various HAS-based activity models), we can proceed to decide what kind of support should be provided, say: automating action which is currently being carried out by people; or informating people (providing information support to people) (Zuboff, 1988); or knowledging teams of people (facilitating their social and mental exchange) (Savage, 1996) as they carry out their tasks. In each case, we need to determine what will help people take the desired action, and what will help to monitor the action and make adjustments if desired outcomes are not emerging. Often the monitoring and control needs to be thought about carefully in terms of some declared measures of performance, which should derive from how the purposeful activity is conceptualized. The key point is that in order to create the necessary IS support that serves the intended organizational scenario, it is first necessary to conceptualize the organizational system that is to be served, since this order of thinking should inform what relevant services would indeed be needed in the IS support.

CONCLUSION

This article describes an initiative to develop an actionable framework for knowledge synthesis, paying particular attention to the design issues in support of participatory knowledge construction, in the context of organization transformation in today's prevailing knowledge economy. Our discussion intends to clarify the ideal of a learning organization (LO) which is designed to help transfer learning from individuals to a group, provide for organizational renewal, keep an open attitude to the outside world, and support a commitment to knowledge. In particular, we have elaborated the design issues of the LOIS support that help structure and facilitate knowledge interconnectivity, in terms of a three-tiered technical knowledge infrastructure comprising the front-end knowledge management services, the mid-layer of knowledge management architecture, and the back-end organizational memory. To realize the LOIS support, it is also necessary to examine the underlying processes in which, in a specific organizational context, a particular group of people can conceptualize their world and hence the purposeful action they wish to undertake. We need to understand why, among these people, certain data are selected and treated as relevant items in order to get the best possible definitions of accepted purposes and the intentional action that follows from pursuing them. The examination of meanings and purposes, in support of designing the necessary IS functions, should be broadly based, and its richness will be greater the larger the number of people who take part in it. Nevertheless, the examination should try to home in on the question: If we want to pursue this purpose, which seems meaningful to us, what would we have to do and how could we do it? Remembering the many possible relationships that have to be managed, we have to acknowledge the rarity of complete consensus among different people. What are sought are often the accommodations, which enable some meaningful work to be sustained in undertaking actions relevant to plausible purposes. This consequently provides the basis for ascertaining the organization's communal knowledge space: namely, what IS support is truly needed by those undertaking their actions, and how modern IT can help to provide that support.

REFERENCES

Argyris, C. (1992). *On organizational learning.* Cambridge, MA: Blackwell Business.

Checkland, P. (1981). *Systems thinking, systems practice*. Chichester: John Wiley & Sons.

Checkland, P. (1983). Information systems and systems thinking: Time to unite? *International Journal of Information Management, 8*, 230-248.

Checkland, P., & Holwell, S. (1995). Information systems: What's the big idea? *Systemist, 17*(1), 7-13.

Checkland, P., & Scholes, J. (1990). *Soft systems methodology in action*. Chichester, UK: John Wiley & Sons.

Conklin, E.J. (1996). *Designing organizational memory: Preserving and utilizing intellectual assets of an organization's members to compete in a knowledge-based economy.* Retrieved September 30, 2004, from www.touchstone.com/tr/whitepapers.html

Cortada, J.W., & Woods, J.A. (Eds.). (2000). *The knowledge management yearbook 2000-2001.* Boston: Butterworth-Heinemann.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

De Hoog, R., Benus, B., Vogler, M., & Metselaar, C. (1996). The CommonKADS organization model: Content, usage, and computer support. *Expert Systems with Applications, 11*(1), 247-260.

Dierkes, M., Marz, L., & Teele, C. (2001). Technological visions, technological development, and organizational learning. In M. Dierkes, A.B. Antal et al. (Eds.), *Handbook of organizational learning and knowledge* (pp. 282-304). Oxford: Oxford University Press.

Drucker, P.F. (1992). The new society of organizations. *Harvard Business Review,* (September-October).

Garvin, D.A. (1993). Building a learning organization. *Harvard Business Review, 71*(4), 78-91.

Grant, R.M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(Winter Special Issue), 109-122.

Hackbarth, G., & Grover, V. (1999). The knowledge repository: Organization memory information systems. *Information Systems Management, 16*(3), 21-30.

Kim, D. (1993). The link between individual and organizational learning. *Sloan Management Review,* (Fall), 37-50.

King, W.R. (1996). IS and the learning organization. *Information Systems Management, 13*(3), 78-80.

King, W.R. (1999). Integrating knowledge management into IS strategy. *Information Systems Management, 16*(4), 70-72.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Levine, L. (2001). Integrating knowledge and processes in a learning organization. *Information Systems Management*, (Winter), 21-32.

Markova, I., & Foppa, K. (Eds.). (1990). *The dynamics of dialogue*. New York: Harvester Wheatsheaf.

Nonaka, I., Toyama, R., & Konno, N. (2002). SECI, Ba and leaderships: A unified model of dynamic knowledge creation. In S. Little, P. Quintas, & T. Ray (Eds.), *Managing knowledge: An essential reader* (pp. 41-67). London: Sage Publications.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.

O'Leary, D.E. (1998). Enterprise knowledge management. *IEEE Computer, 31*(3), 54-61.

Perrow, C. (1970). *Organizational analysis: A sociological view*. Belmont, CA: Wadsworth.

Probst, G., & Buchel, B. (1997). *Organizational learning: The competitive advantage of the future*. Herdsfordshire, UK: Prentice-Hall (Europe).

Savage, C.M. (1996). *Fifth generation management (revised edition): Co-creating through virtual enterprising, dynamic teaming and knowledge networking.* Boston: Butterworth-Heineman.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. London: Currency Doubleday.

Senge, P., Kleiner, A., Roberts, C., Ross, R.B., & Smith, B.J. (1994). *The fifth diciplin fieldbook: Strategies and tools for building a learning organization*. New York: Currency Doubleday.

Stalk Jr., G., Evans, E., & Shulman, L.E. (1992). Competing on capabilities: The new rules of corporate strategy. *Harvard Business Review,* (March-April).

Stein, E.W. (1992). A method to identify candidates for knowledge acquisition. *Journal of Information Systems, 9*(2), 161-178.

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations.* New York: Doubleday.

Stopford, J.M. (2001). Organizational learning as guided responses to market signals. In M. Dierkes, A.B. Antal et al. (Eds.), *Handbook of organizational learning and knowledge* (pp. 264-281). Oxford: Oxford University Press.

Sveiby, K.E (1997). *The new organizational wealth*. Berrett-Koehler.

Van der Spek, R., & De Hoog, R. (1995). A framework for a knowledge management methodology. In K.M. Wiig (Ed.), *Knowledge management methods* (pp. 379-393). Arlington, TX: Schema Press.

Vat, K.H. (2000, November 1-2). Designing knowledge infrastructure for virtual enterprises in organizational learning. *Proceedings of the 10th Annual Business Information Technology Conference (BIT2000)*, Manchester, England (CD-ROM Paper No. 45).

Vat, K.H. (2001, November 1-4). Towards a learning organizational model for knowledge synthesis: An IS perspective. *CD-Proceedings of the 2001 Information Systems Education Conference* (ISECON2001), Cincinnati, OH.

Vat, K.H. (2002). Designing organizational memory for knowledge management support in collaborative learning. In D. White (Ed.), *Knowledge mapping and management* (pp. 233-243). Hershey, PA: IRM Press.

Vat, K.H. (2003, March 1-2). An IS-based architectural modeling for learning organization: A conceptual walkthrough. *Proceedings of the 6th Annual Conference of the Southern Association for Information Systems (SAIS2003)* (pp. 55-62), Savannah, GA.

Wiig, K.M. (1993). *Knowledge management: The central management focus for intelligent-acting organizations.* Arlington, TX: Schema Press.

Wiig, K.M. (1997). Integrating intellectual capital and knowledge management. *Long Range Planning, 30*(3), 399-405.

Williamson, A., & Lliopoulos, C. (2001). The learning organization information system (LOIS): Looking for the next generation. *Information Systems Journal, 11*(1), 23-41.

Zuboff, S. (1988). *In the age of the smart machine: The future of work and power.* New York: Basic Books.

Chapter 1.28
Communities of Practice and Organizational Development for Ethics and Values

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INTRODUCTION AND BACKGROUND

Ethics is the study of moral issues and choices. In organizations, such a study inevitably involves consideration of decision-making practices and interpersonal relationships. This in turn may require the investigation of complex combinations of influences which include personality characteristics, values, and moral principles as well as organizational mechanisms and the cultural climate that rewards and reinforces ethical or unethical behavioral practices. Organizations ignore ethical issues at their peril as we know from recent examples of:

- past claims of brutality, poor wages, and 15-hour days in the Asian sweatshops run by Adidas, Nike and GAP,
- banks that rate their customers by the size of their accounts,
- the race for commercial control by private firms, universities, and charities claiming exclusive development rights over natural processes in the human body and patents sought by organizations, overwhelmingly from rich countries, on hundreds of thousands of animal and plant genes, including those in staple crops such as rice and wheat,
- a lack of people management skills and supervision which was said to be responsible for the falsification of some important quality control data of an experimental mixed plutonium and uranium fuel at the Sellafield nuclear reprocessing scandal which led to cancelled orders and the resignation of its chief executive.

We can all think of other examples that have hit the headlines to indicate that modern business management must recognize its responsibility to provide an ethical framework to guide action. This is the case in respect to human resources policy, health and safety policy, marketing policy, operations management, and environmental management.

Ethical policymaking has become the watchword for both national and local government. Ethics is now taught in the police force in order to be proactive and combat discrimination. Concern is now expressed in all forms of decision making from genetic modification of foods and the patenting of human organs to the ethical decisions of pharmaceutical companies or the marketing dilemmas of global corporations. Despite these developments, we continue to find many examples of decision makers making bad ethical decisions and people who blow the whistle on many of those actions. On the positive side, we have seen how so called green organizations have proved that ethics and profit are not incompatible goals.

COMMUNITIES OF PRACTICE AND SOCIAL RELATIONSHIPS

While many of these issues will engage people at the organizational level, communities of practice need to be aware of ethical issues particularly in relation to social relationships. This is because compromises have often to be made in relation to decision making as well as in the production of products and the provision of services. We can therefore distinguish between deliberate practices which include activities to deceive others such as consumers, employees, or colleagues and stakeholders from actions which are not premeditated to deceive but do, nevertheless, contravene what we might call ethical standards.

There are also many practices that may not be legally defined as unethical but which may result from collusion between subordinates and others who hold positions of power. Such examples are often not perceived as controversial and tend to be rationalized by means of situational expediency. These are related to the five main sources of power articulated by French and Raven (1968) and involves the relative perceptions of the manager and subordinate relationship. The examples below indicate how this can occur when an individual makes decisions that are informed by perceptions and situational circumstances that constrain reflective judgment.

1. Reward power is seen to legitimize actions when a subordinate perceives the manager has the ability and resources to obtain rewards for compliance with directives. These often take the form of pay, promotion, praise, recognition, and the granting of various privileges. While this is quite a natural process, it can give rise to conflicts of interest when the motives of a subordinate are informed by personal gain, and those of the manager seek to achieve instrumental objectives.
2. Coercive power may not legitimize the actions to conform in the eyes of subordinates, but it does explain how collusion is sometimes related to perceived fear of punishment. This may, of course, be extremely subtle since the perception of punishment may be related to desired personal objectives or rewards such as promotion or an increase in pay. The abuse of power occurs when power holders can exercise power to the extent that subordinates fear that non-compliance may lead to the allocation of undesirable tasks or to lost opportunities to progress their careers.
3. Legitimate power reflects the assumptions of subordinates that a power holder as manager or supervisor has a right to expect compliance with a particular course of action. This is fairly typical of the position power that exists within bureaucratic structures. Unless subordinates are extremely knowledgeable about their own rights in relation to a particular manager's legitimate right to command obedience, they are likely to be drawn along by the situation.
4. Referent power occurs when a particular manager exercises influence because of charismatic reasons or because of personal

attributes perceived to be desirable by subordinates. In situations where a conflict of interest may occur, collusion in a course of action may result because subordinates may be over-zealous in their pursuit of particular objectives while failing to reflect on the consequences of their actions. This may often be the motive for group-think, the consequences of which may be disastrous for an organization.

5. Expert power occurs when a leader is perceived to have a special knowledge, expertise, or degree of competence in a given area. In such cases, subordinates and, indeed, other stakeholders are likely to defer to the expertise of a particular individual. Thus, alternative judgments and information can be overlooked.

Because individuals often seek to achieve organizational objectives, their tendency to ignore conflicting value systems can create value dilemmas and ethical conflicts of interest. Many people do report conflict of interest in their work. Examples often cited in relation to overt practices include bribes, gifts, slush funds, concealing information from customers, shareholders, or, more generally, from the market place, engaging in price-fixing, and so on. We can regard these examples as institutionalized practices, but there are also examples where ethical problems emerge because of workplace pressures to achieve results.

How people come to rationalize their judgments is partly explained by the exercise of power but is also informed by the belief that actions are not illegal or unethical. This is illustrated by Gellerman (1986) who argues that there are four commonly held rationalizations that lead to ethical misconduct:

1. The belief that the activity is within reasonable ethical and legal limits—that it is not “really” illegal or immoral.
2. A belief that the activity is in the individual’s or the corporation’s best interests—that the individual would somehow be expected to undertake the activity.
3. A believe that the activity is “safe” because it will never be found out when publicized—the classic crime-and-punishment issue of discovery.
4. A belief that, because the activity helps the company, the company will condone it and even protect the person who engages in it.

LESSONS FROM ORGANIZATIONAL DEVELOPMENT

While ethical issues in organizations can be addressed from a variety of perspectives and raise complex theoretical issues, it would be more instructive for the reader to consider whether a community of practice should address ethical issues separately from the procedures and guidelines identified within their own organizations. Where guidelines and ethical codes for practice exist, as they do in many organizations, then members of a CoP will be obliged to be guided by them. In this respect, employees are likely to be informed by organizational values, rules, and guidelines or by professional codes of practice. However, as a general principle, it is recommended that members of a CoP consider their own activities in relation to the extent to which interventions will be a consequence of their actions.

Some lessons from organizational development (OD) may assist CoP members in meeting their objectives. The first point to be made is that OD is informed by its own value system, and OD consultants accept that they are bound by humanistic and democratic values. These are seen to be essential to building trust and collaboration within an organization. Nevertheless, there are some difficulties here.

The first major dilemma for an OD consultant is the extent to which the pursuit of humanistic values is contradicted or compromised by the desire to achieve organizational effectiveness. As Cummings and Worley (1997) argue, "more practitioners are experiencing situations in which there is conflict between employees' needs for greater meaning and the organisation's need for more effective and efficient use of its resources" (p. 57). As a result, it is important to identify any areas of potential concern at the point of agreeing to a contract with the client system. It should be clear, therefore, that any contract must make it transparent that organizational efficiency and effectiveness will depend upon an open and democratic concern for improvement through the organization's employees. And this, of course, has not always been the case where more programmed approaches to change management (for example, TQM, BPR) have sometimes adopted more instrumental and formulaic approaches to their interventions.

The second dilemma is related to the value conflict that OD practitioners are likely to face in relation to the different perspectives of stakeholder groups. Whereas traditional OD tended to adopt a relatively naive functionalist perspective, contemporary OD practitioners/consultants are much more likely to be aware of the plurality of interests operating within an organization. This inevitably means that different stakeholders will need to be consulted and their views explored in order to arrive at a workable intervention strategy. Each of these potential value conflicts may arise when consultants are not clear about their roles. In other words, role conflict and role ambiguity can give rise to value dilemmas.

A third dilemma relates to technical ability. In other words, a change agent who fails to act with sensitivity to the needs of the client system and who fails to possess sufficient knowledge and skill of underpinning behavioral issues is acting unethically. Thus, the ability to analyze a problem situation and to diagnose a potential solution requires an awareness of the variety of intervention strategies appropriate to the nature of the problem identified.

CONCLUSION AND FUTURE TRENDS: ETHICAL GUIDELINES FOR COMMUNITIES OF PRACTICE

Communities of practice might therefore consider whether they have a helping role in relation to a particular client system. If they do, then they will need to question the following:

1. The needs of the client system in its widest possible sense which, of course, may include all stakeholders and/or different employee groups.
2. The extent to which compromises are possible in relation to organizational efficiency and effectiveness vis-a-vis humanistic values.
3. The clarity of purpose or remit of the CoP in order to achieve its defined objectives.
4. The extent to which members of the CoP possess sufficient knowledge and internal skills in relation to (a) intrapersonal skills; (b) interpersonal skills; (c) consultation skills; (d) knowledge of underpinning organizational behavior.

A useful set of guidelines has been provided by the Human Systems Development Consortium (HSDC). These are stated in-depth in Cummings and Worley (1997) and refer to four main areas that should be addressed. These are (1) responsibility for professional development and competence; (2) responsibility to clients and significant others; (3) responsibility to the profession; (4) social responsibility. The reader is advised to read these issues in more depth and consider their relevance to any CoP activities they are currently undertaking.

As we noted previously, an organization's reward system can compound the problem of ethical dilemmas caused by the pressure for results. Like organizations, a CoP should consider rules for its own ethical climate. A basic framework should include the following:

1. Act as a role model by demonstrating positive attitudes and behaviors that signal the importance of ethical conduct.
2. Develop a code of ethics which (a) is distributed to everyone; (b) refers to specific practices and ethical dilemmas likely to be encountered; (c) rewards compliance and penalizes non-compliance.
3. Where necessary, provide ethics training designed to identify solutions to potential problems.
4. Create mechanisms such as audits to deal with ethical issues.

REFERENCES

Cummings, T. G., & Worley, C. G. (1997). Organizational development and change (6th ed.). Cincinnati: Southwestern College.

French, J. R. P., & Raven, B. (1968). The bases of social power. In D. Cartwright & A. F. Zander (Eds.), Group dynamics: Research and theory (3rd ed.). Harper and Row.

Gellerman, S. W. (1986, July-August). Why "good" managers make bad ethical choices. Harvard Business Review.

Chapter 1.29
Social Capital Knowledge

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INTRODUCTION

Organizations have capabilities for creating and sharing knowledge (intellectual capital) that give them their distinctive advantage over other institutional arrangements, such as markets (Ghoshal & Nahapiet, 1998). But, what is the basis of a firm's knowledge development capabilities? At least in part, the answer is that these capabilities stem from the social capital that an organization possesses as a result of bringing people together for extended periods of time, creating interdependence through specialization and integration, forcing interaction, and providing boundaries and directions. Following the resource-based theory of the firm (Conner & Prahalad, 1996), enterprises that cultivate particular forms of social capital are likely to realize competitive advantages (Ghoshal & Nahapiet, 1998).

This article traces the connections between an organization's social capital and the organization's development of knowledge. Understanding these connections is important for leaders of knowledge management initiatives, particularly if they seek to leverage knowledge production into enhanced competitiveness. We begin with a background discussion of the nature of social capital including its structural, cognitive, and relational dimensions. This is followed by a consideration of intellectual capital (i.e., knowledge that can be used to achieve an organization's purpose) and an explanation of the supportive role of social capital in furnishing conditions necessary for developing this knowledge. We describe a model of knowledge conversion processes whereby intellectual capital is developed within a social capital context known as Ba. Some future trends in socially-based processes of knowing by people and organizations are outlined, followed by concluding remarks.

BACKGROUND

Social capital is the "sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network" (Nahapiet & Ghoshal, 1998, p. 243). All social capital constitutes some aspect of social structure and facilitates the actions of individuals within that structure (Coleman, 1990). Social capital is inherent in relationships among persons and is a productive asset facilitating some forms of social action while inhibiting others. It has three dimensions: (1) structural, (2) relational, and (3) cognitive.

The structural dimension of social capital includes three "properties of the social system and of the network of relations as a whole" (Nahapiet & Ghoshal, 1998, p. 244): appropriable organization structure, network ties, and network configuration within a set of relationships. Appropriable organization structure refers to structure created for one purpose which provides a valuable source of resources for another purpose. Network ties are social relations that provide information benefits in the form of access, timing, and referrals. Network configuration refers to the structure of network ties that influence the range of information and the cost in accessing it.

The cognitive dimension of social capital includes those resources providing shared representations, interpretations, and systems of meaning among parties (Cicourel, 1973). Examples are shared language and codes, ontologies, and shared narratives.

- Shared language and codes: The means by which people discuss and exchange information, ask questions, and conduct business. Language and codes organize sensory data into perceptual categories and provide a frame of reference for observing and interpreting our environment. Language and codes filter our awareness. A common language enhances the capacities for sharing knowledge and for combining knowledge.
- Ontologies: Simplified, abstract views of a domain adopted by participants in an organization that characterizes key concepts and offers axioms about them and their relationships (Gruber, 1995). Commitment by participants to an ontology promotes sharing and reuse of knowledge, collaborative exploration of the domain, and development of new knowledge about the domain.
- Shared narratives: Myths, stories, and metaphors that provide powerful means in communities for creating, exchanging, and preserving rich sets of meanings (Denning, 2000).

The relational dimension of social capital includes the kinds of personal relationships that people have developed with each other through a history of interactions (Granovetter, 1992). This dimension stems from, or is conditioned by, an organization's culture and subcultures. It includes the trust, norms, obligations, and identification within a set of relationships.

Trust is a belief that results of an entity's intended action will be beneficial (or at least not harmful) to our interests (Miztal, 1996). Factors that promote trust include open communication, participation in decision-making, sharing valuable knowledge, and sharing viewpoints and attitudes (Mishra & Morrisey, 1990). Where relationships are high in trust, people are more willing to engage in social exchange, in general, and cooperative interaction, in particular (Nahapiet & Ghoshal, 1998). A norm exists when the socially-defined right to control an action is held not by the actor but by others; norms are expectations that bind (Kramer & Goldman, 1995). Norms may have a significant influence on exchange processes involved in knowledge development, opening up access to parties for the exchange of knowledge and ensuring the motivation to engage in such exchange (Nahapiet & Ghoshal, 1998).

Obligations and expectations refer to commitments or responsibilities to undertake some activity in the future. They differ from norms in that they are developed within the context of a particular relationship (Coleman, 1990). Obligations and expectations are likely to influence both access to parties for exchanging and combining knowledge and the motivation to combine and exchange such knowledge (Nahapiet & Ghoshal, 1998). Identification refers to a self perception of belonging within a social group or network, carrying with it an adherence to its culture and an understanding of characteristics or boundaries of that group that distinguish it from other groups.

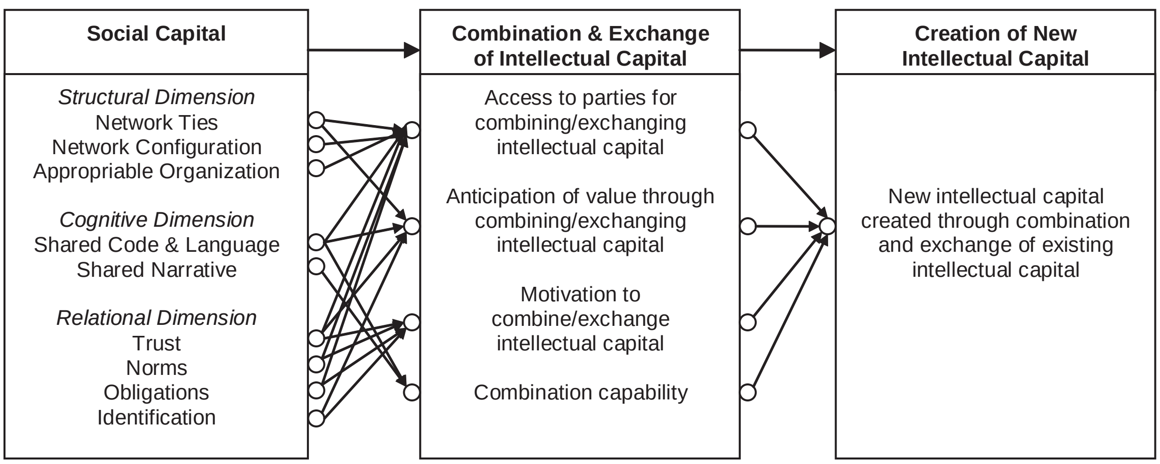
INTELLECTUAL CAPITAL CREATION AND SOCIAL CAPITAL

Intellectual capital (IC) has been defined in many ways. Relative to social capital, IC is defined as the knowledge of an organization's participants that results in a competitive advantage for that organization (Stewart, 1991), or as knowledge and knowing capability belonging to a social collective (Nahapiet & Ghoshal, 1998). Moran and Ghoshal (1996) maintain that all resources, including intellectual capital, are created primarily through the generic processes of combination and exchange of existing resources. (We note that it is unclear whether creation involving discovery, insight, or imagination can be fully described in terms of combination and exchange.) Intellectual capital, then, is developed through processes that combine knowledge and experience of different parties and is therefore dependent on exchange, which implies that knowledge development in an organization is influenced by the organization's social capital.

Because exchange often occurs through social interaction and coactivity permitted by a firm's social capital, firms provide the necessities for creating new intellectual capital through opportunities for the sustained interaction, conversations, and sociability (Nahapiet & Ghoshal, 1998). Thus, a firm can be defined as a "social community specializing in the speed and efficiency in the creation and transfer of knowledge" (Kogut & Zander, 1996, p. 503).

Through their purpose and organizational structure, firms develop social closure and interdependence. Closure is a feature of social relationships that is conducive to the development of high levels of relational and cognitive social capital. Formal organizations such as firms, by definition, imply a measure of closure through the creation of explicit legal, financial, and social

Figure 1. Social capital in the creation of intellectual capital (Nahapiet & Ghoshal, 1998)



boundaries (Kogut & Zander, 1996). Because they promote specialization and integration (i.e., interdependence), firms encourage development of social capital and, hence, intellectual capital as well.

There are four conditions that must exist for the creation of new intellectual capital through exchange to take place: (1) opportunity, (2) expectation of the creation of value, (3) motivation (expectation of realizing and benefiting from some of the newly created value), and (4) capability (Nahapiet & Ghoshal, 1998). The links between the elements and dimensions of social capital and these four conditions are shown in Figure 1. The structural elements of social capital are shown promoting access to participants and anticipation of value. The cognitive elements support access to participants, anticipation of value, and combination capability. The relational dimension elements support access, anticipation of value, and motivation for exchange.

Social Knowledge

In addition to supporting the creation of new intellectual capital through combination and exchange, social relationships become the locus for their own type of intellectual capital, called social knowledge. Social knowledge is knowledge inextricably embedded in complex, collaborative social practices, separate from individual knowledge. This is consistent with the notion of schematic knowledge resources (Holsapple & Joshi, 2004), which exist independent of any organizational participant and include an organization's purpose/vision, strategy, culture, and infrastructure (i.e., roles, relationships, regulations).

Nahapiet and Ghoshal (1998) have identified two modes of social knowledge: explicit and tacit. They define the former as "objectified" knowledge shared across the organization. Social tacit knowledge, on the other hand, is fundamentally embedded in the forms of social and institutional practice; it resides in the tacit experiences and enactment of the collective (Brown & Duguid, 1991). Such knowledge and knowing capacity may remain relatively hidden from individual actors but manifests and is sustained through their interactions (Spender, 1994). The notions of tacit and explicit knowledge play a central role in the SECI model.

The SECI Model and Ba

The SECI model is a conceptualization of how new intellectual capital is developed via processes of socialization, externalization, combination, and internalization (SECI). The SECI model focuses on the perspective of knowledge as existing in two modes: tacit and explicit. Value creation by an organization emerges from using the four processes to convert knowledge between tacit and explicit modes. This conversion happens within Ba, "a shared space for emerging relationships" (Nonaka & Konno, 1998, p. 40). The concept of Ba is a perspective on the idea of social capital as discussed.

Tacit and Explicit Knowledge

One of the many attributes for characterizing knowledge is its mode (Holsapple, 2003). Two modes of knowledge are tacit and explicit. Sometimes, a third mode, called implicit knowledge, also is considered. "Tacit knowledge is highly personal and hard to formalize, making it difficult to communicate or share with others. Subjective insights, intuitions, and hunches fall into this category of knowledge. It is deeply rooted in an individual's actions and experience as well as in the ideals, values, or emotions he/she embraces." (Nonaka & Konno, 1998, p. 42) They go on to contend that there are two dimensions of the tacit mode:

- Technical dimension of tacit knowledge: "The informal personal skills or crafts often referred to as 'know-how.'"

- Cognitive dimension of tacit knowledge: "Beliefs, ideals, values, schemata, and mental models which are deeply ingrained in us and which we often take for granted. It shapes the way we view the world."

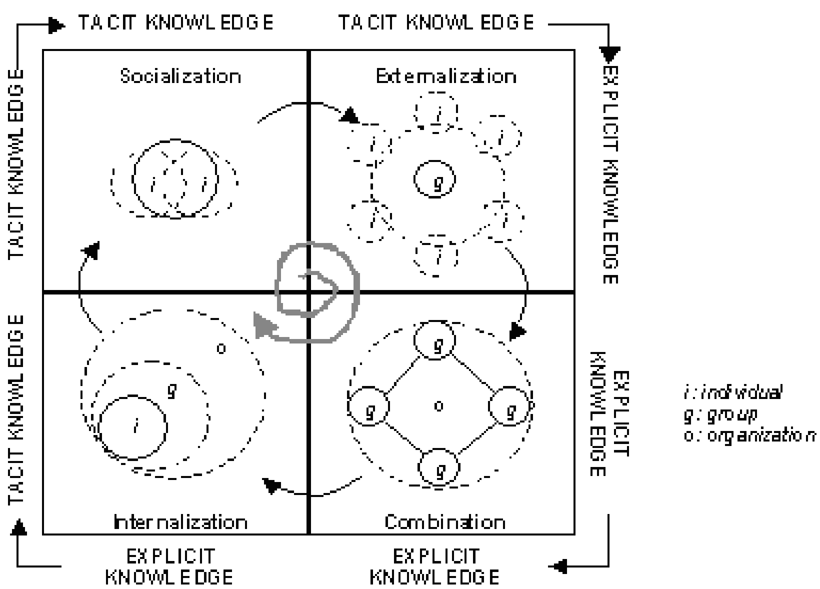
Explicit knowledge is knowledge that can be codified into symbolic representations such as words and numbers. As such, it can be readily transferred among persons in formal, systematic ways.

THE SECI SPIRAL OF KNOWLEDGE CREATION

In the SECI model, knowledge creation is a spiraling process of conversions between explicit and tacit knowledge. The combinations of possible interactions between the two modes lead to four conversion patterns called socialization, externalization, combination, and internalization. These are illustrated in Figure 2 and characterized by Nonaka and Konno (1998) as follows:

- Socialization is the process of individuals sharing tacit knowledge. It is shared through interaction over time, rather than through written or verbal instructions. It involves transcending oneself and empathizing with another.
- Externalization is the articulation into explicit knowledge of previously held tacit knowledge to others within a group setting. In externalization, the individual fuses with the group and transcends their inner and outer boundaries of self.
- Combination is the process of synthesizing explicit knowledge into new, more complex explicit knowledge.

Figure 2. Spiral evolution of knowledge conversion and self-transcending process (Nonaka & Konno, 1998)



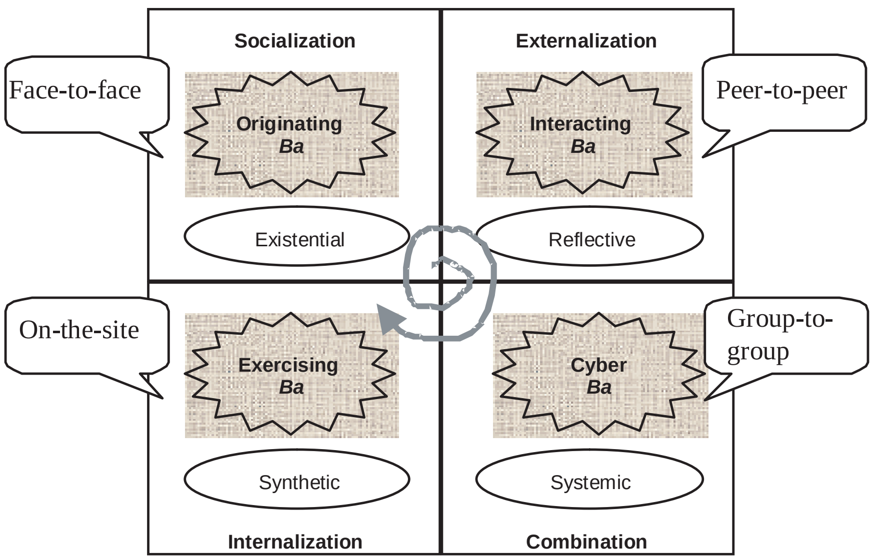
- Internalization is the process whereby new knowledge is shared throughout the organization and various participants convert it to their own tacit knowledge through using it to broaden, extend, and reframe their own tacit knowledge.

The Shared Space of Ba

The four conversion processes for developing knowledge take place in Ba: "a shared space for emerging relationships.…This space can be physical, mental, virtual, or any combination.…It is the platform for the "resource concentration" of the organization's knowledge assets and the intellectualizing capabilities within the knowledge-creation process" (Nonaka & Konno, 1998, p. 40). Organizations manage knowledge creation through nurturing the Ba (i.e., social capital) that provides its context. The four aspects of Ba illustrated in Figure 3 correspond with the four stages of the SECI model: originating, interacting, exercising, and cyber Ba. Each is especially suited to the knowledge conversion process that it supports. Nonaka and Konno (1998, pp. 46-47) describe the four social capital spaces as follows:

- Originating Ba is the "space where individuals share feelings, experiences, and mental models. An individual sympathizes or further empathizes with others, removing the barrier between self and others." Originating Ba produces care, love, trust, and commitment leading to self-transcendence and therefore sharing and new knowledge. It is the primary Ba from which the knowledge creating process begins.
- Interacting Ba is the "shared space where people's mental models and skills are converted into common terms and concepts through dialogue. It is the place where tacit knowledge is made explicit and represents the externalization process."
- Cyber Ba is a "place of interaction in a virtual world instead of real space and time; and it represents the combination phase. Here the

Figure 3. Four characteristics of Ba (Nonaka & Konno, 1998)



combining of new explicit knowledge with existing information and knowledge generates and systematizes explicit knowledge throughout the organization." Cyber Ba supports the combination process.

- Exercising Ba is the space that supports the internalization process. It facilitates the conversion of explicit knowledge to tacit knowledge in the individual. "Rather than learning from teaching based on analysis, it stresses learning through continuous self-refinement via on-the-job training or peripheral and active participation."

Thus, the SECI model identifies four social capital spaces that an organization needs to cultivate as a basis for developing knowledge by way of the four conversion processes. Further information about the SECI model and Ba can be found in Nonaka and Takeuchi (1995, 1996) and Nonaka (1991, 1994). For instance, Nonaka and Takeuchi (1995) indicate that even when there is social capital conducive to knowledge creation, further conditions need to be met: vision, autonomy, fluctuations, redundancy, and variety. The organization needs a clear vision that allows it to evaluate the utility of developed knowledge relative to the organization's purpose and strategy. The condition of autonomy means that participants in the organization should be self-motivated in their quests for new knowledge. Fluctuation refers to the introduction of breakdowns in rigid, stale processes as a means for fostering creative chaos. The redundancy condition refers to having knowledge available beyond what is necessary for supporting short-run operations. Finally, variety is concerned with ensuring sufficient internal diversity to deal with the dynamics and complexity of situations imposed by external circumstances.

The Knowing Organization

Extending the work of Nonaka and colleagues, Choo (1998) advances the notion of a knowing organization as one in which knowledge is developed not only by knowledge conversion processes of the SECI model, but also by knowledge building and knowledge linking. Like knowledge conversion, both knowledge building and knowledge linking are rooted in an organization's social capital, in the social networks that shape an organization's potential for creating knowledge.

The idea of knowledge building comes from Leonard-Barton's (1995) observation that organizations can engage in such activities as experimentation, prototyping, joint problem-solving, adopting new techniques/tools, acquiring knowledge, and acquiring special processing skills (e.g., new participants with some special expertise). These kinds of activities are both enabled and constrained by the structural, relational, and cognitive dimensions of an organization's social capital. They build on an organization's current knowledge base in the sense of expanding its scope and quality, and leave the organization poised to better cope with its future knowledge needs.

The idea of knowledge linking holds that knowledge is developed not only by networks of participants within an organization but also by forming networks of links to external entities (e.g., customers, suppliers, partners) to encourage interorganizational knowledge flows (Badaracco, 1991; Wikstrom & Normann, 1994). That is, the social capital of an organization can be seen as having two components: internal and external. The internal orientation of social capital is concerned with internal networks among core participants in an organization (Tsai & Ghosal, 1998). The external orientation of social capital involves networking across organization boundaries, encompassing knowledge-intensive interactions between core participants and virtual or ancillary participants from outside the organization. As in the internal case, externally- oriented social capital needs to be cultivated to furnish a healthy context for fostering knowledge development.

Thus, knowledge creation can be seen as being developed from other knowledge via processes of knowledge conversion, knowledge building, or knowledge linking, each of which is conditioned by extant social capital. Choo (1998) goes on to point out that there are three kinds of organization knowing: Knowledge is used not only for knowledge creation, but also for sensemaking and decision-making. Here, we contend that both sensemaking and decision-making are knowledge creation processes that are conditioned by social capital.

Sensemaking occurs in situations that are open to multiple interpretations (Weick, 1995). It involves (1) the production or selection of an interpretive scheme to apply to the situation so as to grasp its meaning, thereby giving a basis for determining appropriate responses, and (2) the assimilation of helpful interpretive schemas to be reused or adapted for making sense of future ambiguous situations (Boland & Yoo, 2003). The immediate goal of sensemaking is for the organization's participants to share a common understanding of what the organization is and what it is doing; the longer-term goal is to ensure that the organization adapts and therefore continues to thrive in a dynamic environment (Choo, 1998).

The outcome of sensemaking is shared meanings and intents for the organization. Such sharing implies the pre-existence of social capital, a network of social relationships in which the meanings and intents can incubate and propagate. The meanings and intents are, in essence, knowledge about what is and what is should be. These did not exist before the sensemaking exercise, but rather are the result of it. Thus, sensemaking is a process of developing new knowledge, just as knowledge conversion, knowledge building, and knowledge linking are processes for developing new knowledge.

Results of sensemaking can be important ingredients for decision-making. "All organizational actions are initiated by decisions, and all decisions are commitments to action. In theory decision-making is rational, based upon complete information about the organization's goals, feasible alternatives, probable outcomes of these alternatives, and the values of these outcomes to the organization. In practice choicemaking is muddled by the jostling of interests among stakeholders, idiosyncrasies of personal choice making and lack of information" (Choo, 1996, p. 329). In other words, decision-making processes happen within the context of social networks which have the property of either facilitating/enhancing the process or muddling/obstructing it. This is certainly the case for multi-participant decision-making (i.e., multiple entities participate in the making of a decision). It is also the case, albeit indirectly, for individual decision-making (i.e., the individual's deliberations are affected by the organization's social capital).

Decision-making has long been recognized as a knowledge-intensive activity (Bonczek, Holsapple, & Whinston, 1981; Holsapple, 1995). Knowledge is the raw material, work-in-process, byproduct, and final outcome of decision-making. That is, a decision is knowledge that indicates a commitment to action. Thus, decision-making processes are knowledge creation processes, just as sensemaking, knowledge conversions, knowledge building, and knowledge linking. All five of these approaches to developing knowledge unfold in and as a result of an organization's social capital.

FUTURE TRENDS

Understanding knowledge development and its antecedents, particularly those related to social capital, is an important issue for KM practitioners and remains an area for continuing investigation by researchers. For instance, is there a difference in how social capital manifests in large enterprises vs. small firms? Characterizations of social capital are often made from the standpoint of the large enterprise. Davenport, Graham, Kennedy, and Taylor (2003) are studying how social capital manifests in small firm networks that rely on rapid turnover of projects, as a basis for devising prescriptions about building, maintaining, and refreshing social capital. As another example, consider the constructs that contribute to social capital. One of these is trust. Ford (2003) analyzes trust implications for knowledge processes such as knowledge creation. She poses a series of propositions that give a starting point for future research into the connections between trust and the development of knowledge. Similar analyses and detailed proposition statements wait to be performed for the connections between other social constructs and knowledge development.

At a more macro level, social capital connections to knowledge development are related to several broad topic areas within the KM field. Advances in these topic areas will impact our understanding of better creating the social capital needed for effective knowledge development, and vice versa. One of these topics is communities of practice (Brown & Duguid, 1991; Wenger, 2000). These are social networks (often technologically supported or enabled) that are dedicated to knowledge sharing and development pertaining to some domain of interest/expertise that is common to participants in the community. Another topic area is organizational learning (Bennet & Bennet, 2003) which is concerned with the means whereby organizations learn (i.e., develop greater intellectual capital) and the impacts of that learning. All five of the knowledge development approaches identified in this article can be regarded as variants of organizational learning. For organizational learning to happen, there must be sufficient social capital in terms of communication, interaction, and flexibility (Allard, 2003).

The knowledge management ontology (Holsapple & Joshi, 2004) suggests that we need to better understand techniques and technologies that can foster knowledge development episodes in an organization; specifically how do we lead, coordinate, control, and measure such episodes relative to the organization's present resources and environing situation? These and other questions remain for practitioners and researchers to resolve.

CONCLUSION

An organization's intellectual capital includes the knowledge that it can apply to enhance performance through increased productivity, agility, innovation, and/or reputation. Given the challenges of a dynamic, global, hypercompetitive environment, it is imperative that organizations be actively and consciously engaged in developing knowledge. One prerequisite for doing so is social capital. This article has outlined basic considerations important for cultivation of social capital and described its connections with the development of intellectual capital. It has identified five kinds of knowledge creation: knowledge conversions, knowledge building, knowledge linking, sensemaking, and decision-making. All of these deserve and can benefit from attention by leaders of KM initiatives and by the cultivation of appropriate networks of social relationships. The result is a more competitive organization.

REFERENCES

Allard, S. (2003). Knowledge creation. In C.W. Holsapple (Ed.), *Handbook of knowledge management: Knowledge matters* (pp. 367-379). Berlin: Springer-Verlag.

Badaracco, J.L. (1991). *The knowledge link: How firms compete through strategic alliances.* Boston: Harvard Business School Press.

Bennet, A., & Bennet, D. (2003). The partnership between organizational learning and knowledge management. In C.W. Holsapple (Ed.), *Handbook of knowledge management: Knowledge matters* (pp. 439-455). Berlin: Springer-Verlag.

Bonczek, R.H.,, Holsapple, C.W., & Whinston, A.B. (1981). *Foundations of decision support systems*. New York: Academic Press.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-57.

Choo, C.W. (1996). The knowing organization: How organizations use information to construct meaning, create knowledge, and make decisions. *International Journal of Information Management, 16*(5), 329-340.

Choo, C.W. (1998). *The knowing organization: How organizations use information to construct meaning, create knowledge, and make Decisions*. New York: Oxford University Press.

Cicourel, A.V. (1973). *Cognitive sociology*. Harmondsworth, UK: Penguin Books.

Coleman, J. (1990). *Foundations of social theory*. Cambridge, MA: Harvard University Press.

Conner K, & Prahalad, C.K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science*, *7*(5) 477-501.

Davenport, E., Graham, M., Kennedy, J., & Taylor, K. (2003, October 20-23). *Managing social capital as knowledge management: Some specification and representation issues*. American Society of Information Science and Technology Annual Meeting, Long Beach, CA.

Denning, S. (2000). *The springboard: How storytelling ignites action in knowledge-era organizations*. Amsterdam: Butterworth-Heinemann.

Ford, D. (2003). Trust and knowledge management: The seeds of success. In C.W. Holsapple (Ed.), *Handbook of knowledge management: Knowledge matters* (pp. 553-575). Berlin: Springer-Verlag.

Granovetter, M.S. (1992). Problems of explanation in economic sociology. In N. Nohria & R. Eccles (Eds.), *Networks and organizations: Structure, form and actions* (pp. 25-26). Boston: Harvard Business School.

Gruber, T.R. (1995). Toward principles for the design of ontologies used for knowledge sharing. *International Journal of Human and Computer Studies, 43*(5/6) 907-928.

Holsapple, C.W. (1995). Knowledge management in decision making and decision support. *Knowledge and Policy, 8*(1) 5-22.

Holsapple, C.W. (2003). Knowledge and its attributes. In C.W. Holsapple (Ed.), *Handbook of knowledge management: Knowledge matters* (pp. 165-188). Berlin: Springer-Verlag.

Holsapple, C.W., & Joshi, K. (2004). A formal knowledge management ontology: Conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science, 7*(5), 502-518.

Kramer, R.M., & Goldman, L. (1995). Helping the group or helping yourself? Social motives and group identity in resource dilemmas. In D. A. Schroeder (Ed.), *Social dilemmas*. New York: Praeger.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston, MA: Harvard Business School Press.

Moran, P., & Ghoshal, S. (1996). Bad for practice: A critique of the transaction cost theory. *Academy of Management Review, 21*(1), 13-47.

Mishra, J., & Morrisey, M. (1990). Trust in employer/employee relationships: A survey of West Michigan Managers. *Public Personnel Management, 19*(4), 443-463.

Misztal, B. (1996). *Trust in modern societies.* Cambridge, UK: Polity Press.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review, 69*(6), 96-105.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., & Takeuchi, H. (1996). A theory of organizational knowledge creation. *International Journal of Technology Management*, *11*(7/8), 833-845.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company.* New York: Oxford University Press.

Polanyi, M. (1974). *Personal knowledge: Towards a post-critical philosophy* (2nd Ed). Chicago: University of Chicago Press.

Schein, E. (1985). *Organizational culture and leadership.* Washington, DC: Jossey-Bass.

Spender, J.C. (1996). Knowing, managing and learning: A dynamic managerial epistemology. *Management Learning, 25,* 387-412.

Stewart, T.A. (1991). Brain power: How intellectual capital is becoming America's most valuable asset. *Fortune,* June 3.

Tsai, W., & Ghoshal, S. (1998). Social capital and value creation: The role of intrafirm networks. *Academy of Management Journal*, *41*(4), 464-476.

Weick, K.E. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publication

Wenger, E. (2000). Communities of practice and social learning systems. *Organization Articles, 7*(2), 225-246.

Wikstrom, S., & Normann, R. (1994). *Knowledge and value: A new perspective on corporate transformation*. London, UK: Routledge.

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Chapter 1.30
Knowledge Communication

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INTRODUCTION: THE IMPORTANCE OF KNOWLEDGE COMMUNICATION IN MANAGEMENT

Communicating professional knowledge is a key activity for today's specialized workforce. The efficient and effective transfer of experiences, insights, and know-how among different experts and decision makers is a prerequisite for high-quality decision making and coordinated, organizational action (Straub & Karahanna, 1998). Situations of such deliberate (interfunctional) knowledge transfer through interpersonal communication or group conversations (Gratton & Goshal, 2002) can be found in many business constellations, as the following typical examples illustrate:

Technology experts present their evaluation of a new technology to management in order to jointly devise a new production strategy (McDermott, 1999). Engineers who have discovered how to master a difficult manufacturing process need to convey their methods to engineers in other business units (Szulanski, 1996, 1999). Legal experts brief a management team on the implications of new regulations on their business model (Wilmotte & Morgan, 1984). Experts from various domains need to share their views and insights regarding a common goal in order to agree on a common rating of risks, requirements (Browne & Ramesh, 2002), industries, or clients. Project leaders need to present their results to the upper management and share their experiences of past projects in order to assess the potential of new project candidates (Schindler & Eppler, 2003). Scientists who work as drug developers present new avenues for future products that business unit managers must assess. Market researchers present their statistical analyses of recent consumer surveys to the head of marketing (Boland et al., 2001). Strategy consultants present the findings of their strategic company assessment to the board of directors in order to devise adequate measures (Creplet, Duouet, Kern, Mehmanzapir, & Munier, 2001).

What these diverse situations all have in common is the problem of knowledge asymmetry (Sharma, 1997) that has to be resolved through interpersonal communication. While the manager typically has the authority to make strategic or tactical decisions, he or she often lacks the specialized expertise required to make an informed decision on a complex issue (Watson, 2004). Because of the wide scope of decisions that need to be made, a manager frequently has to delegate the decision preparation to experts who—based on their professional training and previous experience—can analyze complex situations or technological options in a more reliable manner. The results of such analyses then need to be communicated back to the manager, often under considerable time constraints. The knowledge communication challenge, however, begins long before that, at the time when the manager has to convey his or her knowledge needs and decision constraints to the experts in order to delegate the analysis task effectively.

BACKGROUND: THE CONCEPT OF KNOWLEDGE COMMUNICATION

Based on the reasoning described in the previous section, we define knowledge communication as the (deliberate) activity of interactively conveying and co-constructing insights, assessments, experiences, or skills through verbal and non-verbal means. Knowledge communication has taken place when an insight, experience, or skill has been successfully reconstructed by an individual because of the communicative actions of another. Knowledge communication thus designates the successful transfer of know-how (e.g., how to accomplish a task), know-why (e.g., the cause-effect relationships of a complex phenomenon), know-what (e.g., the results of a test), and know-who (e.g., the experiences with others) through face-to-face (co-located) or media-based (virtual) interactions. This type of knowledge communication can take place synchronously or asynchronously.1 The first mode of communication refers to (often face-to-face) real-time interactions, while the latter designates delayed (usually media-based) interactions.

We use the term knowledge dialogues for the first type of (synchronous) knowledge communication, stressing the interactive and collaborative style of knowledge exchange in this communication mode (see Isaacs, 1997; Nonaka, Toyama, & Konno, 2000). Depending on the knowledge-focused goal of such dialogues, we distinguish among Crealogues (that focus on in the creation of new insights), Sharealogues (facilitating knowledge transfer), Assessalogues (focusing on the evaluation of new insights), and Doalogues (e.g., turning understanding into committed action, i.e., 'talk the walk'). Each type of knowledge dialogue requires different behavior and interaction patterns and support measures (e.g., whereas Assessalogues require critical, convergent evaluation tools, Crealogues require an open atmosphere for divergent thinking and rapid idea generation without judgment).

With regard to asynchronous knowledge communication, we refer to the concept of knowledge media (see Eppler, Röpnack, & Seifried, 1999) as enabling knowledge transfer through technology-based communication, collaboration, e-learning, aggregation, retrieval, and archiving services. Knowledge media can be differentiated in terms of their target community, such as scientific knowledge media, public knowledge media, professional knowledge media, and so forth. The concept of knowledge media in general stresses the importance of a community that collaborates regularly using a common platform that consists not only of IT functionalities, but also of common communication norms and (usage) rules.

In this understanding, knowledge communication is more than communicating information (e.g., facts, figures, events, situations, developments, etc.) or emotions (e.g., fears, hopes, reservations, commitment) because it requires conveying context, background, and basic assumptions. It requires the communication of personal insights and experiences. Communicating insights requires the elicitation of one's rationale and reasoning (i.e., one's argumentation structure); of one's perspective, ratings, and priorities; and of one's hunches and intuition. At times it may even be necessary to present an overview of the expert's relevant skills along with his/her previous professional experiences and credentials (Lunce, Iyer, Courtney, & Schkade, 1993) in order to build trust and enable an adequate atmosphere for effective knowledge transfer. Thus, in addition to pure information (and at times emotion), a myriad of other indicators need to be provided in order to transfer knowledge. These indicators help the person who requires insights from another to understand the other's perspective, to reconstruct the other's insights correctly, and to connect them to one's own prior knowledge.

Still, knowledge communication does not only differ in terms of what is communicated (knowledge in context rather than isolated data or information2), but also how one communicates. The transfer of information can often be successful without additional effort beyond an ordinary, everyday communication style. Communicating expertise-based, complex insights, by contrast, calls for didactic tricks and at times sophisticated indirect speech acts and visualization means that help the other side to become actively involved in the communication and engage in a collaborative, goal-directed sense-making process—a prerequisite for the construction of new knowledge (see Weick, 1995). The process of knowledge communication hence requires more reciprocal interaction between decision makers and experts because both sides only have a fragmented understanding of an issue and consequently can only gain a complete comprehension by iteratively aligning their mental models. All of this means that when we communicate knowledge, we are still communicating information and emotions, but we also create a specific type of context so that this information can be used to re-construct insights, create new perspectives, or acquire new skills.

This (interpersonal) communication perspective on knowledge transfer has already been emphasized by other researchers—who explicitly label this view as 'knowledge communication' (Scarbrough, 1995, p. 997; Antonelli, 2000; Harada, 2003; Reiserer, Ertl, & Mandl, 2002)—and by several practitioners (e.g., Watson, 2004). Nevertheless, these authors have often treated knowledge communication as a kind of black box that is described only in broad terms and general traits, such as the major communication goals or steps. By examining the communication problems that often impede knowledge transfer in detail, we can look into this black box and propose pragmatic ways of improving knowledge communication, especially among experts and managers where the chasm between in-depth knowledge and decision authority is particularly apparent.

PROBLEMS IN COMMUNICATING KNOWLEDGE AMONG EXPERTS AND DECISION MAKERS

In order to better understand the problems that can impede the effective transfer of decision-relevant knowledge from experts to managers and from managers to experts, we will review relevant constructs and prior findings from social and engineering sciences, as there are in fact numerous concepts that describe issues related to sub-optimal knowledge transfer. These concepts regard topics such as interdepartmental knowledge transfer, professional communication, decision making, communication technology, or the nature of expert knowledge. By screening these disciplines and topic areas, we can establish a first overview of possible knowledge communication problems and we can create a systematic terminology to speak more explicitly (and consistently) about knowledge communication barriers.

Previously identified barriers of knowledge communication are summarized in Table 1. There are three main criteria for including concepts in this table: First, the concept has to be closely related to problems of interpersonal, professional knowledge transfer.3 Second, the concept has to describe a problem of major impact on the quality of knowledge transfer (rare or very specific issues are not included). Third, the concept has to be influential—that is, it has to be cited with the same construct label by several authors (other than the creator of the concept). The resulting list in Table 1 first includes 'umbrella' concepts that designate a group of closely related problems, such as cognitive biases, decision-making problems, argumentation fallacies, communication biases, or defensive routines, and then concepts that label individual problems, such as the not-invented-here syndrome or the ASK problem.

The problems listed in Table 1 are neither mutually exclusive nor collectively exhaustive. Nevertheless, Table 1 summarizes many of the key pitfalls in communicating knowledge. It is in the nature of the phenomenon that these problems are not isolated, but that they rather interact in many, sometimes unpredictable ways.

Based on the concepts from Table 1, and based on 10 focus groups4 and 10 personal interviews with engineers who frequently collaborate with managers in their companies, as well as interviews with 20 IT managers5 who regularly interact with experts for their decision making, we distinguish among five types of knowledge communication problems. These are briefly summarized below, followed by examples of each type of problem, cited from both experts and managers.

The first type of knowledge communication problems is expert-caused difficulties. These mistakes make it cumbersome for the decision maker to grasp the insights of a specialist. This type of problem also includes issues that make it difficult for the manager to explain his or her own constraints and priorities. Examples of this kind of problem are the use of overly technical jargon, not relating the insights to the manager's situation, starting with details before an overview is given, or lacking interest of the expert in related (but relevant) issues. From the list provided in Table 1, knowledge-sharing hostility and the paradox of expertise clearly belong to this category.

The second type of knowledge communication challenges is manager-caused problems that leave it unclear to the expert what the manager actually expects from him or her (briefing). This makes it difficult for the expert to convey what he or she knows. Management mistakes make it harder for the manager to fully profit from the offered expertise. For example, a manager's reluctance to discuss detailed problems may have major effects on an issue, such as lack of concentration

Table 1. Key research concepts that illustrate knowledge communication barriers

Key Concept/Knowledge Communication Barrier	Description	References
Cognitive biases (confirmation, availability, recency, dichotomized reasoning, framing, anchoring, representativeness, etc.)	Knowledge may not be correctly interpreted or used due to biases in one's reasoning, such as listening only to those insights that confirm one's prior opinion.	Tversky & Kahnemann, 1974
Decision problems (plunging in, shooting from the hip, poor feedback, taking shortcuts, frame blindness, etc.)	The decision maker may for example believe that he/she can make a complex decision right away without looking further at the provided analysis.	Russo & Shoemaker, 1989

Table 1. continued

Key Concept/Knowledge Communication Barrier	Description	References
Communication biases (audience tuning, misattribution bias, saying-is-believing, shared reality)	The knowledge is inadvertently manipulated through communication itself: • *Audience Tuning*: Communicators spontaneously tune their messages to: –the personal characteristics of the audience, or –the situational factors. • *Misattribution Bias:* Communicators tend to consider their audience-tuned messages to be about the topic of the message rather than about the audience. • *Saying-Is-Believing Effect:* Autopersuasion has stronger effects because one does not activate regular mechanisms of critical reflection. • *Shared Reality*: You consider your audience-tuned message to provide objective, accurate information on the message topic because it was shared with others.	Higgins, 1999
Argumentation fallacies (begging the question, overgeneralizing, personal attacks, defective testimony, problematic premise, slippery slope, red herring, etc.)	In demonstrating one's ideas and insights, people fall into argumentative traps, such as begging the question (circular reasoning), over-generalizing, appealing to false majorities or false expertise, reasoning ad consequentiam (what should not be true, cannot be true) or reacting with direct attacks at a person (at hominem) rather than at a knowledge claim.	van Eemeren et al., 1992
Defensive routines (skilled incompetence, learned helplessness, easing-in, etc.)	New knowledge is sometimes not accepted (or provided) due to mechanisms or habits that prevent the identification and acceptance of one's own ignorance. This may lead to a reduced effort to understand complex issues (learned helplessness).	Argyris, 1986, 1990
Knowledge disavowal	A number of factors have been found which limit information use in organizations, such as not spending enough time collecting advice, refusal to share, fear of exposure, and so forth. Knowledge disavowal occurs when reliable and relevant information is not shared among decision makers.	Zaltman, 1983; Deshpande & Kohli, 1989
Knowledge sharing hostility	Knowledge communication fails because the 'knowledge givers' are reluctant to share their insights due to micropolitics, strenuous relationships, or fear.	Husted & Michailova, 2002
Micropolitics of knowledge	The 'knowledge claims' of an expert are discredited by the decision makers due to their differing (hidden) agenda, because of a coalition of people with an alternative view, or due to the expert's lack of formal authority.	Lazega, 1992
Internal knowledge stickiness	Knowledge can sometimes not be transferred because of arduous relationships or casual ambiguities regarding the knowledge, or because of the lack of absorptive capacity of the knowledge receivers.	Szulanski, 1996, 1999

Table 1. continued

Key Concept/Knowledge Communication Barrier	Description	References
Groupthink	A (management) team may not truly listen to the input of an expert because of the team's group coherence, and group dynamics sometimes block outside advice and feel omniscient.	Janis, 1982
Information overload	An individual is sometimes not able to integrate new information into the decision-making process because too much complex information has to be interpreted too quickly.	O'Reilly, 1980; Eppler & Mengis, 2004
Self/other effect	Individuals tend to discount advice and favor their own opinion.	Yaniv & Kleinberger, 2000
Knowing-doing gap/smart talk trap	Sometimes organizations know where a problem resides and how to tackle it, but do not move from knowledge to action (due to unhealthy internal competition or lacking follow-up).	Pfeffer & Sutton, 2000
Absorptive capacity	Limited ability of decision makers to grasp the knowledge of the expert based on lack of prior knowledge.	Bower and Hilgard, 1981; Cohen & Levinthal, 1990
Paradox of expertise	Experts sometimes find it difficult to articulate their knowledge or rephrase their insights in a way that a non-expert can understand. Sometimes experts indicate other rules than they actually apply.	Johnson, 1983
Ingroup outgroup behavior	We tend to interact more with likewise groups than with others, thus reducing our chances to acquire radically new knowledge.	Blau, 1977
Task closure	In our communication, we may choose to use a one-way communication medium because it permits us to close an open task without having to have a conversation. Thus leaner communication channels are used that may be necessary. In other words: We tend to want to close a communication process in order to complete an open task.	Straub & Karahanna, 1998; Meyer, 1962
Set-up-to-fail syndrome	Managers are projecting their initial expectation of an expert's likely performance unto him/her, leading to the self-fulfilling prophecy of (at times) lower performance. This is aggravated by de-motivating feedback to the expert.	Manzoni & Barsoux, 2002
ASK problem	Anomalous State of Knowledge: When a decision maker does not have the knowledge base to really know what to ask for. People need to know quite a bit about a topic to be able to ask or search for relevant information.	Belkin, 1980 ; Chen et al., 1992
Not-invented-here (NIH) syndrome	Knowledge from others is sometimes rejected because it originated elsewhere.	Katz & Allen, 1982
Preference for outsiders	This is the opposite of the NIH syndrome and describes the tendency of managers to value outside knowledge higher than internal knowledge because it has a higher status, it is scarcer (because of difficult access), and it is less scrutinized for errors than internal knowledge.	Menon & Pfeffer, 2003
False consensus effect	We assume others see situations as we do, and fail to revise our framing.	Manzoni & Barsoux, 2002

Table 1. continued

Key Concept/Knowledge Communication Barrier	Description	References
Inert knowledge	The knowledge that the decision maker has acquired from the expert does not come to mind when it is needed or useful for decision making or actions. The transferred knowledge is stuck in the situation where it has been acquired.	Whitehead, 1929
Hidden profile problem	One often does not know other people's background (profile)—that is, what they know and could contribute to a problem's solution. The knowledge that is thus frequently shared in a discussion is what is expected by everyone.	Stasser 1992; Stasser & Stewart, 1992
Common knowledge effect	The tendency of a group to focus merely on commonly shared (rather than unique) pieces of information.	Gigone & Hastie, 1993
Lack of common ground	Common ground refers to the manager's and expert's assumptions about their shared background beliefs about the world. If those assumptions are wrong or inconsistent, communication becomes more difficult.	Clark & Schaefer, 1989; Olson & Olson, 2000
Cassandra syndrome	The decision makers do not give sufficient weight or attention to an expert's warning because they face many other important problems. Only when the situation has deteriorated dramatically do they start taking the expert's advice.	Mikalachki, 1983

and attention or lack of technical know-how. From the list in Table 1, the decision problems, the ASK problem, the Cassandra syndrome, or the inert knowledge problem are typical examples of this group.

The third type of knowledge communication problems are caused by the mutual behavior of experts and managers, including their experiences or attitudes (e.g., reciprocal stereotypes). Examples from the list of concepts that belong to this group are lacking feedback on both sides, the set-up to fail syndrome, groupthink, and ingroup outgroup behavior.

Fourth, we see problems caused by the interaction situation of the expert-manager interaction, such as time constraints, communication infrastructure, distractions, interventions from others, and so forth. The problem of information overload in Table 1 can arise due to the time constraints in a communication situation. But the hidden profile problem can also be due to the communicative situation, where the background of the participants is not fully revealed or discussed at the beginning of a manager-expert interaction.

The fifth and final type of knowledge communication problems includes issues that are caused indirectly by the overall organizational context of managers and experts, such as their organizational constraints and their differing tasks, priorities, and interests. The 'micropolitics of knowledge' concept listed in Table 1 would be an example of the (negative) impact of the organizational context on the transfer of knowledge.

CONCLUSION AND FUTURE TRENDS

Many studies in knowledge management examine the structural, macro aspects of knowledge transfer on an organizational level (Szulanski, 1999). There are also studies that examine the general motivational barriers to such transfers (Husted & Michailova, 2002). The field of knowledge communication, by contrast, examines the micro perspectives of knowledge transfer, thus highlighting the role of adequate or inadequate communication behavior patterns for knowledge transfer. These examined patterns go beyond the question of motivation and encompass issues such as the use of adequate language, timing, group interventions, or media use for knowledge transfer. This article has defined this approach as knowledge communication. It has outlined the various problems that exist when individuals (particularly experts) communicate their knowledge to others (e.g., managers).

Future knowledge management research should examine ways of facilitating and thus improving knowledge communication. This can be achieved through such tools as knowledge visualization suites, dialogue techniques, or knowledge elicitation methods. In doing so, future research should pay particular attention to the influence of (expert and manager) behavior, and to situational and organizational factors that affect the quality of knowledge communication.

REFERENCES

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alvesson, M. (1993). Organizations as rhetoric: Knowledge-intensive firms and the struggle of ambiguity. *Journal of Management Studies, 30*(6), 997-1020.

Antonelli, C. (2000). Collective knowledge communication and innovation: The evidence of technological districts. *Regional Studies, 34*(6), 535-547.

Argyris, C. (1986). Skilled incompetence. *Harvard Business Review, 64*(5), 74-79.

Argyris, C. (1990). *Overcoming organizational defenses*. New York: Prentice-Hall.

Belkin, N.J. (1980). Anomalous states of knowledge as a basis for information retrieval. *Canadian Journal of Information Science, 5*, 133-143.

Blackler, F. (1995). Knowledge, knowledge work and organizations. *Organization Studies, 16*(6), 1021-1046.

Blau, P.M. (1977). *Inequality and heterogeneity: A primitive theory of social structure*. New York: The Free Press.

Boland, R.J., Singh, J., Salipante, R., Aram, J.D., Fay, S.Y., & Kanawattanachai, P. (2001). Knowledge representations and knowledge transfer. *Academy of Management Journal*, *44*(2), 393-417.

Bower, G.H., & Hilgard, E.R. (1981). *Theories of learning.* Englewood Cliffs, NJ: Prentice-Hall.

Bouty, I. (2000). Interpersonal and interaction influences on informal resource exchanges between R&D researchers across organizational boundaries. *Academy of Management Journal, 43*(1), 50-65.

Bradley, S. & Braude, M. (1995). *The "magic quadrant" process*. Gartner Research Note, (February 22). Retrieved October 8, 2001, from www.gartnerweb.com

Bromme, R., Rambow, R., & Nückles, M. (2001). Expertise and estimating what other people know:

The influence of professional experience and type of knowledge. *Journal of Experimental Psychology, 7*(4), 317-330.

Browne & Ramesh (2002). Improving information requirements determination: A cognitive perspective. *Information & Management, 39,* 625-645.

Chen, H. (1994). Collaborative systems: Solving the vocabulary problem. *IEEE Computer,* (May), 58-69.

Clark, H.H., & Schaefer, F.S. (1989). Contributing to discourse. *Cognitive Science, 13,* 259-294.

Creplet, F., Duouet, O., Kern, F., Mehmanzapir, B., & Munier, F. (2001). Consultants and experts in management consulting firms. *Research Policy,* 30, 1517-1535.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Deshpande, R., & Kohli, A.K. (1989). Knowledge disavowal: Structural determinants of information processing breakdown in organizations. *Knowledge, 11*(2), 155-169.

Eppler, M., Röpnack, A., & Seifried P. (1999). Improving knowledge intensive processes through an enterprise knowledge medium. In J. Prasad (Ed.), *Proceedings of the 1999 ACM SIGCPR Conference 'Managing Organizational Knowledge for Strategic Advantage: The Key Role of Information Technology and Personnel'* (pp. 222-230).

Eppler, M., & Mengis, J. (2004). The concept of information overload. *The Information Society—An International Journal, 20*(5), 1-20.

Gigone, D., & Hastie, R. (1993). The common knowledge effect: Information sharing and group judgment. *Journal of Personality and Social Psychology, 65,* 959-974.

Goldhaber, G.M., Yates, M.P., Porter, D.T., & Lesniak, R. (1978). Organizational communication. *Human Communication Research, 5,* 76-96.

Gratton, L., & Ghoshal, S. (2002). Improving the quality of conversations. *Organizational Dynamics, 31,* 209-223.

Gülich, E. (2003). Conversational techniques used in transferring knowledge between medical experts and non-experts. *Discourse Studies, 5*(2), 235-263.

Harada, T. (2003). Three steps in knowledge communication: The emergence of knowledge transformers. *Research Policy, 32,* 1737-1751.

Higgins, T. (1999). Saying is believing effects: When sharing reality about something biases knowledge and evaluations. In L. Thompson, J. Levine, & D. Messick (Eds.), *Shared cognition in organization: The management of knowledge.* Mahwah, NJ: Lawrence Erlbaum.

Husted, K., & Michailova, S. (2002). Diagnosing and fighting knowledge-sharing hostility. *Organizational Dynamics, 31*(1), 60-73.

Isaacs, W. (1997). *Dialogue and the art of thinking together: A pioneering approach to communicating in business and in life.* New York: Doubleday.

Janis, I. (1982). *Groupthink: Psychological studies of policy decisions and fiascoes.* Boston: Houghton Mifflin.

Johnson, P.E. (1983). What kind of expert should a system be? *Journal of Medicine and Philosophy, 8,* 77-97.

Katz, R., & Allen, T.J. (1982). Investigating the Not Invented Here (NIH) syndrome: A look at the performance, tenure, and communication patterns of 50 R&D project groups. *R&D Management, 12*(1), 7-19.

Kirmeyer, S.L., & Lin, T. (1987). Social support: Its relationship to observed communication with peers and superiors. *Academy of Management Journal, 30*(1), 151-162.

Lazega, E. (1992). *Micropolitics of knowledge. Communication and indirect control in workgroups*. New York: deGruyter.

Lunce, S.E., Iyer, R.K., Courtney, L.M., & Schkade, L.L. (1993). Experts and expertise: An identification paradox. *Industrial Management and Data Systems, 93*(9), 3-9.

Manzoni, J.-F., & Barsoux, J.-L. (2002). *The set-up-to-fail syndrome, how good managers cause great people to fail*. Cambridge. Harvard Business School Press.

McDermott, R. (1999). Learning across teams. *Knowledge Management Review, 8,* 32-36.

McLeod, J.M., & Chaffee, S.H. (1973). Interpersonal approaches to communication research. *American Behavioral Scientist, 16*(4), 469-499.

Menon, T., & Pfeffer, J. (2003). Valuing internal vs. external knowledge: Explaining the preference for outsiders. *Management Science, 49*(4), 497-513.

Meyer, R.L. (1962). *A communications theory of urban growth*. Boston: MIT Press.

Mikalachki, A. (1983). Does anyone listen to the boss? *Business Horizons*, (January-February), 18-24.

Newman, J., & Newman, R. (1985). Information work: The new divorce? *British Journal of Sociology, 24,* 497-515.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33,* 5-34.

O'Reilly, C.A. (1980). Individuals and information overload in organizations: Is more necessarily better? *Academy of Management Journal, 23,* 684-696.

Olson, G., & Olson, J. (2000). Distance matters. *Human-Computer Interaction, 15*(2-3), 107-137.

Pfeffer, J., & Sutton, R.I. (2000). *The knowing-doing gap: How smart companies turn knowledge into action*. Boston: Harvard Business School Press.

Probst, G., Romhardt, K., & Raub, S. (1999). *Managing knowledge: Building blocks for success*. London: John Wiley & Sons.

Reiserer, M., Ertl, B., & Mandl, H. (2002). Fostering collaborative knowledge construction in desktop videoconferencing. Effects of content schemes and cooperation scripts in peer teaching settings. *Proceedings of the International Workshop on Barriers and Biases in Computer-Mediated Knowledge Communication—and How They May Be Overcome*, Münster, Germany.

Russo, J.E., & Shoemaker, P.J.H. (1989). *Decision traps*. New York: Simon and Schuster.

Scarbrough, H. (1995). Blackboxes, hostages and prisoners. *Organization Studies, 16*(6), 991-1019.

Schindler, M., & Eppler, M. (2003). Harvesting project knowledge: A review of project learning methods and success factors. *International Journal of Project Management, 21,* 219-228.

Sharma, A. (1997). Professional as agent: Knowledge asymmetry in agency exchange. *Academy of Management Review, 22*(3), 758-798.

Starbuck, W.H. (1992). Learning by knowledge-intensive firms. *Journal of Management Studies, 29,* 147-175.

Stasser, G., Stewart, D.D., & Wittenbaum, G.M. (1995). Expert roles and information exchange during discussion: The importance of knowing who knows what. *Journal of Experimental Social Psychology, 31,* 244-265.

Stasser, G., & Stewart, D. (1992). Discovery of hidden profiles by decision-making groups: Solving a problem versus making a judgment. *Journal of Personality and Social Psychology, 63*, 426-434.

Straub, D., & Karahanna, E. (1998). Knowledge worker communications and recipient availability: Toward a task closure explanation of media choice. *Organization Science, 9*(2), 160-175.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practices within the firm. *Strategic Management Journal, 17*(Winter), 27-43.

Szulanski, G. (1999). The process of knowledge transfer: A diachronic analysis of stickiness. *Organizational Behavior and Human Decision Processes, 82*(1), 9-27.

Tsoukas, H. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal, 17,* 11-25.

Tversky, A., & Kahnemann, D. (1974). Judgment under uncertainty: Heuristics and biases, *Science, 1.185,* 1124-1131.

van Eemeren, H., & Grootendorst, R. (1992). *Argumentation, communication, and fallacies: A pragma-dialectical perspective*. Mahwah, NJ: Lawrence Erlbaum.

Vaughan, D. (1997). *The Challenger launch decision*. Chicago; London: The University of Chicago Press.

von Krogh, G., & Roos, J. (1995). *Organizational epistemology.* New York: St. Martin's Press.

Watson, C.M. (2004). Don't blame the engineer. *Sloan Management Review,* (Winter), 26-29.

Weick, K.E. (1995) *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publications.

Whitehead, A.N. (1929). *The aims of education and other essays.* New York: McMillan.

Wilmotte, R.M., & Morgan, P.I. (1984). The discipline gap in decision making. *Management Review,* (September), 21-24.

Yaniv, I., & Kleinberger, E. (2000). Advice taking in decision making: Egocentric discounting and reputation formation. *Organizational Behavior and Human Decision Processes, 83,* 260-281.

Zaltman, G. (1983). Knowledge disavowal in organizations. In R.H. Kilmann, K.W. Thomas, D.P. Slevin, R. Nath, & S.L. Jesell (Eds.), *Producing useful knowledge for organizations* (pp. 173-187). New York: Praeger.

ENDNOTES

1 Both modes can be used in one-to-one or one-to-many contexts. Both modes can rely on speech, text, graphics, and other means of communication (i.e., verbal and non-verbal).

2 Our distinction between data, information, and knowledge follows the mainstream conception found in current literature (e.g., Davenport & Prusak, 1998). We view data as isolated recordings that are often generated automatically and cannot be directly used to answer questions. Information is connected, condensed, or generally processed data that allows an individual to answer questions. Knowledge is what enables an individual to ask relevant questions (Newman & Newman, 1985, p. 499). It refers to the capability of an individual to solve problems (Probst, Romhardt, & Raub, 1999). Information only becomes knowledge if a person interprets that information correctly, connects that piece of information with his or her prior knowledge, and can apply it to problems or decisions (see also Alavi & Leidner, 2001).

3 The concept does not have to originate in the context of interpersonal communication research, but its application to it must be obvious and fruitful, as in the example of the ASK problem. The ASK problem was first discussed in the information retrieval community, but it has ramifications for

interpersonal knowledge communication as well.

4 Each focus group lasted for approximately one hour and consisted of 12-20 participants. The focus groups were conducted in 2002 and 2003 in Switzerland and Germany, with engineers and IT specialists from eight companies (each employing more than 1,000 people). Focus group facilitation and documentation was provided by the research team. The topic of the focus group discussion was "communication problems among engineers/specialists and managers."

5 Each interview lasted between 30 minutes and two hours. Interviewees were mostly senior IT managers or chief information officers of medium-sized and large Swiss companies, as well as select line managers with considerable experience. The main topic of the interviews was "problems in the knowledge communication with specialists."

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Chapter 1.31
Biological and Information Systems Approaches

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INTRODUCTION

Knowledge of past activities, discoveries, and events is applied by businesses to support everyday operations in much the same manner that human beings use their personal memories. But the true nature of organizational memory (OM) remains obscure, and information-systems practitioners have no clear definitional model of what they are working toward and have been unable to build a convincing organizational memory system (Olfman, 1998).

Having apparently reached a dead end, OM studies have been subsumed into knowledge management (KM) research as a subsidiary field. OM research is currently focused on the faculties of an organization that are capable of storing knowledge perceived or experienced beyond the duration of the actual event. Researchers and practitioners in the field use a definitional frameworks and models of organizational memory derived from flawed models of aggregate human behavior used in earlier sociological studies (Frost, 1942; Wilson, 1998). Models derived from earlier sociological studies rarely consider the exact nature and sources of commonplace thinking and memory use, and focus on highly visible and significant behavior and activities. Rapid theoretical and technological advances made in psychology research, brought about by the advent of sophisticated technological aids, have disparaged and largely disproved many of the naive systemic models of human cognition developed by earlier social scientists (Dominowski & Bourne, 1994; Sternberg, 1994) and were incorporated into information-systems sciences in the early years.

Before we consign the hope of deeper knowledge of business memory to the "too hard basket," it might be fruitful to examine an alternative path to understanding the nature of organizational memory and its application: The impersonal and generalized models of business activity (and cognitive operations) inherited from social sciences have not proved fertile, but the individual and personal models of memory and cognition found in biological and related sciences offer some promise in light of recent advances.

BACKGROUND

The human mind has always been, and always will be, an area of great interest to the layperson and scientist alike (Luria, 1973). The sheer volume, and constancy, of research attention it receives has inevitably resulted in a plethora of knowledge that enlightens us about various aspects of the human mind, but, on the other hand, it has tended to add a complexity to our view of human cognitive functioning. The modeling theory and conceptual analysis techniques, however, offer a means whereby the complexity and controversies of a topic can be isolated or marginalized in the interest of building a clear overall picture of a concept or phenomenon (Dubin, 1969). This can be particularly valuable in a field of study like human cognition where scholarly research has branched into many unreconciled and introverted schools of thought.

While many gaps still exist in our knowledge of exactly how humans think and remember (Baddeley, 1998), and the mind is shrouded in scientific (and nonscientific) controversy and beliefs, many incontrovertible aspects and fundamental elements of biological memory offer a path to a less controversial understanding of what organizational memory might be.

Biological studies offer some clues as to the purpose memory has been put to and the structure of memory elements (Carlson, 1994). Anthropology offers an indication of how simple behaviors dependent on memory have evolved over time into sophisticated activities of modern man (Hallpike, 1979). Studies of the psychology of memory provide an increasingly vivid breakdown of what happens when people remember (Carter, 1998). Specialist research into cognitive subelements such as consciousness (Dennett, 1991), emotion (Dimasio, 2000), language (Jackendoff, 1992), and perception (Sowa, 1984) offer insight into the essential nature of human ideas and at the same time provide a means for isolating many of the complexities involved in understanding the relationship between thinking and memory. Some of the more interesting ideas that can be gleaned from these research fields in respect to memory phenomena, and which could stabilize and enrich our current model of organization-centered memory, are presented here.

A BIOLOGICAL MODEL OF MEMORY

Organizational Self

Deutsch's (1966) central idea in his influential model of organizational cognition is an "organizational self," which, like a personal human self, has a central role in focusing and directing all organizational behavior. This idea was studiously avoided in subsequent OM research (Stein, 1995) probably because such a concept is problematic in the context of the shifting (and often private) constitutional and motivational elements that focus and direct modern collective business behavior: Deutsch's example was a formally constituted government authority whose purpose and goals were published and generally unchanging.

KM and OM researchers have recognized the efficacy of personalizing organizational knowledge (e.g., Spender, 1995; Tuomi, 1999), but not the power of one integral element—a person—as an organizing device. Dimasio's (2000) work describes how an individual biological body informs all that organism's cognitive function and provides a single point of reference for all its cognitive artifacts.

The critical nature of an executive intervention in the component processes of memory might be a fruitful area for further organizational memory systems studies in view of Dimasio's (2000) work. An executive that guides organizational behavior is not a new concept (see Corbett, 1997; Middleton, 2002), but its potential as a unifying element in organizational cognitive behavior is not fully appreciated.

Ubiquity of Memory Application in Everyday Operations

Memory function is a faculty inherited by humans from organisms of a much lower order of complexity (Monod, 1971/1997), and the advanced nature of human cognitive achievement owes much more to an ability to consciously hold more than one idea at a time (which lower organisms seem unable to do) than it does to any sophistication in the fundamental cognitive equipment used to perceive and remember (Dennett, 1991).

Human memory supports seemingly simple operations as well as complex ones, and in order for an organism to operate independently from moment to moment and across space, such services must somehow be ever present. What we pursue in organizational memory studies is not necessarily a complex and mysterious set of functions and artifacts, but rather a collection of well-tested and refined things that interact seamlessly with one another to deliberately preserve past experiences and make them available to support subsequent and increasingly sophisticated actions. Pilot studies carried out by the authors to test a biological model of memory in an organizational setting suggest that memory of past organizational events may be applied to many seemingly minor, but possibly essential, organizational activities given little attention in the current OM and KM research literature.

OM practitioners recognize the need to support access to organizational memory via e-mail and the Internet (Schwartz, Divitini, & Brasethvik, 2000), but neither the support nor the process is recognized as worthy of attention at an organizational policy level. Often we identify the office culture, traditional business practices, conscientious employees, and common sense as coordinators and directors of a relationship between organizational behavior and the organization's best interests without investigating organizational memory, which underpins them. Many seemingly inconsequential business behaviors are the foundational support for ensuring the best interests of the organization in critical day-to-day operations.

Biological memory offers constant and continual support for its owners' endeavors; similar support might be offered to a wider variety of organizational memory applications if they were recognized as such.

Memory Ownership

The unifying element in organic memory systems is the self: a personal prototype that provides an impetus and steers the various component operations, giving them a fundamental associative fulcrum (Dimasio, 2000)—a fulcrum that might provide the key to the efficiency and power we admire in memory systems.

With this in mind, it is easier to appreciate the significance of the personal nature of memory. Each memory system is inextricably bound to an individual owner with its own individual history, individual interests, individual desires, and individual goals, preserving its individual perceptions for its individual use. This perspective also illustrates that knowledge objects that have not passed through the owner's cognitive processes cannot be added to the memory store.

Organizational memories, if they are to be real memories and not simply information, must be consciously collected and laid down in the store of memories by the organization itself. Having acquired and laid down the memories by its own hand, the organization is best placed to know the contents of its stores and where a particular memory is likely to be found. Just because a document or idea relates to the past events or activities of an organization, it does not mean that it is accessible for application by the organization in subsequent deliberations or activities (see Wilson, 1997; Yates, 1990).

Information-systems and information-management theorists and practitioners generally recognize the value of information ordering (Simon, 1957), but the relationship between the individual who orders and stores the information and the individual who uses it may be underappreciated.

The biological phenomenon memory does not accord with established concepts of systems and mechanics: The input plus the process may not fully describe the product, and vice versa; what goes into memory may not come out; and the cause or stimulus might not result in any discernable effect (Haberlandt, 1997). Many independent functions might provide services to memory operation while appearing to provide diverse and valuable services in their own right (Chomsky, 1968).

Many established and familiar organizational information and knowledge operations and devices might actually serve essential organizational memory functions. OM researchers risk misidentifying (or ignoring altogether) memory components by taking a systemic view of memory. The relationship between a linking and directing executive and such tasks as the archiving and summarization of documents, and document search operations might not be fully appreciated, and the potential in the relationship for ensuring the best interests of the organization might be overlooked.

Memory psychologist Baddeley (1998) and cognitive scientist Ashcraft (1994) detail a number of sustaining functions and operations supporting memory:

- separate short-term and long-term memory stores and functions, immediate postperception memory stores and functions, and separate autobiographical (sequenced) remembrance stores and functions
- an attention system to monitor prospective sources of memories, and a sensory-perception system to search a stimulus for cues and provide raw material for the subsequent creation of memories
- percept construction systems to associate new experiences to previous knowledge
- an encoding process that transcribes sensory perception into proprietary physiochemical neural matter that matches the structure of those previously stored

The concept of divisions of organizational memory faculties is an interesting one given the diversity of OM support functions previously identified by KM, OM, and information-management researchers. Maier (2002) provides a survey of diverse KM tools and systems. Middleton (2002) describes a history of information-management tools and strategies. These comprehensive lists of technological solutions illustrate the diversity of applications that attempt to operationalise OM functions without an overriding coordination by the particular organization. They can be utilized as guides to OM developers when implementing OM solutions. However, this will require a level of integration across applications to ensure that the knowledge objects are all robustly related to an organizational self.

Focusing attention on prospective sources of valuable information is not a new idea, but its dependence on direction and preexisting contents of information stores is not readily appreciated. In order to attend to the most appropriate sources in the biological world, memory owners must give some thought to who and what are the most potentially valuable sources (Bergson, 1907/1975, 1896/1996). Constant monitoring of the environment to discover other better sources of knowledge are readily appreciated everyday tasks of living things (Sternberg, 1994).

Memory Percepts

Hallpike's (1979) investigation into the anthropology of cognition discovers many simple and universal cognitive operations in primitive, and comparatively unsophisticated, societies. More complex and powerful cognitive operations, familiar in modern Western cultures and clearly the product of enlightened public education systems, are possible because of remembered algorithms, strategies, formulas, and models (made up of a finite set of rules or operations that are unambiguous) rather than from ambiguous reflection, contemplation, or remembrance of past events and facts. Moreover, many of these strategies and models have been deliberately refined to allow a lighter cognitive load: That is, we remember the source of information in lieu of carrying the information itself (aides memoires).

Current models of organizational memory used in information-systems sciences presume a file, book, or document prototype for memory artifacts (see Ackerman, 1994; Walsh & Ungson, 1990) rather than a discrete fact or formula, or discrete pictorial or aural representation. Neither is the source of information recognized as having a value equal to that of a whole document or complete file.

Biological memories are based on percepts created in response to an eternal stimulus and can best be compared to the concept of an idea (Baddeley, 1998). Memory artifacts themselves are not unitary but comprise a network of component mental elements, which together can evoke a memory. The current concept of a whole file, a complete document, or a work practice as a unit of organizational memory is unhelpful to OM researchers: Storing whole files, archiving complete documents, and articulating a tacit work practice are expensive and time consuming, and maybe storing, preserving, and articulating underlying ideas might be more cost effective in the long run.

Memory Encoding

The biological model of memory encoding describes the recording of responses to sensory stimuli in a series of mental artifacts (Baddeley, 1998) richer than the mere articulation in language of an idea or perception. Chomsky (1968) and Jackenoff (1992) have illustrated how the flexibility of biological memories (they can be rearranged, reinterpreted, reused, colored, and decomposed ad infinitum) may derive from their insubstantialness beyond the confinement of concrete or specific language representation.

While language is clearly a primary method whereby ideas can be organized, categorized, associated, and communicated, OM theorists' current view of organizational memories as communicable and substantial language-based informational artifacts (Walsh & Ungson, 1991; Yates, 1990) appears restrictive. Memories put into words are a transfiguration carried out more for communication with others than for the preservation of memories themselves, and it necessarily alters the totality of the idea to accord with a set of commonly shared word concepts and categories. Polanyi's (1964) often misconstrued notion of tacit knowledge was a description of many kinds of knowledge artifacts (remembrances) that are inexpressible in words for one reason or another. OM and KM theorists might consider his work was a call not necessarily to articulate tacit knowledge into words, but to consider inexpressible ideas as equally relevant and often more powerful than those expressed in language.

FUTURE TRENDS

The nature and composition of organizational memory remains obscure, while theoretical models derived from outmoded psychology, common sense, and social theory continue to provide a framework for research.

In contrast, the phenomenological model of human memory (and simpler biological memory systems) offers an easily appreciated and robust representation of the totality of the processes, components, and functions that make up memory systems generally.

While it is generally recognized that organizational memory exists, researchers have been unable to make unequivocal discovery of it (Walsh & Ungson, 1991). It appears to be applied in modern business activity, but the mechanism whereby organizations apply it remains obscure.

Organizational learning studies, organizational memory research, and information-systems and information-management theories all offer credible and effective explanations of aspects of organizational cognitive operations, but they are without a consilience of the various terminologies and conflicting theories across the different research disciplines. The model of human memory promises to provide that if we can reconcile the personal aspect of the human organism to the collective and shared superpersonal nature of the organization. Maturana (1970) offers some constructive ideas toward this reconciliation in his description of unity. He suggests that if we distinguish the behavior of an organizational agent, which is applied primarily in the service of a particular organization, from its private behavior, it becomes easier to distinguish between organizational memory and private memory. From that point, a differentiation of aspects of agent behavior might lead to an insight about what constitutes organizational-memory-directed behavior and what does not.

CONCLUSION

The model of memory offered by biological studies is a rich one. Many aspects have not been touched here, but remain to be discovered by researchers provided they have a flexible but robust definitional framework to base their investigations on. Biological sciences indicate to us that memory is applied in the seemingly trivial activities of everyday life, and that many of those seemingly commonplace activities support more profound actions. While our current usage of organizational memory might be supported in respect to major decisions and activities, we might question how well it is supported in more mundane, and quite possibly critical, tasks.

By reconciling the concepts of organizational memory systems research to the familiar model of biological human memory, theorists might offer a reconciliation of many information-systems and information-management concepts based on the idea that the knowledge management they are working toward involves the same common objects.

REFERENCES[1]

Ackerman, M. S. (1994). Definitional and conceptual issues in organizational and group memories. *Proceedings of the 27th Hawaii International Conference of Systems Sciences (HICSS 1994)* (pp. 199-200).

Argyris, C., & Schön, D. A. (1996). *Organizational learning II.* Reading, MA: Addison-Wesley Publishing Company.

Ashcraft, M. H. (1994). *Human memory and cognition* (2nd Ed.). New York: Harper Collins College Publishers.

Baddeley, A. (1998). *Human memory: Theory and practice* (Rev. Ed.). Needham Heights, MA: Allyn and Bacon.

Bannon, L. J., & Kuutti, K. (1996). Shifting perspectives on organizational memory: From storage to active remembering. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences (HICSS 1996)* (pp. 156-167).

Bergson, H. (1975). *Creative evolution* (A. Mitchell, Trans.). Westport, CT: Greenwood Publishing. (Original work published 1907).

Bergson, H. (1996). *Matter and memory*. New York: Zone Books. (Original work published 1896).

Bloom, F. E., & Lazerson, A. (1988). *Brain, mind and behavior* (2nd Ed.). New York: W. H. Freeman & Co.

Broad, C. D. (1925). *The mind and its place in nature*. London: Keagan Paul, Trench, Trubner & Co. Ltd.

Brown, D. E. (1991). *Human universals*. New York: McGraw-Hill, Inc.

Carlson, N. R. (1994). *The physiology of behavior*. Boston: Allyn & Bacon.

Carter, R. (1998). *Mapping the mind*. London: Weidenfeld & Nicholson.

Checkland, P. (1981). *Systems thinking, systems practice*. Chichester, UK: John Wiley & Sons.

Chomsky, N. (1968). *Language and mind*. New York: Harcourt Brace Jovanovich, Inc.

Corbett, J. M. (1997). Towards a sociological model of organizational memory. *Proceedings of the 30th Annual Hawaii International Conference on System Sciences (HICSS 1997)* (pp. 252-261).

Cotterill, R. (1998). *Enchanted looms: Conscious networks in brains and computers*. Cambridge, MA: Cambridge University Press.

Dennett, D. C. (1991). *Consciousness explained*. Little, Brown & Company.

Deutsch, K. (1966). *The nerves of government*. New York: The Free Press.

Dimasio, A. (2000). *The feeling of what happens: Body, emotion and the meaning of consciousness*. London: Heinemann.

Dimasio, A. R. (1999). *The feeling of what happens: Body, emotion and the making of consciousness*. London: Heinemann.

Dominowski, R. L., & Bourne, L. E., Jr. (1994). History of research on thinking and problem solving. In R. J. Sternberg (Ed.), *Thinking and problem solving (Handbook of perception and cognition series)*. San Diego: Academic Press.

Dubin, R. (1969). *Theory building* (Rev. ed.). New York: The Free Press.

Frost, S. E. (1942). *Basic teachings of the great philosophers*. New York: Doubleday.

Gorry, G. A., & Scott Morton, M. S. (1971). A framework for management information systems. *Sloan Management Review, 13*(1), 55-70.

Haberlandt, K. (1997). *Cognitive psychology*. Boston: Allyn and Bacon.

Hallpike, C. R. (1979). *The foundations of primitive thought*. Oxford, UK: Clarendon Press

Hedberg, B. (1981). How organizations learn and unlearn. In P. C. Nystrom & W. H. Starbuck (Eds.), *Handbook of organizational design*. London: Oxford University Press.

Jackenoff, R. (1992). *Languages of the mind*. Cambridge, MA: The MIT Press.

Jackenoff, R. (1993). *Patterns in the mind: Language and human nature*. New York: Simon & Schuster.

Krippendorff, K. (1975). Some principles of information storage and retrieval in society. In *General systems* (Vol. 20).

Lackoff, G. (1987). *Women, fire and dangerous things: What categories reveal about the mind*. Chicago: University of Chicago Press.

Langer, E. J. (1983). *The psychology of control*. Beverly Hills, CA: Sage.

Levitt, B., & March, J. G. (1988). Organizational learning. *Annual Review of Sociology, 14*, 319-340.

Luria, A. R. (1973). *The working brain: An introduction to neuropsychology.* London: Penguin Books.

Maier, R. (2002). *Knowledge management systems: Information, communication technologies for knowledge management.* Berlin, Germany: Springer Verlag.

Maturana, H. R. (1970). The biology of cognition. In H. R. Maturana & F. J. Varela (Eds.), *Autopoiesis and cognition: The realization of the living.* Dordrecht, The Netherlands: D. Reidel.

Meltzer, M. L. (1983). Poor memory: A case report. *Journal of Clinical Psychology, 39,* 3-10.

Middleton, M. (2002). *Information management: A consolidation of operations analysis and strategy.* Wagga Wagga, New South Wales: CIS Charles Sturt University.

Monod, J. (1997). *Chance and necessity: On the natural philosophy of modern biology* (A. Wainhouse, Trans.). London: Penguin Books. (Original work published 1971).

Morrison, J., & Olfman, L. (1997). Organizational memory. *Proceedings of the 30th Annual Hawaii International Conference on System Sciences (HICSS 1997).*

Norman, D. A. (Ed.). (1970). *Models of human memory.* New York: Academic Press.

Norman, D. A. (1993). *Things that make us smart: Defending human attributes in the age of the machine.* Reading, MA: Perseus Books.

O'Hear, A. (1997). *Beyond evolution: Human nature and the limits of evolutionary explanation.* Oxford, UK: Clarendon Press.

Olfman, L. (1998). *Organizational memory systems: Are they real? A virtual conference transcript.* Retrieved March 18, 2002, from http://www2.cis.temple.edu/isworld/vmc/april98/olfman/default.htm

Pinker, S. (1994). *The language instinct: The new science of language and mind.* London: Penguin Books.

Pinker, S. (1997). *How the mind works.* London: Penguin Books.

Polanyi, M. (1964). *Personal knowledge: Towards a post critical philosophy.* New York: Harper & Row.

Rose, S. (1993). *The making of memory.* New York: Bantam Books.

Salton, G., & McGill, M. J. (1983). *Introduction to modern information retrieval.* New York: McGraw-Hill Inc.

Schwartz, D. G., Divitini, M., & Brasethvik, T. (Eds.). (2000). *Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Simon, H. A. (1957). *Models of man: Social and rational.* New York: John Wiley.

Sowa, J. F. (1984). *Conceptual structures: Information processing in mind and machine.* Reading, MA: Addison-Wesley Publishing Company.

Spender, J.-C. (1995). Organizational knowledge, learning and memory: Three concepts in search of a theory. *Journal of Organizational Change and Management, 9*(1), 63-78.

Stein, E. W. (1989). *Organizational memory: Socio-technical framework and empirical research.* PhD dissertation, University of Pennsylvania.

Stein, E. W. (1995). Organizational memory: Review of concepts and recommendations for management. *International Journal of Information Management, 15*(2), 17-32.

Stein, E. W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Sternberg, R. J. (Ed.). (1994). *Thinking and problem solving: Handbook of perception and cognition*. San Diego: Academic Press, Inc.

Tulving, E. (1983). *Elements of episodic memory*. London: Oxford University Press.

Tuomi, I. (1995). Abstraction and history: From institutional amnesia to organizational memory. *Proceedings of the 28th Annual Hawaii International Conference on System Sciences* (pp. 303-312).

Tuomi, I. (1999). *Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory.*

Walsh, J. P., & Ungson, G. R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Washburn, S. L., & Shirek, J. (1967). Human evolution. In J. Hirsch (Ed.), *Behavior-genetic analysis.* New York: McGraw-Hill Book Company.

Wilson, E. O. (1998). *Consilience: The unity of knowledge*. London: Little, Brown and Company (UK).

Wilson, F. A. (1997). The brain and the firm: Perspectives on the networked organization and the cognitive metaphor. *Proceedings of the Pacific Asia Conference of Information Systems* (pp. 581-587).

Wilson, R. A., & Keil, F. C. (1999). *The MIT encyclopedia of the cognitive sciences.* Cambridge, MA: The MIT Press.

Yates, J. (1990). For the record: The embodiment of organizational memory, 1850-1920. In *Business and economic history* (2nd series, Vol. 19, pp. 172-182).

ENDNOTE

[1] Not all of these sources are explicitly referenced in the text, but they are still listed here as relevant bibliographical material for the purposes of completeness.

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Chapter 1.32
Internet-Based Spatial Decision Support Using Open Source Tools

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ABSTRACT

In the last half decade, there has been growing interest in the concept of collaborative geographic information systems (GIS) in support of decision making, especially in the context of various domains of planning. This interest has spawned an already substantial literature in what is now becoming popularly known as public participation GIS (PPGIS) or community GIS. A central and general objective of PPGIS is to encourage the use of GIS technology by broadly based and geographically dispersed nonexpert users. In the context of planning decision support, this involves creating software with map-based functionality that is responsive to the needs of user groups that have limited experience with computers and only a rudimentary knowledge of even simple spatial analysis concepts. This functionality should be designed to enable these individuals to communicate and interact with higher level users and agencies on an equal footing so that all participants can be both better informed of each others perspectives and more involved in decision-making processes that involve land and resource use planning and management. This chapter considers the general issue of PPGIS in the context of use of the Internet and the World Wide Web as a means of achieving broad participation and collaboration in decision making among dispersed participants with a diversity of backgrounds and competencies in using spatial concepts and analyses. The chapter also considers the role that open source software tools can play in crafting accessible and highly customizable solutions using an example for assessing the quality of primary-level education in Peru.

INTRODUCTION

Research into supporting human decision-making processes through the use of computer-based applications is well established in many fields. This research includes the spatial data domain that, although relatively young by comparison, has a history of over 10 years of experimentation, which has produced a large literature. Several threads of research are intertwined within and between specific application areas that use spatial data resources (such as health, education, urban planning, resource management, etc.). These threads have persisted in the literature and have recently diverged into several new areas.

Much of the emphasis in spatial decision-support research continues to focus on developing tools, typically using macrolanguage scripting exclusively or scripting linked to compilable programming and commercial geographic information systems software, such as workstation Arc/Info and desktop ArcGIS. More recently, however, there is an emergent trend in developing spatial decision-support tools on other software platforms (see, for example, Andrienko, Andrienko, & Voss, 2003; Rinner & Malczewski, 2002; Voss, enisovich, Gatalsky, Gavouchidis, Klotz, Roeder, & Voss, 2004), and especially using the Internet as a deployment and communications medium (Dragievi & Balram, 2004; Evans, Kingston, & Carver, 2004; Rivest, Bedard, & Marchand, 2001).

The applications that are bound to mainstream commercial GIS are characterised to varying degrees by a number of limitations. These limitations have been itemized by a number of researchers. They include, among others, relatively cumbersome and potentially difficult to use interfaces (due to the relative difficulty of developing common user interface dialogs and menus with scripting languages, especially in the earlier tools); a preponderance to a single-user, single-decision problem orientation, often using proprietary spatial and tabular data formats, but with far less dependence on import and export of nonstandard file formats and nonscenario-based and nonshared (stand-alone) spatial analysis than in the past; limited flexibility and options in the support functions, which are required to address specific types of decision problems (Jankowski & Nyerges, 2003); and steep learning curves in the use of the tools for nonexpert users (Feick & Hall, 1999; Uran & Jensen, 2003).

These problems have plagued the practical use of GIS use in decision support to the point where some researchers have recently reevaluated progress in order to facilitate more constructive use of the technology for this purpose (see, for example, Higgs, 2004; Merrick, 2003; Nyerges, Jankowski, & Drew, 2002; Uran & Jansen, 2003;). This critical reevaluation is in part due to the fact that relatively few cases of deployment of spatial decision-support tools have resulted in successful outcomes beyond the academic arena. Certainly, while many tools have been developed, there are few published or well-documented cases that can be heralded as having clear and continued utility in improving public decision-making processes (for example, while it is possible to develop an Internet map-based tool for broad-based public input into where nuclear waste disposal sites should be located (Evans et al., 2004), it would be quite another matter to have such a tool used by a nuclear power authority to guide actual site choices). This dislocation between academic research and its practical uses is complex, and by no means limited to the domain of spatial decision support. However, it is likely that the relative lack of successful use of spatial decision support tools for actual decision making is in part related to a basic mistrust of academic research by some practitioners, as well as a combination of the factors outlined previously.

New research threads in spatial decision support may offer renewed optimism for this area of investigation. In particular, four strands can be identified. These include, first, interest in facilitating the use of GIS technology by nonexpert members of the general public, more commonly known as public participation or community GIS (PPGIS or simply PGIS), especially within the context of collaboration in decision processes that relate to various forms of planning (Craig, Harris, & Weiner, 2002). Second, the varied dynamics of individual and group participant, colocated and dispersed, facilitated and non-facilitated decision support have also received increased research attention (Hendriks & Vriens, 2000; Jankowski & Nyerges, 2003). Third, the advent and rapid diffusion of open source GIS (OSGIS) and other software have created a surge of innovation that offers many possibilities for crafting nontraditional and, when tightly coupled with Internet-based delivery, highly accessible and flexible software architectures to address spatial decision-support problems. Finally, the possibilities offered by the now widespread (in economically advanced) and rapidly growing (in developing countries) use of the Internet itself as the major global communications medium has revealed many new possibilities (Carver, Blake, Turton, & Duke-Williams, 1997; Dragicevic & Balram, 2004; Dragicevic, 2004).

These four threads of research are closely interrelated, and build upon the existing body of knowledge on decision support within the spatial data domain. They have allowed improvements to be made and new approaches to be developed to address problems that relate to collaboration during decision processes. This chapter focuses specifically on the potential of OS software, the Internet, and the World Wide Web (Web) to liberate access to spatial data and broaden their use through the creation of tools that allow, in principle, any person or group with a connection to the Internet to be able to use spatial data in general, and for supporting decision processes in particular.

The domain of interest in the chapter is primary-level education planning and specifically, the evaluation of education quality at the individual school level in Peru. An application is described that is developed exclusively with the use of Web-based OSGIS software that is freely available for download, enhancement, and deployment with no financial costs in acquisition or licensing. Moreover, the databases and decision-support tools are themselves provided on the Internet with full source code for others to download, modify, and enhance. The approach subscribes to the concept and manifesto of the OS initiative (http://www.opensource.org) and the objectives of PGIS in the sense that the only restrictions placed on either developers or users are those imposed by the limits of their interest and/or willingness to learn.

The approach can equally serve the participatory goals of individuals and/or groups who can be colocated and working together on evaluating education quality with a view to decision making, or dispersed and working independently on the same sorts of issues via the Internet. The groups can be diverse with highly varied computing skills, perspectives, and knowledge bases. For example, in the application discussed in this chapter, participants can include parents seeking to evaluate the performance of neighbouring schools relative to an important choice they have to make for their children about to enter school, or to evaluate performance of the school their children already attend relative to others nearby; school administrators seeking to identify aspects of their school that need to be improved relative to other schools; teachers who are interested in assessing aspects of the education process so they can enhance the learning of their students; and Education Ministry planners at the local, regional, and central government levels who need to make important decisions on resource allocations for schools they are responsible for administering. In addition, the tool is also useful for independent researchers from the academic and nongovernment organization (NGO) sectors as it provides these participants with ready access to clean and well-compiled spatial databases, as well as freely available analysis tools that offer flexibility in problem scoping and decision making support. It is possible for any number of individuals within these groups to collaborate on evaluating education quality and building strategies for improving this.

The chapter is structured as follows. The next section briefly reviews the migration from single user to group collaboration, and from standalone GIS to the Web as a means of facilitating various types of spatial decision support, noting the strengths and weaknesses of the approaches. This discussion also highlights needs that can be filled with the use of OS Web-based software in current spatial decision support applications. The innovation that is made possible through the use of OSGIS-based tools is discussed more fully in Section 3, focusing specifically on the Web. This discussion includes OS Web mapping, object-relational databases that have spatial data capabilities, open Web programming languages, and Web services. The design and functions of the specific decision-support tool developed to assess education quality in Peru using these components is described in Section 4. Section 5 presents a sample application of the tool. The chapter is concluded in Section 6 with a summary of the main points and directions for future application development.

INDIVIDUAL AND GROUP DECISION SUPPORT AND THE INTERNET

One of the four emergent research threads noted above concerns the dynamics of individual vs. group, colocated vs. dispersed, and facilitated vs. nonfacilitated participation. This thread recognizes the important fact that there are many possible forms of participation, and that flexibility in selecting the best form of participation for participants will enhance the success of addressing a decision problem. It is therefore important to create high-level architectures for decision support tools that can be relatively easily modified to accommodate multiple decision approaches that allow for varied practices, preferences, and abilities of the decision participants. Further, it is important to accommodate group collaboration as well as individual participation as, unlike buying a new car or developing an investment strategy, very few decisions in the spatial domain, and especially those in the context of urban or regional planning, are made by a single individual. Hence, independent of the use of the Internet, which is discussed below, it is important to facilitate group interaction in problem scoping and analysis as well as individual use. This expansion of the scope of interest represents a shift from building decision support tools by programming for individuals (and single problems), to consider explicitly how these tools might best be used in facilitating both individual use and group collaboration in a variety of decision contexts. In addition, the cultural and political context of the decision problem needs to be considered, along with the actual tools that are used.

Generic spatial decision support tools that cover all possible end-user needs and forms of participation have yet to be developed, as virtually all instances of the tools reported in the literature are specific to a particular domain and/or to a specific type of user interaction. However, recent research (for example, Peng, 1999; Peng & Zhang, 2004) has investigated and reported on the use of emergent data and open programming standards for the development of tools using the Internet and the Web as a deployment medium. In particular, current research on new and potentially revolutionary "sensor web" technologies, including sensor model language (SensorML) and associated services, seeks to create enabling tools primarily for environmental sensors and applications to connect across the Internet independent of their location (Reichardt, 2004).

These standards, most of which combine the use of OS software tools, herald the introduction of an era that will likely witness new and much more flexible approaches in terms of crafting generic tools that can address individual use as well as group collaboration, colocated and dispersed use, and moderated vs. nonmoderated decision support problems within the spatial data domain.

In this context, scalable vector graphics (SVG), geography markup language (GML), and the Web feature services specifications established by the Open Geospatial Consortium (OGC) offer many possibilities for crafting tools that have the capability to be adapted relatively easily to various types of decision problems, as well as to various forms of use (OGC, 2005). Moreover, in the last 3 or 4 years, the arrival and rapid uptake of OSGIS and other software components, such as those noted in Section 3 that can use the OGC standards, breathes new life into this area of research. However, given the relative recency of these standards and the OS components, their impact on application development will not likely be immediate, but will rather appear incrementally over the coming years.

In addition to experimenting with new data, Web features standards, and OS components, the progression of spatial decision support development has moved increasingly toward the use of languages such as Java, GML, and prehypertext processor (PHP). These new tools provide the needed flexibility in software development that can produce applications for single and group users as well as stand-alone applications and distributed participation via applications deployed on the Web. In this context, the development of the CommonGIS platform (Andrienko et al., 2003) comes close to being generic in its ability to address decision problems, as well as function as a general purpose GIS. The software, which is not open but is fully developed in Java, achieves its Web readiness through the use of Java applets and plug-ins (Voss et al., 2004). In addition, functions already developed in CommonGIS can be used by individuals for selection, prioritization, and integration of decision options. For group decision making, the developers have created a voting interface for interactive ranking and classification options for groups and that can be moderated by a facilitator to survey and analyze submitted votes (Andrienko et al., 2003).

CommonGIS also has the ability to facilitate, in conjunction with a tool named Dito, user communication via asynchronous use of self-guided or moderated messaging, which can be assembled into communication threads created by e-mail or directly on the Web (Voss et al., 2004). This creates the ability for decision participants to communicate using messaging with one another, independent of whether they are colocated, dispersed, and participating either in virtual groups, or working individually on a decision problem via the Internet. In addition to CommonGIS, other proprietary tools such as the Java-developed Web-based mapping software JMap (KHEOPS, 2005) have been developed to support online collaboration that allows individual and group participants in decision problems to communicate asynchronously with each other by annotating and sharing maps in common views.

The conceptual underpinnings of the research thread on participatory decision making is lead especially by the contributions of Nyerges and Jankowski (see, for example, 2001a, 2001b, 2003) and others (Hendriks & Vriens, 2000). Their contributions have focused primarily on developing frameworks and strategies for determining the strengths and weaknesses of various approaches to participatory GIS use and decision support for the general public (see also, Craig et al., 2002; Seiber, 2000a, 2000b; Weiner et al., 2001). In this work it is recognized that in order for spatial (and other) decision support tools to be used to advantage, they must be built not to satisfy the objectives of the developer, but rather to meet the objectives and needs, as well as the preferred practice of participation, that are most useful to the user(s). Moreover, there must be a close alignment between the construction of a tool and the decision process it is intended to support, explicitly taking into account issues that relate to usability and collaboration (Haklay & Tobón, 2003; Merrick, 2003). To achieve this, ease of use and flexibility of architecture in terms of individual use and group collaboration must be recognized as being at least as important as functionality that determines, for example, how decision alternatives get specified and evaluated by participants. This suggests that in the new generation of software the form of user participation in the decision process should take on elevated importance, as should the need to focus on the practice of participation (individual group, colocated vs. Dispersed, etc.), rather than the mechanics of evaluating decision alternatives.

This conceptualization represents a general move toward thinking beyond the traditional single problem, single decision maker focus of early spatial decision support development, where capacities existed for only one person (or potentially one group working on the same machine at the same time) to assess a problem by generating decision alternatives, and then using a ranking mechanism to identify the most suitable option. The new approaches that are required are not only conceptually, but also operationally considerably more complex. They also represent an implicit acknowledgement that system developers must take into account what Hendriks and Vriens (2000) refer to as spatial complexity in helping users navigate the evaluation of a decision problem. Here, rather than pursuing a solitary objective of solving a decision problem by finding a satisfactory outcome, a dual objective of decision support must be to understand better the nature of the problem under discussion through interactive use of spatial data, and through synchronous and asynchronous communication between participants during the decision process.

In the quest to achieve heightened understanding of a decision problem and to create a framework for informed input on the part of a wide spectrum of participants, the objective, therefore, is not to confuse or confound issues through the use of overly complex concepts and procedures (Uran & Jansen, 2003). Rather, the objective is to make the use of spatial data and analysis/evaluation procedures as transparent as possible, so users can link the procedures used to generate an evaluation with the nature of the results they generate. To enhance the possibilities for grassroots-level participation in spatial decision processes, tools should also accommodate a wide range of user needs and skill sets, from the very basic to the very sophisticated, and allow a user to work with the level of complexity that he/she is most comfortable with. However, it is important not to reduce the roles of spatial data and geographical thinking to those of “ghosts in the machine” (Schuurman, 2003) in achieving this level of transparency. That is, rather than analyses being black box-oriented, they must be understandable to users, with the premise that if a user understands the process, then they are more likely to understand the outcomes. Merrick (2003) has shown that this level of understanding can be achieved through the collaboration of participants with varied skill sets, working together and mutually reinforcing each other’s perspectives.

In the above discussion, the role of the Internet and Internet-based GIS is central to realizing the needs that are identified. What Kling (1999) described as recently as 1999 as the “next generation Internet” is already about to be superseded by a second generation of advanced Internet. Social access to the Internet is now broadly supported for ordinary people at home and in public service agencies worldwide, especially in economically advanced countries. Moreover, recent advances in the Internet’s presence in developing countries means that access is not privy only to the economically advantaged, but that local solutions, such as low access cost Internet cabinas (using the Latin American term), have emerged in virtually all communities in response to market-driven demand for access (Fernandez-Maldonaldo, 2001). This has both broadened and intensified the use of the Internet globally.

The pervasiveness of the Internet has had an important spillover effect on the development of online GIS in general and in the domain of spatial decision support in particular (Dragicevic, 2004). Current decision support applications are dominated by Web-mapping extensions developed by the mainstream commercial software vendors (such as ESRI's ArcIMS, Intergraph's Geomedia Web Map, MapInfo's MapXtreme, and Autodesk's MapGuide, among others). Recent research has shown that commercial Web-mapping products can be used constructively for collaborative online decision making with spatial data (for example, Dragicevic & Balram, 2004). However, other noncommercial Web-based GIS products are appearing from within the OS software community.

The possibilities that exist for innovation with the use of OS tools are considerably greater than with commercial products by virtue of the flexibility that is available through the openness of the former for developers. That is, it is possible to experiment with new architectures, new functions, and whole new approaches to decision support that address most if not all of the needs identified in this section. Before describing the design and general implementation of an OS spatial decision support tool developed for use in Peru, it is first necessary to outline the enabling software used, and its genesis within the OS software movement.

INNOVATION AND OPEN SOURCE SOFTWARE

The third thread of research noted in the introduction to this chapter refers to the rapidly growing trend in innovation through the use of OS software development. This approach essentially means that the original source code for software is left "open" and available for those who are interested in viewing the code, using it, and/or modifying it to suit their specific needs. This approach is not a new phenomenon, however it has gained prominence over recent years as the number of developers and users of OS software have steadily increased. In 1998, the Open Source Initiative (OSI, 2005) was established as a nonprofit organization to manage and promote the definition of OS, and to prevent abuse of the name "open source" as a brand or label.

By 1999, the term "open source" had become integrated fully into mainstream computing parlance, but was considered too overly descriptive or general to be registered as a trademark by the OSI. The open source definition (OSD) that was adopted outlines the principles that must be upheld by licenses applied to OS software. First, licenses must not restrict distribution of the software as either source code or in compiled form. Second, OS licenses must permit either derived works based on the original source code, or modifications through third-party patches to change the software. Third, OS software licenses must be unbiased in every sense, such that people, groups, or fields of endeavour are not discriminated against, and such that the license applies equally to all whom the software is distributed. Finally, the OSD also implies neutrality towards technology such that OS licenses may not restrict software to be used with any other software, or restrict the use of other software, nor may it be predicated towards any individual technology or interface (OSI, 2005).

The rapid diffusion of OS software that has taken place since the late 1990s is the outcome of several trends that have converged in recent years. In particular, the efforts made by the OSI have effectively turned around the negative image that "free software" had outside the OS community, and has made the OS concept a viable alternative to standard commercial software. Over the same time period, the expansion of the Internet, in terms of coverage, bandwidth, and usage has increased significantly. This has allowed the geographically dispersed software developers and organizations that volunteer time, or operate in a nonprofit manner based on funding from donations and research grants, to be able to communicate and collaborate in the development of OS projects.

Initially, OS was predominantly associated with high-profile projects such as the Linux operating system, the Apache Web server (which remains the most commonly used Web server in the world), and the Mozilla Web browser. As the principles and benefits of software developed using the OS approach have increasingly become common knowledge, the number of projects and people using them has grown steadily. On the surface, the most commonly identified benefit of using OS software is that it can be used, modified, and distributed by anyone at no financial cost. Yet there are subtler and more significant benefits. In particular, quality control of the software is essentially in the hands of the developer and user communities, since OS projects typically provide avenues for nonaffiliated users to give feedback, report problems, and/or submit their own solutions or upgrades to OS tools. Thus, in a sense, the OS approach can be viewed as a form of public participation in software development. Unlike commercial businesses selling proprietary or "closed source" software, OS projects generally stand to lose nothing by announcing problems or security issues. In fact, OS software benefits from this by enabling the entire user and developer communities to respond immediately and contribute to solutions. In contrast, proprietary software can only be maintained by the original authors or copyright owners, and software upgrades or security patches are only produced and released when it best suits the owners. This dynamic interaction between developers and users within the OS community has led to some of the most successful and highest quality software yet developed (such as those mentioned earlier).

The main challenges associated with the use of OS software generally stem from the fact that it is normally developed to satisfy the needs of developers and, as noted in section 2, this is an approach that is almost guaranteed to fail relative to the goal of developing broad-based and highly usable decision support tools. In addition, OS software is generally distributed "as is," such that its authors or distributors are not liable in any way, nor are obligated to provide documentation, user support, or warranties. Consequently, the use of many OS projects is limited to experts familiar with the use and manipulation of low-level source code. However, where OS software meets the needs of a large enough number of people, members of the user community have contributed considerable effort to produce documentation, enhance the user-friendliness of the software, and provide supplementary support to peers and users.

In addition to major nodes of OS development such as SourceForge.net (the most recent statistics report that SourceForge.net hosts approximately 100,000 OS projects, and has over 1,000,000 registered users (http://www.sourceforge.net)), many well-organized or established OS projects are hosted by independent sites or by community sites that cater to specific themes. In addition, numerous Web sites have been assembled as catalogues of OS projects available from various independent or public sources, usually referring to software related to a particular theme or area of interest. As the OS community has grown in general, so too has the open source GIS (OSGIS) community. While the number of developers and users supporting OSGIS projects is relatively small, several notable projects are under development.

Among the most common requirements among organizations that make use of spatial data is the ability to generate and distribute data as cartographic maps or via interactive mapping tools. The establishment of open standards for spatial data formats, processing, and Internet-based transfer protocols by the OGS was noted earlier. These standards have helped to promote many OSGIS projects, as well as to standardize interoperability between both OS and commercial GIS tools. From this environment of innovation, numerous OSGIS projects have emerged. While it is beyond the scope of this chapter to describe these in any detail, most of these projects can be located on the Internet via the FreeGIS.org (http://www.freegis.org) Web site, which catalogues all forms of OS software related to GIS and spatial data processing. Further, the MapTools.org Web site (http://www.maptools.org), hosted by DM Solutions in Ottawa, Canada, has also emerged as a project-hosting service similar to SourceForge.net (though at a much smaller scale), catering specifically to OSGIS projects.

In general, there are two areas of development in OSGIS that are relevant to this chapter. The first relates to the need to display and interact with spatial data in distributed environments for which the concept of Web mapping has become a standard solution. In this category, MapServer has emerged as a particularly popular OSGIS solution. The plans for development of MapServer began in 1996 with the partnering of the University of Minnesota with the Minnesota Department of Natural Resources (DNR) in the ForNet project funded by NASA (Lime, 2004). Its initial purpose was to deliver remote sensing projects to field forestry staff. Web-mapping solutions at the time were either proprietary (e.g., the Xerox Parc Map Server released in 1994), or relied on commercial tools such as the early ESRI Web-map servers. MapServer 1.0 was first released in 1997 as an independent common gateway interface (CGI) program, taking advantage of existing OS tools for graphics and interaction with GIS data using the ”open” ESRI ShapeFile format (.shp).

MapServer was first released as public OS software in 2000. Since that time it has grown steadily, both in terms of its overall functionality and its acceptance by the OSGIS community (Lime, 2004). The number of contributors has grown from 2 at the time of its OS release to 19 developers and 15 documenters around the world. The various contributors have made significant improvements to MapServer by enhancing its overall functionality, and producing tools to make it easier to use. DM Solutions, for example, has produced a series of tools that make development of MapServer applications much easier. These include a version of the MapScript library that interfaces with MapServer from within server-side PHP code; the Rosa java applet which provides a dynamic Web-based user interface (beneficial for interacting with maps generated by MapServer); MapLab, a PHP-based tool that provides a programming interface for authoring map files for MapServer; and, more recently, Chameleon, a PHP-based system of “widgets” that can be used to produce highly functional and flexible Web-based interfaces for MapServer projects. Contributions such as these have enabled many MapServer users to develop highly functional Web-mapping applications.

Despite its growing success, MapServer is not a fully functional GIS, nor should this be a development objective. Rather, it is a tool that enables the development of visual interfaces primarily via Web pages, based on the most well-known spatial data formats. This leaves a second area of development that had to be filled by other OSGIS projects, namely the storage and processing of spatial data. In 2001 following the OS release of MapServer, Refractions Inc., a company located in Vancouver, Canada, initiated the development of PostGIS, which ultimately reached full maturity when it was released as version 1.0 in April, 2005. PostGIS is an add-on module for the OS PostgreSQL object-relational database management system (ORDBMS) that enables the storage and processing of spatial data in PostgreSQL databases via structured query language (SQL). The SQL that is used in Postgre is based on the OGC simple features for SQL specification (OGC, 2005). PostGIS also relies on two other OS tools, namely the geometry engine open source (GEOS), also developed by Refractions Inc., for spatial topological functions, and the Proj.4 library available from RemoteSensing.org (http://www.remotesensing.org), for projection and transformation of spatial coordinates.

Essentially, PostGIS provides all of the standard functionality expected of any GIS, with the added advantage of advanced functionality available through spatially-enhanced SQL in PostgreSQL. In addition, upon the recent release of PostgreSQL 8.0 in late 2004, major improvements have made it comparable to most commercial enterprise-level database systems. Since the latest releases of both PostgreSQL and PostGIS, contributors have worked to package the software to make it as easy to use as possible (e.g., producing documentation and/or installer programs for MS Windows). Although there are existing commercial equivalents to PostgreSQL such as ESRI's Spatial Database Engine (SDE) and Oracle Spatial, these tend to be very costly and have high-management overhead. Following PostgreSQL, MySQL, an OS ORDBMS with a much larger developer and user community than PostgreSQL, also released a version (version 4.1 in September, 2004) with spatial object support based on the OGC standards. However, the spatial functionality incorporated into MySQL has yet to reach the level of that provided by PostGIS.

Together, the use of the PostgreSQL and PostGIS projects form an excellent starting point for alternatives to commercial GIS software. Recent user trends are a testament to this. Since late 2003, the number of registered users of PostGIS has more than doubled from approximately 230 to approximately 600 as of May 2005. Over the same time period, the number of downloads of the PostGIS source code per month has more than tripled from approximately 350 to 1200 (Ramsey, 2005).

In 2002, not long after the initial development releases of PostGIS, support for the PostGIS data format was added to MapServer. Although optional support has also been added to MapServer for other spatially enabled database systems (namely SDE and possibly also Oracle Spatial), the pairing of MapServer with PostGIS has become an ideal solution for Web-based spatial decision support projects that require highly flexible and scalable architectures. With the option to control both MapServer and PostGIS using application programming interfaces (APIs) available for PHP with MapScript and PostgreSQL functionality included with PHP, it is highly feasible to develop an entirely OS approach to address the design and functionality needs of spatial decision support tools identified in section 2. Combined with tools contributed by the MapServer/PostGIS community (particularly those contributed by the DM Solutions group), all of the requirements for building Web-based tools with highly adaptable and advanced functionality for both individual and collaborative use are available through OS tools.

This combination of OS components was used to develop an operational Web-based tool that uses an intuitive interface for individuals and groups to assess the quality of early childhood education in Peru, and to assist in generating dialogue between stakeholders that will result in planning for systemic improvements. The databases and information derived from use of the tool relate to all levels of the education hierarchy, as well as to locational data on community-based characteristics of school contexts. The approach used is of particular interest as the level of computing skills among users is highly variable: from indigent parents living in very poor urban, rural and jungle areas of Peru, to school teachers and administrators in the same areas, as well as local, regional, and national planners within the Peruvian Ministry of Education and researchers within the NGO and University sectors. The high-level design and a sample application of the tool are presented in the following sections.

DESIGN AND FUNCTIONS OF THE EDUCAL DECISION SUPPORT TOOL

The issue of education development during the formative years of the education process is high on the agenda of many governments, especially in developing nations. This is a function of the recognition that education is a fundamental aspect of the development process, and that access to a good quality education is a prerequisite for the populations of nations to compete and operate in today's globalized marketplaces. Moreover, ensuring fundamental principles of equal access to a quality education independent of gender, religion, ethnicity, wealth, and geographic location (among other things) is a basic human right that must be sought by all nations in the world.

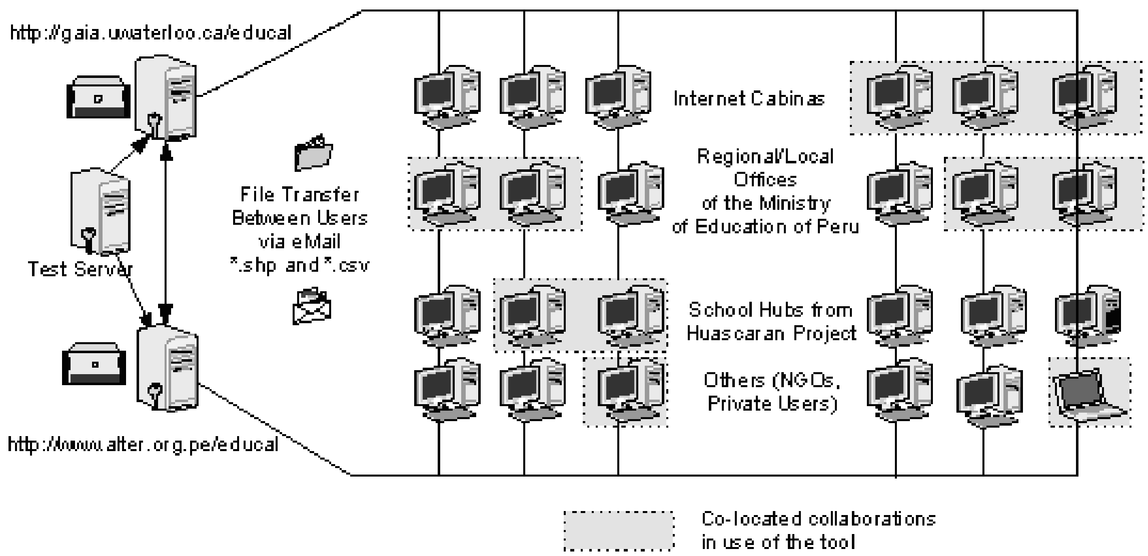
These considerations have been addressed in different ways by different nations. Since 2002 in Peru, for example, the government has passed a number of laws that require decentralized education planning and management, as well as greater transparency in the access of all members of Peruvian society to basic government information (Hall & Peters, 2003; Peters & Hall, 2004). These actions have created in Peru the need for mechanisms that enable data to be returned back to its original collection points, packaged as information. Subsequently, according to the principles of decentralized management and planning, there is a further need for knowledge-generating tools that allow stakeholders in the education sector to dialogue with each other, and to make informed local-level decisions that seek to improve the quality of education.

The required mechanisms and tools are provided in Peru by the EduCal project. The acronym EduCal stands for in English Education Calculations and in Spanish Educación de Calidad, or an education of quality, and it represents both a specific tool as well as an approach to fostering decision-oriented collaboration between stakeholders in the education planning process. In short, EduCal allows stakeholders to use a custom programmed, Internet-based tool developed entirely using OSGIS and other OS software to evaluate school and area-based education quality. The tool uses an intuitive multilingual interface (Spanish and English) with scenario-based methods that function equally well for colocated users as for independent, dispersed users. Use of the tool allows stakeholders to understand better the absolute and relative performance of schools and their geographic contexts according to easily customizable assessments of school-based education quality and community-based indicators of well-being.

The Internet is central to the way that EduCal is conceived and the way that it functions. As noted in the previous section, the pervasiveness of Internet access points in even the most remote corners of many developing countries, including the ubiquitous public cabinas in Peru, provides an infrastructure that facilitates the access of a wide range of stakeholders to participate in education assessment and planning. EduCal allows users to work individually or to collaborate in group, colocated evaluations, as shown in Figure 1. The software and associated databases are served from two mirrored servers, one located in Waterloo, Canada and one in Lima, Peru. Both are PHP-enabled production servers and are linked to a similarly configured test server that is not advertised to users. All servers require authenticated login using a secure socket layer (SSL) certificate. This allows users to save scenarios they have generated to their own userid and password-secured accounts for future recall and comparison or modification. Users can create group and/or individual accounts, depending on the preferred or most practical form of participation identified in Figure 1.

Basically, four types of uses are anticipated with the tool, namely individual or colocated group use for parents, teachers, or administrators working in an Internet cabina; individual or colocated education planners working from the local or regional offices of the Ministry of Education; parents, teachers, or administrators working individually or in groups on networked computers running at schools participating in the Huascarán project (for more information see http://www.huascaran.edu.pe/); and NGO, university, or private users who can also work

Figure 1. High-level architecture of Web-based user interaction of EduCal tool



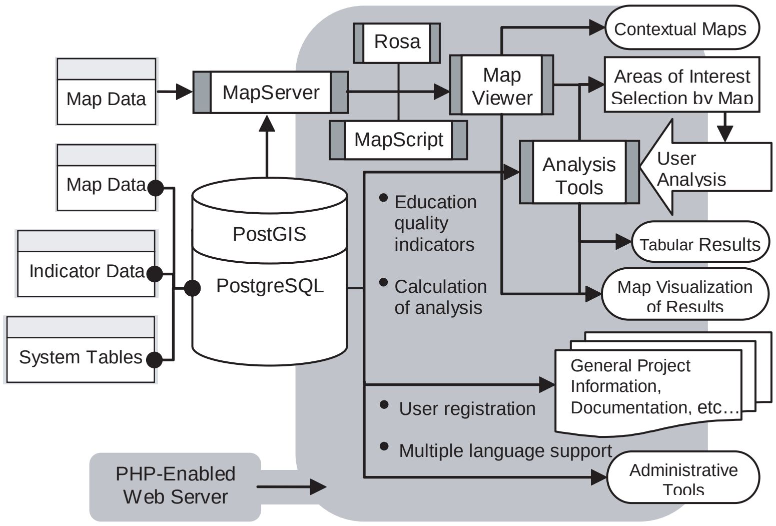
in colocated groups or by themselves. As shown in Figure 1, it is also possible to have vertical or mixed interaction between different access points and types of users to encourage further collaboration and dialogue.

EduCal's object relational database managed by PostgreSQL and PostGIS. The database contains basic map layers including, among others, school points, population centre points for rural areas, city block polygons for urban areas, and all relevant areas of higher spatial aggregation (districts, zones, provinces, departments (recently renamed to regions), and the entire nation). Attached to the school points are detailed normalized and cleaned (parsed for obvious errors and either corrected or flagged as suspect and not analyzed) data from the regularly enumerated (at least every 2 years) censo escolar or school census. In addition, other databases are included on individual student nutrition and height. The education databases are available for approximately all 33,000 state-managed primary schools in the country. Data are keyed on the codigo_modular, which is a unique identifier for all schools.

Approximately 500 variables are available for education quality assessment from the school database. These indicators are sorted into four closely related, yet distinct dimensions of the education process (Peters & Hall, 2004), namely inputs, processes, outputs, and outcomes. In addition, EduCal provides a large database of approximately 150 indicators of contextual variables assembled from the most recent Peruvian census of population and dwellings at city blocks in urban areas and population centres in rural areas. This recognizes that education quality is not simply a function of what occurs during the school day, but also the quality of life of students in their homes.

The conceptual design of the EduCal tool is illustrated in Figure 2. As noted earlier, the Web site runs within the environment of a PHP-enabled Web server that allows server-side programming to generate dynamic Web pages that users interact with. Supporting this Web site is the PostgreSQL

Figure 2. High-level interface diagram of OS components of the EduCal tool

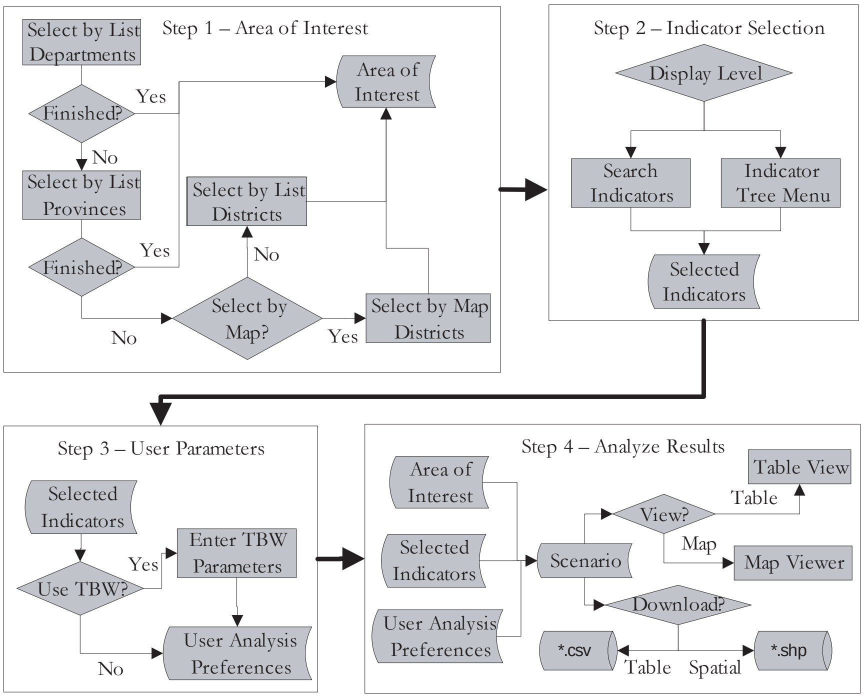


database, described earlier, with the PostGIS extension installed for spatial data handling. The database also contains various system tables that support the Web site's functionality, such as user authentication, and embedded multilingual presentation. These tables can be managed through basic utilities accessible to users with administrative privileges to the Web site. In addition, the database stores the indicator data and associated map layers required for the education quality analysis tool.

The map viewer, also developed in PHP code, utilizes MapScript's API to load dynamic map information, generate a map image with MapServer, and present the map to users. The Rosa Java applet incorporated in the map viewer's output adds a more dynamic mapping interface, improving the user's interaction with the software. The map viewer is configured such that it can operate as a mapping interface alone for presentation of contextual maps using PostGIS map data or other spatial data types. In addition, it enhances the education quality analysis tool by enabling map-based selection of study areas and presentation of assessment results.

The analysis tool is EduCal's main feature for users interested in accessing data and assessing education quality as a basis for making improvements through dialogue between stakeholder groups. The tool is presented to the user in four steps, as illustrated in Figure 3. The first step begins by asking the user to identify a geographical area of interest. Selection of a study area begins by allowing departments/regions, the top level of administration within Peru, to be selected from a scrolling list box. Having selected one or more departments, users may choose to use their selection to define the geographical extent of their analysis, or proceed to select from a list of provinces (the next administrative level) that are nested within the departments/regions. Finally, if any provinces have been selected, districts within the selected provinces may optionally be selected from a list, or selected spatially using one of several methods available on the toolbar within the map viewer.

Figure 3. Four-step procedure for education quality assessment with EduCal



Having completed the first step, the second step prompts users to select a set of indicators for analysis from those available in the database. The indicators are presented in a Java-based expandable tree comprising five categories based on the four dimensions of the education process and the social context. Options are available to select from a basic subset of indicators, an intermediate list including more indicators, or a complete list that allows selection from all available indicators within any category. This leads to the third step, where users may choose to analyze the indicators directly, thus proceeding on to the fourth step. Alternatively, users may choose to assess the indicators selected in the previous step with a target-based weighting (TBW) method. The TBW approach allows users to discuss their perspectives if working together in a group, or if working alone, to use their own perspective of education quality by defining how each indicator should be interpreted. To do this, users must specify a range of acceptable values for each indicator (minimum to maximum), and the ideal value or target within the range. In addition, the relative importance of each indicator can be specified by relative numerical scalar weights assigned by the user(s). These parameters are processed by the EduCal tool to produce an overall index (optionally normalized between 0 and 1) for education quality and social context that can be used to rank cases (i.e., schools, districts, provinces, etc.) in a way that reflects the analyst's perspectives. Further information on this method and its use can be obtained from either the Guided Tour or the Help system within the EduCal Web site (Figure 1).

The fourth step of the analysis process provides options for further dialogue by viewing, evaluating, and saving the output from an analysis.

In this step, users are presented with options to view results in tabular form for various levels of aggregation (depending on the study area selected in step one). In addition, users may select options to view classified thematic maps based on the calculated TBW indices (or based on the unweighted indicators, if TBW is not used). The analysis scenario itself may be saved in a user profile on the Web site so that it may be reloaded and/or modified on the Web site at a later time. Finally, results from the analysis may be downloaded in tabular (*.csv) or spatial (*.shp) file formats, enabling users to save the results locally and examine them off-line using other statistical or spatial analysis software packages. In addition, results in the form of map outputs and attached comma delimited tables can be sent to other participants in a group evaluation by automated e-mail from within the tool. To illustrate better how these functions work, a sample scenario is presented in the following section.

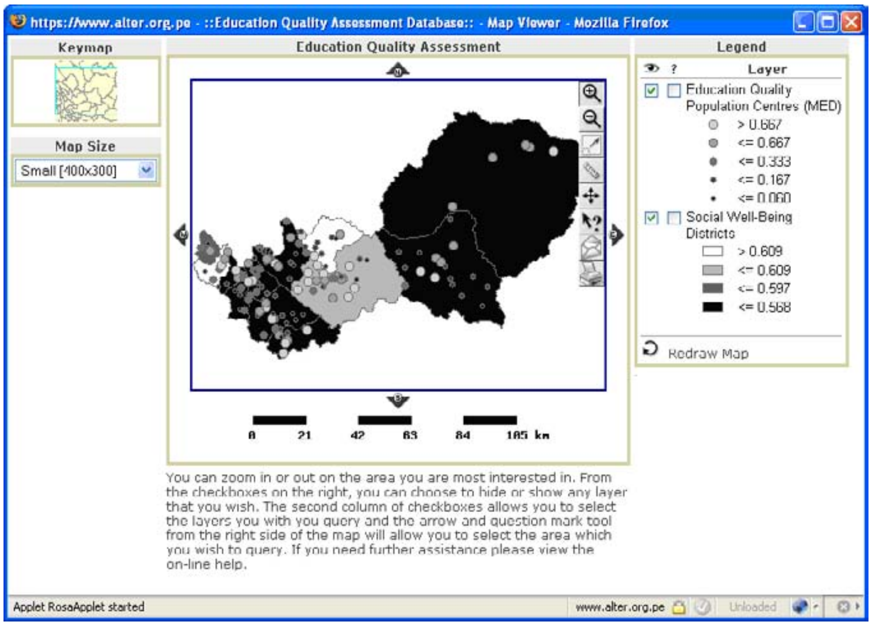
APPLICATION

To illustrate one of the multiple ways in which the EduCal tool can be deployed, consider the perspective of a planner working at the local education management unit (Unidad de Gestión Educativa Local - UGEL) of the Peruvian Ministry of Education in the rural province of Quispicanchi in southern Peru (department/region of Cusco). The general objective is to examine (visually and numerically) education quality at the individual school level based on user-defined indicators. In this case, the net loss of children by grade from schools (desertion) is examined, combined with an analysis of the number of children under the age of 15 who work at the level of the districts within the province. Desertion from school for paid or unpaid family work is a common phenomenon in the Andean highlands, and represents a substantial problem within the Peruvian education sector in general.

To create the scenario, the province of Quispicanchi in the department/region of Cusco is selected to represent the study area in step one. Indicators relating to desertion and youth labour are selected in step two, and parameters are defined in step three using the TBW method to determine how education quality and social context should be represented using these indicators. Desertion rates are selected for both boys and girls for grades 1 and 6. Minimum and target levels for desertion rates are set to zero, indicating that no desertion by grade is the value required for a school to receive a perfect score. As the lower grades in Quispicanchi tend to have higher desertion rates (as revealed by default values from the database in the TBW parameters), the maximum values, at which the indicators would receive the worst (zero) overall scores were set higher for grade 1 (0.25) than in grade 6 (0.10) in order to capture a better range of values. However, the weights for grade 6 are set twice as high as for grade 1, thus making grade 6 desertion rates have twice the influence on the overall education quality index than grade 1 desertion rates.

The youth employment rate is the only indicator selected for the social context, hence its weight is effectively unimportant and therefore left equal to unity. The index for context is therefore entirely determined by the youth employment rate relative to the minimum/target (also set to zero) and the maximum limit of 10%, at and beyond which the context would receive a zero (worst possible) score, whereas cases of zero youth employment would receive a maximum (best case) value of unity. After the scenario is generated, the results can be examined in both tabular and map form, directly within the EduCal tool itself (e.g., Figure 4 shows the results for schools and districts with both indices ranging from 0 to 1, with values nearer 1 being better). In addition, the data from the results can be downloaded from the EduCal tool in tabular form, and analyzed using a spreadsheet program such as Excel to produce general summaries and more advanced statistical analysis

Figure 4. Map view of calculated Indices, Quispicanchi, Cusco, Peru



of results. While this level of analysis is beyond the capacity of most EduCal users (outside the user communities within NGOs, universities, and the regional offices of the Ministry of Education), the basic results that are produced are readily understandable by all users in Peru after basic training in the use of the tool.

It is straightforward to generate a list of schools where desertion appears to be a significant problem. Table 1 shows the results for the 10 worst schools in Quispicanchi as far as desertion is concerned. This list is particularly useful to Ministry planners as well as school administrators, teachers, and parents at the affected schools as it provides a basis for community consultations

that seek to establish why children are leaving school prematurely. Moreover, it allows planners to be able to dialogue with parents over the importance of keeping their children in school, and encourage them to ensure that their children pass beyond primary education to complete at least the required minimum number of years of secondary education (Table 1).

It is important to emphasize that the simple analysis described above could be undertaken by one or more Ministry planners independently within or between local management units (UGEL), as well as for an extended area by planners at the more geographically aggregate regional level of administration. Each participant has the ability to develop his or her own scenario targets and weights for indicators, and then convene either online or in person to discuss and refine their results as part of the education quality improvement process. In addition, a group of parents working together and producing several scenarios with varied parameters that may include additional indicators to those identified by the ministry planners can produce comparator scenarios that promote the perspective of the parents as opposed

Table 1. Results from 10 schools in Quispicanchi with lowest values for education quality

School Name	Education Quality Index	Social Well-Being Index	Male student desertion rate in grade 1	Female student desertion rate in grade 1	Male student desertion rate in grade 6	Female student desertion rate in grade 6	Percent of population that employed under the age of 15
Canchapata	**0**	**0**	0.66	0.55	0.14	0.5	14
Alto Serranuyoc	**0.02**	**0.362**	0.4	0.22	0.33	1	6.38
Huatshua / Huatshua Laguna	**0.06**	**0.646**	0.16	0.55	0.16	0.5	3.54
Ullpo	**0.06**	**0.239**	0.57	0.16	0.66	0.33	7.61
Urin Ccoscco	**0.073**	**0**	0.21	0.18	0.28	0.33	23.83
Pampa Chulla	**0.093**	**0.786**	0.33	0.11	0.12	0.22	2.14
Tiomayo	**0.12**	**1**	0.12	0.2	0.18	0.26	0
Muñapata	**0.12**	**0.913**	0.14	0.18	0.25	0.37	0.87
Coline	**0.167**	**0.677**	0	0.25	0.2	0.5	3.23
Ccollcca	**0.167**	**0.286**	0	0.44	0.33	0.1	7.14

to the perspective of the Ministry. Clearly, while there are no right or wrong perspectives and/or scenarios in the evaluation of education quality, there are certainly as many perspectives as there are participants.

The EduCal tool facilitates consideration of these multiple perspectives in a flexible manner that accommodates participation independent of whether a user has his or her own computer and /or an Internet connection. By virtue of being accessible through public Internet cabinas, in this case in Peru, the tool promotes true democratic access to and participation in decision processes. Operationally the tool is easy to use and powerful, without requiring a high level of computing knowledge. It is possible that parent associations, administrators, and teachers can each be asked to develop their own analyses using the tool, and then to convene with the explicit objective of developing a common vision and plan for improving the quality of early childhood education. In this context, the integration of mapping and spatial selection functionality in the tool provides a visual and interactive environment that hides much of the complexity of the analysis process from the end user.

CONCLUSION

This chapter has discussed several emergent threads in the literature on decision making with the use of spatial data. Fundamental to these new threads is the fact that spatial decision making, especially in the planning realm, is seldom undertaken by a single individual. Rather, multiple participants are typically involved in collaboration through the course of a decision process. Given this, new approaches within the spatial domain seek to provide greater flexibility in the way that participants can interact and communicate effectively not only with the software that supports decision analysis, but more importantly with each other. Participation in this context must be broad-based or public, and accommodate diverse knowledge bases and computing skills that range from very basic to advanced. This represents a divergence away from previous approaches to achieve the goal of dialogue building and collaboration through the development of easily understandable user interfaces that are flexible in the manner in which they are deployed.

The emergent role of the Internet as the dominant international information and communication technology of the current era makes this medium well suited to facilitate broad-based participation in decision processes. This is especially true in developing countries where Internet uptake is facilitated through publicly accessible Internet cabinas in lieu of personal computer ownership and relatively high Internet access costs. Further, the diffusion of open source software technologies goes beyond the initial popular operating system and server tools to include a wide variety of software products, including conventional and Web-based GIS, and has added further flexibility to the various types of user interaction the Internet makes possible. OSGIS and other OS tools allow experimentation with a variety of software and system architectures de novo, as the availability of source code and the lack of financial burden due to software acquisition are pervasive incentives for innovative research.

The EduCal tool that was described in this chapter represents one example of what is possible without the dependency on commercial GIS or other commercial software products. While the tool, in its current release has been warmly received by the education community in Peru, there are still many areas in which it can be further improved. For example, work currently underway using the same OS tools as EduCal seeks to achieve true collaboration for dispersed individual users and group collaborators through synchronous scenario development, including threaded messaging and shared map views between multiple users. Linkages between text messages and spatial objects allow the construction of a potentially rich integrated database that can subsequently be mined to understand better the process of generating alternatives, and their evaluation in making decisions.

Further, additional functions are being added to the EduCal tool to provide spatial online analytic processing with a three-dimensional temporal data model rather than conventional two-dimensional database tables. This will allow educators to examine temporal trends in education quality for schools, as well as perform spatial drill-down, roll-up, and drill-across operations that ultimately, using natural language spatial queries, seek to identify areas and/or schools that have similar characteristics.

With the flexibility that OS software provides for low-level coding, the possibilities for future enhancement to the EduCal tool are essentially open ended. Certainly, the advent of a flourishing international OSGIS community allows innovation to flourish without the encumbrances of closed code and the proprietary data structures that have constrained research possibilities in the past.

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REFERENCES

Andrienko, G., Andrienko, L., & Voss. H. (2003). GIS for everyone: The CommonGIS project and beyond. In M. Peterson (Ed.), *Maps and the Internet.* Oxford, UK: Elsevier Science.

Carver, S. (2001, December 6-8). *Participation and geographical information: A position paper.* Presented at ESF-NSF Workshop on Access to Geographic Information and Participatory Approaches Using Geographic Information. Spoleto.

Carver, S., Blake, M., Turton, I., & Duke-Williams, O. (1997). Open spatial decision making: evaluating the potential of the World Wide Web. In Z. Kemp (Ed.), *Innovations in GIS 4.* London: Taylor & Francis.

Craig, W. J., Harris, T. M., & Weiner D. (Eds.). (2002). *Community participation and geographic information systems.* London: Taylor & Francis.

Dragicevic, S. (2004). The potential of Web-based GIS. *Journal of Geographical Systems, 6*, 79-81.

Dragicevic, S., & Shiananad, B. (2004). A Web GIS collaborative framework to structure and manage distributed planning processes. *Journal of Geographical Systems, 6,* 133-153.

Evans, A. J., Kingston, R., & Carver, S. (2004). Democratic input into the nuclear waste disposal problem: The influence of geographical data on decision making examined through a Web-based GIS. *Journal of Geographical Systems, 6*, 117-132.

Feick, R. D., & Hall, G. B. (1999). Consensus building in a multiparticipant spatial decision support system. *Journal of the Urban and Regional Information System Association, 11,* 17-24.

Fernandez-Maldonaldo, A. M. (2001) The diffusion and use of information technologies in Lima, Peru. *Journal of Urban Technology, 8,* 21-43.

Hall, G. B., & Peters, P. A. (2003). Global ideals and local practicalities in education policies and planning in Lima, Peru. *Habitat International, 27*, 629-651.

Haklay, M., & Tobón, C. (2003). Usability evaluation and PPGIS: Towards a user-centred design approach. *International Journal of Geographic Information Science, 17,* 577-592.

Hendricks, P., & Vriens, D. (2000). From geographical information systems to spatial group decision support systems: A complex itinerary. *Geographical and Environmental Modelling, 4,* 83-104.

Higgs, G. (2004). We haven't got a GIS. It isn't a problem for us; why is it a problem for you? *Computers, Environment and Urban Systems, 28,* 285-288.

Jankowski, P., & Nyerges, T. (2001a). *GIS for group decision making.* London: Taylor and Francis.

Jankowski, P., & Nyerges, T. (2001b). GIS-supported collaborative decision making; results of an experiment. *Annals of the Association of American Association of Geographers, 91,* 48-70.

Jankowski, P., & Nyerges, T. (2003). Towards a framework for research on geographic information-supported participatory decision making. *URISA Journal Online, 15*(1). Retrieved August 18, 2005, from http://www.urisa.org/Journal/APANo1/jankowski.pdf

Jankowski, P., Nyerges, T., Smith, A., Moore T., & Horvath, E. (1997). Spatial group choice: An SDSS tool for collaborative decision making. *International Journal of Geographic Information Science, 11*, 566-602.

KHEOPS. (2005). *KHEOPS Technologies.* Retrieved May 4, 2005, from http://www.kheops-tech.com/en/home/index.jsp

Kling, R. (1999). Can the "next-generation Internet" effectively support "ordinary citizens?" *The Network Society, 15*, 57-63.

Kraak, M. J. (2004). The role of the map in a Web-based environment. *Journal of Geographical Systems, 6*, 83-93.

Lime, S. (2004). *MapServer: Past, present, and future*. Presentation at Open Source GIS Conference 2004 and Second Annual MapServer User Meeting. Retrieved May 12, 2005, from http://www.omsug.ca/osgis2004/proceedings.html

Merrick, M. (2003). Reflections on PPGIS: A view from the trenches. *Journal of the Urban and Regional Information Systems Association, 15*, 33-39.

Nyerges, T., Jankowski, P., & Drew, C. (2002). Data-gathering strategies for social-behavioural research about participatory GIS use. *International Journal of Geographical Information Science, 16*, 1-22.

OGC. (2005). *OpenGIS implementation specifications*. Retrieved May 4, 2005, from http://www.opengeospatial.org/specs/

OSI. (2005). *Open Source Initiative*. Retrieved May 4, 2005, from http://www.opensource.org

Peng, Z-R. (1999). An assessment framework of the development strategies of Internet GIS. *Environment and Planning B: Planning and Design, 26*, 117-132.

Peng, Z-R., & Zhang, C. (2004). The roles of geography markup language (GML), scalable vector graphics (SVG), and Web feature service (WFS) specifications in the development of Internet geographic information systems (GIS). *Journal of Geographical Systems, 6*, 95-116.

Peters, P. A., & Hall, G. B. (2004). Evaluation of education quality and neighbourhood well-being: A case study of Independencia, Peru. *International Journal of Education Development, 24,* 85-102.

Ramsey, P.(2005). *How do you use PostGIS. User survey posted to PostGIS Users Discussion e-mail list.* Retrieved May 12, 2005, from http://postgis.refractions.net/mailman/listinfo/postgis-users

Reichardt, M. (2004). *Building the sensor Web.* Retrieved August 18, 2005, from http://www.geospatial-online.com/geospatialsolutions/article/articleDetail.jsp?id=86713&pageID=1

Rinner, C., & Malczewski, J. (2002). Web-enabled spatial decision analysis using ordered weighted averaging (OWA). *Journal of Geographical Systems, 4,* 385-403.

Rivest, S., Bédard, Y., & Marchand, P. (2001). Towards better support for spatial decision making: Defining the characteristics of spatial online analytical processing. *Geomatica, 5*, 539-555.

Schuurman, N. (2003). The ghost in the machine: Spatial data, information, and knowledge in GIS. *The Canadian Geographer, 47*, 1-4.

Sieber, R. E. (2000a). GIS implementation in the grassroots. *Journal of the Urban and Regional Information Systems Association, 12*, 15-29.

Sieber, R. E. (2000b). Conforming (to) the opposition: The social construction of geographical information systems in social movements. *International Journal of Geographical Information Science, 14,* 775-793.

Uran, O., & Janssen, R. (2003). Why are spatial decision support systems not used? Some experiences from the Netherlands. *Computers, Environment and Urban Systems, 27,* 511-526.

Voss, A., Denisovich, I., Gatalsky, P., Gavouchidis, K., Klotz, A., Roeder, S., & Voss, H. (2004). Evolution of a participatory GIS. *Computers, Environment and Urban Systems, 28,* 635-651.

Weiner, D., Harris, T., & Craig, W. (2002). Community participation and geographic information systems. In W. Craig, T. Harris, & D. Weiner (Eds.), *Community Participation and Geographic Information Systems.* London: Taylor and Francis.

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Chapter 1.33
Measuring Knowledge Management Capabilities

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INTRODUCTION

As business professionals know, creating awareness of a problem and its impact is a critical first step toward the resolution of the problem. That which does not get measured, does not get managed (Redman, 1998). In fact, measurement is a precursor to improvement. This is true for knowledge management (KM) capabilities of an organization. "In today's knowledge-based economy," Alan Greenspan recently said, "70% of organizational assets are knowledge assets." Knowledge assets are intangible capabilities, and there is a recognized need to "make a greater effort to quantify the value of such intangible assets" (Teece, 1998b). How does one measure the worth of an organization's knowledge assets? What does one mean by knowledge assets anyway?

In this article, we afford some formal structure to the idea of measuring knowledge management capabilities of an organization, with the ultimate goal of improving business performance through better management of knowledge assets. We describe a large-scale effort at Intel to assess such capabilities with a view to enhance them. This project started in May of 2002. We describe the different types of knowledge assets identified, the potential capabilities associated with managing knowledge assets, the metrics devised for their measurement, and the assessment methodology that is being standardized across the corporation. We also provide results of the initial validation of the instrument and its ability to ascertain KM capabilities correctly. Hundreds of knowledge workers (Davenport, 2003) have so far participated in this study to benchmark KM capabilities of their units. Some units are already planning the next steps for improving their KM capabilities.

BACKGROUND: WHAT IS KNOWLEDGE?

The direction required to quantify the value of knowledge assets begins to come into focus when one realizes their diversity in an organizational setting. Some knowledge assets are “grounded in the experience and expertise of individuals,” that is, tacit knowledge, while others can be stored as knowledge objects that exist on their own, that is, explicit knowledge (Fahey & Prusak, 1998; Teece, 1998a). Therefore, to describe knowledge assets that exist across organizations, domains that encompass knowledge work and can be studied for improving on-the-job productivity must be identified. For this reason, we start with classifying the whole gamut of knowledge residing in an organization into a knowledge-asset framework.

We categorize institutional knowledge assets into four areas: expertise, lessons learned, knowledge documents, and data. This categorization resulted from the realization that knowledge in each area has a unique (a) mix of tacit and explicit content, (b) method of transfer and contextual value, and (c) life cycle (creation to application), including its shelf life. To contrast the unique nature of each knowledge area, its characterization along these three dimensions needs to be understood.

Expertise

Expertise is high in tacit knowledge. Individuals in an organization are often considered experts within a particular domain. The transfer of expertise occurs via consultation, collaboration, mentoring, and observation, that is, through personal interaction. The shelf life of this type of knowledge depends on the currency of the knowledge in the context of its application, and it can be extended by renewal and learning. The availability of experts and the ability of an organization to locate required expertise for a given situation quickly can result in performance improvement (Dooley, Corman, & McPhee, 2002).

Lessons Learned

Lessons learned are the essence of learning from past successes and failures. They represent highly specific knowledge gained while completing a project or task. They lie toward the tacit end of the tacit-explicit continuum. Undocumented lessons are in the heads of people who learned them. To the extent lessons are documented, their transferability is improved (in a networked organization), but their applicability remains highly contextual. Recognizing the similarities between the characteristics of the current task with those of an earlier one from which the lesson was learned is an important step in their application. This type of knowledge is created when one recognizes that something substantial of recurring value has been learned. The shelf life of a lesson depends on its generalizability and the persistence of the context. The more generalized a lesson, the broader is its applicability and the longer its life. Organizations that exploit this type of knowledge have reported substantial cost savings (O’Dell & Grayson, 1998).

Knowledge Documents

Knowledge documents represent explicit knowledge such as project reports, technical reports, policies and procedures, research reports, publications, pictures, drawings, diagrams, audio and video clips, and so forth. Knowledge documents encompass internally generated as well as external information (Zack, 1999). Market research reports and operating manuals of complex machinery are good examples. Knowledge documents contain the background knowledge that can be referred to by a knowledge worker to educate themselves—to increase their awareness and understanding—about an area that they work in. Well understood taxonomies and archives, as well as the ease of access of relevant documents, is important to maximize the transferability and reuse of this knowledge. In contrast to lessons learned, the knowledge contained in knowledge documents is more permanent.

Data

The most explicit form of knowledge is contained in data used for strategic and tactical decision making (Fahey & Prusak, 1998). Here we do not refer to operational data generated by the day-to-day transactions of a business, but aggregated and historical data such as that stored in a data warehouse. Such data can be a constant source of useful knowledge when used for analytical processing, detecting patterns, modeling business situations, and so forth. The quality of metadata (design of the structure and descriptions of data) determines the availability and usability of this type of knowledge. The shelf life of data as a knowledge source can be very long; many retail corporations have spent millions of dollars on creating large data warehouses that store years of summary data for discovering trends and patterns (knowledge) that can have a direct impact on strategic decisions.

One may argue that there is a substantial overlap among the knowledge assets described above. While we recognize that the lines separating these knowledge assets are gray, the core characteristics of the knowledge areas differ substantially, and therefore the knowledge needs of an organization can be more clearly understood if they are broken up among the different types of knowledge assets. Hansen, Nohria, and Tierney (1999) describe the differing views of knowledge in different organizations and show how an organization's business strategy drives its knowledge needs. We found that, particularly in large organizations, the functional nature of a business unit emphasizes the unit's knowledge needs.

While each business unit within Intel utilized all types of knowledge, we found that the importance, and therefore the strategic focus of a business unit, varied based on its core functional responsibility. TMG, an organizational unit focused on the rapid ramp-up of production operations, required a high level of capability within the lessons-learned category. Identifying shortcomings within this unique capability area therefore became critical. In contrast, SSG, a unit responsible for the development of system software solutions, required emphasis on different capability areas, namely, in expertise and knowledge documents. Being able to assess the existing capability levels in these differing knowledge areas is not only essential for benchmarking, but also for directing efforts to improve them and to monitor progress over time. The importance of KM capability assessment is validated by the actions of the business units subsequent to the assessment; most of the business units have already started investing in planned KM initiatives in those knowledge areas that are deemed important but low in capability level.

WHAT DOES MANAGING KNOWLEDGE MEAN?

Like any other intangible asset, knowledge needs to be managed in order to maximize its value by fully exploiting its utility. Each type of knowledge asset has its own unique characteristics as described above, however, a common framework can be applied to understand how it can be managed. One such framework stems from the concept of the knowledge life cycle (Alavi & Leidner, 2001). The four distinct stages of the knowledge life cycle are creation and capture, storage and archival, retrieval and transfer, and application and reuse. We found that, although these stages seem to apply only to explicit knowledge, they do apply to tacit knowledge as well. For example, in the context of highly tacit knowledge such as expertise, the capture stage corresponds to the process of identifying domain experts and registering their expertise. This information about specific fields of expertise is then stored in an expertise database. The retrieval stage occurs when a potential user of knowledge searches for and locates the appropriate expert, and the application stage is the culmination of the life cycle resulting in a consultation with the expert. The knowledge life-cycle framework can thus be applied to manage both explicit and tacit knowledge.

In assessing KM capabilities of an organization, ascertaining how well each stage of the knowledge life cycle is managed becomes important. Stages of the life cycle may be assisted by the necessary technology support and the integration of KM-related activities into normal business processes. While technology automates parts of the knowledge life cycle, process integration ensures participation in KM-related activities. In addition, the cultural underpinnings of an organization determine the extent to which organizational knowledge may be shared.

Technology Support

Although technology is not the solution to managing knowledge, it provides the means to participate in certain stages of the knowledge life cycle. KM systems are a class of information systems built around this need. Examples of KM systems that offer support for sharing knowledge in various capability areas are a form-based registration system for capturing the areas of expertise of experts, a storage and retrieval system for categorizing and searching knowledge documents, a data warehouse with decision-support and modeling tools, and so forth.

Process Integration

If knowledge-sharing activities are made part of normal business processes, it is more likely to result in higher KM capabilities. Purely voluntary participation in KM-related activities is hard to come by because its direct and immediate benefits are difficult to measure. Nevertheless, large and small organizations have started embedding knowledge capture and access activities into work flows. Examples of such practices are routine engagement in reflective activities after reaching major milestones of projects to capture lessons learned, or looking for relevant knowledge documents at the beginning of a new task or project.

The Role of Culture

Organizational culture plays a significant role in defining the extent to which knowledge may be shared. The environments in which employees work can affect both the supply and demand aspects of every type of knowledge. On the supply side, it is the willingness to share expertise, taking the time to catalog important knowledge documents, and investing time in postmortems and debriefings to capture lessons learned from completed projects and tasks. On the demand side, culture can promote looking for and reusing available knowledge.

The existence of a positive knowledge-sharing culture is a precondition for an organization to have any capability in KM (Adams & Lamont, 2003). No amount of sophisticated KM systems and process changes can enhance KM capabilities if the culture discourages sharing and promotes hoarding. Organizations that have this problem and recognize it need to work on creating the appropriate environment for their knowledge workers. As a first step, immediate supervisors may encourage the regular sharing of work-related problem solutions and be role models by demonstrating knowledge-sharing behavior. The next higher level in this direction may be reached by recognizing and rewarding knowledge-sharing behavior, and instituting training and education on systems and processes used for knowledge sharing. At the highest level, the top management of the company may demonstrate its commitment by having a well articulated KM strategy and setting goals for KM-related undertakings.

HOW CAN ONE MEASURE KNOWLEDGE MANAGEMENT CAPABILITY?

Since KM assessment is an opportune topic, a few assessment tools and frameworks have been developed and presented at practitioner conferences and Web sites of such companies. Noteworthy among these are two methods, both based on the five level capability maturity model of the Software Engineering Institute (Humphrey, 1995). One is from Siemens that divides KM-related issues into eight key areas and a progressive maturity-level scale (Ehms & Langen, 2002; Langen, 2002), and another is from InfoSys Technologies focusing on three key result areas and a maturity model (Kochikar, 2002). However, apart from the terminology and some semantic transformations from software engineering to KM, there is no detailed description of the model, no operational classification of different types of knowledge, and no definitions of levels in terms of goals. For example, the general and specific goals of each level and the activities needed to attain the various levels of maturity are not available. Moreover, there is no scientific study reporting attempts made to test for content and construct validity of either the measurement instrument or the process adopted.

Our case-study team consisted of experts from Intel Corporation from process management, value measurement, change management, and information technology, in addition to the external academic researchers (authors). We undertook a structured conceptual development process to design a knowledge management capability assessment (KMCA) instrument. With the identification of knowledge-asset areas, a consistent nomological measure across all knowledge areas was needed to identify the capability level achieved within each area of knowledge.

Development of the KMCA Instrument

The KMCA model also adapts the framework of the five level capability maturity model to the KM context. The conceptual structure of the KMCA emphasizes the top-down design of the measurement instrument. The five capability levels of the KMCA are described in terms of their general goals in Table 1. The general goals indicate the milestones to be achieved in order for an organization (or an organizational unit) to reach the corresponding capability level. These goals are general enough to apply to each of the four knowledge capability areas. One can see that lower level goals are easier to achieve than higher level goals. This progression gives the questionnaire the ability to discern between capability levels accurately, an important design aspect of the KMCA.

The KMCA team mapped each general goal to one or more specific goals for each knowledge area: expertise, lessons learned, knowledge documents, and data. For example, consider one of the general goals of Capability Level 3 (see Table 1): “Systems/tools to enable KM activities exist.” Emanating from this general goal, one of the corresponding specific goals for the expertise area is “Experts are able to register their expertise in an expertise profiling system.” Such mapping was completed for each general goal of each capability level (for every capability area). Specific goals of each capability level of each knowledge area were then mapped to one or more specific practices, which are work practices that employees could identify with in their day-to-day work life. Specific practices were, in turn, converted into questions for the first version of the questionnaire. By strictly adhering to this procedure, the team was not only able to include questions represent-

Table 1. Capability levels

Capability Level	General Goals	Examples of Specific Goals
Level 1: Possible	Knowledge sharing is not discouraged. There is a general willingness to share. People who understand the value of sharing do it. The meaning of knowledge assets is understood.	Previous lessons learned can be found with perseverance.
		Some experts are willing to share expertise when consulted.
Level 2: Encouraged	The culture encourages the sharing of knowledge assets. The value of knowledge assets is recognized. Knowledge assets are stored/tracked in some fashion.	Supervisors encourage regular meetings to share knowledge/solutions.
		Experts and their expertise are identifiable.
		The importance of prior lessons learned is recognized.
Level 3: Enabled/ Practiced	The sharing of knowledge assets is practiced. Systems/tools to enable KM activities exist. Rewards/incentives promote knowledge sharing.	Organizational leadership understands how KM is applied to business.
		Lessons learned are captured.
		Taxonomies and centralized repositories for knowledge documents exist.
		Experts are able to register their expertise.
		Historical data is available for decision making.
Level 4: Managed	Employees expect to locate knowledge. Training is available. KM-related activities are part of work flow. Systems/tools for supporting KM activities are easy to use. KM capabilities and benefits are assessed. Leadership exhibits commitment to KM. Leadership provides a KM strategy.	Senior management sets policy, guidelines, and goals with respect to KM.
		Tools to locate experts are easy to use.
		Capturing, storing, and using lessons learned are part of normal work process.
		Knowledge-document retrieval is fast and easy.
		Historical data utilized for decision making is easy to access and manipulate.
Level 5: Continuous Improvement	KM processes are reviewed/improved. KM systems/tools are widely accepted, monitored, and updated. The KM assessment generates realistic improvement.	Senior management periodically reviews the effectiveness of KM investments to the whole organization.
		Recent improvements in document access have been implemented.
		Expert and expertise identification has expanded and been refined.
		New tools for data manipulation are tested and implemented.
		The impact of lessons learned on operations is communicated.

ing all levels (Level 1 through Level 5), but also able to maintain the relative progression of levels of questions within each area.

The prototype and subsequent versions of the instrument were developed and validated in four distinct phases over a 24 month period. These phased activities and accomplishments are described in Table 2, which details the deliberate, step-by-step process. The questionnaire consists of sections for each knowledge area and one for the cultural aspects of an organization. Within each section, questions are grouped by the components of that knowledge area. For example, the components under the knowledge documents section are taxonomy, the categorization process, the repository, the search and retrieval process, and the application and use process. Each question is mapped to a capability level according to the specific goals of that level. The final questionnaire consists of about 120 questions that can be completed in about 20 minutes.

Instrument Validation

Translation validity, which includes both the face and content validity of items included in the instrument, attempts to assess the degree to which the accurate translation of the constructs occurs while operationalizing the instrument (Trochim, 2001). This was a major focus in the early phases of the project, which provided substantial input as to the applicability of the concepts to Intel.

The criterion-related validity assesses the measurement accuracy of the instrument. It checks the predictive capability of the instrument based on the theory of the construct. In our case, this is the ability of our instrument to accurately measure the capability level of an organization in each knowledge area. Because of the strict design considerations, we expected to observe that for each capability area, all the requirements of a lower level of capability would be fully met before requirements of any of the higher levels are met. Results from the three business units at Intel confirmed this expectation, and we conclude that the capability levels are a progression. We also expected the KMCA to be able to compare relative capabilities across knowledge areas within a single organization and across multiple organizations for a given knowledge area. Our results also

Table 2. Instrument construction in validation

	Activities	Accomplishments
Phase 1 May 2002– Aug. 2002	Background research and identification of knowledge capability areas Conceptual design of the instrument, capability levels, and goals Initial survey construction Focus group of 12 knowledge workers	Confirmation of knowledge areas Initial questionnaire with about 145 questions and a 45-minute completion time Applicability of the survey to the work environment (face and content validity)
Phase 2 Aug. 2002– Nov. 2002	Survey administration to 38 volunteers from one business unit	Ability of the instrument to measure KM capabilities of the unit (criterion-related validity) Survey modification based on open-ended feedback (face and content validity)
Phase 3 Nov. 2002– Aug. 2003	Full-scale pilot study administration to a large business unit Elimination of redundant questions after data analysis, formatting, and readability improvements Interrater reliability test utilizing six domain experts on KM	Final questionnaire with about 120 questions and a 20-minute completion time Improvement in the instrument's ability to recommend specific KM practices Ability of the instrument to discern between capability levels
Phase 4 Aug. 2003– May 2004	Final version administered to three large business units (population 650 to 1,000 employees) Confirmatory factor analysis and other testing of capability areas, their components, and measurement accuracy	Ascertaining the ability of the instrument to measure capability levels in each knowledge area Response bias test indicated no bias Ability to make comparisons of KM capabilities within and between business units

confirmed this expectation. The overall results thus confirm that the mapping from general goals to specific goals and practices, and then to actual questions was accurately accomplished, and that KMCA is able to measure and compare the separate KM capabilities of organizations.

Up to this point, we have focused on item construction and its translation to knowledge areas and levels. The overall goal is one of establishing the four capability areas as measurable constructs. For this final step, we used confirmatory factor analysis and represented each capability area as a latent factor whose measurement consistency was established using two measurement model forms: (a) the general-specific model and (b) the second-order model (Chen, West, & Sousa, in press). The results of both structural equation models provided fit indices for all capability areas, indicating models of good fit. The significance of the general factor and the second-order factor representing the overall capability area provides strong evidence supporting these knowledge assets as measurable capabilities. Using both measurement models within each business unit provided experimental rigor and external validity.

Measurement Results

The results of the KMCA are in the form of capability-level scores in each knowledge area accompanied by a report describing the highlights and detailed information concerning the status

Figure 1. Sample KMCA results page

Unit Name:	________________
Capability Area:	***Lessons Learned***
Capability Level Achieved:	***3 (on a scale of 1 to 5, with 5 being the highest)***

<u>Highlights:</u>

Usage

- **Ninety percent of the respondents use lessons learned.**
- **Among the four knowledge areas, lessons learned were considered the least important to the job.**
- **Individuals use lessons learned three to four times a week and spend a total of 30 to 60 minutes a week looking for lessons learned.**

Observations

- **Looking for lessons learned is part of work practices; lessons learned do provide insights that promote successful practices and avoiding mistakes.**
- **Although the electronic storage system for lessons learned seems to be adequate, it is deficient in terms of ease of use, documentation, accessibility, and search categories.**

Recommendations

- ✓ **Electronic storage and search systems for lessons learned need improvement.**
- ✓ **A systematic process for the capture and periodic review of existing lessons learned needs to be instituted.**

<u>Detailed Information:</u>

Component Analysis: Detailed analysis of each component of the lessons-learned area: capture, taxonomy, repository, and application and use

Descriptive Statistics: Detailed statistics regarding the response rate, mean, variance, maximum, minimum, and so forth for every question

Summary of open-ended qualitative comments made by respondents

of KM capability in each area. Figure 1 shows a sample page from the results of the lessons-learned knowledge area pertaining to one of the business units at Intel. "Usage" summarizes the usage and importance of the knowledge area to the unit. The observations are factual statements that convey to the business unit the highlights of the unit's capability in a particular area. The recommendations are prescriptions for action. The specificity of the recommendations allows a unit to start planning for KM initiatives. Additionally, "Detailed Information" contains the capability analysis of each component of the knowledge area (which, in the case of lessons learned, are capture, taxonomy, repository, and application and use), descriptive statistics, and a summary of respondents' qualitative comments.

As a consequence of the KMCA, one of the business units, SSG, has already started major efforts in most of the suggested directions. SSG has constituted five overlapping teams of knowledge workers to plan and design KM initiatives: one in each of the knowledge areas and one specifically to address organizational culture in the context of knowledge sharing. The long-term effect of these efforts needs to be seen.

FUTURE TRENDS: IMPACT ON BUSINESS PERFORMANCE

Ultimately, the proof of the pudding is in eating. Assessing KM capabilities is an interim step toward the ultimate goal of making a positive impact on business performance. The direct impact of KM initiatives on bottom-line performance metrics, such as profit, revenue, and market share, is difficult to establish. Nonetheless, efforts need to be made in choosing the appropriate metrics. In the case of semiautonomous business units, bottom-line metrics are not pertinent. In such cases, indicators more relevant to the business of the unit, such as productivity, quality (of the product or service), and responsiveness, may be chosen. Complicating the relationship between KM initiatives and business performance is the fact that the gestation period for reaping benefits is longer, unlike installations of new equipment or implementations of business process changes. Thus, investments in KM initiatives must be viewed longitudinally.

Of the three large business units that have participated in the KM capability assessment at Intel, one is a manufacturing unit (TMG), another is responsible for providing systems software embedded in chips (SSG), and the third is the corporate quality-assurance unit (CQN). The population surveyed within the manufacturing unit was the engineers and technicians responsible for maximizing the yield and quality of semiconductor wafers using the most sophisticated and expensive equipment in its category. By far, the most important goal of this group is keeping the machines up and running at the optimum levels. Given the nature of their responsibility, as a relatively short-term measure of performance, we devised a metric to measure the delay experienced in getting the right knowledge (expertise, lessons learned, knowledge documents, and data) to the right person whenever needed. A longer term metric of performance is the average down times and ultimately the yield of the particular factory.

In the case of the other two units, although there are no direct measures of white-collar productivity, the effects of knowledge sharing and reuse can be observed by way of time saved in isolating a problem, finding solutions, and completing projects. The effects of knowledge sharing may also result in better decisions in choosing vendors, arriving at more accurate lab test results, and so forth. Hence, in addition to the quantitative measures of time spent to get the knowledge, we used qualitative measures such as the adequacy of various knowledge sources in satisfactorily fulfilling the requirements of individual managers.

As one moves away from the direct impact of KM initiatives to improvements over the long term, confounding factors obfuscate the relationship between KM and business performance. The benefits of KM become harder to assert, and investments in KM initiatives become harder to justify.

CONCLUSION

Knowledge management is increasingly viewed as a way to improve firm performance and potentially to provide a competitive advantage. Successes have been documented in corporate initiatives (sometimes referred to as KM initiatives) by utilizing knowledge in the form of best practices that resides within the firm. The descriptions of success have been predominantly anecdotal. To allay the complexity of the concept of knowledge assets, we identified four distinct types of knowledge assets, each with its own mix of tacit-explicit content, method of transfer, and life cycle. Through our case study, we demonstrated that it is not only possible to obtain a realistic assessment of KM capabilities of an organization in each knowledge area, but that the assessment offers specific directions for improving such capabilities. We found that the business units that we analyzed had differing knowledge-area emphases and capabilities based on the business unit's function and objectives. These results have several implications going forward for both business practice and research.

From a business perspective, our study demonstrates that the assessment of KM capabilities can be prescribed as a key component of an organization's KM program. Since organizations possess and require varied capabilities in different areas of knowledge, a capability assessment (such as the KMCA) should occur as one of the first steps toward improvement. Additionally, an organization should conduct a macrolevel review of its business goals and the knowledge needs of its processes to most effectively achieve those goals. Once a review of these goals and knowledge needs is completed, an assessment of the capability areas will provide an alignment analysis of the fit with the stated business objectives. Initiatives can then be designed to target those knowledge capabilities that are deemed important but deficient within the organization. Such goal-directed targeting of specific capabilities via well-designed initiatives, coupled with the tracking of business performance metrics, would greatly enhance the effectiveness of a KM program. The ability to correctly measure knowledge capabilities and prescribe improvements thus provides an initial step to capitalize fully on the management of knowledge.

For successfully contributing to research in the area of KM capability assessment, two items need to be kept in focus: the choice of success metrics and the longitudinal nature of this research. The business performance metrics chosen must be measurable and should be an acceptable measure of success of KM initiatives; they are critical in establishing relationships between KM capabilities and business performance. Since the return on investments in KM initiatives of any kind—systems, processes, or cultural aspects—usually occurs over an extended period, an organization participating in such a scientific study has to recognize the long-term nature of its commitment. A standardized instrument that can measure various KM capabilities consistently over long periods becomes an essential component of the undertaking.

REFERENCES

Adams, G. L., & Lamont, B. T. (2003). Knowledge management systems and developing sustainable competitive advantage. *Journal of Knowledge Management, 7*(2), 142-154.

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 1-7-136.

Chen, F. F., West, S. G., & Sousa, K. H. (in press). A comparison of general-specific and second-order models of quality of life. *Structural Equation Modeling.*

Davenport, T. H. (2003). A measurable proposal. *CIO Magazine*.

Dooley, K. J., Corman, S. R., & McPhee, R. D. (2002). A knowledge directory for identifying experts and areas of expertise. *Human Systems Management, 21*, 217-228.

Ehms, K., & Langen, M. (2002). *Holistic development of knowledge management with KMMM*. Siemens AG.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106.

Humphrey, W. S. (1995). *A discipline for software engineering.* Reading, MA: Addison-Wesley.

Kochikar, V. P. (2002). *The knowledge management maturity model: A staged framework for leveraging knowledge*. Unpublished manuscript.

Langen, M. (2002). *Knowledge management maturity model: KMMM methodology for assessing and developing maturity in knowledge management.*

O'Dell, C., & Grayson, C. J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154.

Redman, T. C. (1998). The impact of poor data quality on the typical enterprise. *Communications of the ACM, 41*(2), 79-82.

Teece, D. J. (1998a). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review, 40*(3), 55.

Teece, D. J. (1998b). Research directions for knowledge management. *California Management Review, 40*(3), 289.

Trochim, W. M. (2001). *The research methods knowledge base* (2nd ed.). Retrieved from http://atomicdogpublishing.com

Zack, M. H. (1999). Developing a knowledge strategy. *California Management Review, 41*(3), 125.

Chapter 1.34
Knowledge Management as an E-Learning Tool

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INTRODUCTION

The goal of educational methods is to allow the pupil the acquisition of knowledge. Even so, the way in which this aim is pursued originates four different currents of methods sorted by two criteria: (1) who leads the educational process and (2) requirement of pupil physical attendance. Regarding the former criterion, the process may be conducted either by the teacher—Teaching-Oriented Process—or by the pupil—Learning-Oriented Process. Obviously, both processes have the same aim: the interiorization and comprehension of knowledge by the pupil. But the difference between them is based on the distinctive procedure followed in each case to achieve the common goal. Regarding the second criterion, the methods may or may not require pupil attendance.

Bearing in mind this classification, four different types of educational methods could be described:

1. Teaching Method: This includes the already known classic educational methods, the Conductivity Theory (Good & Brophy, 1990) being the foremost one. This method is characterized by the fact that the teacher has the heavier role during education—the transmission of knowledge.
2. E-Teaching Method: This second type comes from the expansion and popularity of communication networks, especially the Internet. This method brings the teacher to the physical location of the pupil; one of its most important representative elements is the videoconference.
3. Learning Method: This constitutes a new vision of the educational process, since the teacher acts as a guide and reinforcement for the pupil. The educational process has the heavier role in this method. In other words, the teacher creates a need for learning and afterwards provides the pupil with the necessary means in order to fill these created requests. Piaget Constructionist Theory is one of the most remarkable methods for this (Piaget, 1972, 1998).
4. E-Learning Method: This method is supported both by learning methods and by the expansion of communication networks in order to facilitate access to education with no physical or temporal dependence from pupil or teacher. As in learning methods, the pupil, not the teacher, is the one who sets the learning rhythm.

Each of these types of educational methods may be suitable for a given context, the e-learning systems being the preferred ones in the following circumstances:

1. When looking for a no-attendance-required educational method.
2. When the pupil, not the teacher, wants to set the educational rhythm. This choice might be based on several reasons, ranging from the need of adaptation to the availability of a pupil (i.e., to achieve temporal independence), to the consideration of learning as a more accurate approach than teaching, bearing in mind a particular application context (Pedreira, 2003).
3. When the knowledge to be transmitted is to be accessible to a high number of pupils. In teaching methods, the teacher is the one who transmits knowledge and supervises the pupils; therefore, the quality of the education is influenced by the number of pupils. Nevertheless, in e-learning the core of the educational process is the relationship between pupil and didactical material, with the teacher acting as a consultant. In this way, a teacher could pay attention to a higher number of pupils without causing any damage to the quality of the education.

This article is focused both on the study of e-learning systems and on the application procedure for this new discipline. The Background section is a brief discussion regarding currently used e-learning systems and their points of view. The Main Focus of the Article section suggests a new focus for this type of system in an attempt to solve some shortages detected in already existing systems. The Future Trends section introduces some guidelines that may conduct the evolution of this discipline in the future. Finally, the Conclusion section presents the conclusion obtained.

BACKGROUND

Nowadays, there are numerous applications that are self-named as e-learning tools or systems. Table 1 shows the results of the study regarding main identified applications such as Moodle (http://moodle.org), Ilias (http://www.ilias.uni-koeln.de/ios/index-e.html), ATutor (http://www.atutor.ca/atutor), WebCT (http://www.webct.com), BlackBoard (http://www. blackboard.net),

Table 1. Functional summary of main e-learning applications

	Moodle	Ilias	ATutor	WebCT	BlackBoard	QSTutor
Course Manager	√	√	√	√	√	√
Content Manager	√	√	√	√	√	√
Complementary readings	√			√	√	
FAQ's				√	√	√
Notebook	√	√	√		√	
Search		√	√			
Chat	√	√	√	√	√	√
Videoconference						√
Forum	√	√	√	√	√	√
E-mail		√	√			√

and QSTutor (http://www. qsmedia.es). Each of these applications has been analyzed from the point of view of the functionality to which it gives support. As can be noticed in the table, these applications are based mainly on document management and provide a wide range of communication possibilities (especially forum and chat) and agendas.

Nevertheless, and despite the increasing appearance of e-learning applications, the point of view of this discipline currently is being discussed. This is due to the fact that, despite the important conceptual differences that e-learning has with classical teaching methods, the developers of that type of application usually operate with the same frame of mind as with classical methods; that is, an editorial mindset. In other words, it is common to find the situation in which an e-learning application merely is reduced to a simple digitalization and distribution of the same contents used in classical teaching (Martínez, 2003). In this scenario, pupils read content pages that have been structured in an analogous way to student books or traditional class notes, using multimedia applications with self-evaluating exercises in order to verify the assimilation of what previously has been read.

The systems developed in this way, and which should not be considered as e-learning but as e-reading (Martínez, 2002), are inappropriate, since technology must not be seen as a purpose in itself but as a means that eases the access to education. Then again, the docent material that has been elaborated as described needs attendance to an explanative lesson; therefore, it is not enough for pupils to auto-regulate their apprenticeship. All that has been said should induce a change in the existing orientation of this discipline, paying more attention instead to the elaboration and structuration of docent material.

MAIN FOCUS OF THE ARTICLE

In this situation, the present work intends to palliate the shortages previously identified by means of the definition of the basic structure; that is, any docent material should have to accurately achieve the goal of any e-learning application—the appropriate transmission of knowledge. In order to obtain this structure, the selected route has been the knowledge management (KM) discipline; one of its main purposes is the determination of knowledge representation intended for easier assimilation.

The following subsections detail not only the proposed structure for development of an e-learning application but also the defined ontology that should be used to structure one of its key aspects: the knowledge base.

Proposed Structure for E-Learning Systems

Three key elements may be identified at any educational process: pupil, teacher, and contents/docent material. E-learning is not an exception to this, therefore, any system that may give support to this discipline should be structured with the same triangular basis (Friss, 2003) by means of the definition of modules regarding the three described factors. All these modules should be supported by a communication module.

Pupil Information Module

This module provides pupils and teacher with information regarding the former. More specifically, this information should include for every pupil not only his or her personal information (especially contact data) together with an academic and/or professional profile, but also more dynamic aspects such as current courses and levels achieved, along with the evolution related to what was expected and a reflection of problems that might have been aroused.

Teacher Information Module

This module makes teacher information available for pupils. In this way, a given pupil should know not only how to contact a specific teacher but also the topics in which this teacher could help him or her.

Contents Module

The different resources available for pupils in order to acquire, consolidate, or increase their knowledge are contained in this module. The organization proposed for this module is based on the three basic pillars of KM discipline for the structure setting of the knowledge to be transmitted: knowledge base, lessons learned, and yellow pages (Andrade et al., 2003). These pillars, after subtle adaptations, are perfectly valid for the organization of this module:

1. The submodule named as knowledge base constitutes the central nucleus, not only of this module but also of e-learning, since it is the container for each course-specific content. Given its importance, this aspect will be approached later on.
2. The lessons learned (Van Heijst, Van der Spek & Kruizinga, 1997) submodule contains the experiences of both pupils and teacher regarding knowledge base. It is important to point out not only the positive experiences, like hints for a better solution, but also the negative ones, such as frequent mistakes during the application of knowledge.
3. The yellow pages (Davenport & Prusak, 2000) help the pupil to identify the most suitable teacher in order to solve a particular question as well as to distinguish the appropriate resources (books, class notes, etc.) for digging out a specific topic.

Communication Module

This module, as shown in Figure 1, gives support to the previous ones. Its main task is giving users access to the e-learning system. By this means, teachers and pupils have access not only to the previous modules but also to communication and collaboration among the different system users. It

Figure 1. Structure of e-learning systems

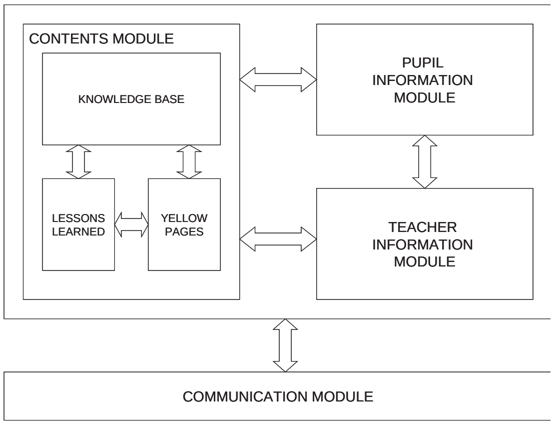
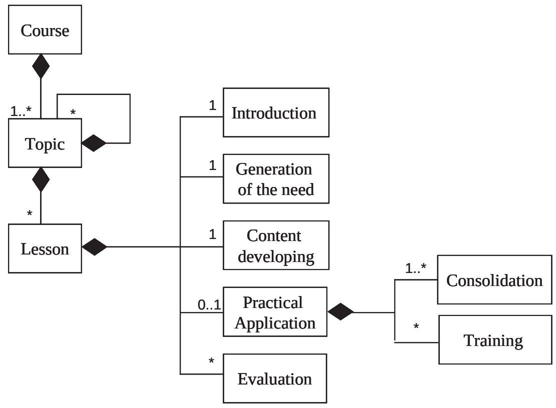


Figure 2. Ontology for the development and implementation of a knowledge base



is important to point out that this communication should not be limited to that between a pupil and a teacher, but in some domains, it also could be interesting to allow pupils and even teachers to intercommunicate.

Ontology for the Definition of Knowledge Base

As previously mentioned, the knowledge base acts like a storage space and a source of specific contents for the pupils to obtain the desired knowledge. The type of organization of these contents should allow significant learning in which pupils should be able to assimilate, conceptualize, and apply the acquired knowledge to new environments (Ausubel, David, Novak, & Hanesian, 1978; Michael, 2001).

In order to achieve this type of structure, the first step is the partition of the course into topics and subtopics for the identification of the specific lessons. This division will generate a subject tree that represents a useful tool for the pupil, so that he or she may understand the global structure of the course.

The following step should be the description of those lessons that have been identified. To achieve this, it is proposed that every lesson should be preceded by a brief introduction. Having done this, it is suggested to generate a genuine need of learning into the pupil, aiming for an increased receptiveness of the contents. Once the lesson has been displayed, the pupil should be guided with regard to the practical application of previously acquired theoretical knowledge. As a final stage, a verification of the evolution might be performed by means of an evaluation of the acquired knowledge.

Figure 2 shows the proposed ontology for definition and implementation of the knowledge base, supported by these components. As can be noticed, on some occasions, one or more components might not be applicable for a specific lesson. The necessary distinction of the relevant aspects for each case should be performed by the teacher. These components are detailed next.

Introduction of the Lesson

The aim of this component is to show the pupil a global vision of the lesson that is going to start. To achieve this, not only the purposes of its performance should be outlined clearly, but also the contents have to be described briefly. In addition, it should be made noticeable that lessons are codependent regarding themselves and/or the rest of the basic knowledge. It is also important to specify clearly what the basic knowledge requirements are for a successful approach.

Generation of the Need

The motivation of the pupil constitutes a key aspect of learning. A good strategy for achieving this is to stimulate the pupil's understanding of the usefulness of the knowledge that he or she is going to acquire (Wilkerson & Gijselaers, 1996). This purpose might be accomplished by generating need exercises, which consisting of a problem proposal whose method of solving is not known by the learner.

Content Developing

This is the component where the knowledge included in the lesson is maintained and transmitted. That knowledge may be dynamic or static, both constituting the so-called functional taxonomy of knowledge, which more specifically makes a distinction between them (Andrade et al., 2004a):

1. Dynamic Knowledge: Knowledge related to the behavior that exists in the domain; that is, functionality, action, processes, and control.
   This level can be divided into two sublevels:
   a. Strategic: Specifies what to do and where as well as when, in what order, and why to do it. This knowledge handles the functional decomposition of each operation in its constituent steps as well as the order in which they have to be undertaken.
   b. Tactical: Specifies how to do the tasks and under what circumstances they have to be done. This type of knowledge is associated with the execution process for each strategic step of the latest level.
2. Static Knowledge: Conforms the structural or declarative domain knowledge and specifies the elements—concepts, relations, and properties—that are handled when carrying out the tasks (i.e., handled by tactical knowledge) and the elements that are the basis for the decisions (i.e., implied in the decisions of strategic knowledge).

Therefore, a lesson should give support to the types of knowledge that have been identified. With this intention and given the different characteristics of each of them, they should be described on the basis of different parameters. In this way, Table 2 shows in schematic fashion those aspects that should be kept in mind when describing a knowledge asset, depending on the type of considered knowledge.

This taxonomy has been used by the authors not only for conceptualization and modeling of problems (Andrade et al., 2004b) but also for KM systems definition and implementation (Andrade et al., 2003). As a result, it has been concluded that the organization of knowledge, based on this taxonomy, facilitates its transmission, understanding, and assimilation. This statement is supported by the fact that functional taxonomy is consonant with human mindset, and therefore, it is sensitive to people (Andrade et al., 2004a).

Practical Application

Once the pupil has acquired the required knowledge assets, he or she should put them into practice for proper interiorization and assimilation. This task will be performed in two phases: consolidation and training.

The consolidation phase intends to reinforce theory by means of practice. With this aim, a group of examples will be made available for the pupil, who will be guided through his or her

Table 2. Aspects to be considered when describing a type of knowledge

Level	Characteristics to consider	
Strategic	Functional decomposition of each operation in its constituent sub-steps. Execution order for the identified steps for operation fulfilling. Pre-conditions and post-conditions for the execution of every identified step. Entries and exits of each identified step. Responsible for each step.	
Tactical	Operation mode—algorithm, mathematical expression or inference—of each identified step. Limitative aspects in its application. Elements—concepts, relations and properties—which it handles and produces.	
Declarative	Concepts	Relevant properties. Relations in which it participates.
	Relations	Properties, concepts and, or, relations participating in the relation. Limitative aspects in its application.
	Properties	Type of value. Possible values which it can take. Source which provides its value/s. Limitative aspects in its application.

resolution by means of the rationalization of every decision made.

During the training phase, the aim is for the pupil to apply the resolution method straightforward by the use of a group of exercises increasingly complex.

It should be highlighted that when exercises are more similar to real circumstances, the results obtained will be enhanced; consequently, exercises and examples should be as realistic as possible.

Evaluation

The evaluation of the acquired knowledge will provide useful information for both pupils and teachers who would be able to verify a pupil's evolution regarding what was expected and whether pre-established levels have been accomplished or not. Likewise, the evolution would allow the detection of any learning problem in order to handle it appropriately.

FUTURE TRENDS

As previously mentioned in this article, e-learning discipline has been shown as an inappropriate approach; it is the mere digitalization and publication of the same docent material commonly used at attendance lessons, making technology not a tool but a goal in itself. The perception of this situation should induce a change when dealing with the development of e-learning systems in terms of fitting the definition and structuration of the docent material to the needs that human beings might present. In other words, as human computer interaction (HCI) emphasizes, human beings should not be servants of but served by technology.

Shown here is a first attempt toward the attainment of this objective. A lot of work remains to be done; therefore, it is predicted that future investigations will be focused on a more exhaustive definition regarding the way in which docent material should be elaborated in order to be more easily assimilated by pupils.

CONCLUSION

The present work has catalogued the different existing educational methods that attend both to who may lead the process and to whether physical attendance of the pupil is required or not. This classification has allowed, for every method and especially for e-learning, the identification of their inherent particulars.

Nonetheless, most of the so-called e-learning systems do not properly support the intrinsic characteristics of these types of systems, since they merely provide an electronic format for the docent material of classical teaching.

KM techniques have been used with the aim of providing an answer to this situation. This discipline tries to find the optimal strategies for the representation and transmission of knowledge so that its latter comprehension might be facilitated. Following this, a basic structure for e-learning systems was defined using modules and submodules. Similarly, after the identification of the knowledge base as one of the key aspects of the mentioned structure, a specific ontology was described for its definition and implementation.

Finally, it should be mentioned that the attainment of auto-content and auto-explanative docent material for an easier acquisition of knowledge could be achieved by the use of the defined ontology.

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REFERENCES

Andrade, J., Ares, J., García, R., Pazos, J., Rodríguez, S., & Silva, A. (2004a). A methodological framework for generic conceptualisation: Problem-sensitivity in software engineering. *Information and Software Technology, 46*(10), 635-649.

Andrade, J., Ares, J., García, R., Pazos, J., Rodríguez, S., & Silva, A. (2004b). A methodological framework for viewpoint-oriented conceptual modeling. *IEEE Transactions on Software Engineering, 30*(5), 282-294.

Andrade, J., Ares, J., García, R., Rodríguez, S., Silva, A., & Suárez, S. (2003). Knowledge management systems development: A roadmap. In V. Palade, R.J. Howlett, & L. Jain (Eds.), *Knowledge-based intelligent information and engineering systems* (pp. 1008-1015). Berlin: Springer-Verlag.

Ausubel, D., David P., Novak, J.D., & Hanesian, H. (1978). *Educational psychology: A cognitive view* (2nd ed.). New York: Holt, Rinehart, and Winston.

Davenport, T.H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Friss de Kereki, I. (2003). Use of ontologies in a learning environment model. In V. Uskov (Ed.), *Computers and advanced technology in education* (pp. 550-555). Calgary: ACTA Press.

Good, T.L., & Brophy, J.E. (1990). *Educational psychology: A realistic approach* (4th ed.). New York: Longman.

Martínez, J. (2002). *E-learning: Nuevo medio, viejas costumbres*. Retrieved August 9, 2004, from http://www.gestiondelconocimiento.com/articulos.php

Martínez, J. (2003). *Aprendizaje efectivo-e(ffective) learning*. Retrieved August 9, 2004, from http://www.gestiondelconocimiento.com/articulos.php

Michael, J. (2001). In pursuit of meaningful learning. *American Journal in Physiology, 25*, 145-158.

Pedreira, N. (2003). *Un modelo de deuteroaprendizaje virtual* (doctoral thesis). Spain: University of A Coruña.

Piaget, J. (1972). *Psychology and epistemology: Towards a theory of knowledge*. New York: Viking Press.

Piaget, J. (1998). *Jean Piaget selected works*. New York: Routledge.

Van Heijst, G., Van der Spek, R., & Kruizinga, E. (1997). Corporate memories as a tool for knowledge management. *Expert Systems with Applications, 13,* 41-54.

Wilkerson, L., & Gijselaers, W.H. (1996). *The power of problem-based learning to higher education: Theory and practice*. San Francisco: Jossey-Bass.

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Chapter 1.35
Knowledge Management as a Reference Theory for E-Learning:
A Conceptual and Technological Perspective

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ABSTRACT

E-learning as a scientific field is in an era of transition. In the last decade, several scientific fields worked as reference disciplines for the promotion of the value delivery that new technologies offered to learning. In this paper, we will emphasize the role of knowledge management as a reference theory for e-learning.

INTRODUCTION

E-learning provides an extremely challenging research context. The facilitation of learning through technology requires a multifold consideration of issues that fall into the categories of cognition, behavior, beliefs, attitudes, and social constructions such as networks, communities, group formations, recommendations, and utilization of human capital.

Knowledge management, on the other hand, poses a critical question to researchers: How do we justify abstractions that provide a systematic way for the management of knowledge? Extremely interesting literature covers a wide range of issues that relate to knowledge management processes and knowledge category models, as well as to knowledge networks and communities. From another point of view, the discussion of knowledge management strategies is based on a five-layer approach: Artifact, Individual, Group, Organization, and Interorganizational Network are recognized as critical locations where knowledge can be identified and utilized.

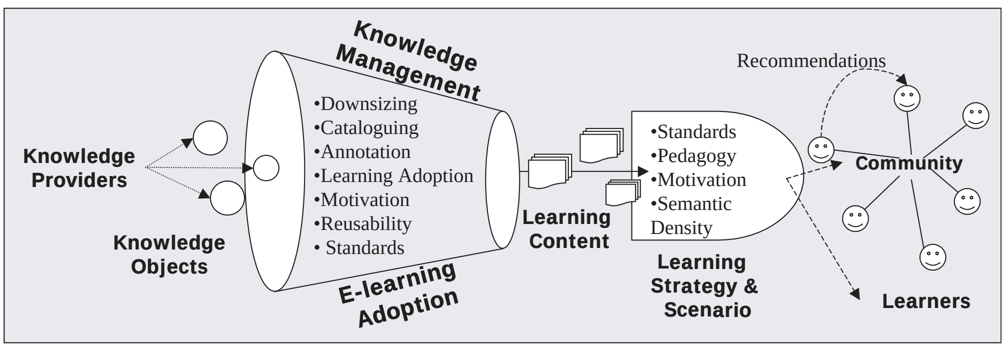
This paper summarizes the importance of knowledge management for e-learning. In the past, researchers have tried to investigate the role of knowledge management for e-learning. The convergence of these approaches is visualized in Figure 1.

In Figure 1, knowledge management is presented as a critical diode, where a plethora of knowledge objects have to be managed and adopted in order to fulfill the requirements for learning utilization. The issue of learning utilization is not a linear function nor even guided from a well-defined cause-and-effect formula, where learning outcome is directly related to independent variables. Knowledge management can be utilized in many different ways in the context of e-learning. A first point of argument is the direct linkage of knowledge to learning content and, thus, the need to justify the ways that diverse knowledge objects are used in an e-learning system in order to provide learning material. The downsizing of knowledge in reusable parts, the annotation of relevant knowledge objects, and the establishment of effective management mechanisms require the promotion of standards as well as the specification of a clear learning strategy. These issues are critical milestones for knowledge management and e-learning convergence.

In this article, two general pillars from the knowledge management literature are discussed further:

- The knowledge artifact approach, where knowledge management's main emphasis is on the epistemology of knowledge and the specification of relevant types of knowledge. As depicted in Figure 2, there is a direct linkage of knowledge types to learning content types. The debate on tacit and explicit knowledge provides an epistemological background for the analysis of their implications in an e-learning environment: In the past years, the e-learning community seems to have been dominated by the learning objects research stream, where the relevant research agenda includes semantic annotation, embodiment of instructional design, and guidance on the transformation of learning content to the learning object metaphor.
- The knowledge process approach, where several value-adding processes summarize significant transformation mechanisms and a life cycle that brings together providers and users of knowledge.

Figure 1. Investigating knowledge management role in e-learning

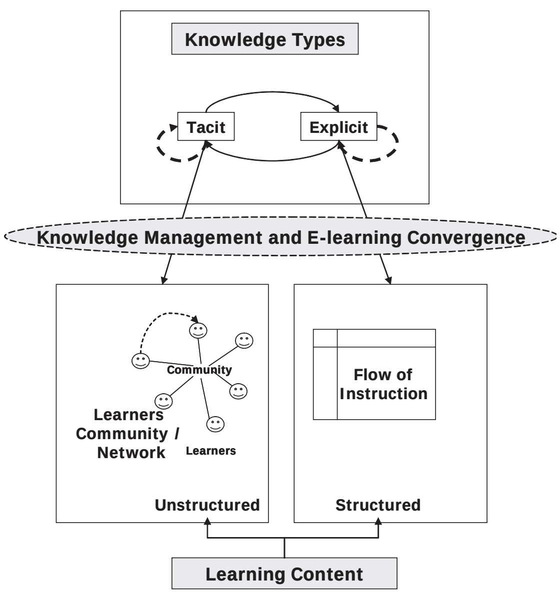


A number of complementary approaches to knowledge category models promote an interesting discussion for types of learning content that can be identified and managed in an e-learning setting. The evolution of databases, multimedia technologies, human computer interactivity, adaptive hypermedia, mobile and wireless technologies, and the advent of the Semantic Web have moved the emphasis from the traditional artifact approaches to a process approach to the utilization of unstructured content.

Figure 2 summarizes the underlying linkage between knowledge types and learning content. Knowledge management literature utilizes further the epistemology of knowledge and promotes a number of knowledge category models.

The knowledge management research community has promoted an interesting discussion on the role of ontological engineering toward the development of adaptive, flexible, and dynamic systems. Miguel-Ángel Sicilia and Elena García from the University of Alcala, Spain, provide an excellent discussion on the convergence of formal ontologies and standardized e-learning. Current efforts to standardize e-learning resources are centered on the notion of a learning object as a piece of content that can be reused in diverse educational contexts. The embodiment of instructional design to learning objects poses new challenges for the standardization process: In e-learning, the key issue is neither the interoperability nor the reusability of content, but rather the support of learning as a cognitive and constructive process. For the development of this critical milestone, knowledge management and ontologies provide several alternative options and new reference models for the representation and diffusion of content. Value delivery through annotation and semantics will be forthcoming as an excellent research context for e-learning.

Figure 2. A rich picture



The other critical point of view for the convergence of knowledge management and e-learning refers directly to the community of learners that promote the social character of e-learning. This community is anticipated to have a great potential of unutilized knowledge, which basically is considered to be unstructured. The next paper summarizes a quite promising work: Sheizaf Rafaeli and Yuval Dan-Gur from the University of Haifa, Mt. Carmel, Israel, and Miri Barak from the Massachusetts Institute of Technology, discuss the importance of the social recommendation systems on e-learning. In such systems, users can receive guidance in locating and ranking references, knowledge bits, test items, and so forth. In these systems, users' ratings can be applied to items, users, other users' ratings, and, if allowed, raters of raters of items recursively. This is an interesting issue concerning the flow of instruction. The traditional author-led design and implementation of online learning experiences require a greater openness and utilization of contributions directly derived from learners (with some prerequisites).

In the same context, agent-based e-learning systems will realize sophisticated and integrated approaches to dynamic learning content assembly.

H.K. Yau, E.W.T. Ngai, and T.C.E. Cheng from Hong Kong Polytechnic University, Hong Kong, PR China, provide an interesting conceptual model and an architecture for an agent-based and knowledge-management-enabled e-learning system.

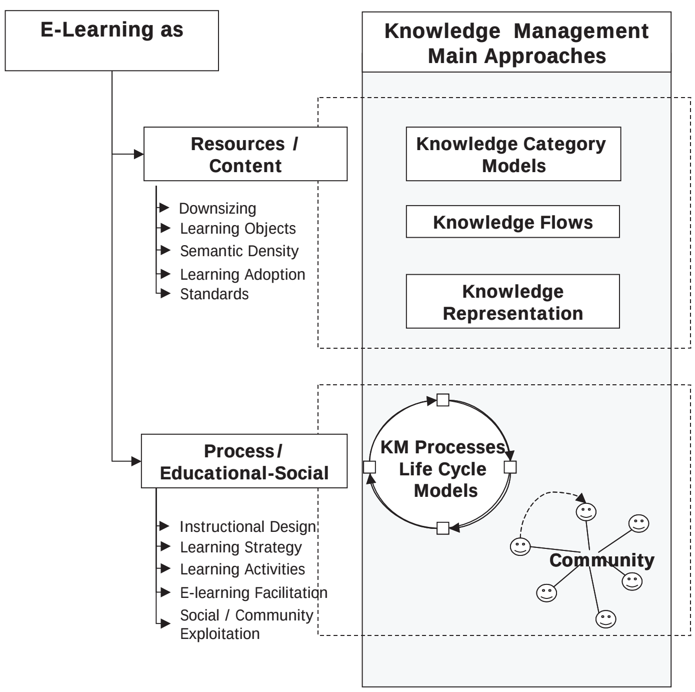
DISCUSSION OF KEY PROPOSITIONS AND THE CONTRIBUTION OF THIS PAPER

The initial idea for a special issue on the role of knowledge management for E-learning was derived from the extraordinary interest of many researchers all around the world to investigate conceptual frameworks and technologies from the knowledge management field toward the promotion of more effective, dynamic, and personalized e-learning.

The decision of JDET editors to approve our idea for this paper was a critical milestone, and several alternative strategies were considered in order to promote a high-quality issue with balanced contributions. With an acceptance rate of 15%, we decided finally to accept three areas that cover a wide range of knowledge management aspects and pose significant research questions for the future. Moreover, we decided to follow a strategy in which selected topics as a whole volume could promote a balanced theoretical and practical overview with a significant contribution for the emerging, knowledge-management-enabled research agenda in e-learning.

In this section, we will try to outline the contribution of this special issue. From the beginning, we have said that in each section of the issue, there are several significant "hidden" aspects that could initiate a PhD research.

Figure 3. Aspects of e-learning and knowledge management convergence



In Figure 3, the e-learning and knowledge management convergence is linked to five general pillars of literature:

- Knowledge Category Models
- Knowledge Flows
- Knowledge Representation
- Knowledge Management Processes and Life Cycle Models
- Communities and Social Capital

In this issue, Sicilia and Garcia discuss from an interesting point of view the convergence of formal ontologies and standardized e-learning. In fact, they extend the debate on learning objects' metadata and provide to the reader an excellent and intensive presentation of organizational and technical issues that have to be addressed. According to their concluding remark, "the use of modern Web-enabled ontology languages has been sketched, and an illustration of the benefits of the integration of learning object descriptions has been provided through OpenCyc examples. More comprehensive learning object specifications, including the description of learning process, should be addressed in the future."

From this point of view, the annotation of the learning objects has to promote further the dynamic features of modern e-learning systems as well as their value proposition. In fact, this criticism brings forward the need to define learning objects.

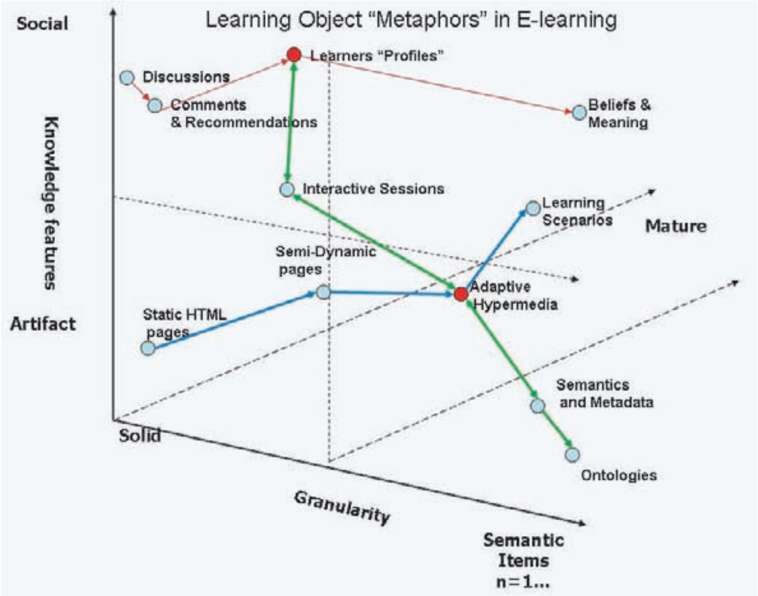
The literature on learning objects is extremely substantial (McGreal, 2004). The limited length of this paper does not allow us to present it in detail. Instead, we will summarize the basic properties of a learning object. In other words, we have selected some typical characteristics for learning objects found either in the literature or in practical implementations of e-learning systems. In Figure 4, a three-dimensional space provides the setting for our constructive point of view. Several items directly related to learning objects have been summarized, and three paths (from several others already mapped in our research) have been indicated.

The basic idea is that three critical perceptions provide significant considerations for value adding features of learning objects:

- Knowledge Features: Ranges from artifact to social (an analogy of explicit to tacit); the great challenge is to investigate new ways for utilizing meaning, belief, and community.
- Granularity: Refers to the modular nature of learning objects. This dimension ranges from solid, in which case only a component realizes the LO, to Semantic Items, where a significant number of semantic items provide new meaningful insights to learning objects (e.g., context, learning processes, target groups, etc.).
- Maturity: This dimension is a critical but rather blurred dimension. Maturity is perceived as a continuous process where the usage of innovative technologies provides new possibilities for adaptive and personalized e-learning environments. This aspect will not be discussed in detail in this paper but provides input for the process of designing new generations of learning objects.

In Figure 4 we have specified a number of heterogeneous metaphors for learning objects that depict the quite different approaches in LO design: static HTML pages, comments and recommendations, learners' profiles, interactive sessions, adaptive hypermedia, learning scenarios, ontologies, semantic, and metadata provide an overall idea. From this point of view, it is extremely interesting as outlined in the work of Rafaeli, Dan-Gur, and Barak, to investigate new methods for incorporating tacit knowledge elements in learning objects. The annotation of LOs should not be considered as a technical issue but purely as a cognitive process with direct linkage to the learning outcome. According to Rafaeli, Dan-Gur, and Barak, the convergence

Figure 4. Outlining learning object metaphors in e-learning



of recommenders in e-learning requires learners to employ critical judgment, first when they rank various knowledge items, and then when they choose the source of recommendation. The sharing of their judgments and information in a way that encourages collaboration and trust can increase the delivered value of an e-learning system and also has the potential to enhance critical thinking and promote the growth of tactic knowledge among its users. By implementing various recommendation approaches, learners engage in critical reading and learn to choose the most sought and required knowledge items. Moreover, participating in the community of learners might designate the intuitions that are gained through experience and enhance the sense of competency acquired by participating in communities of practice.

The work of Sicilia and Garcia as well as the interesting proposition of Rafaeli, Dan-Gur, and Barak justify the need to modify our mental model of learning objects in order to meet pedagogical as well as social and learning challenges. In this context, we will use the term Semantic Learning Cube in order to summarize this new paradigm for learning content.

Learning Cubes are an alternative proposition for learning objects representation and utilization. In fact, they can be defined in a simple way: Learning Objects (LOs) with well defined meaning and scalable embedded pedagogical value that can be adjusted to social characteristics of learners promoting a mature learning experience in highly adaptive e-learning environments.

From their definition, Learning Cubes require significant work in several issues and themes which can be undertaken in the near future from several researches whose origins are in various disciplines: Artificial Intelligence, Semantic Web, Knowledge Management, E-business, and so forth.

Concerning well-defined meaning, ontologies and the Semantic Web set specific challenges to the Semantic Learning Cube paradigm. In our perspective, ontology of Learning Cubes provides answers to three critical questions:

1. How do we codify scalable pedagogical value in LOs?
2. How do we incorporate social or tacit knowledge features with LOs?
3. How do we outline the paths for mature learning experiences through constructive learning tasks?

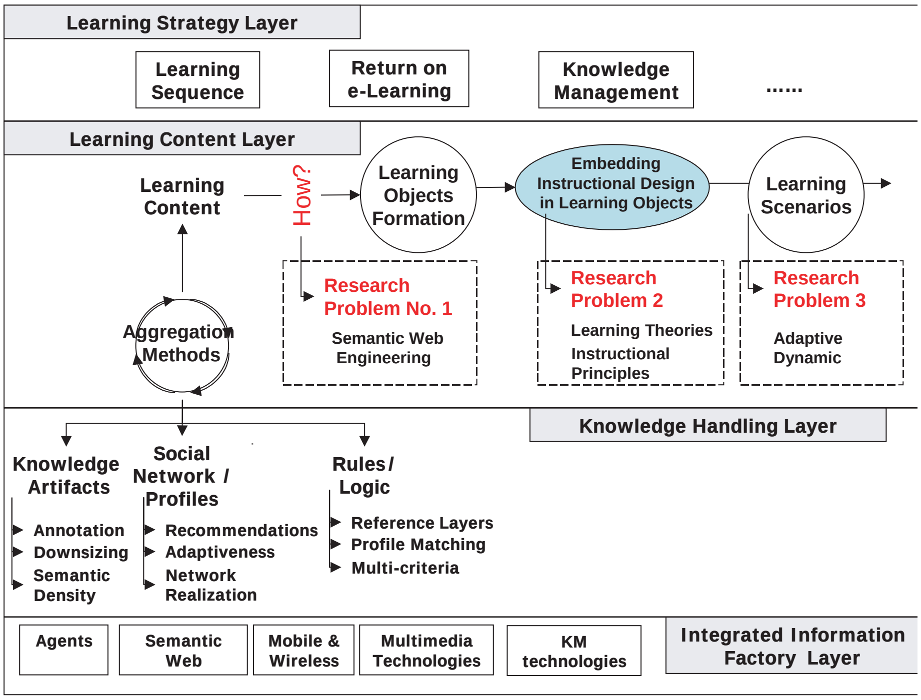
Scalable embedded pedagogical value relates to semantic annotation of content that promotes the learning context realization in terms of learning processes. The benefits from such a practice have been pointed out in extensive literature. Associating meaning to content through semantic markup will facilitate search, interoperability, and the composition of complex information through an interoperable meaning (Fiensel et al., 2000). According to Lytras et al. (2002a), e-learning cannot be evaluated as value-adding without promoting unique learning experiences. Semantic Learning Cubes go a step further in this approach by developing a Semantic-Web-enabled tool for the composition of Learning Cubes and relevant services (marketplaces of Learning Cubes, Dynamic Learning Cubes Composition).

Towards this direction, the work of Yau, Ngai and Cheng is extremely important. The design and implementation of intelligent agents is critical for the promotion of e-learning. In order to be successful, intelligent infrastructures supporting unique learning experiences and fulfilling a motivating learning context will have to be based on well chosen theoretical abstractions. Multiagent Societies will provide an extremely interesting research area within the near future. The mobility of agents is also an exciting area for further research. Mobile agents that travel from one machine to another (e.g., from a desktop to a palm pilot) will promote the vision of ubiquitous learning.

In order to summarize this paper, we have tried to develop a "rich misture" of research problems that are linked directly to the convergence of knowledge management and e-learning. In Figure 5, a four-level approach to e-learning strategy is provided. Four levels provide a concrete strategy targeting the utilization of different knowledge items for learning purposes:

- Integrated Information Factory Layer: Refers to a number of diverse technologies like Agents, Semantic Web, Mobile and Wireless Networks, Knowledge Management Technologies, and so forth, that have established a holistic approach for the management of information resources.
- Knowledge Handling Layer: This layer addresses the key demand for managing knowledge in codified formats and social flows. Thus, knowledge artifacts, Social Network, Profiles Management, Specifications of Rules, and logic are issues of critical significance for the performance of knowledge resident in an Information Factory.
- Learning Content Layer: In e-learning implementations, this layer is of critical importance. Several dynamic aggregation methods provide the convergence of knowledge handling and learning content layer. Diverse knowledge items are utilized in a learning content item, and for this reason, we have to decide on the structural unit. In our LO Cube approach the Learning Objects formation is facilitated by the advent of Semantic Web Engineering. This is depicted as the first critical aspect of the research problem: The specification of SW-enabled content formation according to clear descriptive logic. Ontologies and other approaches play a key role in this direction. In our approach, a new ontology titled Learning Process (Figure 5) is the key contribution toward this direction. The second critical aspect of the research problem is the Embedding of Instructional Design Principles in Learning Objects. This ultimate objective requires an extensive transformation of guiding learning theories to principles and guidance for

Figure 5. A learning process to LO formation



LO construction. In the next step, learning context (Figure 5) is anticipated as the third pillar of our research problem.

- Learning Strategy Layer: The fourth layer guides the whole process. Learning strategy has to be crafted, and several decisions have to be made. In Figure 2, we did not provide an exhaustive list of relevant themes, but in our whole approach, there is a concrete discussion of the whole strategy agenda.

Over the next years, we will face an extraordinary interest in research in e-learning and KM. According to Prof. Michael Spector:

Technology changes. Technology changes what people do and can do. Technology is changing how people learn and work. Embracing innovation and changes is characteristically human. Technology-based changes are pervasive, which means that researchers interested in the impact of technology on learning and working are living in the best of times. How fortunate. (Spector in Lytras, 2002, Knowledge and Learning Management, Papasotiriou Publications)

In this direction, we encourage researchers to continue and to strengthen their interest in the convergence of Knowledge Management and E-Learning. In a visioning section at the end of the paper titled, "A Knowledge Management Roadmap for E-Learning: The Way Ahead," we discuss in more detail the future of this convergence.

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FURTHER READINGS

Adams, E., & Freeman, C. (2000). Communities of practice: Bridging technology and knowledge assessment. *Journal of Knowledge Management, 4*(1), 38-44.

Benjamins, R., Fensel, D., & Gomez Perez, A. (1998). Knowledge management through ontologies. In U. Reimer (Ed.), *Proceedings of the Second International Conference on Practical Aspects of Knowledge Management,* Oct 29-30, Basel, Switzerland (p. 5).

Bhatt, G.D. (2000). Organizing knowledge in the knowledge development cycle. *Journal of Knowledge Management, 4*(1), 15-26.

Binney, D. (2001). The knowledge management spectrum—Understanding the KM landscape. *Journal of Knowledge Management, 5*(1), 33-42.

Hahn, J., & Subramani, M. (2000). A framework of knowledge management systems: Issues and challenges for theory and practice. *21st Annual International Conference on Information Systems,* Brisbane, Australia.

Holsapple C.W., & Joshi, K.D. (2001). Organizational knowledge resources. *Decision Support Systems, 31*(1), 39-54.

Lytras, M.D., & Pouloudi, A. (2001). E-learning: Just a waste of time. In D. Strong, D. Straub, & J.I. DeGross (Eds.), *Proceedings of the Seventh Americas Conference on Information Systems* (pp. 216-222), Boston, Massachusetts.

Lytras M., Pouloudi, A., & Korfiatis, N. (2003). An ontological oriented approach on e-learning: Integrating semantics for adaptive e-learning systems. In Ciborra (Ed.), *New paradigms in organizations, markets and society. Proceedings of the 11th European Conference on Information Systems.*

Lytras, M., Pouloudi, A., & Poulymenakou, A. (2002). Dynamic e-learning settings through advanced semantics: The value justification of a knowledge management oriented metadata schema. *International Journal on E-Learning 1*(4), 49-61.

Lytras M., Pouloudi, N., & Poulymenakou, A. (2002). Knowledge management convergence: Expanding learning frontiers. *Journal of Knowledge Management, 6*(1), 40-51.

Lytras M., Tsilira, A., Themistocleous, M. (2003). Towards the semantic e-learning: An ontological oriented discussion of the new research agenda within the e-learning field. *Proceedings of the 9th Americas Conference on Information Systems.*

Maedche, A. & Staab, S. (2001). Ontology learning for the semantic Web. *IEEE Intelligent Systems, 16*(2), 72-79.

McAdam, R., & McCreedy, S. (1999). A critical review of knowledge management models. *The Learning Organization: An International Journal, 6*(3), 91-101.

Naeve, A. (2001). The concept browser: A new form of knowledge management tool. *Proceedings of the Second European Web-Based Learning Environment Conference (WBLE 2001)* October 24-26, Lund, Sweden (pp. 151-161). http://kmr.nadad.kth.se/papers/ConceptualBrowsing/ConceptBrowser.pdf

Naeve, A. (2001). The knowledge manifold: An educational architecture that supports inquiry-based customizable forms of e-learning. *Proceedings of the Second European Web-Based Learning Environments Conference (WBLE 2001)* October 24-26, Lund, Sweden, (pp. 200-212). http://kmr.nada.kth.se/papers/knowledgemanifolds/knowledge manifold.pdf

Naeve, A., Nilsson, M., Palmér, M., & Paulsson, F. (2005). *Contributions to a public e-learning platform: Infrastructure, architecture, frameworks, and tools.*

Nilsson, M., Naeve, A. & Palmér, M. (2004). The Edutella P2P Network: Supporting Democratic e-learning and communities of practice. In R. McGreal (Ed.), *Online education using learning objects.* New York: Routledge-Falmer.

Norris, D., Mason, J. & Lefrere, P. (2003). *Transforming e-knowledge: A revolution in the sharing of knowledge*. Society for College and University Planning. http://www.scup.org/eknowledge

Rubenstein-Montano, B., Liebowitz, J.B., & McCaw, D. (2001). A systems thinking framework for knowledge management. *Decisions Support Systems Journal, 31*(1), 5-16.

Zack, M.H. (1999a), Developing a knowledge strategy. *California Management Review 41*(3), 125-145.

Zack, M.H. (1999b). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

Zhang, H., Kim, D.J., & Ramesh, R. (2001). Multiagent systems: An ontological meta-model. In D. Strong, D. Straub, & J.I. DeGross (Eds.), *Proceedings of the Seventh Americas Conference on Information Systems (AMCIS)* (pp. 406-408), Boston, Massachusetts.

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Chapter 1.36
Beyond Knowledge Management:
Introducing Learning Management Systems

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EXECUTIVE SUMMARY

In the knowledge economy, a firm's intellectual capital represents the only sustainable source of competitive advantage; accordingly, the ability to learn, and to manage the learning process are key success factors for firms. The knowledge management approach to learning in organizations has achieved limited success, primarily because it has focused on knowledge as a resource rather than on learning as a people process. Many world-class organizations, such as Procter & Gamble, Cisco Systems and Deloitte Consulting, are now employing a new breed of systems known as Learning Management Systems (LMS) to foster and manage learning within their organizations1. This article reports on the deployment of an LMS by a major US multinational, CEM Corporation, and proposes a framework for understanding learning in organizations, which highlights the roles that LMS can play in today's knowledge-intensive organizations.

ORGANIZATIONAL BACKGROUND

CEM Corporation2 is a world leader in the design, development and manufacture of Internetworking storage IT infrastructures. The company's core competencies are in networked storage technologies, storage platforms, software, and, also, in services that enable organizations to better and more cost-effectively manage, protect and share information. CEM was founded in 1979 and launched its first product in 1981 — a 64-kilobyte integrated circuit memory board developed for the then popular Prime minicomputer platform. CEM's sales passed the $3 million mark in 1982 and reached $18.8 million two years later. In the mid-1980s, CEM launched a series of memory and storage products that improved performance and capacity for minicomputers made by IBM, Hewlett-Packard, Wang, and Digital Equipment Corporation. The company went public in April 1986; a year in which sales hit $66.6 million and a net income of $18.6 million was achieved.

In the late 1980s, CEM expanded strongly into the auxiliary storage arena, where it remarketed other suppliers' magnetic disk drive storage subsystems, often coupled with its own controller units. In 1987, the company introduced solid state disk (SSD) storage systems for the minicomputer market and its headquarters moved to Hopkinton, Massachusetts. In 1988, its stock was listed on the New York Stock Exchange and in 1989 CEM accelerated the transition from a supplier of memory enhancement products to a provider of mass storage solutions. In 1997, more than 70% of the company's engineers were dedicated to software development for mass storage technologies. Software sales rose from $20 million in 1995 to $445 million in 1998, making CEM the fastest growing major software company in the industry sector. In 2001, CEM was named as one of Fortune's 100 best companies to work for in America. In the same year, the company launched a major new global branding initiative. CEM Corporation's total consolidated revenue for 2002 was $5.44 billion.

SETTING THE STAGE

From its inception, CEM recognized the importance of learning within the organization: accordingly, it facilitated learning development and support for its employees, including: technical skills; business skills; IT skills; management skills; and individual personal development. Prior to 2000, learning development and support was facilitated through a number of training services, which included:

- A Corporate University, which provides training throughout CEM, including induction training for new staff, corporate guidelines, professional and project management guidelines, and computer skills.
- A Professional Global Services Training department, which supports field and sales staff at CEM.
- A Global Technical Training Department, whose main aim is to address the advancing technologies in the ever-evolving hardware, software products, and support applications and processes.
- Human Resources Training Centers, which support the soft skill training of managers, supervisors and individual employees.
- Technical Libraries and Personal Development Libraries.
- A Continuing Education Program, which provides financial support and study leave.

These diverse training services within CEM had, for some time, been successfully delivering training and learning support to a number of distinct areas within the corporation. However, by the year 2000, CEM recognized that it was facing a number of key challenges in relation to its organizational learning processes. These included the following:

- As a large multinational organization with a constantly growing global workforce of 20,000-plus employees, the overall management of the learning of all employees using multiple training organizations was becoming increasingly difficult. In particular, the management of course enrollments, training paths and individual competency levels posed a significant challenge.
- There was some duplication of effort across many of the training services and a distinct lack of consistency in how training was being developed and delivered. Specifically, there

was a lack of coherence in relation to how content was being created and administered. From the point of view of an employee, there was no overall catalogue of courses available that outlined the training or learning programs available from each of the training services.

- By 2000, the business environment in which CEM Corporation operated was rapidly evolving and becoming more intensely competitive: hence, learning and the management of learning began to play an increasingly critical role in the ongoing success of the organization. Within this context, CEM needed to replace the isolated and fragmented learning programs with a systematic means of assessing and raising competency and performance levels of all employees throughout the organization.
- In addition, CEM wished to establish itself as an employer of choice by offering its people extensive career planning and development opportunities.

In response to these challenges, CEM decided to implement an enterprise learning solution. The stated business drivers for deploying this enterprise learning solution were to:

- Decrease time-to-competency.
- Develop and manage skill sets for all employees.
- Leverage global, repeatable and predictable curriculum.
- Integrate competency assessments with development plans.
- Accelerate the transfer of knowledge to employees, partners, and customers.
- Provide a single learning interface for all internal and external users.

CEM went to the market looking for an off-the-shelf corporate-based learning management system (LMS) that could be used to formulate and manage learning across multiple functions within the organization, including: technical functions; business functions; IT professional functions; and management functions. The system would also need to facilitate the delivery and tracking of disparate training programs, including the tracking of individual personal development training. Having considered several LMS then available from different vendors, CEM Corporation chose Saba Learning Enterprise™ (see Appendix A for a brief overview of Saba Software Inc.). In February 2001, CEM deployed its enterprise learning solution, incorporating this new LMS to employees across the entire organization as well as to CEM customers and business partners.

Based on an exhaustive analysis of previous research in the area and an extensive case study of the deployment and use of Saba Learning Enterprise™ at CEM Corporation, this article proposes a framework that places LMS in context with other categories of IS said to underpin learning in organizations. The framework also highlights the roles that LMS can play in the support and management of learning within knowledge-intensive business enterprises. Thus, it is hoped that this framework will deepen the IS field's understanding of the contribution of LMS to learning within organizations.

Motivation for the Study

Significance of Learning in Organizations

The importance of facilitating and managing learning within organizations is well accepted. Zuboff (1988), for example, argues that learning, integration and communication are critical to leveraging employee knowledge; accordingly, she maintains that managers must switch from being drivers of people to being drivers of learning. Harvey and Denton (1999) identify several antecedents that help to explain the rise to prominence of organizational learning, viz.

- The shift in the relative importance of factors of production away from capital towards labor, particularly in the case of knowledge workers.
- The increasing pace of change in the business environment.
- Wide acceptance of knowledge as a prime source of competitive advantage.
- The greater demands being placed on all businesses by customers.
- Increasing dissatisfaction among managers and employees with the traditional "command control" management paradigm.
- The intensely competitive nature of global business.

Deficiencies in the Knowledge Management Approach

During the 1990s, there was a major shift in focus from organizational learning to knowledge management in both applied and theoretical contexts (Alvesson & Kärreman, 2001; Easterby-Smith, Crossan & Nicolini, 2000; Scarbrough & Swan, 2001). Knowledge management systems (KMS) sought to facilitate the sharing and integration of knowledge (Alavi & Leidner, 1999; Chait, 1999; Garavelli, Gorgoglione & Scozzi, 2002). However, these systems had limited success (Shultz & Boland, 2000), with reported failure rates of over 80% (Storey & Barnett, 2000). This was because many of them were, for the most part, used to support data and information processing, rather than knowledge management (Borghoff & Pareschi, 1999; Butler, 2003; Garavelli et al., 2002; Hendricks, 2001; Sutton, 2001) and also because many implementations neglected the social, cultural and motivational issues that were critical to their success (Huber, 2001; McDermott, 1999; Schultze & Boland, 2000). Indeed, some argue the knowledge management paradigm may be little more than the latest "fad" to be embraced by the IS field (Butler, 2000; Galliers & Newell, 2001; Swan, Scarborough & Preston, 1999), and its popularity may have been heightened by glossing over complex and intangible aspects of human behavior (Scarborough & Swan, 2001).

New Potential Offered by Learning Management Systems

It is perhaps time to admit that neither the learning organization concept, which is people oriented and focuses on learning as a process, nor the knowledge management concept, which focuses on knowledge as a resource, can stand alone. These concepts compliment each other, in that the learning process is of no value without an outcome, while knowledge is too intangible, dynamic and contextual to allow it to be managed as a tangible resource (Rowley, 2001). She emphasizes that successful knowledge management needs to couple a concern for systems with an awareness of how organizations learn. Researchers believe that what is needed is to better manage the flow of information through and around the "bottlenecks" of personal attention and learning capacity (Brennan, Funke & Andersen, 2001; Wagner, 2000) and to design systems where technology services and supports diverse learners and dissimilar learning contexts (McCombs, 2000). In response to these needs, learning management systems (LMS) evolved; accordingly, an increasing number of firms are using such technologies in order to adopt new approaches to learning within their organizations. This new learning management approach has been led primarily by practitioners and IT vendors; as it is a relatively new phenomenon, there is a dearth of empirical research in the area. Therefore, an important challenge for the IS field is to better understand LMS and to examine the role that these new systems play in organizations.

CASE DESCRIPTION

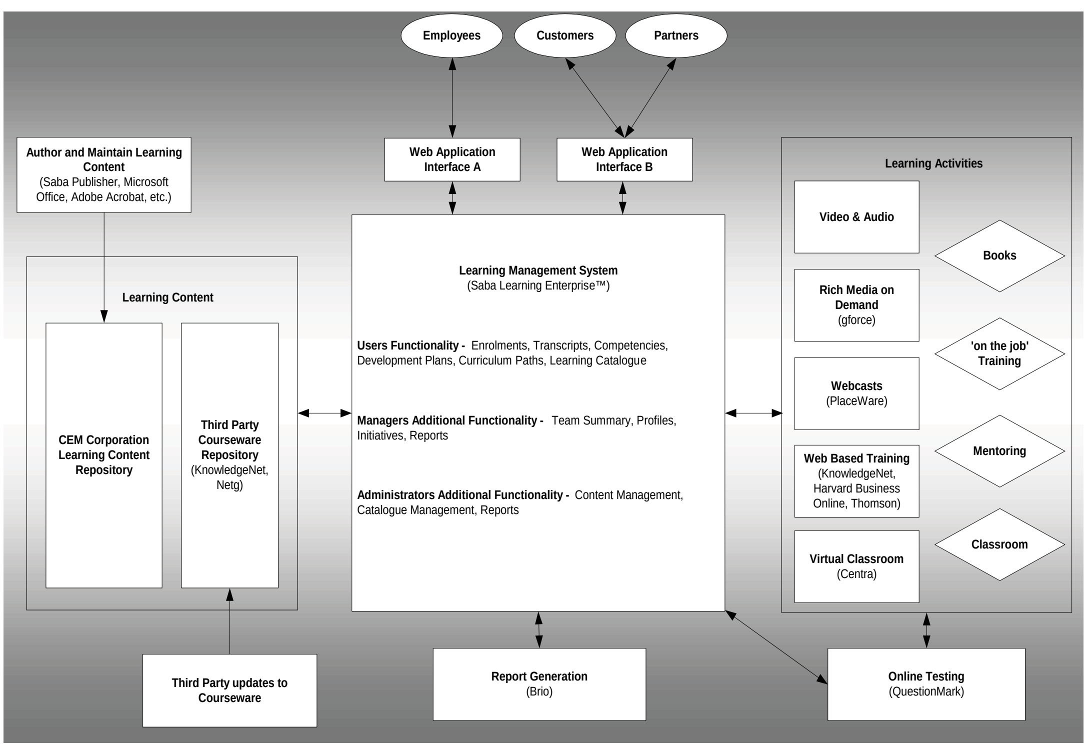
Conduct of the Study

This case study was conducted over a period of 11 months from October 2002 to August 2003. The LMS in use at CEM is a complex and multifaceted system; hence, it was necessary to first conduct several exploratory interviews with the subject matter expert. Five such site visits occurred over a six-month period and each meeting lasted between one and one and a half hours. This type of elite interviewing (Marshall & Rossman, 1989) is sometimes necessary to investigate little understood phenomena. In one of these sessions, a detailed demonstration of how the system operates was provided by this expert. A second demonstration of the system was subsequently obtained from a training manager within CEM Corporation. This provided the researchers with an understanding of the system's capabilities and an insight into how the system is used on a day-to-day basis. The human resources manager was also interviewed at this stage. Subsequently, the researcher carried out eight semi-structured interviews with key personnel, including an administrator of the system, a number of employees and managers who use the system, and several training specialists, one of whom had responsibility for knowledge management initiatives at CEM. Appendix B provides an outline of the interview guide used in the semi-structured interviews.

The Enterprise Learning Solution

The Enterprise Learning Solution implemented by CEM Corporation consists of several components, one of which is an LMS called Saba Learning Enterprise™ (Figure 1). Much of the learning material is created and maintained by CEM employees using a range of off-the-shelf products that includes Microsoft Office, Adobe

Figure 1. CEM Corporation – Enterprise learning solution components



Acrobat and Saba Publisher, while the systems learning content is stored in CEM's own on-site storage repository. In addition, courseware is created and maintained directly by third parties including KnowledgeNet and Netg, and is stored offsite in the storage repository of both third-party organizations.

Employees at CEM manage their own learning processes by accessing the LMS through the Internet. Using the Web, they can enrol in classroom courses; search for learning material; engage in online learning activities; and look at what development options are suitable for their role within the organization. Managers also use the system to administer the employee learning processes; for example, managers can examine the status of the learning activities of their employees; assign learning initiatives to their employees; and generate reports on learning activities. Administrators and training personnel use the system to supervise employee training; for example, they publish and manage learning content; manage a catalogue of courses; and create reports on learning activities. While much of the required reporting is provided by the LMS, administrators also use a third-party software application called Brio to generate more sophisticated reports.

The Saba Learning Enterprise™ LMS has the capability of managing and tracking offline activities (e.g., books, "on the job" training, mentoring, classroom training) and online activities (e.g., video and audio, Webcasts, Web-based training, virtual classroom training, and rich media). Learning content for online activities may be accessed and delivered through the Web application interface either from CEM's own learning content repository or from a third party's storage repository. Certain post-training testing is built into the learning content itself, but additional pre-training testing and post-training testing may be invoked, and this is provided by another third-party product called QuestionMark.

LMS: Toward a Better Understanding

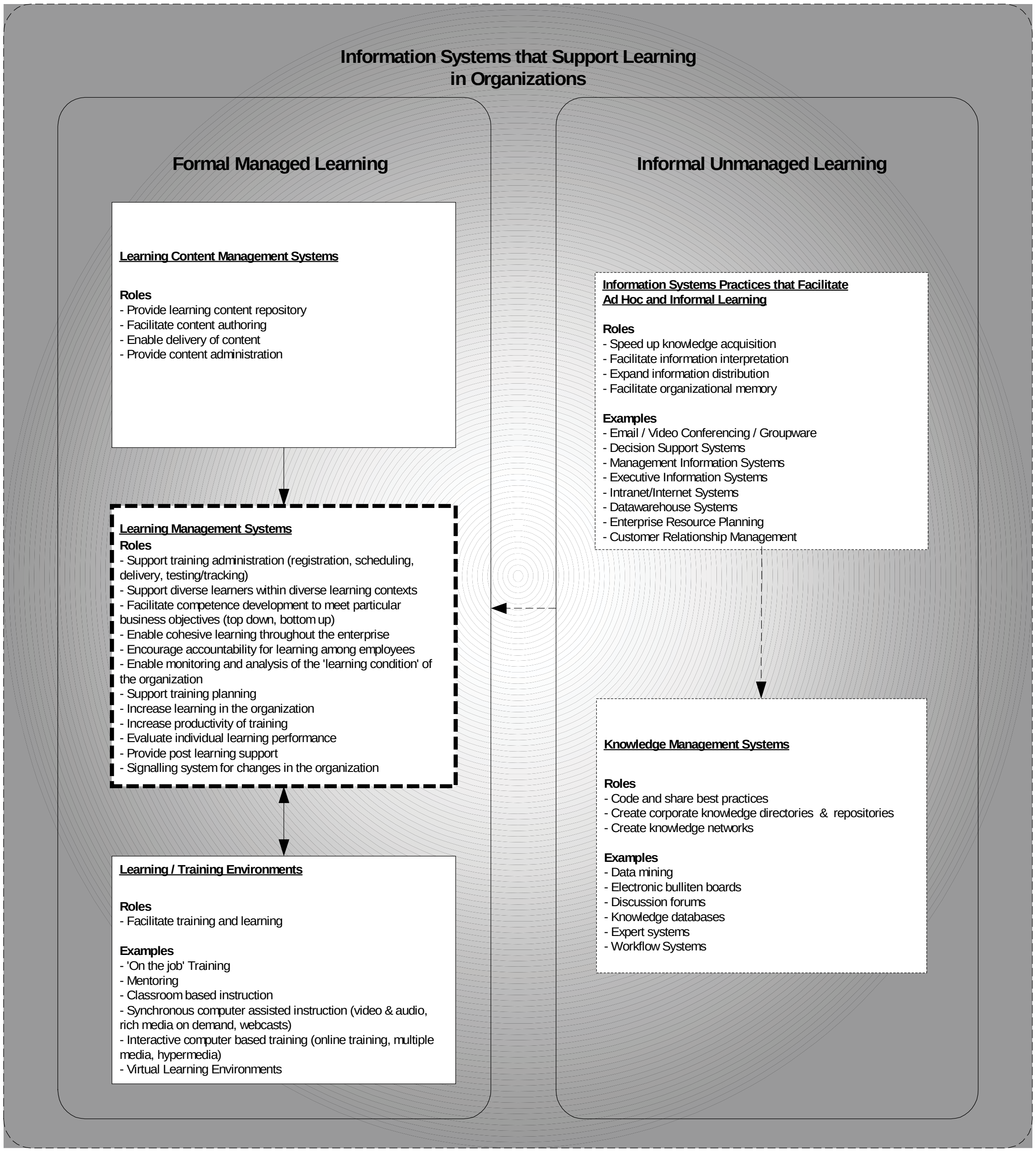
Figure 2 summarizes the case study findings. In this diagram, an empirically tested framework is presented that places LMS in context within a wider topology of the key categories of IS that underpin learning in organizations. Furthermore, the framework describes the principal attributes of each category of IS and highlights the roles that LMS can play in the support and management of learning within an organization. The categories of IS have been segregated into two groups: those that support formal managed learning within the organization, and those that support informal or unmanaged learning. The IS category of LMS is highlighted within the framework to emphasize that this new breed of system is central to the strategic "people oriented" approach to managing learning that is now emerging in many organizations.

LMS: In Context

On one hand, the findings illustrate that CEM found that their new LMS, learning content management systems (LCMS), and learning/training environments all contributed to the process of formal managed learning in the organization. On the other hand, it was clear that informal unmanaged learning within the organization was facilitated through IS that supported ad hoc learning in concert with the extant knowledge management system (KMS). The reason for this situation is that KMS, while supporting knowledge management in a formal way, only support informal learning, as learning is not facilitated in a structured way, nor is it measured or validated by the KMS.

In Figure 2, the arrows describe the links that exist from one IS category to another (i.e., LMS, LCMS, KMS, etc.), signifying the interrelationships between them. For example, the case study findings indicate that LMS are fed content directly by LCMS (as illustrated by the solid

Figure 2. Learning in organizations – Framework incorporating LMS



arrows lines). The LMS Manager elaborated on this: "a link is created in the LMS that contains the address where content is located, either on CEM's own storage repository or on the third party courseware repository." The findings also highlighted that LMS have a strong two-way relationship with learning/training environments, as training programs are often initiated from within the LMS and information on the outcome of this training is often captured directly by the

LMS. It was clear that LMS had only a tenuous link to other information systems that support ad hoc or informal learning (as illustrated by the broken arrowed lines). In describing this type of linkage, the LMS Manager pointed out that "the link from these systems consists primarily of a need which they generate for formal learning and training programs to be carried out." He added that "the content for this training will often stem from the IS itself and the type of environment used will, more than likely, be decided by the nature of the system in question." He indicated that KMS often store information on problems and solutions relating to other systems that support informal learning; hence, there is a tenuous link between these two categories of IS.

LMS: Key Roles

The framework shown in Figure 2 lists a number of key roles that LMS can play in supporting and managing learning. These roles indicate the dimensions, factors, or variables that future researchers should try to capture when evaluating the roles of LMS. One of the more significant roles listed is that LMS can support the administration of training3 across large organizations with a variety of training needs (Barron, 2000; Brennan et al., 2001; Zeiberg, 2001). A training manager within CEM Corporation commented that "the main role of the LMS is to automate training administration and then to add value." He also maintained that "with the LMS, the amount of work that you can get through is greater…it improves the efficiency of delivering and managing training." Thus, the LMS facilitates an increase in the productivity of training. From a learner's perspective, the principal role of the LMS is that it can provide a central repository for a range of learning material in a structured way that enables the system to support a diverse body of learners within diverse learning contexts (Brennan et al., 2001; McCombs, 2000; Wagner, 2000). As one user of the LMS within CEM Corporation put it, "employees who work in areas of the business can identify their role and cross reference the LMS for recommendations on what training is appropriate for that role…the system also provides guidance with recommended paths through several training courses." Another user of the LMS emphasized that "before, it was known that the Training Organization facilitated training, but you couldn't put your finger on something you wanted…now there is a central repository and you can see all the training that is being delivered." This leads to the most critical role of all, which is that it can increase the degree to which training is utilized and hence, increase learning in the organization. Also, from the perspective of the learner, the research findings identified two other significant and emerging roles of the LMS, which are listed within the framework. The first of these is the provision of post learning support, whereby, as the LMS manager explained, "the LMS enables employees to return to material from a course or download documents associated with a course that they have already completed." The second emerging role of the LMS is that it acts as a signaling system for changes in the organization. This was highlighted by one user of the system, who holds a software development role within the organization. He argued that "when new training becomes available on the LMS within our area, this normally signals that either new software product features have been released or that software product changes have taken place."

CEM's LMS also allows for competency mapping and facilitates career development paths. Using the LMS, an employee's competencies may be assessed using a predefined competency model for their particular job role. Subsequently, a number of development options or learning activities are suggested by the system, which may be carried out by the individual in order to fill any skill gap or competency deficiency for their role type. Thus, the LMS facilitates competence development to meet particular business objectives (see also: Brennan et al., 2001; Hall, 2001). The competency assessment process enables a dual approach to learning management (i.e., top-down and bottom-up). From a top-down perspective, training managers can use the LMS skill-assessment process to automate the training needs analysis process, which will assist them in the identification of training needs and will support training planning. Furthermore, from a management perspective, it is possible for a manager to get an overall picture of the competency levels within their department. One technical manager maintained that "although it started as just automation of training needs analysis, managers then saw that they can get a picture of training gaps and competency levels …they can also see overlaps in competencies." The LMS manager also commented on the bottom-up approach facilitated by the system viz. "self assessment and self directed learning is offered, which has passive approval." In this context, passive approval means that if an employee registers for a particular course or learning activity, they are automatically approved for that training unless the training is specifically disapproved by their manager within a certain limited time period. In this way, employees are encouraged to self-manage their own learning using the LMS: this has the added benefit of encouraging accountability for learning among employees (see also Hall, 2000).

The use of competency models for assessing and developing employee capabilities forms the basis of a number of other evolving roles of the LMS. Through standardizing role-based competency requirements and development options, the LMS can enable more consistent and cohesive learning throughout the enterprise (see also Greenberg, 2002). The LMS manager pointed out that "the status of competencies within the organization may be reported on at a number of different levels, using the LMS." This enables the monitoring and analysis of the "learning condition" of an organization (see also Nichani, 2001). Furthermore, a department manager described how "the LMS can support a manager in assessing an employee's role-based competencies and having agreed development plans with that employee, a subsequent competency assessment can help that manager to determine the employee's 'learning performance' in acquiring the new competencies, as per the development plan." Thus, by reviewing progress between one competency assessment and the next, the evaluation of individual learning performance for an employee is facilitated. This may then form part of the individual's overall performance evaluation.

CEM Corporation: Overall Benefits of the Enterprise Learning Solution

The deployment of the enterprise learning solution has enabled CEM Corporation to address many of the challenges that it faced in 2000, prior to the system's implementation. In particular, CEM has achieved the following:

- CEM now has a single enterprise system that supports the administration of all training across the entire organization. From the point of view of the employees, the system provides a centralized mechanism that enables them to search for and to enrol in selected courses or training programs; it also offers guidance on recommended training paths and curriculums. Furthermore, the competency assessment facility enables employees to determine and rectify competency gaps as well as providing management at CEM with a means of monitoring and managing overall employee competency levels within the organization.
- The enterprise learning solution supports all training content whatever its subject matter or form and enables the management and control of access to this content using one system. This has the added advantage of highlighting duplication of training material in different parts of the organization and paves the way for streamlining the efforts

of different training services within the company.

- The flexibility and dynamic nature of the system allows CEM Corporation to unilaterally introduce and to quickly implement new training requirements across the organization in response to changing business needs or new technical advances.
- The Saba Learning Enterprise™ LMS may help to attract or retain key personnel by offering them a unique opportunity to monitor and develop their competencies and to manage their careers within the organization.

CURRENT CHALLENGES/ PROBLEMS FACING THE ORGANIZATION

As outlined earlier, CEM Corporation is a hi-tech organization that operates in a very competitive and dynamic business environment. Managing learning and measuring learning outcomes are in themselves difficult tasks, but they are made even more problematic within complex learning domains, such as those that exist at CEM. It is unlikely that the LMS will enable the full management of all of the learning in the organization in a truly scientific way, though it will assist greatly in managing the diverse and extensive array of learning contexts and learning processes that must be supported. The system's strengths lie in the new approach and attitude that it will encourage and inspire in the hearts and minds of individuals within the organization, as it enables learning that is highly visible, structured, and more accessible within the organization. This stimulation of the hearts and minds is a major contributing factor to learning and is known as "emotional quotient" (Goleman, 1996). Having deployed the enterprise learning solution, CEM Corporation now faces a number of key challenges. These are outlined next:

Control vs. Creativity: Managing the Delicate Balance

The findings of this case study demonstrate that CEM's new LMS can play a vital role in increasing learning within across the organization. This will be achieved by improving the control and management of employee competency levels, and also by empowering employees to be creative in managing their own learning and competency development. Thus, the key challenge for management at CEM is to increase their influence and control over training and learning within the organization, while at the same time increasing employee commitment to managing their ongoing self-development by taking responsibility for improving their knowledge of the business and building related competencies. These objectives are delicately balanced and must therefore be handled carefully. Too much control may de-motivate employees and discourage them from engaging with the system, but at the same time, enough control must be exerted to ensure that employees are developing competencies that support the day-to-day operational requirements of the organization, as well as being in sync with the overall goals and objectives of the company.

Exploiting the Benefits of the LMS: Incorporating all Training & Learning

Another key challenge presently facing CEM Corporation is that they have a long way to go before all of the benefits offered by their new LMS can be fully exploited. Not all formal training is currently being tracked and managed through the LMS and some departments independently organize their own training outside of the system. One engineer argued that "there doesn't appear to be a large amount of suitable training available for our department." The benefits offered by this enterprise learning solution will not be fully realized until sufficient training or learning programs are offered to all employees in all departments within the organization. Furthermore, while it is possible to take certain online training directly through the Internet, it is not possible to track or manage associated learning outcomes, as this training is initiated and completed outside of the LMS, and is not currently recorded by it. It is understandable that it will take some time to incorporate every training program for all employees onto the system, but it is critical that this is achieved as quickly and efficiently as possible, to ensure support for the system and ongoing use of the system across the entire organization.

Drawing Up Competency Models for All Employees

Role-based competency models have not yet been drawn up for all roles within the organization. As the LMS Manager pointed out, "there is difficulty in having accurate competency models for all roles when there is such a vast array of diverse technical positions." He added that "as you drill down, you find that there are a lot of specialist functional competencies and you get into the ROI question…because there is such a large investment in time and effort involved in devising competency models for all technical roles, it has to be driven by the local business needs". Competency assessments are instrumental to determining if positive learning outcomes have been achieved and they will also demonstrate if the organization is obtaining a return on its investment in implementing and deploying the LMS. Furthermore, competency assessments offer management at CEM an opportunity to identify and rectify gaps or overlaps in competency levels as well as providing a means of assessing and managing overall competency levels within the organization. CEM Corporation is now faced with the daunting task of drawing up and maintaining competency models for the vast array of role types of its 20,000-plus employees, many of whom work in dynamic and highly technical areas.

Managing the Competency Assessment Process

Even where competency models are available, the study revealed that the process of self-management of career development has, for the most part, not yet been taken up within the organization. Moreover, many employees, and indeed managers, have not yet engaged with the competency assessment process. A structured plan or roadmap needs to be formulated in conjunction with local business needs for the formal migration of all employees onto the system for competency assessment and competency development planning to take place.

Fully Mobilizing the LMS within the Organization

One manager observed that "many employees still feel that the system is primarily designed for course registration and the other elements of the system may need to be emphasized more internally." Another user of the LMS argued that "although the initial rollout of the LMS seems to have been good and although there is a growing awareness of the system, people still have not got to grips with using it." The challenge facing CEM Corporation is to raise internal awareness of the functions and capabilities that are now provided by the LMS, and to educate the employees on how these functions and features operate. This education program needs to address cultural issues, as well as dealing with the fears and anxieties that employees may have in relation to the use of the system. This finding was supported by one manager who noted that "some employees may fear that if they use the system to log their competencies, their career may be negatively affected."

CEM Corporation needs to encourage the active participation of senior management in the mobilization of the LMS and perhaps consider the appointment of an overall champion for the initiative at senior management level. This chief learning officer4 could promote the utilization of the system at a senior level within the business units and ensure that any synergies that exist between them are exploited. Finally, a number of managers felt that CEM needs to publicize and promote the benefits of engaging with the LMS and find ways of formalizing and integrating this novel strategic learning management system with extant business processes and work practices.

REFERENCES

Alavi, M., & Leidner, D. (1999). Knowledge management systems: Issues, challenges and benefits. *Communications of the Association of Information Systems, 1(*2).

Alvesson, M., & Kärreman, D. (2001). Odd couple: Making sense of the curious concept of knowledge management. *Journal of Management Studies*, *38*(7), 995-1018.

Barron, T. (2000). *The LMS guess.* Learning Circuits, American Society for Training and Development. Online: http://www.learningcircuits.org/2000/apr2000/barron.html

Borghoff, U.M., & Pareschi, R. (1999). *Information Technology for Knowledge Management.* Heidelberg: Springer-Verlag.

Brennan, M., Funke, S., & Andersen, C. (2001). *The learning content management system: A new elearning market segment emerges.* IDC White Paper. Online: http://www.lcmscouncil.org/resources.html

Butler, T. (2000, August 10-13). Making sense of knowledge: A constructivist viewpoint. *Proceedings of the Americas Conference on Information Systems,* Long Beach, CA (vol. II, pp. 1462-1467).

Butler, T. (2003). From data to knowledge and back again: Understanding the limitations of KMS. *Knowledge and Process Management: The Journal of Corporate Transformation*, *10*(4), 144-155.

Chait, L.P. (1999). Creating a successful knowledge management system. *Journal of Business Strategy, 20*(2), 23-26.

Easterby-Smith, M., Crossan, M., & Nicolini, D. (2000). Organizational learning: Debates past, present and future. *Journal of Management Studies, 37*(6), 783-796.

Galliers, R., & Newell, S. (2001, June 27-29). Back to the future: From knowledge management to data management. *Global Co-Operation in the New Millennium, 9th European Conference on Information Systems*, Bled, Slovenia (pp. 609-615).

Garavelli, A.C., Gorgoglione, M., & Scozzi, B. (2002). Managing knowledge transfer by knowledge technologies. *Technovation, 22*, 269-279.

Goleman, D. (1996). *Emotional Intelligence*. London: Bloomsbury Publishing.

Greenberg, L. (2002). *LMS and LCMS: What's the difference?* Learning Circuits, American Society for Training and Development. Online: http://www.learningcircuits.org/2002/dec2002/greenberg.htm

Hall, B. (n.d.). *Learning Management Systems 2001.* CA: brandon-hall.com.

Harvey, C., & Denton, J. (1999). To come of age: Antecedents of organizational learning. *Journal of Management Studies, 37*(7), 897-918.

Hendriks, P.H. (2001). Many rivers to cross: From ICT to knowledge management systems. *Journal of Information Technology, 16*(2), 57-72.

Huber, G.P. (2001). Transfer of knowledge in knowledge management systems: Unexplored issues and suggestions. *European Journal of Information Systems, 10*(2), 72-79.

Marshall, C., & Rossman, B.G. (1989). *Designing Qualitative Research.* CA: Sage.

McCombs, B.L. (2000). *Assessing the role of educational technology in the teaching and learning process: A learner centered perspective*. The Secretary's Conference on Educational Technology, US Department of Education. Online: http://www.ed.gov/rschstat/eval/tech/techconf00/mccombs_paper.html

McDermott, R. (1999). Why information technology inspired, but cannot deliver knowledge management. *California Management Review, 41*(4), 103-117.

Nichani, M. (2001). *LCMS = LMS + CMS [RLOs].* Online: http://www.elearningpost.com/features/archives/001022.asp

Rowley, J. (2001). Knowledge management in pursuit of learning: The learning with knowledge cycle. *Journal of Information Science, 27*(4), 227-237.

Scarbrough, H., & Swan, J. (2001). Explaining the diffusion of knowledge management: The role of fashion. *British Journal of Management, 12,* 3-12.

Schultze, U., & Boland, R.J. (2000). Knowledge management technology and the reproduction of knowledge work practices. *Journal of Strategic Information Systems, 9*(2-3), 193-212.

Storey, J., & Barnett, E. (2000). Knowledge management initiatives: Learning from failure. *Journal of Knowledge Management, 4,* 145-156.

Sutton, D.C. (2001). What is knowledge and can it be managed? *European Journal of Information Systems, 10*(2), 80-88.

Swan, J., Scarbrough, J., & Preston, J. (1999, June 23-25). Knowledge management – The next fad to forget people. In J. Pries-Heje et al. (Eds.), *Edition Proceedings of the 7th European Conference on Information Systems,* Copenhagen, Denmark (vol. I-II, pp. 668-678).

Wagner, E.D. (2000). *E-learning: Where cognitive strategies, knowledge management, and information technology converge. Learning without limits* (vol. 3). CA: Informania Inc. Online: http://www.learnativity.com/download/LwoL3.pdf

Zeiberg, C. (2001). *Ten steps to successfully selecting a learning management system*. In L. Kent, M. Flanagan & C. Hedrick (Eds.). Online: http://www.lguide.com/reports

Zuboff, S. (1988). *In the Age of the Smart Machine: The Future of Work and Power.* New York: Basic Books.

ADDITIONAL RESOURCES

The following is a list of other resources that may be relevant for obtaining additional information related to the case:

Alavi, M., & Leidner D. (2001). Research commentary: Technology mediated learning – A call for greater depth and breadth of research. *Information Systems Research, 12*(1), 1-10.

Aldrich, C. (2001). *Can LMSs survive the sophisticated buyer?* Learning Circuits, American Society for Training and Development. Online: http://www.learningcircuits.org/2001/nov2001/ttools.html

Broadbent, B. (2002). *Selecting a Learning Management System*.

Brown, J., & Duguid, P. (1998). Organizing knowledge. *California Management Review, 40*(3), 90-111.

Evangelisti, D. (2002). *The must-have features of an LMS.* Learning Circuits, American Society for Training and Development. Online: http://www.learningcircuits.org/2002/mar2002/evangelisti.html

Hall, B. (2003). *LMS 2003: Comparison of Enterprise Learning Management Systems.* CA: bandon-hall.com.

Hodgins, W., & Conner, M. (2002). *Learning objects and learning standards.* IEEE Learning Objects Groups Overview. Online: http://www.learnativity.com/standards.html

Lennox, D. (2001). *Managing knowledge with learning objects.* A WBT Systems White Paper. Online: http://www.wbtsystems.com/news/whitepapers

ENDNOTES

1 http://www.saba.com/english/customers/index.htm

2 For reasons of confidentiality, the organization on which this case study is based cannot be identified; it will be referred to as CEM Corporation throughout the document.

3 Bold text within this section indicates that this is a role fulfilled by the learning management system.

4 Akin to a chief information officer (CIO) or chief knowledge officer (CKO).

APPENDIX A

Saba Software Inc. Overview

Founded in 1997, Saba Software Inc. (quoted on the NASDAQ stock exchange as SABAD) is a global company headquartered in Redwood Shores, California, and is a leading provider of Human Capital Development and Management (HCDM) solutions. The Saba vision is to make it possible for every enterprise to manage its human capital by bringing together learning, performance, content and resource management in a holistic, seamless way. To satisfy this vision, Saba offers two key products sets, namely, its "Enterprise Learning Suite" and "Saba Performance". "Saba Learning" is an Internet-based learning management system within the Enterprise Learning Suite that automates many of the learning processes for both learners and learning providers. Table A(1) lists some of Saba Software's major customers.

Table A(1). Saba Software Incorporated – Major customers

Business Area	**Customers**
High Tech	Cisco Systems, Cypress, EMC^2, Xilinx, i2 Technologies, VERITAS Software
Telecommunications	ALCTEL, Telecom Italia, CENTEC, Lucent Technologies
Professional Services	Kendle International, Deloitte & Touche, EDS, Bearing Point (Formerly KPMG)
Financial and Insurance Services	ABN Amro, Royal & Sun Alliance, Scotiabank, Principal Financial Group, BPM, Standard Chartered, Wells Fargo
Government	United States of America Department of the Army, Distributed Learning Services, LearnDirect Scotland
Life Science	Aventis, Novartis, Procter & Gamble, Medtronic
Automotive	Ford Motor Company, General Motors, Daimler Chrysler
Transportation	Continental Airlines, BAA
Energy	Duke Energy, Energy Australia
Manufacturing and Distribution	Caterpillar, Cemex, Grainger.
Consumer Goods and Retail Distribution	Best Buy, Kinkos

APPENDIX B

<u>What are the roles of the LMS in managing learning within the organization?</u>

1.1 Does LMS support training administration?
- registration
- scheduling
- delivery
- testing
- tracking/reporting of individual learning

1.2 Does LMS support diverse learners within diverse learning contexts?
- large number of learners
- diverse learning contexts
- online and offline learning

1.3 Does LMS facilitate competence development to meet particular business objectives?
- skills specification needed to fulfil particular objective
- skills assessment to establish gap in learning
- recommended learning to fill identified gap in learning

1.4 Does LMS enable cohesive learning throughout the enterprise?
- learning development plan for organization
- learning plan for individuals in sync with overall learning plan

1.5 Does LMS encourage accountability for learning among employees?
- self-service learning
- self-planning and self-assessment of career development

1.6 Does LMS enable monitoring and analysis of “learning condition” within the organization?
- overall picture of competencies within the organization
- overall picture of learning achieved in organization
- overall picture of learning required within the organization

1.7 What are the other key roles/attributes of the LMS?
- provision of any content authoring
- provision of any content management
- provision of any knowledge management
- synchronization with HR system
- provision of post-learning support
- adherence to learning content standards
- integration of incompatible systems for learning management
- support for large range of third-party courseware
- other

<u>What are the roles of the LMS in managing learning within the organization?</u>	
1.1	Does LMS support training administration? - registration - scheduling - delivery - testing - tracking/reporting of individual learning
1.2	Does LMS support diverse learners within diverse learning contexts? - large number of learners - diverse learning contexts - online and offline learning
1.3	Does LMS facilitate competence development to meet particular business objectives? - skills specification needed to fulfil particular objective - skills assessment to establish gap in learning - recommended learning to fill identified gap in learning
1.4	Does LMS enable cohesive learning throughout the enterprise? - learning development plan for organization - learning plan for individuals in sync with overall learning plan
1.5	Does LMS encourage accountability for learning among employees? - self-service learning - self-planning and self-assessment of career development
1.6	Does LMS enable monitoring and analysis of "learning condition" within the organization? - overall picture of competencies within the organization - overall picture of learning achieved in organization - overall picture of learning required within the organization
1.7	What are the other key roles/attributes of the LMS? - provision of any content authoring - provision of any content management - provision of any knowledge management - synchronization with HR system - provision of post-learning support - adherence to learning content standards - integration of incompatible systems for learning management - support for large range of third-party courseware - other

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Chapter 1.37
Computational Experimentation

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INTRODUCTION

Systematic development of new knowledge is as important in the developing field of knowledge management (KM) as in other social science and technological domains. Careful research is essential for the development of new knowledge in a systematic manner (e.g., avoiding the process of trial and error). The problem is, throughout the era of modern science, a chasm has persisted between laboratory and field research that impedes knowledge development about knowledge management.

This article combines and builds upon recent results to describe a research approach that bridges the chasm between laboratory and field methods in KM: computational experimentation. As implied by the name, computational experiments are conducted via computer simulation. But such experiments can go beyond most simulations (e.g., incorporating experimental controls, benefiting from external model validation). And they can offer simultaneously benefits of laboratory methods (e.g., internal validity, lack of confounding) and fieldwork (e.g., external validity, generalizability). Further, computational experiments can be conducted at a fraction of the cost and time associated with either laboratory experiments or field studies. And they provide a window to view the kinds of meta-knowledge that are important for understanding knowledge management. Thus, computational experimentation offers potential to mitigate many limitations of both laboratory and field methods and to enhance KM research. We discuss computational modeling and simulation as a complementary method to bridge the chasm between laboratory and field methods—not as a replacement for either of these methods.

BACKGROUND

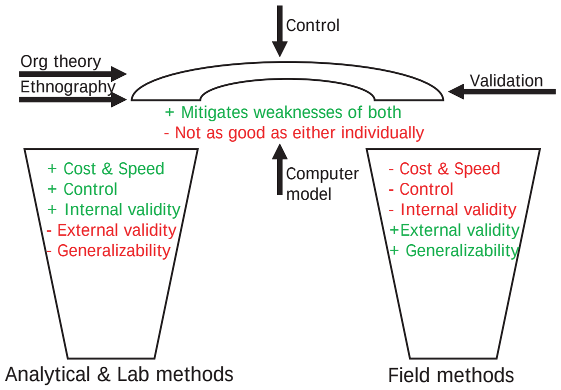
To appreciate the power of computational experimentation, we draw heavily from Nissen and Buettner (2004) in this section, and outline the key relative advantages and disadvantages of laboratory and field methods. To begin, the laboratory provides unparalleled opportunity for controlled experimentation. Through experimentation the researcher can manipulate only a few variables of interest at a time and can minimize the confounding associated with the myriad factors affecting complex systems and processes in the field (Box, Hunter, & Hunter, 1978; Johnson & Wichern, 1992). However, limitations of laboratory experimentation are known well (Campbell & Stanley, 1973) and are particularly severe in the KM domain. In KM experimentation such limitations center on problems with external validity. Laboratory conditions can seldom replicate the complexity, scope, and scale of the physical organizations and systems of interest for research. KM experiments also include problems with generalizability. Many experiments utilize samples of convenience (esp. university students) instead of working professionals. This practice calls into question how closely the associated experimental results are representative of KM behavior in operational organizations.

Alternatively, field research provides unparalleled opportunity for realism (Denzin & Lincoln, 1994). The researcher in the field can study full-scale artifacts in operational environments (Yin, 1994) and can minimize the abstraction away from working people, systems, and organizations (Glaser & Strauss, 1967). However, limitations of field research are known well also (Campbell & Stanley, 1973) and are particularly severe in the KM domain also. In KM field research such limitations center on problems with internal validity. Field research affords little opportunity for controlled experimentation (cf. Cook & Campbell, 1979). Also, confounding results often from the myriad influences on complex systems and organizations that cannot be isolated in the field. This practice makes it difficult to identify and trace the causes of differential behaviors—better as well as worse—in KM. In addition, field research can be very expensive, particularly to support researchers' efforts to enhance internal validity and ameliorate confounding. And many research designs for fieldwork (e.g., case study, ethnography, natural experiment) require considerable time for planning and analysis.

As implied by the name, computational experiments are conducted via computer simulation. As such, they offer all of the cost and time advantages of computational analysis (see Law & Kelton, 1991). But computational experiments go beyond most simulations. Rigorous experimental designs are employed to capture the benefits of laboratory experimentation. The variables affecting physical systems and organizations in the field can be isolated and examined under controlled conditions. This also addresses the internal validity and confounding limitations of field research. Yet computational experiments can be conducted at a fraction of the cost and time required to set up and run experiments with human subjects in the laboratory. Further, through external validation, computational models can emulate key qualitative and quantitative behaviors of the physical systems and organizations they represent with "good" fidelity (e.g., good enough to have confidence that results of computational experiments will track those of physical experiments in the laboratory or field). This mitigates the problems of external validity and generalizability noted above.

Figure 1 illustrates the essential elements of computational experimentation as a research method. The top of the figure includes a shape to depict the bridge metaphor associated with this method. It spans a wide gap between laboratory and field methods. From the left side of this "bridge," two arrows represent inputs to describe the behaviors of computational models. Organization theory, which is predicated upon many thousands of studies over the last half century, provides the basis for most such behaviors. Behaviors pertaining to organizational factors such as centralization, division of labor, task interdependence, function, coordination, formalization, technology, and information processing are captured from organization theory. Where extant theory does not address a behavior of interest (e.g., knowledge flows) well, ethnographic

Figure 1. Bridge method (Adapted from: Nissen and Buettner, 2004)



and similar immersive field studies (Bernard, 1998) are conducted to understand the associated organizational behaviors. Because organization theory attempts to be general, and is not based on any single organization, the associated behaviors have broad applicability across organizations in practice. This provides in part for the generalizability attainable through the method of computational experimentation.

From the bottom of the "bridge," an arrow represents the use of computer models to represent organizations and emulate their key behaviors. Some variety exists in terms of specific implementations. But most computer models adhere to standards, norms, and conventions associated with the field of Computational Organization Theory (COT; see Carley & Prietula, 1994). The central goal is to develop computer models that emulate the key behaviors of organizations and to use such models to examine alternate methods of organization and coordination. As such COT shares a focus on many factors of importance in knowledge management.

From the right side of the "bridge" in the figure, one arrow represents a requirement in our approach for model validation. Through validation, the organizational behaviors emulated by computer models are examined and compared with those of operational organizations in the field. We view this as an essential step. It provides confidence that the behaviors emulated by the computer model have sufficient fidelity to mirror faithfully the behaviors of the operational organizations they represent. This provides in part for the external validity attainable through the method of computational experimentation.

It is important to note, not all COT models are subjected to such validation. Many researchers use computational models to conduct theorem-proving studies. Such studies are valuable in their own right to demonstrate various aspects of organization theory (e.g., see Carley, 1999). But without thorough validation of representation and usefulness (Thomsen, Levitt, Kunz, Nass, & Fridsma, 1999), such researchers have difficulty making claims that the theoretical insights derived from their models mirror the behavior of organizations in the field. Hence comprehensive validation represents an important characteristic to distinguish computational experimentation as the research method described specifically in this article from COT in general.

Finally, from the top of the "bridge," an arrow represents the use of experimental controls in research. Following the same rich set of experimental designs available to laboratory researchers, computational experimentation as a research method can be used to control for myriad factors and manipulate just one or a few variables at a time to examine causality. Further, the same experimental design and setup can be replicated any number of times, for instance using Monte Carlo techniques or other computational approaches to introduce variation. This provides for the internal validity attainable through the method of computational experimentation. Combining these "bridge" inputs together—organization theory and ethnography, computer models, validation, and control—the method of computational experimentation can be understood in terms of, and indeed inherits, the various properties of its constituent elements.

COMPUTATIONAL EXPERIMENTATION IN KM

In this section, we draw heavily from Nissen and Levitt (2004) to summarize our approach to computational experimentation in KM. We begin by highlighting key aspects of our research on agent-based modeling and then illustrate its KM application through an example of technological development.

Virtual Design Team Research

The Virtual Design Team (VDT) Research Program (VDT, 2004) reflects the planned accumulation of collaborative research over two decades to develop rich, theory-based models of organizational processes. Using an agent-based representation (Cohen, 1992; Kunz, Levitt, & Jin, 1998), micro-level organizational behaviors have been researched and formalized to reflect well-accepted organization theory (Levitt et al., 1999). Extensive empirical validation projects (e.g., Christiansen, 1993; Thomsen, 1998) have demonstrated representational fidelity and have shown how the emulated behaviors of VDT computational models correspond closely with a diversity of enterprise processes in practice.

The development and evolution of VDT has been described in considerable detail elsewhere (e.g., Jin & Levitt, 1996; VDT, 2004), so we do not repeat such discussion here. The VDT modeling environment has been developed directly from Galbraith's (1977) information processing view of organizations. This information processing view has two key implications (Jin & Levitt, 1996). The first is ontological: we model knowledge work through interactions of tasks to be performed, actors communicating with one another and performing tasks, and an organization structure that defines actors' roles and that constrains their behaviors. In essence this amounts to overlaying the task structure on the organization structure and to developing computational agents with various capabilities to emulate the behaviors of organizational actors performing work.

The VDT modeling environment benefits from extensive fieldwork in many diverse enterprise domains (e.g., power plant construction and offshore drilling, see Christiansen, 1993; aerospace, see Thomsen, 1998; software development, see, Nogueira 2000; healthcare, see Cheng & Levitt, 2001). Through the process of "backcasting"—predicting known organizational outcomes using only information that was available at the beginning of a project—VDT models of operational enterprises in practice have demonstrated dozens of times that emulated organizational behaviors and results correspond qualitatively and quantitatively to their actual counterparts in the field (Kunz et al., 1998). Thus the VDT modeling environment has been validated repeatedly and longitudinally as representative of both organization theory and enterprises in practice. This gives us considerable confidence in its results.

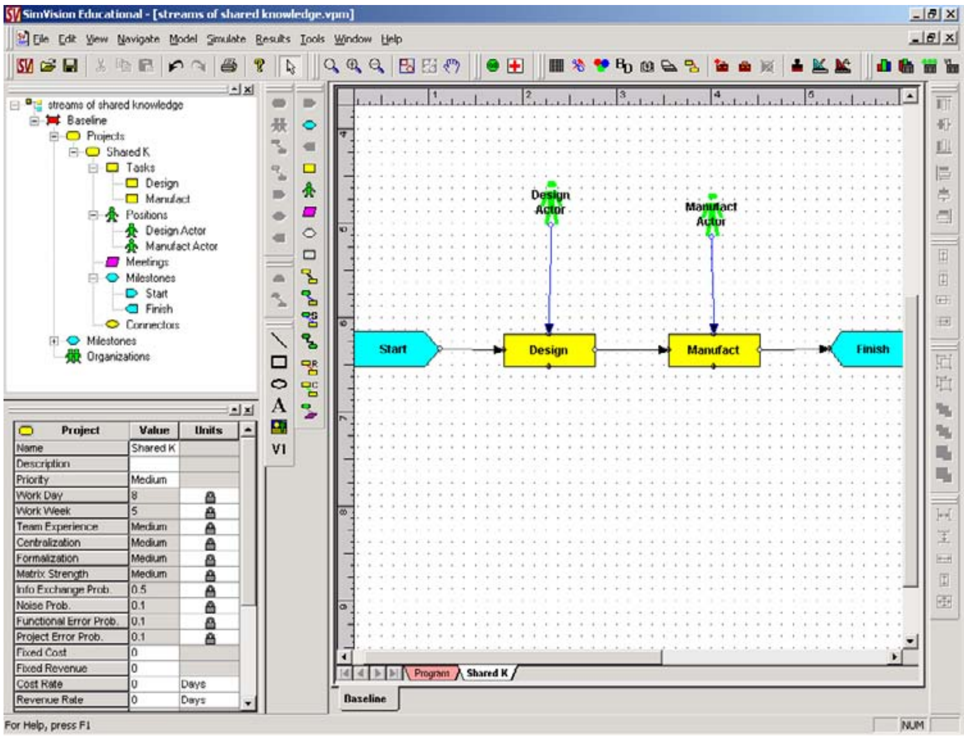
Moreover, VDT is designed specifically to model the kinds of knowledge work and information processing tasks that comprise the bulk of KM processes. In this sense, the computational model is imbued with meta-knowledge in terms of the constructs and relationships that are important to KM. In particular, building upon emerging knowledge-flow theory (e.g., see Nissen, 2002)—which describes the dynamics of how knowledge "moves" between various people, organizations, locations, and points in time—we are extending VDT methods and tools to reproduce increasingly fine-grained behaviors of knowledge in motion. This includes knowledge-flow processes and tools such as direct experience, formal training, transactive memory, mentoring, and simulation, in addition to commonplace KM approaches such as Web portals, knowledge maps, and communities of practice.

VDT Knowledge Management Model

Here we employ the VDT modeling environment to represent work processes associated with a high-level technology development project. The key KM question of interest here is: To what extent should the organization focus on developing specialist knowledge within its two functional areas of design and manufacturing vs. promoting generalist knowledge across functional areas? Figure 2 presents a screenshot delineating two primary tasks (i.e., design and manufacturing), each performed by a corresponding organizational unit (i.e., design actor and manufacturing actor). The two milestone markers ("Start" and "Finish") shown in the figure are used in VDT to denote progress, but such markers neither represent tasks nor entail effort. The tree structure shown in the top left of the figure displays several of the different ontological elements of the VDT model (e.g., tasks, positions, milestones). The table shown in the bottom left displays numerous program-level parameters (e.g., team experience, centralization, formalization), which are all set to empirically determined "normal" values for product development work. Values for such parameters are held constant (i.e., controlled) across simulations of alternate cases and scenarios.

To set up a computational experiment, this model is parameterized to reflect "medium" specialist knowledge and "medium" cross-functional knowledge. The null hypothesis is: varying the relative levels of specialist and cross-functional knowledge has negligible impact on project performance. To test this null, we conduct a full-factorial experiment, with knowledge levels at both "low" and "high" levels for all combinations of specialist and cross-functional settings. Examining each

Figure 2. VDT baseline product development model



case individually provides us with precise control over which factors can vary and hence excellent insight into causality. Examining exhaustively all combinations of specialist and cross-functional knowledge levels provides us with insight into the entire design space associated with these KM variables of interest. Using consistently the output measure project duration enables us to employ a common metric to assess relative performance. These benefits all accrue from our experimental methods and controls. Moreover, using empirically determined and validated "normal" settings to depict the behavior of a representative technology project provides us with confidence that results of our simulations bear resemblance to those of operational organizational projects in the field. This benefit accrues from employing the general and validated modeling environment VDT.

Computational results for the product development model are summarized in Table 1. The values listed in the table reflect simulated project duration and are expressed in workdays. For instance, notice the result in the table's center (highlighted in bold print for emphasis): a project staffed with actors possessing medium levels of manufacturing specialist knowledge (z) and medium levels of cross-functional knowledge (h) is projected by the model to require 216 workdays to complete. This reflects a nominal 200 days of work specified (i.e., work volume), along with 16 days of additional problem solving (e.g., internal communication, delay, and exception handling associated with noise, uncertainty, and errors). The additional 16 days' problem-solving time reflects empirically determined relationships between model parameters (e.g., levels of z and h) and organizational performance.

Table 1 reports full-factorial results of nine simulation runs, with both the z (i.e., specialist knowledge) and h (i.e., cross-functional) parameters varying across three levels: low, medium, and high. Notice the simulation results vary in understandable ways across the three levels of both specialist and cross-functional knowledge. For instance, holding the parameter h constant at the medium level of cross-functional knowledge, performance in terms of project duration ranges from 264 days when specialist knowledge is low, to 178 days when specialist knowledge is high. This indicates the marginal product of such knowledge is positive (i.e., consistent with classical microeconomic theory). This same monotonic relationship is evident at the other levels of cross-functional knowledge (i.e., low h, high h) as well. Likewise, holding the parameter z constant at the medium level of specialist knowledge, performance in terms of project duration ranges symmetrically from 264 days when cross-functional knowledge is low, to 178 days when cross-functional knowledge is high. This is also consistent with classical microeconomic theory and is evident too at the other levels of specialist knowledge (i.e., low z, high z).

The symmetry reflected in the results of Table 1 corresponds to the microeconomic case of perfect knowledge substitution: specialist and cross-functional knowledge can be substituted—unit for unit—to maintain performance at some arbitrary level (e.g., along an isoquant). For instance, from the table, where specialist knowledge (z) is low, but cross-functional knowledge (h) is medium, performance (264 workdays) is the same as where specialist knowledge (z) is medium (i.e., one unit higher), but cross-functional knowledge (h) is low (i.e., one unit lower). Other instances of such substitutability can be identified readily through different combinations of knowledge types z and h (e.g., low z, high h <—> high z, low h [226

Table 1. Computational model results

Parameter	Low z	Medium z	High z
High h	226	178	141
Medium h	264	**216**	178
Low h	310	264	226

Project Duration in Workdays

days]; high z, medium h <—> medium z, high h [178 days]). With this our computational model indicates that specialist and cross-functional knowledge represent substitutes for one another. It is important to note here, this result reflecting perfect substitution reflects an emergent property of the computational model, not an explicit behavior—that is, nowhere in the development of the VDT environment or this computational project model do we specify behaviors of perfect substitution. Rather, the nature of interactions between VDT actors, tasks, organizations, and environmental settings lead dynamically to this result. In a sense this provides some additional validation of VDT (i.e., from classical microeconomics) behaviors.

Clearly this relatively simple computational experiment excludes several factors and aspects of the world that would complicate the analysis and alter the symmetry of results. For instance, we model the design and manufacturing tasks as sequential, with little interaction and no rework. However, few contemporary technology development projects separate design and manufacturing so cleanly. Designers today are required to understand an organization's manufacturing capabilities, and manufacturers today need to understand the limitations of design. In the case, the coordination requirements associated with concurrency between design and manufacturing functional tasks would skew our results in terms of substitution between specialist and generalist knowledge. Similarly, few contemporary technology development projects are devoid of rework between design and manufacturing tasks. Indeed, a key aspect of concurrency in fast-track projects involves multiple prototypes that are developed, evaluated, and reworked through successive iterations and refinements.

In the case, the rework requirements associated with iterative prototyping would also skew our results in terms of substitution between specialist and generalist knowledge. Other complications (e.g., inclusion of marketing and service organizations, differential pay scales, different rates of change pertaining to specialist and generalist knowledge, different learning rates among actors in the various organizations, different KM technologies in place) can be modeled and simulated as well—one at a time—using experimental controls. Through such computational experimentation, researchers and managers alike can learn much about how knowledge flows in a modeled project organization. Such knowledge can be used to help researchers focus on the most sensitive variables to study in future laboratory and field experiments. It can also be instrumental directly in enhancing the organization's KM projects.

FUTURE TRENDS

The kind of computational experimentation illustrated in the simple example above represents only a modest beginning to what can be accomplished over time by exploiting these new tools and techniques. For instance, as the theoretical basis of KM continues to develop and accumulate, an increasing number of knowledge-specific micro-behaviors can be represented and incorporated into modeling environments such as VDT. This will enable increasingly fine-grained and complex analyses to be conducted, with computational experimentation used to differentiate between closely matched KM alternatives (e.g., competing organizational designs, process flows, personnel systems, technological architectures). In complementary fashion, as computational models become increasingly sophisticated and based on KM theory, using such models through experimentation will enable new KM knowledge to develop and accumulate at an ever faster rate. Hence in a mutually reinforcing manner, KM theory can inform and improve upon computational experimentation, while computational experiments can inform and accelerate the development of KM theory.

Moreover, as computer technology continues to advance, larger and more complex computational experiments can be conducted in less time. As the approach of computational experimentation diffuses through the research and management communities, it may become increasingly routine to employ this technique in everyday settings (Schrage, 1999). Today, the designs of airplanes, bridges, and computers are accomplished principally via computational modeling and analysis. Tomorrow, such modeling and analysis may become indispensable to designing organizations, work processes, personnel systems, and information technologies (Levitt, 2004). Before any KM project reaches a stage of prototyping, much less organizational implementation, it will have undergone extensive computational analysis. Thus, the approach of computational experimentation that we illustrate in this article offers potential to become a mainstay of KM research and practice.

CONCLUSION

Systematic development of new knowledge in the developing field of knowledge management (KM) is impeded by a chasm between laboratory and field research methods. This article describes computational experimentation as a research approach that bridges this chasm and hence offers potential for understanding KM better. Examining a high-level project model, we illustrate how the VDT modeling environment can be employed for computational experimentation through a full-factorial design. And we indicate how this approach can be extended to examine large, complex, and detailed organizations and projects, in addition to adding increasingly sophisticated and analytically demanding factors to the models.

More than simply simulating organizational behaviors, computational experimentation can facilitate the development of knowledge about knowledge management. In time we may find such experimentation used to design KM projects and associated organizations in a manner similar to the use of computational models for the design of complex physical artifacts such as airplanes, bridges, and computers. Should this vision obtain, the KM researcher, manager, and practitioner alike will all be well versed in—and indeed critically dependent upon—computational experimentation. The research described in this article represents a substantial step toward such vision.

REFERENCES

Bernard, H.R. (1998). *Handbook of methods in cultural anthropology*. Walnut Creek, CA: Altamira Press.

Box, G.E.P., Hunter, W.G., & Hunter, J.S. (1978). *Statistics for experimenters: An introduction to design, data analysis and model building*. New York: John Wiley & Sons.

Campbell, D.T., & Stanley, J.C. (1973). *Experimental and quasi-experimental designs for research*. Chicago: Rand McNally.

Carley, K.M. (1999). On generating hypothesis using computer simulations. *Systems Engineering, 2*(2).

Carley, K.M., & Prietula, M.J. (Eds.). (1994). *Computational organization theory*. Hillsdale, NJ: Lawrence Erlbaum.

Cheng, C.H.F., & Levitt, R.E. (2001, November 3-7). Contextually changing behavior in medical organizations. *Proceedings of the 2001 Annual Symposium of the American Medical Informatics Association*, Washington, DC.

Christiansen, T.R. (1993). *Modeling efficiency and effectiveness of coordination in engineering design teams*. PhD Dissertation, Department of Civil and Environmental Engineering, Stanford University.

Cohen, G.P. (1992). *The virtual design team: An object-oriented model of information sharing in project teams*. PhD Dissertation, Department of Civil Engineering, Stanford University.

Cook, T.D., & Campbell, D.T. (1979). *Quasi-experimentation: Design and analysis issues for field settings.* Boston: Houghton Mifflin.

Denzin, N.K., & Lincoln, Y.S. (Eds.). (1994). *Handbook of qualitative research* (pp. 500-515). Thousand Oaks, CA: Sage Publications.

Galbraith, J.R. (1977). *Organization design*. Reading, MA: Addison-Wesley.

Glaser, B.G., & Strauss, A.L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine de Gruyter.

Jin, Y., & Levitt, R.E. (1996). The virtual design team: A computational model of project organizations. *Computational and Mathematical Organization Theory, 2*(3), 171-195.

Johnson, R.A., & Wichern, D.W. (1992). *Applied multivariate statistical analysis* (3rd ed.). Englewood Cliffs, NJ: Prentice-Hall.

Kunz, J.C., Levitt, R.E., & Jin, Y. (1998). The Virtual Design Team: A computational simulation model of project organizations. *Communications of the ACM, 41*(11), 84-92.

Law, A.M., & Kelton, D. (1991). *Simulation modeling and analysis* (2nd ed.). New York: McGraw-Hill.

Levitt, R. (2004). Computational modeling and simulation come of age. *Journal of Computational and Mathematical Organization Theory.*

Levitt, R.E., Thomsen, J., Christiansen, T.R., Junz, J.C., Jin, Y., & Nass, C. (1999). Simulating project work processes and organizations: Toward a micro-contingency theory of organizational design. *Management Science, 45*(11), 1479-1495.

Nissen, M.E. (2002). An extended model of knowledge-flow dynamics. *Communications of the AIS, 8*, 251-266.

Nissen, M.E., & Buettner, R.R. (2004, June). Computational experimentation: bridging the chasm between laboratory and field research in KM. *Proceedings of the Knowledge Management Research and Technology Symposium*, San Diego, CA.

Nissen, M.E., & Levitt, R.E. (2004, January). Agent-based modeling of knowledge flows: Illustration from the domain of information systems design. *Proceedings of the Hawaii International Conference on System Sciences,* Waikoloa, HI.

Nogueira, J.C. (2000). *A formal model for risk assessment in software projects.* PhD Dissertation, Department of Computer Science, Naval Postgraduate School, USA.

Schrage, M. (1999). *Serious play: How the world's best companies simulate to innovate*. Cambridge, MA: Harvard Business School Press.

Thomsen, J. (1998). *The Virtual Team Alliance (VTA): Modeling the effects of goal incongruency in semi-routine, fast-paced project organizations.* PhD Dissertation, Department of Civil and Environmental Engineering, Stanford University, USA.

Thomsen, J., Levitt, R.E., Kunz, J.C., Nass, C.I., & Fridsma, D.B. (1999). A trajectory for validating computational emulation models of organizations. *Journal of Computational & Mathematical Organization Theory, 5*(4), 385-401.

VDT. (2004). Retrieved from http://www.stanford.edu/group/CIFE/VDT/

Yin, R.K. (1994). *Case study research: Design and methods* (2nd ed.). Thousand Oaks, CA: Sage Publications.

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Chapter 1.38
Object–Process Methodology

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INTRODUCTION

Capturing the knowledge about existing systems and analysis and design of conceived systems requires an adequate methodology, which should be both formal and intuitive. Formality is required to maintain a coherent representation of the system under study, while the requirement that the methodology be intuitive stems from the fact that humans are the ultimate consumers of the knowledge. Object-Process Methodology (OPM) is a vehicle for knowledge representation and management that perfectly meets the formality and intuition requirements through a unique combination of graphics and natural language.

Function, structure, and behavior are the three main aspects that systems exhibit. Function is the top-level utility that the system provides its beneficiaries who use it or are affected by it, either directly or indirectly. The system's function is enabled by its architecture—the combination of structure and behavior. The system's architecture is what enables it to function so as to benefit its users.

Most interesting, useful, and challenging systems are those in which structure and behavior are highly intertwined and hard to separate. For example, in a manufacturing system, the manufacturing process cannot be contemplated in isolation from its inputs—raw materials, model, machines, and operators—and its outputs—the resulting product. The inputs and the output are objects, some of which are transformed by the manufacturing process, while others just enable it.

Modeling of complex systems should conveniently combine structure and behavior in a single model. Motivated by this observation, OPM (Dori, 1995, 2002) is a comprehensive, holistic approach to modeling, study, development, engineering, evolution, and lifecycle support of systems. Employing a combination of graphics and a subset of English, the OPM paradigm integrates the object-oriented, process-oriented, and state transition approaches into a single frame of reference. Structure and behavior coexist in the same OPM model without highlighting one at the expense of suppressing the other to enhance the comprehension of the system as a whole.

Rather than requiring that the modeler views each of the system's aspects in isolation and struggle to mentally integrate the various views, OPM offers an approach that is orthogonal to customary practices. According to this approach, various system aspects can be inspected in tandem for better comprehension. Complexity is managed via the ability to create and navigate across possibly multiple detail levels, which are generated and traversed through by several abstraction/refinement mechanisms.

Due to its structure-behavior integration, OPM provides a solid basis for representing and managing knowledge about complex systems, regardless of their domain. This chapter provides an overview of OPM, its ontology, semantics, and symbols. It then describes applications of OPM in various domains.

THE OPM ONTOLOGY

The elements of the OPM ontology, shown in Figure 1, are divided into three groups: entities, structural relations, and procedural links.

Entities

Entities, the basic building blocks of any system modeled in OPM, are of three types: stateful objects, namely objects with states, and processes. As defined below, processes transform objects by (1) creating them, (2) destroying them, or (3) changing their state. The symbols for these three entities are respectively shown as the first group of symbols at the left-hand side of Figure 1, which are the symbols in the toolset available as part of the GUI of OPCAT 2 (Dori, Reinhartz-Berger et al., 2003).

OPM Things: Objects and Processes

Objects are (physical or informatical) things that exist, while processes are things that transform (create, destroy, or change the state of) objects. Following is a set of basic definitions that build upon each other.

An object is a thing that exists.

Objects are the things that are being transformed in the system.

Transformation is generation (creation) or consumption (destruction) of an object, or a change of its state.

Processes are the things that transform objects in the system.

A process is a thing that represents a pattern of object transformation.

Table 1 shows the OPM things and their basic attributes. The third column on Table 1 contains a description of each thing or attribute and below it the syntax of the corresponding sentence in Object-Process Language (OPL)—a subset of English that

Figure 1. The three groups of OPM symbols in the toolset of OPCAT 2

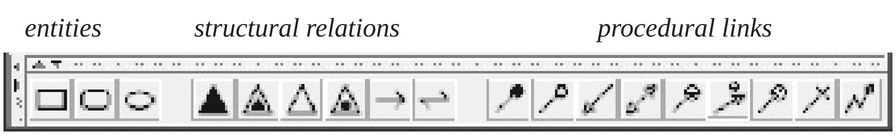


Table 1. Things of the OPM ontology and their basic attributes

Thing / Attribute	Symbol	Description / OPL sentence
Object	Object	A thing (entity) that has the potential of stable, unconditional physical or mental existence.
		Object Name is an object.
Process	Processing	A thing representing a pattern of transformation that objects undergo.
		Processing is a process.
Essence	Object Processing	An attribute that determines whether the thing (object or process) is physical (shaded) or informatical.
		Processing is physical.
Affiliation	Object Processing	An attribute that determines whether the thing is environmental (external to the system, dashed contour) or systemic.
		Processing is environmental.

Table 2. States and values

	Symbol	Description / OPL sentence
Stateful object with two states	Website reachable unreachable	A situation at which an object can exist.
		Web site can be reachable or unreachable.
Value	Temperature 15	A value that an object can assume.
		Temperature is 15.
Stateful object with three states: initial, default, and final	Car new used junk	A state can be initial, default, or final.
		Car can be new, which is initial, used, which is default, or junk, which is final.

reflects the graphical representation. In OPL, bold Arial font denotes non-reserved phrases, while non-bold Arial font denotes reserved phrases. In OPCAT, various OPM elements are colored with the same color as their graphic counterparts (by default, objects are green, processes are blue, and states are brown).

Objects and processes are collectively called things.

The first two lines of Table 1 show the symbol and a description of the two types of OPM things. The next two lines show two basic attributes that things can have: essence and affiliation.

Essence is an attribute that determines whether the thing is physical or informational.

The default essence is informatical. A thing whose essence is physical is symbolized by a shaded shape.

Affiliation is an attribute that determines whether the thing is environmental (external to the system) or systemic.

The default affiliation is systemic. A thing whose affiliation is environmental is symbolized by a dashed contour.

OPM States

Objects can be stateful, that is, they may have one or more states.

A state is a situation at which an object can exist at certain points during its lifetime or a value it can assume.

Stateful objects can be affected, that is, their states can change.

Effect is a change in the state of an object.

OPM STRUCTURE MODELING

Structural relations express static, time-independent relations between pairs of entities, most often between two objects. Structural relations, shown as the middle group of six symbols in Figure 1, are of two types: fundamental and tagged.

The Four Fundamental Structural Relations

Fundamental structural relations are a set of four structural relations that are used frequently to denote relations between things in the system. Due to their prevalence and usefulness, and in order to prevent too much text from cluttering the diagram, these relations are designated by the four distinct triangular symbols shown in Figure 1.

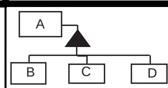
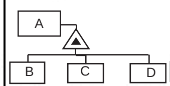
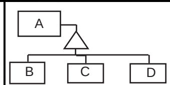
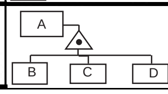
The four fundamental structural relations are:

1. Aggregation-participation: A solidtriangle, , which denotes the relation between a whole thing and its parts
2. Generalization-specialization: A blank tiangle, , which denotes the relation between a general thing and its specializations, giving rise to inheritance;
3. Exhibition-characterization: A solid inside blanktriangle, , which denotes the relation between an exhibitor—a thing exhibiting one or more features (attributes and/or operations)—and the things that characterize the exhibitor; and
4. Classification-instantiation: A solid circle inside a blanktriangle, , which denotes the relation between a class of things and an instance of that class.

Table 3 lists the four fundamental structural relations and their respective OPDs and OPL sentences. The name of each such relation consists of a pair of dash-separated words. The first word is the forward relation name, i.e., the name of the relation as seen from the viewpoint of the thing up in the hierarchy. The second word is the backward (or reverse) relation name, i.e., the name of the relation as seen from the viewpoint of the thing down in the hierarchy of that relation.

Each fundamental structural relation has a default, preferred direction, which was determined by how natural the sentence sounds. In Table 3, the preferred shorthand name for each relation is underlined. As Table 3 shows, each one of the four fundamental structural relations is characterized by the hierarchy it induces between the root—the

Table 3. The fundamental structural relation names, OPD symbols, and OPL sentences

Structural Relation Name		Root Refineables	OPD with 3 refineables	OPL Sentences with 1, 2, and 3 refineables
Forward	Backward			
Aggregation	Participation	Whole Part		A consists of B. A consists of B and C. A consists of B, C, and D.
Exhibition	Characterization	Exhibitor Features		A exhibits B. A exhibits B and C. A exhibits B, C, and D.
Generalization	Specialization	General Specializations		B is an A. B and C are As. B, C, and D are As.
Classification	Instantiation	Class Instances		B is an instance of A. B and C are instances of A. B, C, and D are instances of A.

thing attached to the tip of the triangle, and the leaves—the thing(s) attached to the base of the triangle, as follows.

1. In aggregation-participation, the tip of the solidtriangle, , is attached to the whole thing, while the base is attached to the parts.
2. In generalization-specialization, the tip of the blanktriangle, , is attached to the general thing, while the base is attached to the specializations.
3. In exhibition-characterization, the tip of the solid inside blanktriangle, , is attached to the exhibitor (the thing which exhibits the features), while the base is attached to the features (attributes and operations).
4. In classification-instantiation, the tip of the solid circle inside a blanktriangle, , is attached to the thing class, while the base is attached to the thing instances.

The things which are the leaves of the hierarchy tree, namely the parts, features, specializations, and instances, are collectively referred to as refineables, since they refine the ancestor, the root of the tree.

Refineable is a generalization of part, feature, specialization, and instance.

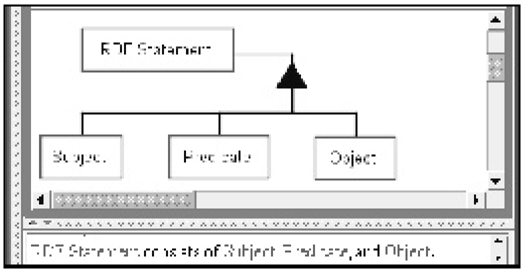
The third column in Table 3 lists for each fundamental structural relation the name of the root (whole, exhibitor, general, class) and the corresponding refineables (parts, features, specializations, and instances). The next column contains an OPD with three refineables, while the rightmost column lists the syntax of three OPL sentences for each fundamental structural relation, with one, two, and three refineables, respectively.

Having presented the common features of the four fundamental structural relations, in the next four subsections we provide a small example for each one of them separately.

Aggregation-Participation

Aggregation-participation denotes the relation between a whole and it comprising parts or components. Consider, for example, the excerpt taken from Section 2.2 of the RDF Primer (Manola & Miller, 2003):

Figure 2. OPD of the sentence "RDF statement consists of subject, predicate, and object"



…each statement consists of a subject, a predicate, and an object.

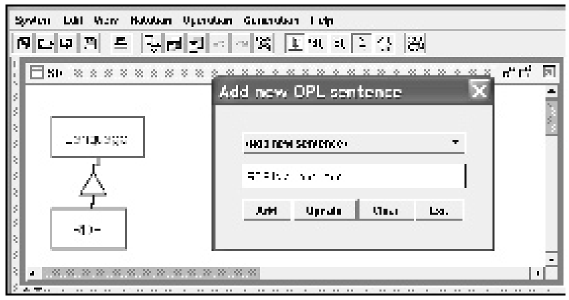
This is a clear case of whole-part, or aggregation-participation relation. The OPM model of this statement, which consists of both the OPD and the corresponding OPL, is shown in Figure 2. Note that the OPL sentence, "RDF Statement consists of Subject, Predicate, and Object," which was generated by OPCAT automatically from the graphic input, is almost identical to the one cited from the RDF Primer. The same OPD exactly (disregarding the graphical layout) can be produced by inputting the text of the OPL sentence above. This is a manifestation of the OPM graphics-text equivalence principle.

Generalization-Specialization

Generalization-specialization is a fundamental structural relationship between a general thing and one or more of its specializations. Continuing our example from the RDF Primer (Manola & Miller 2003), consider the very first sentence from the abstract:

The Resource Description Framework RDF is a Language for representing information about resources in the World Wide Web.

Figure 3. The OPD obtained by inputting into OPCAT the OPL sentence "RDF is a Language"



Let us take the main message of this sentence, which is that RDF is a language. This is exactly in line with the OPL syntax, so we can input the OPL sentence "RDF is a Language" into OPCAT and see what we get.

The result, without any diagram editing, is shown in Figure 3, along with the conversation window titled "Add new OPL sentence," in which this sentence was typed prior to the OPD creation.

Exhibition-Characterization

Continuing to scan the RDF Primer (Manola & Miller 2003), in Section 2.2.1 we find the sentence:

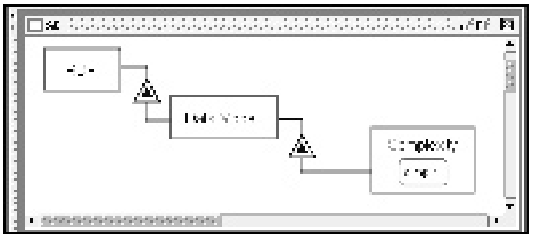
RDF has a simple data model.

To model this statement, we need to rephrase this sentence into the following three sentences:

1. RDF is characterized by a data model.
2. The data model of RDF is characterized by a complexity attribute.
3. The value of this complexity attribute is "simple."

These three sentences are further rephrased to conform to the OPL syntax as follows:

Figure 4. The OPD representing the sentence "RDF has a simple data model"



1. RDF exhibits Data Model.
2. Data Model exhibits Complexity.
3. Complexity is simple.

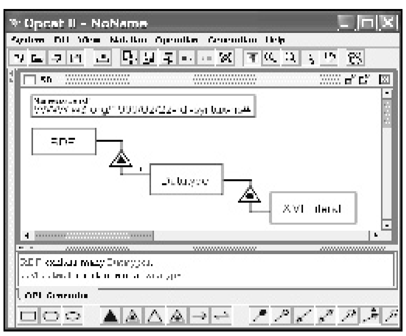
Classification-Instantiation

Reading through the RDF Primer, we find:

Datatypes are used by RDF in the representation of values, such as integers, floating point numbers, and dates.
…

RDF predefines just one datatype, rdf:XMLLiteral, used for embedding XML in RDF.

Figure 5. The OPM model of XMLLiteral, an instance of a Datatype of RDF



An OPL interpretation of these two sentences, respectively, is:

1. RDF exhibits many Datatypes.
2. XMLLiteral is an instance of Datatype.

Figure 5 is the OPM model of XMLLiteral, an instance of a Datatype of RDF.

OPM BEHAVIOR MODELING

Procedural links connect entities (objects, processes, and states) to express dynamic, time-dependent behavior of the system. Behavior, the dynamic aspect of a system, can be manifested in OPM in three ways:

1. A process can transform (generate, consume, or change the state of) objects
2. An object can enable a process without being transformed by it
3. An object or a process can trigger an event that might, in turn, invoke a process if some conditions are met

Accordingly, a procedural link can be a transformation link, an enabling link, or an event link.

In order to be able to talk about object transformation, we need to first define state and demonstrate how states are used.

Object States

In Figure 6 we added to the object Check two states: the initial state uncashed and the final state cashed. This causes the addition of the following OPL sentence to the OPL paragraph:

Check can be uncashed, which is initial, or cashed, which is final.

Figure 6. Adding states to Check

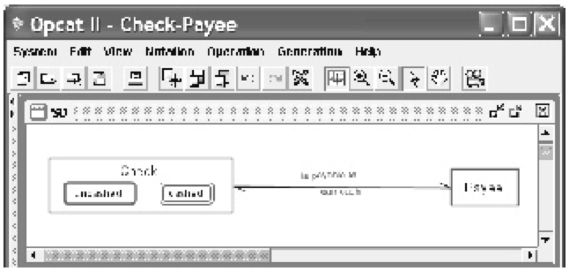


Table 4 shows the OPD and OPL syntax for objects with one, two, and three or more states, and optional time designator attributes: initial, final, and default.

Transformation Links

A transformation link expresses how a process transforms one or more objects. The transformation of an object can be its consumption, generation, or state change. The transforming process is the transformer, while the object being transformed is called transformee.

Input and Output Links

Having added the states to the object Check , we can now show how the process Cashing affects Check by changing its state. In Figure 7, Cashing was added and linked to the two states of Check: an input link leads from the initial uncashed state to Cashing, while an output link leads from Cashing to the final state cashed.

Figure 7. The Cashing process changes the state of Check from uncashed to cashed

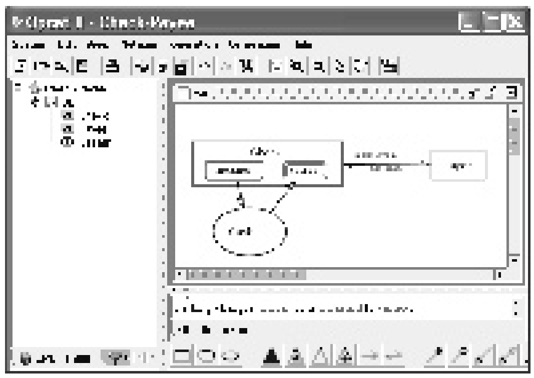


Table 4. OPD and OPL syntax for objects with one, two, and three or more states, and optional time designator attributes

Number of states or timeline	OPD	OPL
Single state	Stateful Object [singular]	Stateful Object is singular.
Two states	Stateful Object [singular] [plural]	Stateful Object can be singular or plural.
Three states or more	Stateful Object [first] [second] [third] [fourth]	Stateful Object can be first, second, third, or fourth.
Three states or more	Stateful Object [first] [second] [third] [fourth]	Stateful Object can be first, which is initial, second, third, which is default, or fourth, which is final.

The OPL sentence generated automatically by OPCAT as a result of adding these input and output links is:

Cashing changes Check from uncased to cashed.

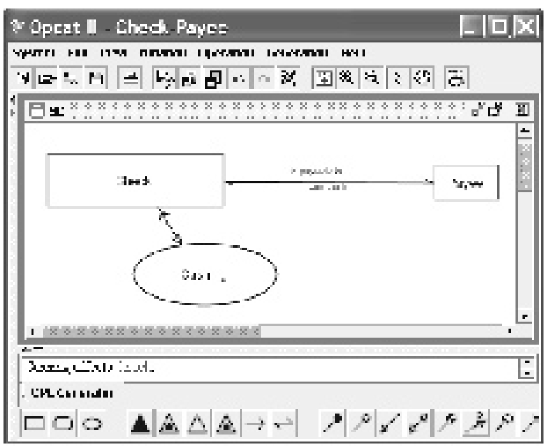
Effect Link

Sometimes we may not be interested in specifying the states of an object, but still show that a process does affect an object by changing its state from some unspecified input state to another unspecified output state. To express this, we suppress (hide) the input and output states of the object, so the edges of the input and output links "migrate" to the contour of the object and coincide, yielding the effect link shown in Figure 8.

The OPL sentence that represents this graphic construct is:

Cashing affects Check.

Figure 8. Suppressing the input and output states of Check causes the two link edges to migrate to the contour of Check and coincide, yielding the single bidirectional effect link between Check and Cashing



Result and Consumption Links

We have seen that one type of object transformation is effect, in which a process changes the state of an object from some input state to another output state. When these two states are expressed (i.e., explicitly shown), then we can use the pair of input and output links to specify the source and destination states of the transformation. When the states are suppressed, we express the state change by the effect link, a more general and less informative transformation link.

State change is the least drastic transformation that an object can undergo. Two more extreme transformations are generation and consumption, denoted respectively by the result and consumption links.

Generation is a transformation that causes an object, which had not existed prior to the process execution, to become existent. For example, Check is born as a result of a Check Making process.

As Figure 9 shows, the object Check is generated as a result of executing the process Check Making. The result link is the arrow originating from the generating process and leading to the generated object. The OPL sentence that

Figure 9. The object Check is generated as a result of executing the Check Making process.

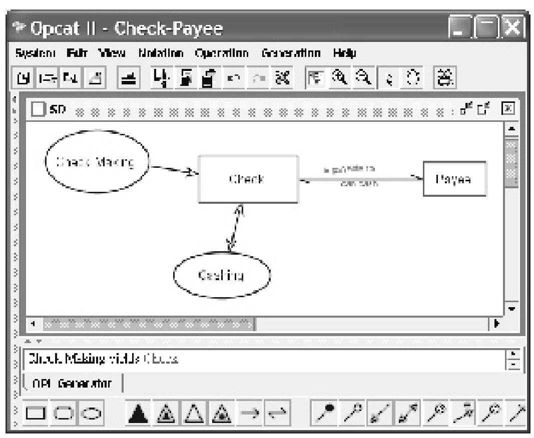
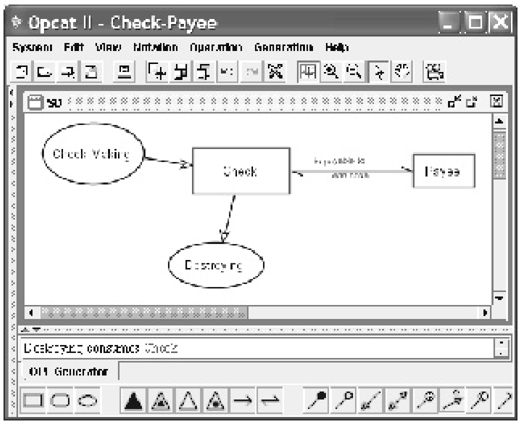


Figure 10. The object Check is consumed as a result of executing the Destroying process.



represents this graphic construct (shown also in Figure 9) is:

Check Making yields Check.

In contrast to generation, consumption is a transformation which causes an object, which had existed prior to the process execution, to become non-existent. For example, Check is consumed as a result of a Destroying process.

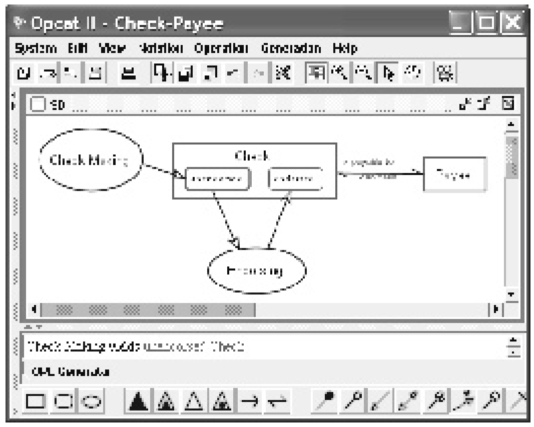
As Figure 10 shows, the object Check is consumed as a result of executing the process Destroying. The consumption link is the arrow originating from the consumed object and leading to the consuming process. The OPL sentence that represents this graphic construct (shown also in Figure 10) is:

Destroying consumes Check.

STATE-SPECIFIED RESULT AND CONSUMPTION LINKS

We sometimes wish to be specific and state not only that an object is generated by a process, but also at what state that object is generated. Some

Figure 11. The object Check is generated in its unendorsed state as a result of executing the Check Making process



other times, we might wish to be able to state not only that an object is consumed by a process, but also at what state that object has to be in order for it to be consumed by the process. As Figure 9 shows, the object Check is generated in its unendorsed state as a result of executing the process Check Making.

The OPL sentence that represents this state-specified result link graphic construct (shown also in Figure 11) is:

Check Making yields unendorsed Check.

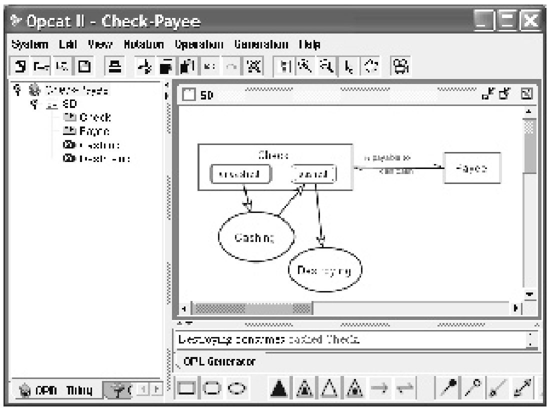
In comparison, the "regular," non-state-specified result link is the same, except that the (initial) state is not specified:

Check Making yields Check.

The difference is the addition of the state name (unendorsed in our case) before the name of the object (Check) that owns that state.

Analogously, a state-specified consumption link leads from a (final) state to the consuming process. For example, assuming a check can only be destroyed if it is cashed, Figure 12 shows the

Figure 12. The object Check is consumed in its cashed state as a result of executing the Destroying process



state-specified consumption link leading from the final state cashed of Check to the consuming process Destroying.

The OPL sentence that represents this state-specified consumption link graphic construct (shown also in Figure 12) is:

Destroying consumes cashed Check.

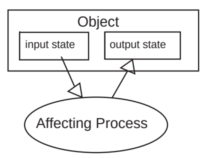
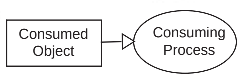
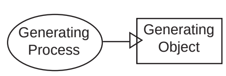
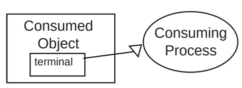
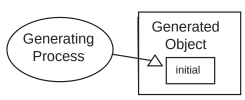
Summary of Procedural Links Between Processes and Objects

Table 5 provides a summary of the six procedural links between a process and a (possibly stateful) object. They are divided into three pairs: input and output links, which always come as a pair; consumption and result links; and state-specified consumption and result links.

Enablers and Enabling Links

An enabler is an object that is required for a process to happen, but is not transformed by the process.

Table 5. Summary of the procedural links between a process and an object or its state

Transformation Link Type	Source Entity	Destination Entity	OPD	OPL
Input link	Input state	Affecting process		Affecting Process changes Object from input state to output state.
Output link	Affecting process	Output state		
Consumption link	Consumed object	Consuming process		Consuming Process consumes Consumed Object
Result link	Generating process	Resulting object		Generating Process yields Generated Object
State-specified Consumption link	Final state of the consumed object	Consuming process		Consuming Process consumes terminal Consumed Object
State-specified Result link	Generating process	Initial state of the resulting object		Generating Process yields initial Generated Object

An enabling link expresses the need for a (possibly state-specified) object to be present in order for the enabled process to occur. The enabled process does not transform the enabling object. Enablers are divided into instruments and conditioners, each of which can be stateless or stateful.

APPLICATIONS OF OPM AND SUMMARY

OPM has been applied in many domains, including education (Dori & Dori, 1996), computer integrated manufacturing (Dori, 1996a; Dori, Gal, & Etzion, 1996), the R&D universe and its feedback cycles (Myersdorf & Dori, 1997), real-time systems (Peleg & Dori, 2000), banking (Dori, 2001), requirements engineering (Soffer, Golany, Dori, & Wand, 2001), Web applications development (Reinhartz-Berger, Dori, & Katz, 2002a), ERP modeling (Soffer, Golany, & Dori, 2003), axiomatic design (Soderborg, Crawley, & Dori, 2002), computational synthesis (Dori & Crawley, 2003), software reuse (Reinhartz-Berger, Dori, & Katz, 2002b), systems architecture (Soderborg, Crawley, & Dori, 2003), and Web Service Composition (Yin, Wenyin, & Chan. 2004).

This article has presented an overview of Object-Process Methodology and its applications in a variety of domains. There are a number of important OPM-related issues that could not be discussed in detail in this article due to space limitations. One such topic is complexity management. Complexity is managed in OPM via in-zooming, unfolding, and state-expression, which provide for looking at any complex system at any desired level of granularity without losing the context and the "big picture." Another issue is the systems development and evolution methodology with OPM, for which a comprehensive reflective metamodel (which uses OPM) has been developed. These issues and others are treated in detail in the book, Object-Process Methodology: A Holistic Systems Paradigm (Dori, 2002).

The domain-independent nature of OPM makes it suitable as a general, comprehensive, and multidisciplinary framework for knowledge representation and reasoning that emerge from conceptual modeling, analysis, design, implementation, and lifecycle management. The ability of OPM to provide comprehensive lifecycle support for systems of all kinds and complexity levels is due to its foundational ontology that builds on a most minimal set of stateful objects and processes that transform them. Another significant uniqueness of OPM is its unification of system knowledge from both the structural and behavioral aspects in a single diagram—OPD. It is hard to think of a significant domain of discourse and a system in it, in which structure and behavior are not interdependent and intertwined. A third unique feature of OPM is its dual knowledge representation in graphics and text, and the capability to automatically switch between these two modalities. Due to its single model, expressed in both graphics and text, OPM lends itself naturally for representing and managing knowledge, as it is uniquely poised to cater to the tight interconnections between structure and behavior that are so hard to separate.

OPM and its supporting tool OPCAT continue to evolve. The site www.ObjectProcess.org is a rich, continuously updated resource of OPM-related articles, free software downloads, and more.

REFERENCES

Dori, D. (1994). Automated understanding of engineering drawings: An object-oriented analysis. *Journal of Object-Oriented Programming,* (September), 35-43.

Dori, D. (1995). Object-process analysis: Maintaining the balance between system structure and behavior. *Journal of Logic and Computation, 5*(2), 227-249.

Dori, D. (1996A). Object-process analysis of computer integrated manufacturing documentation and inspection. *International Journal of Computer Integrated Manufacturing, 9*(5), 39-353.

Dori, D. (2001). Object-process Methodology applied to modeling credit card transactions. *Journal of Database Management, 12*(1), 2-12.

Dori, D. (2002). *Object-process methodology: A holistic systems paradigm*. Berlin, Heidelberg, New York: Springer Verlag.

Dori, D., & Crawley, E. (2003). Towards a common computational synthesis framework with Object-Process Methodology. *Proceedings of the 2003 AAAI Spring Symposium Series: Computational Synthesis: From Basic Building Blocks to High Level Functionality*, Stanford University, USA. Technical Report SS-03-02.

Dori, D., Gal, A., & Etzion, O. (1996). A temporal database with data dependencies: A key to computer integrated manufacturing. *International Journal of Computer Integrated Manufacturing, 9*(2), 89-104.

Dori, D., & Dori, Y.J. (1996). Object-process analysis of a hypertext organic chemistry module. *Journal of Computers in Mathematics and Science Teaching, 15*(1/2), 65-84.

Myersdorf, D., & Dori, D. (1997). The R&D universe and its feedback cycles: An object-process analysis. *R&D Management, 27*(4), 333-344.

Peleg, M., & Dori, D. (2000). The model multiplicity problem: Experimenting with real-time specification methods. *IEEE Transaction on Software Engineering, 26*(8), 742-759.

Reinhartz-Berger, I., Dori, D., & Katz, S. (2002a). OPM/Web: Object-process methodology for developing Web applications. *Annals of Software Engineering, 13*, 141-161.

Reinhartz-Berger, I., Dori, D., & Katz, S. (2002b). Open reuse of component designs in OPM/Web. *Proceedings of the IEEE 26th Annual International Computer Software and Applications Conference* (pp. 19-26).

Soderborg, N., Crawley E., & Dori D. (2002). System definition for axiomatic design aided by Object-Process Methodology. *Proceedings of the 2nd International Conference on Axiomatic Design* (pp. 134-140), Cambridge, MA.

Soderborg, N., Crawley E., & Dori D. (2003). OPM-based system function and architecture: Definitions and operational templates. *Communications of the ACM, 46*(10), 67-72.

Soffer, P., Golany, B., & Dori, D. (2003). ERP modeling: A comprehensive approach. *Information Systems, 28*(6), 673-690.

Soffer, P., Golany, B., Dori, D., & Wand Y. (2001). Modeling off-the-shelf information systems requirements: An ontological approach. *Requirements Engineering, 6*, 183-199.

Wenyin, L., & Dori, D. (1998). A generic integrated line detection algorithm and its object-process specification. *Computer Vision: Image Understanding (CVIU), 70*(3), 420-437.

Wenyin, L., & Dori, D. (1998A). Genericity in graphics recognition algorithms. In K. Tombre & A.K. Chhabra (Eds.), *Graphics recognition: algorithms and systems. Lecture Notes in Computer Science, 1389*, 9-18.

Wenyin, L., & Dori, D. (1999). Object-process based graphics recognition class library: Principles and applications. *Software: Practice and Experience, 29*(15), 1355-1378.

Yin, L., Wenyin, L., & Changjun, J. (2004). Object-process diagrams as explicit graphic tool for Web service composition. *Journal of Integrated Design & Process Science: Transactions of the SDPS, 8*(1), 113-127.

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Chapter 1.39
Uncertainty and Information in Construction: From the Socio-Technical Perspective 1962-1966 to Knowledge Management — What Have We Learned?

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ABSTRACT

This chapter questions the possibility of knowledge management in construction, other than among leading organisations handling a restricted population of projects. Socio-technical research in UK coal mining from the 1950s and construction from the 1960s and other relevant studies are compared. The extent to which the tacit order, instability, and diffuseness of construction may, practically, undermine knowledge management is explored. Knowledge management is compared to other methods in terms of the stability required for it to be effective. It is demonstrated that this stability is not usually available in construction, whose projects and processes are subject to an unusually wide range of disturbances.

INTRODUCTION

This book offers a socio-technical perspective on knowledge management in construction. This chapter discusses the original socio-technical research on construction, the Building Industry Communications Research Project (BICRP) by the Tavistock Institute of Human Relations (TIHR) from 1962-1966 (Boyd & Wild, 2003; Wild, 2004). Located between TIHR studies of UK coal mining and concepts of contextual turbulence in 1965, BICRP archives and publications demonstrate the state of construction, revealing the tacit order as deeper and wider than assumed. Problems of information, uncertainty, and indeterminacy pushed socio-technical ideas to their limit.

The knowledge management discourse assumes accessibility of the tacit order through structured inquiry. Are the categories of sense making; communications; information management; intellectual property and capital; innovation, communities of practice, and knowledge capture through IT latent within TIHR ideas? As a then leading analysis for re-framing managerial practice, these compare to knowledge management, which may also reach the limits of analytical penetration in the tacit order of construction. The chapter discusses TIHR work; 1960s studies of organisation; reflective practice and knowledge management, and uncertainty and information in the tacit order of construction and mining.

LEARNING OBJECTIVES

By the end of this chapter, readers will

1. appreciate the intrinsic instability of construction projects and
2. appreciate the effects of this instability on 'methods of management'.

TAVISTOCK (TIHR) STUDIES OF MINING: KNOWLEDGE AND LEARNING; RECURSIVENESS AND REFLEXIVITY IN A TRADITIONAL WORKING CLASS COMMUNITY OF PRACTICE

TIHR studies of mining are organisation theory classics. In the transition to the 'long-wall method', the responsible autonomy of the previous craft mining process was lost. This aligned methods, organisational and legal constraints within the face-to-face, self-managing workgroup; its context of time, space, and darkness; the absence of intermediate management and the moral intensity of the community, which buffered the operational core of collieries, and stabilised the 'organisational ground'. Long-wall technology never realised its production engineering potential. It required an organised, large working group to match the "…structure of the long face and the shift sequence…(creating) difficulties of communication and working relationships…the scale…of the task transcend(ed) the limits of simple spatio-temporal structure…" completion of a job in one place at one time. Engineering difficulties exacerbated the differentiation and interdependence of the workforce. Production required "…one hundred percent performance at each step…working to some extent against the threat of its own breakdown…," creating a tendency to crisis management. Stability implied "…a common skill of a higher order than that required…to carry out, as such, any of the operations belonging to the production cycle…" (Trist & Bamforth, 1951).

Adaptation of the craft system, assisted by the sociologically bounded community and stable political support, created the 'composite long-wall'. This early example of 'learning organisation' and 'community of practice' recorded improved efficiency, safety, and welfare (Trist, Higgin, Murray, & Pollock, 1963). The composite long-wall method was developed from the tacit and local knowledge of the pits without knowledge managers (Heller, 1993).

"At the time the long-wall method developed, there were no precedents for the adaptive underground application of a machine technology. In the absence of relevant experience in the mining tradition, it was…inevitable that…culture borrowing...should have taken place. There was also no psychological or sociological knowledge in existence at that time which might have assisted in lessening the difficulties." (Trist & Bamforth, 1951)

The 'composite long-wall system' resolved tensions between uncertainty and norms of rationality (Thompson, 1967). Consensus in the local industry permitted attainment of the design principle (Clark, 2000) for coordination by mutual feedback through multi-skilling, self-regulation, and redundancy in people (Emery & Trist, 1973), reducing coordination costs. Transferring the concept (Trist et al., 1990) required a learning process involving reflexivity and recursive-ness:

"…the capacity of actors to modify present action by imagining its consequences based on previous experiences…" and "…the socially accomplished reproduction of sequences of activity and action because the actors involved possess a negotiated sense that one template from their repertoire will address a new situation with improvisation through time as events inside processes." (Clark, 2000, p. 69)

Improvisation implies finite capacity for change (Clark, 2000), given the pluralism of social structure in organisations (Burns, 1966) and the re-construction of the role systems of mining.

THE EVOLUTION OF TAVISTOCK RESEARCH AND SOCIAL THOUGHT

TIHR studies in the 1950s confronted problems of communication, learning, information, and uncertainty. Later projects including the BICRP (Higgin & Jessop, 1963, 1965; Crichton, 1966) added wider multi-organisational and longer time horizons as uncertainty and complexity rose in contextual and task environments (Emery & Trist, 1973). BICRP archives clarify the socio-technical theory of construction evolved (Boyd & Wild, 2003) to cope with these problems. Construction exposed the limits of socio-technical ideas, which focus on the inter-penetration of the psychological, social, and technological in work roles and culture. Roles vary in their definition, integration with, and contradiction of other aspects of organisation. People carry the environment as culture to and from work roles, inducing instability and acting as change agents. This personal quality of culture imparts social vitality.

Interactions of individuals and groups involve potentially competing systems including technologies as cultural artefacts (Trist, 1990). Roles constrain through designated rights, obligations of status, mutual expectations, and the array of roles in the role-set. Misalignment generates role conflict, overload, and stress (Merton, 1958). Project teams change through time, implying cultural diversity, unstable roles, and tacit coordination (Stringer, 1967) within "…unpredictable (but inventable) configurations of people and technologies…" (Groak, 1994).

Mining and construction compare in their male workforce and spatio-temporal difficulties. Contextual instability makes the population of construction projects (Groak, 1994) a set of shifting figures on a shifting sociological ground (Trist, 1976). The organisational ground of projects is unstable. Production "…that is subcontracts, is a set of shifting figures in a world of stratified instabilities, sociologically derived at first and then self-induced" (Wild, 2003a).

THE BICRP 1962-1966: AN EMERGING THEORY OF CONSTRUCTION

Higgin and Jessop (1963) used communications and role diagnostically, revealing instability and variability across project role systems and teams. Unsettled definitions of jobs and responsibilities, threat of losses, and absence of agreed rules for relationships induced offensive and defensive behaviour by representative bodies:

"As the social aspects of…communications…embody the fabric of the building team structure, it would be necessary…to learn something of the

way in which the teams get built up from among interdependent, autonomous units…communications in the building team are up against built-in difficulties before they start." (Higgin & Jessop, 1963, p. 37)

External economic, social, and technical forces beyond the control of any party weakened internal coordination. OR analysis had linked communications and roles to the institutions, interests and value systems of construction, and their diverse configurations in projects (Higgin & Jessop, 1963). This diagnosis of a mismatch in "…the network of technical and social relationships forming the structure of the building team" (BICRP Archives, Research Committee, 18 November 1963) was confirmed at two conferences in spring 1963. The research proceeded from this, seeking consensual adaptation and improvement, through appropriate redefinition of roles and responsibilities derived from a formal view of the intrinsic technical relatedness of operations. Design was indeterminate. Construction operations could be foreseen reasonably accurately and had improved in efficiency through critical path and related methods. The phases required different approaches. Signing of contracts changed roles as team members became subject to constructor not architect coordination. The research focussed on acute problems of relationships and communications with complex clients and multiple participants in design and construction processes:

- Building the brief, including sketch plans
- The structure and relationships of the design team beyond this initial stage
- Contractor assumption of responsibility from the design team leading to a planning process
- The conduct and control of the building operations (BICRP Archives, Research Committee, 18 November 1963)

The sequence of briefing, exploration, decision, re-appraisal, and revision in the design team, along with the communications network and reasons for later client intervention were relevant. Operations involved people engaged at the professional and commercial interface where "…many of the tensions created by the instability of the environment were manifested" (BICRP Archives, 18 August 1964).

Scheduling had implications for relationships and communications and was affected by design decisions. Construction operations could be improved given unified control and communications processes. The research would develop critical path methods in design using OR concepts: computer logic; viewing design as a progression of decision 'states', analogous with certain types of statistical system; the 'theory of games' and 'information theory':

"…'sharper' techniques are necessary…which will more closely identify the complex of inter-related decisions necessary for developing a design…reached in various organisational frameworks by a design team of different groups communicating information in different ways at different stages of development…" to formally optimise "…an overall result from a set of value variables, which, at this stage, seems to be the essential operation in developing the brief and in the contractors' building himself into the process." (BICRP Archives, Research Committee, 18 November 1963)

Non-technical aspects of operations originated in institutional roles. This division of responsibility and the personal, group, social, and economic interests implied:

"…the strength of these attachments and…possibilities for change in them, which will allow development…Merging the two lines of inquiry should produce an integrated concept of role. The

connecting concept for this merging will probably be that of distinctive competence, which is at once both a technical and a social definition of a role, or perhaps a combination of roles." (BICRP Archives, Research Committee, 18 November 1963)

In August 1964 the researchers extended indeterminacy to construction planning and control. Construction planning was apparent. They were trying to understand briefing, design, and control to generate the information required for construction operations. A constrained prototype model had emerged from house design. The constraints were:

- Incomplete control over the operational environment translates into instability.
- There is uncertainty in the supply chain over quality, availability, and delivery.
- Formal techniques imply stability, hence their poor performance in practice.
- Attempts to use (and justify) them lead to inter-role tensions.
- Informal (un-verbalised) techniques allowing greater adaptability are applied—what are they and can they be formalised and improved?
- Single pieces of information are generated from many sources, often insufficiently related; confusion results and responsibility is unclear.
- The hidden agendas of site meetings and how these relate to instability in construction control processes.

They were asking about the purpose:

"… any form of communication serves as a contribution to the operations of the building process as a whole…Only when the operations involved and the responsibilities of those undertaking them have been understood, is it possible to know what form an appropriate network of communications…should take." (BICRP Archives, 18 August 1964)

On the 29th of January 1965, a more complex, abstract re-interpretation, essentially Crichton (1966), emerged. There were five interacting systems:

1. Operations: Action necessary to design and construct, divorced of people.
2. Resource Controllers: Architects, QSs, Contractors, and so forth
3. Directive Functions: Briefing, designing, design costing, constructional control
4. Adaptive Functions: Variations, extemporisation, buildability, design ahead of consents, cut and load, claim in anticipation, post-contract working drawings, exploitation of errors and crises, re-deployment, use of substitutes, re-design, and on-site design. There were immense differences between the directive functions and the adaptive functions, and these led to ill-will and confusion and the establishment of the fifth system.
5. A 'Psycho-Social System': Which reflected these differences

Rational accounting was unavailable (Higgin & Jessop, 1963; Crichton, 1966). The construction process was not self-contained as the client:

"…continued to influence action throughout and after the briefing stage and the variation order recognised this fact. The lack of formal links between the different directive functions was exemplified by three different costing systems: cost planning in terms of elements, by trades in the bill of quantities and by certificates etc. in final accounts. Effective comparison between these three was not possible. " (BICRP Archives, 29 January 1965)

But a wider problem existed. No one really knew what was going on. Detailed information on the processes and purposes of communications was lacking (BICRP Archives, 18 August 1964):

"Dr. Higgin elaborated on the normal method of Construction Control. The General Contractor set up agreed time targets (a Programme). This depended on variables not within the control of the Builder, the nature of the contract between the General Contractor and the supplier; the effect of previous negotiations between the Architect and Sub-contractor or supplier and the nature of the Nominated Sub-contractor. The myth of certainty was essential for work to start. The function of contingencies was to reconcile formal/informal systems, and the new contract tried to adapt to the variability of the system. In these conditions, a critical path network became a record, not a planning technique, and rigidity was a common defence against chaos." (BICRP Archives, 29 January 1965)

Andrew Darbyshire, Chairman, stated that his Steering Committee:

"…had always worried about the acceptability and the usefulness of the research from the point of view of the sponsors... They might thus have come to expect too much from the project; but they had come to realise very strongly what immense gaps there were in our knowledge and understanding of the building industry." (BICRP Archives, Research Committee, 15 June 1965)

THE TACIT ORDER OF CONSTRUCTION IN THE 1960S

Turbulent environments demonstrate an intricate enmeshing of diverging causal strands (Emery & Trist, 1965). In construction, contextual and task environments, communications, information, uncertainty, and institutionalised role conflicts inter-penetrated so far, only the most abstract theory was available. The innovative operational research offered required significant development (Friend, 1997) to penetrate the complexity and dynamism of decision processes, align values, and avoid conflicts. The depth, complexity, and impenetrability of the tacit order of this fragmented system characterised by self-interest is asserted. Assumption of the 'myth of certainty' for a project - the transition of so many with different variants of personal knowledge dependent upon verbal transmission through a range of diverse, transient project teams- required tacit coordination within an unstable order.

TIHR presented the problem of knowledge and information as culture. Tacit knowledge is carried by individuals and groups inducing change (Trist, 1990; Trist et al., 1963). In mining, the composite long-wall system was elicited from local and tacit knowledge by a community, bounded by isolation, moral intensity, and political and economic support. In construction diffuseness, diversity, indeterminacy, and fragmentation flow from shifting social priorities and impatience. (Higgin & Jessop, 1963) Dynamic processes confront the unique configuration of many social knowledges and their coordination in the unstable temporal structures (Wild, 2003a) of projects. Tacit knowledge is contextual, but contexts vary in continuity and the potential for knowledge capture.

UNCERTAINTY, INTERDEPENDENCE AND THE SOCIOLOGY OF VALUES

The BICRP is a critical milestone in the analysis of construction. Crichton (1966, p. 19) summarises problems of uncertainty and information played out in communications:

"It was found…in one particular case study that each time a design decision was taken, it set in train a chain of consequences which could and

did cause the initial decision to be changed, a clear example of how decisions and actions depend on one another. Since the full implications of any decision or action can seldom if ever be forecast with absolute accuracy, a communications system which assumes that they can will simply not work"

Projects may be driven towards their origins in the indeterminacy and diffuseness of design at the professional and commercial interface, especially susceptible to value conflicts and environmental instability. This is 'reverse time compression': contingencies stack up against schedules (Wild, 2003b). External, shifting social forces and conservative ideologies acting in fragmented project role systems transformed (Higgin & Jessop, 1963) serial into reciprocal interdependence. This reflects tensions between information, uncertainty, and norms of rationality. Pooled, serial, and reciprocal interdependence require standardisation, planning, and mutual adjustment. Each contains the others, implying increasing costs of coordination and time. The most formally efficient structure works back from reciprocal to pooled interdependence (Thompson, 1967). A valid operational decision sequence implied comprehensive attention and feedback (Crichton, 1966). Computer metaphors assumed serial interdependence, requiring disavowal in the face of tacit coordination (Stringer, 1967), that is 'adaptive functions'. Such organisational pluralism required attention to a:

"…sociology of values, or perhaps a calculus of values, which is more than just experiential…the connections between systems must be realised in terms which are categorically different from those applying within systems. They relate to the value systems of the individuals and of the culture…any preference ordering between systems (which must be a moral ordering) has to be in accordance with fundamentally different criteria from those which obtain within systems (which can be a technical ordering)." (Burns, 1966, p. 248)

Bresnen (1991) demonstrates project integration, attained through contingent alignment of a client interest, seeking allies in a context of shifting client roles with the strategy of a management contractor. At the temporal and organisational boundary of design and contracting to which TIHR researchers attached importance, an alignment of values occurred. It was sufficient to steer the project to completion, confirming the TIHR focus on optimisation through this route. Strategic intent was reflected in project staffing by the contractor and client attention at board level. Management contracting was innovative, requiring new roles and behaviour including re-negotiation of previously adversarial relationships. This led to knowledge exchange in a re-design imposed by a budget cut. Despite tensions, the contextual organisational features facilitated collaboration.

Management contracting emerged after the BICRP. Higgin and Jessop (1963) recognised, in relation to the 'package deal', that procurement method is contingent on a wider envelope of accountability. Techniques are insufficient onto themselves, requiring conditions of stability to work (Beardsworth, Keil, Bresnen, & Bryman, 1988; BICRP Archives, 18 August 1964). Strategic choice - evolved from the BICRP (Friend, 1997) - reflects structured exploration of uncertainties over environments, governing values, and information. Green (2001) argues for this, deconstructing value and risk management, which:

"…do not have any meaning in isolation of the way they are enacted and people enact value management in many different ways. There is no established causal link between the use of value management and a resulting better product…Furthermore there is no consensus on which techniques constitute value management."

Uncertainty and information underpin transaction cost economics (Winch, 1989, 2000, 2001). Rationality and efficiency lie in reduction through hierarchy or markets of information costs. Uncertainty lies in information processing capacity and bounded rationality. Parties to transactions experience different levels of information. Computational difficulties around configurations and interactions in complex problem areas generate uncertainty. The coordination costs of reciprocal interdependence are equivalent to information costs in transaction cost economics (Clark, 2000). Opportunism, driven by self-interest in a fragmented system (Higgin & Jessop, 1963) and the effects of impacted information, are experienced as different uncertainties and communication difficulties.

CONSTRUCTION, SITUATIONS AND REFLECTIVE PRACTICE

Construction is a world of potential situations (Wild, 2004) characterised by complexity, instability, uncertainty, uniqueness, and value conflict (Schon, 1983):

"...the presence of a great number of organisational interests creates a pull towards underboundedness within construction projects whose teams rarely attain stability and this must be recognised as their normal condition." (Boyd & Wild, 1999)

Bresnen (1991) exemplifies non-emergence of a situation as strategic intents fortuitously converged into collaboration. Different interorganisational and power dynamics, including the treatment of subcontractors, facilitated communications and knowledge exchange.

Sub-contracting and indirect management induce a game of wider discretion and instability due to unfamiliarity of people. Implicit strategies reduce uncertainty from project transience affecting power dynamics, surveillance, and performance expectations. Long-term networks with teams of transferable, subcontracted core workers buttress market relationships improving performance and quality. Market variations influence power and dependence. Problems of time and unpredictable activity inhibit management continuity. Spatial constraints clash with parallel events in critical paths inducing a conflicted, improvised production process. Time compression, which concentrates activities more densely into limited space, induces directive management. Roles, authority, and the expectations of site managers are clear in a fragile environment at the mercy of the weather, deliveries, labour and information problems, and accommodating multiple demands in temporally limited contexts of short-termism, a fragmented division of labour and subcontracting; pressures from the client, firm, and the value of the job are also considered (Beardsworth, Keil, Bresnen, & Bryman, 1988).

Construction as a system of Situations (Wild, 2004) requires the judgements of practitioners in constructing and setting problems as a condition for problem solving (Schon, 1983). This counters the recursive drift of managerial solutions into technical rationality, which:

"…responds to Situations through: selective inattention, simplification for situational control and…residual categories…the Reflective Practitioner proceeds through: Appreciative Systems; Over-arching Theories; Role Frames and Media, Languages and Repertoires." (Boyd & Wild, 1999)

Expert consultancy frequently replicates prepackaged (Mumford, 1980) techniques dependent on stability (BICRP Archives, 18 August 1964) and susceptible to institutionalised fragmentation (Wild, 2001). Appreciative Systems (Vickers, 1965) meld judgements of facts and values, returning to the sociology of values; assimilating socio-technical theory to Schon (1983), given technological change as a source of instability (Schon, 1971) and transaction cost economics given problems of uncertainty and information.

CONSTRUCTION, THE TACIT ORDER AND KNOWLEDGE MANAGEMENT

Construction is striking in its cohesive fragmentation (Wild, 2002a, 2002b, 2001) and recalcitrance (Reed, 1989) to official reform efforts. It is a precarious social field, "…constrained…to systemic reproduction…" (Archer, 1995) in which "...conflict may be both endemic and intense…without causing any basic structural change" (Lockwood, 1964, p. 249).

Tacit coordination (Stringer, 1967), a distinctive organising process, involves knowledge exchange, and a 'negotiated order' between roles with a limited time of service to a project.

TIHR metaphors of 'computer logic' (BICRP Archives, Research Committee, 18 November 1963) anticipate the use of IT in knowledge management. Techniques of exploration are emphasised to provide optimisation models. This 1960s discourse did not offer discursive penetration (Clark, 2000) of the shifting complexities of construction. Skills in improvising industry linkages and technology fusion generate opacity in the project. This:

"...defines ad hoc whatever supply of services, finance, information and products are possible and necessary…the project induces its own demand chain, its needs and resources, its own process and consequential processes and its own specific organisation…dominance of the project changes ideas about how we organise highly responsive networks of skills, where we locate research and development effort, on what we focus for productivity improvements...It all gives renewed significance to Hillebrandt's potent and fundamental research question: What do we mean by the capacity of construction?" (Groak, 1994)

There are no intrinsic reasons for supposing that appreciation of construction is more easily attained today. Knowledge management is sophisticated, but construction is more complex than in the 1960s, implying the importance of the tacit order as theories-in-use (Argyris & Schon, 1974). Client experience is critical (Atkins & Wild, 2000; Sabbagh 2000). Why should a client, who has never procured construction previously, see knowledge management as a strategy for reducing his uncertainty about the services offered? "How often does a client find that had he known as much at the beginning of a project as he knows at the end, he would have made quite different decisions?" (Higgin & Jessop, 1963 p. 75).

Post-war reports on British construction reflect a template (Wild, 2004) of problems and rational managerial solutions backed by uncritical research (Connaughton, 2000). Until 1963 they lacked an analytical framework for the wider context of construction operations "…and had not been able to do more than canvass best opinion and agree [to] general precepts on that basis" (Higgin & Jessop, 1963 p. 35).

Policy is always pursuing a shifting, complex, and opaque world. An impressive array of client and public resources backs present attempts at construction 'reform'. The slow response to current initiatives (Murray, 2003) echoes the BICRP. Aylwyn Lewis, BICRP Secretary, wrote to the Research Committee chairman (1 July 1965):

"…I do not think that I have really changed the two basic views with which I started the Project. These were:

1. *that a combination of sociology and operational research was necessary to tackle the problems of communication between the*

autonomous units that make up the building team;

2. *that change in these relationships would only come about in a controlled manner if the research was integrated with a representative but progressive cross-section of the industry who would sponsor and promote its findings." (BICRP Archives)*

Construction apparently replicated the finite capacity for change of organisations (Burns, 1966) exacerbated by production as projects. Crichton (1966) argued that this stability had advantages but changed too slowly for 'modern' needs. Post-war reports (Murray & Langford, 2003) reflect a treadmill of societal impatience (Higgin & Jessop, 1963) and political criticism, a reflexive, double-edged rhetoric of modernisation as its own theme (Beck, 1986) with proliferating change and research agendas. C.E.D. (known as Bertie - BICRP Archives) Wooster, Director of Building Management, Ministry of Public Building and Works, exemplifies this rhetoric:

"To the extent that society is not satisfied with the performance of the industry (already overloaded by about 10 per cent, and who is satisfied with our buildings and towns?), and to the extent that the industry does not match up to the task facing it, in the next ten years, it is failing to meet its objectives; and the failure can only be due to inadequate resources or mis-application of those we have." (Wooster, 1964)

Yet technology fusion (Groak, 1994) implies a capacity for innovation despite the apparent disorganisation of construction. Does this enable change by the tacit transmission of ideas and practices? Does knowledge require formalisation in a managerial system to be made effective? There had been the:

"…remarkable recovery of the building materials…and the construction industries from the war period …their flexibility in meeting new demands on their services in the past fifteen years; the introduction of new materials, increased mechanisation and new techniques; the steady rise in output, and the avoidance of major industrial disputes." (Emmerson, 1962, p. 4)

Does this imply interaction of organisational conservatism, misinterpreted as fragmentation, with technical innovation and tacit R&D inducing disjointed incrementalism (Hirschman & Lindblom, 1962) in projects? In this world taken for granted is innovation and learning denied by 'assumptions of ordinariness' (Trist et al., 1990)? Are paradoxes resolved as mutual adjustment, partly driven by power? Concurrently with BI-CRP there were strikes on the Horseferry Road and Barbican projects. Variations and instability in design provoked disputes over incentive pay, earnings, and related areas (Clegg, 1972). Is this also the metropolitan leading edge?

CONSTRUCTION IN SOCIETY AND SOCIETY IN CONSTRUCTION

"We have…been surprised at the long list of the sorts of people with whom communications, usually of a consulting nature, will be undertaken - chemists, physicists, engineers of all kinds, doctors, financiers, sociologists, other clients, meteorologists, and many others." (Higgin & Jessop, 1963, p.18)

Briefing reveals the socio-technical complexity of buildings. Design intensity (Clark, 2000) is a source of potential uncertainty, instability, and value conflicts in a process, which quickly attains the character of an extensive conference of both sides. A requirement for optimisation emerges here and later in construction from sources related to the client, whose complexity was poorly appreciated. Construction failed to account for and was impatient with such social forces. A general awareness and a capacity to engage with the client, developing appropriate techniques to deal with interdependent decisions, were required. Internal diversity implied an unusually wide range of interests, institutionally conditioned by uncertainty, including that from other projects, creating an ideal context for conflict and intrinsic difficulties for reforms. The system partly determined the behaviour of all the parties (Crichton, 1966).

Schon (1971) provides a comparison. In 1963 the U.S. Government focussed on 'backward' industries, whose R&D lagged behind their contribution to GNP and were composed of a few large firms and lots of small ones, low profit margins, and little investment in technology. American construction was considered fragmented. Only $1 million had been spent on product development in 1962. The report concluded that the government should stimulate building research. The dynamic conservatism of the industry, as an organised constituency, killed off a proposed public R&D programme. The proposals had clarified the networks of a complex coalition of shared interests, livelihoods, and a 'theory-in-use' (Argyris & Schon, 1974) relating prevailing technologies to individual and collective values. Without a clearly visualised future stable state, the existing system would have to be pulled apart. This is a view of construction as embedded (Clark, 2000) in society. London is a dynamic construction forcing-house (Ackroyd, 2001), explaining the metropolitan character of the 'progressive cross section'. Construction reform without public participation would lack viability:

"…no single characteristic…will be appropriate to measure the efficiency of a building process. We must measure the total performance by a yardstick of total performances…In the final analysis the community only gets the building industry it deserves. Therefore the client/user/community complex also needs to associate itself with the industry in…coordinating…further large-scale research." (Crichton, 1966, pp. 59 & 61)

In the context of a politically driven impatience (Higgin & Jessop, 1963) with a wider stagnation, could society attain a viable consensus over the opaque social field of construction disturbed by national planning and political change? (Wild, 2002a, 2002b). The Barbican and Horseferry Road disputes reflected, partly, the disruption of "what sometimes passes for consensus in Britain…the artefact of a tenuous balance of opposing forces" (Birnbaum, 1962, p. 283).

A similar sociological concern pervades Boyd and Wild (1999). They assert the equivalence of construction and organisation development. OD involves those who do the work in diagnosing the efficiency and effectiveness of their work organisation, rather than offering a recipe or formula (French & Bell, 1990). The organisational iceberg reflects a Pareto ratio of the 'formal' and 'informal'. Construction is multi-organisational (Stringer, 1967). The multiple interactions of multiple 'informal systems' imply construction as a 'sociological iceberg' explaining self-induced uncertainty (Stringer, 1967). Beyond this there are objections to the formal-informal systems dichotomy. TIHR researchers (BICRP Archives, 18 August 1964) suggested a synthesis of these, transcending their own assumptions. However:

"…the informal system has served as a receptacle for (matters) which were seen as irrelevant to the formal organisation or incompatible with its purpose…all that had defeated Taylorite attempts at human engineering…." (Burns, 1966, p. 235)

Managers and workers devise multiple interpretations of an organisation and institute mutually sustained working relationships. Multiple organisational goals emerge and a "…different conceptual framework, from that of the formal organisation of management…" (Burns 1966, p. 235).

Rational models imply instrumentalism towards goals and valued future states. This reflects misplaced concreteness and ignores the problem of reconciling the unity of aims in the model with the empirical fact of disunity of purpose within organisations (Burns, 1966). Does under-boundedness (Boyd & Wild, 1999) to society proliferate disunities of purpose in projects? Can demand side conditions of power and organisation insulate the project? Tate Modern (Sabbagh, 2000) was doubly insulated. Stewardship for a protected building avoided internal value conflicts over aesthetics, leaving the 'technical' problem of optimising display space. The clients' establishment constitution and experience rendered the project hegemonic (Lukes, 1974), structuring information to set aside bounded rationality, align values around project prestige, and suppress information uncertainty. Such concerns provoked Green (2001) to comment on one of the many proliferating boundaries (Wild, 2002c) between construction and society:

"The process of risk management…depends… upon…the need to maintain a viable political consistency within the client organisation. It is notable that there is as yet no framework that embraces both the notion of technical risk with the less tangible uncertainties that characterise the strategic interface between construction projects and client organisations…."

CONCLUSION (AND A PROVOCATION TO A DEBATE)

"…Is it somehow 'natural' that we appear to find the challenge of solving new problems (or of finding apparently fresh solutions) more seductive than plugging away at the old?" (Connaughton, 2000)

The BICRP anticipated the discourse of knowledge management. Will this permit us to learn more about construction? Is this relevant when the problem may be to learn to manage projects differently? Successes will be presented. Will they confirm that a new perspective induces these until it reaches its limits, as did socio-technical ideas when exposed to construction in the 1960s?

The diffuseness of construction requires a significant tacit order. Knowledge management assumes this is accessible to structured inquiry (Clark, 2000). Are there constraints such as spatio-temporal fragmentation (Wild, 2003a) appreciable from socio-technical research? Does integration require contextual conditions not readily present in the under-bounded (Boyd & Wild, 1999) world of construction? Is knowledge management a 'fresh solution', a renewed combination of sociology and operational research, an old wine poured in a new bottle by a new generation of 'experts'? As 'technique' is it as dependent on stability as other formal methods reported in the BICRP? Can it operate undisturbed by existing strategic recipes, networks, professional values, and personal constructs (Boyd & Wild, 1996)? The BICRP was assimilated to a construction project. Why should or how could knowledge management avoid being drawn into the turbulence and communication difficulties of construction like previous initiatives? Will it be routinised as a technique and fall away in effectiveness as construction is still improvised to completion in a project-based world of intrinsic unmanageability? (Wild, 2004, 2002c).

"If so many have preached the unification of the UK construction industry for so long with so little effect, how could we succeed? Is it indeed a lost cause? Have we been barking up the wrong tree all these years? Is it our destiny to build a fragmented future on a fragmented past and make the best of it?" (Andrews & Darbyshire, 1993, p. 37)

Andrews (1984) and Connaughton (2000) on the managerial - the socio - and Koskela (2003) on production - the technical side of the socio-technical equation - replicate Darbyshire's statement from June 1965 concerning the need for:

- "…a general theory of the organisation and management of construction." (Andrews, 1984)
- "…consistency and coherence in the development and accumulation of knowledge necessary for a useful, coherent theory of construction management…." (Connaughton, 2000)
- "…integrated prescription for construction renewal…Our present theoretical understanding is not necessarily solid enough. We need to develop fully the theoretical foundation or first principles of production in general and of construction especially." (Koskela, 2003)

In the problem of 'society in construction and construction in society', expectations outrun the capacity of construction to deliver, generating an eternal performance gap. Putative theories and methodologies of reform are drawn into the turbulence of construction as a cohesively fragmented social field. Knowledge management awaits its own partial demise. In contradistinction to 'integration', a theory of improvisation may explain the production of the built environment in under-bounded project worlds of non-recurrence and re-configuration.

Post-war reports (Murray & Langford, 2003) are symptoms of the instability and indeterminacy of construction. Hence the focus of management attention and research can be shifted from control to the steering of projects as negotiated orders (Reed, 1989). The difficulties of construction can be grounded on the qualities sought from the constructed world, which people inhabit, work in, and pass through. What is constructed and how is ideological. Powerful and cohesive clients get the buildings they want. Society, indifferent to other aspirations, gets the constructed order it deserves. This refracts what is there; what can be built; what we are prepared to pay for, and the resulting constraints upon us. In principle, construction is impossible, given the potential for value conflicts in and around the process. Dilemmas are resolved tacitly within the project. Within a mobile, masculine confraternity creativity is re/de-constructed as yarns. That projects are completed is a profound tribute to those who do the work, both because and in spite of the situations within which they labour. This, the real achievement of construction, truly constitutes the management of knowledge.

PRACTICAL TIPS AND LESSONS LEARNED

Construction projects are streams of disturbances punctuated by crises and occasional episodes of calm. The skills of project management (Boyd & Wild, 1999) include:

- Coping with discontinuity at start up
- Eliciting organising behaviour: consulting to the uncertainty in the client
- "Est": working in left- and right-brain modes
- Handling network centrality
- Holding and sharing power, laterally and vertically
- Negotiating and re-negotiating: contracts, roles, and expectations
- Skills of collaboration: managing the uncertainty in the project
- Spanning boundaries
- Steering through complexity
- Working with procedures as diagnostic devices

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This chapter is dedicated to Professor John Andrews who, in the last two years of his life, took an active interest in my attempt to re-interpret construction. He died in November 2003.

REFERENCES

Ackroyd, P. (2001). *London, the biography*. London: Vintage Books.

Andrews, J. (1984). *Comment at the CIB W-65 International Symposium on Organisation and Management of Construction*, University of Waterloo, Ontario, Canada, July.

Andrews, J., & Darbyshire, A. (1993). *Crossing boundaries*. London: CIC.

Archer, M. (1995). Social integration and system integration: Developing the distinction. *Sociology, 30*(4), 679-699.

Archives of the BICRP. (1962-1966). London: Royal Institute of British Architects.

Argyris, C., & Schon, D.A. (1974). *Theory in practice: Increasing professional effectiveness.* San Francisco: Jossey-Bass.

Atkins, J., & Wild, A. (2000, September 6-8). Automotive facilities procurement and the new construction paradigm. *Proceedings of the Sixteenth Annual Conference of the Association of Researchers in Construction Management*, Glasgow Caledonian University.

Beardsworth, A.D., Keil, E.T., Bresnen, M., & Bryman, R. (1988). Management transience and subcontracting: The case of the construction site. *Journal of Management Studies, 25*(6), 603-625.

Beck, U.C. (1986). *Risk society: Towards a new modernity.* London: Sage Publications.

Birnbaum, N. (1962). Great Britain, the reactive revolt. In Birnbaum, N. (1971). *Toward a critical sociology.* New York: Oxford University Press.

Boyd, D., & Wild, A. (1996). Engaging with personal constructs to improve construction projects. In A. Thorpe (Ed.), *Proceedings of 12th Annual Conference of ARCOM*, Sheffield, September.

Boyd, D., & Wild, A. (1999, September 15-17). Construction projects as organisational development. *Proceedings of the 15th Annual Conference of the Association of Researchers Construction Management*, Liverpool John Moores University.

Boyd, D., & Wild, A. (2003). Tavistock studies into the building industry. In M. Murray & D. Langford (Eds.), *Construction reports 1944-98*. Oxford: Blackwell.

Bresnen, M. (1991). Construction contracting in theory and practice: A case study. *Construction Management and Economics, 9,* 247-263.

Burns, T. (1966). On the plurality of social systems. In Burns, T. (Ed.). (1969). *Industrial man*. London: Penguin Books.

Chrichton, C. (1966). *Interdependence and uncertainty: A study of the building industry*. London: Tavistock Publications.

Clark, P.A. (2000). *Organisations in action. Competition between contexts.* London: Routledge.

Clegg, H.A. (1972). *The system of industrial relations in Great Britain*. Oxford: Blackwell.

Connaughton, J. (2000, September 6-8). *How can construction management research matter?* Keynote Address of the 16th Annual Conference of the Association of Researchers in Construction Management. Glasgow Caledonian University.

Emery, F.E., & Trist, E.L. (1965). The causal texture of the environment of organisations. *Human Relations, 18*(1), 21-32.

Emery, F.E., & Trist, E.L. (1973). *Towards a social ecology.* London: Plenum Press.

Emmerson, H. (1962). *Survey of problems before the construction industries: A report prepared for the Minister of Works.* London: HMSO.

French, W.L., & Bell, C.H. (1990). *Organisation development* (4th edition). Englewood Cliffs, NJ: Prentice-Hall International.

Friend, J. (1997). Connective planning from practice to theory and back in: The social engagement of social science, volume 3. In E. Trist, F. Emery, & H. Murray (Eds.), *The socio-ecological perspective*. Philadelphia: University of Pennsylvania Press.

Green, S.D. (2001). Towards an integrated script for risk and value management. *International Journal of Project Management, 7*(1), 52 -58.

Groak, S.(1994). Is construction an industry? *Construction Management and Economics, 12*, 287-293.

Heller, F. (1993). Another look at action research. *Human Relations, 46*(10), 1235-1242.

Higgin, G., & Jessop, N.K. (1963 & 1965). *Communications in the building industry*. London: Tavistock Publications.

Hirschman, A.O., & Lindblom, C.E. (1962). Economic development, research and development, policy making: Some convergent views. *Behavioural Science, 7*, 211-222.

Koskela, L. (2003). Is structural change the primary solution to the problems of construction? *Building Research and Information, 31*(2), 85-96.

Latham, M. (1993). *Trust and money*. London: HMSO.

Lockwood, D.A. (1964). Social integration and system integration. In G.K. Zollschan & H.W. Hirsch (Eds.), *Explorations in social change*. Boston: Houghton Mifflin.

Lukes, S. (1974). *Power: A radical view*. London: Macmillan.

Merton, R.K. (1968). *Social theory and social structure*. New York. The Free Press.

Mintzberg, H. (1989). *Mintzberg on management: Inside our strange world of organisations*. New York: The Free Press.

Mumford, A. (1980). *Making experience pay*. London: McGraw-Hill.

Murray, M. (2003). Re-thinking construction: The Egan report 1998. In M. Murray & D. Langford (Eds.), *Construction reports 1944-98*. Oxford: Blackwell.

Murray, M., & Langford, D. (2003). *Construction reports 1944-98*. Oxford: Blackwell.

Reed, M. (1989). *The sociology of management*. Hemel Hempstead: Harvester Wheatsheaf.

Sabbagh, K. (2000). *Power into art. Creating the Tate Modern, Bankside*. London: Allen Lane.

Schon, D.A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Schon, D.A. (1971). *Beyond the stable state*. London: Temple Smith.

Stringer, J. (1967). Operational research for multi-organisations. *Operational Research Quarterly, 18*(2), 105-20.

Thompson, J.D. (1967). *Organisations in action*. Englewood Cliffs, NJ: Prentice-Hall.

Trist, E.L. (1976). Engaging with large-scale systems. In P.A. Clarke (Ed.), *Experimenting with organisational life*. London: Plenum Press.

Trist, E.L. (1990). Culture as a psycho-social process. In E. Trist & H. Murray (Eds.), *The social engagement of social science, volume 1: The socio-psychological perspective*. Philadelphia: University of Pennsylvania Press.

Trist, E.L., & Bamforth, K.W. (1951). Some social and psychological consequences of the long-wall method of coal getting. *Human Relations, 4*, 3-38.

Trist, E.L., Higgin, G.W., Murray, H., & Pollock, A.B. (1963). *Organisational choice*. London: Tavistock Publications.

Trist, E.L., Higgin, G.W., Murray, H., & Pollock, A.B. (1990). The assumption of ordinariness as a denial mechanism. In E. Trist & H. Murray (Eds.), *The social engagement of social science, volume 1: The socio-psychological perspective*. Philadelphia: University of Pennsylvania Press.

Vickers, G.A. (1965). *The art of judgement.* London: Chapman and Hall.

Wild, A. (2001, September 7-9). Construction projects as teams or situations: Criticising the techniques of communication approach. *Proceedings of the 17th Annual Conference of the Association of Researchers in Construction Management,* University of Salford.

Wild, A. (2002a, September 2-4). False coherence and cohesive fragmentation in the post-war corporatist coordination of construction. *Proceedings of the Eighteenth Annual Conference of the Association of Researchers in Construction Management*, University of Northumbria.

Wild, A. (2002b, September 2-4). The management college that never was. *Proceedings of the Eighteenth Annual Conference of the Association of Researchers in Construction Management,* University of Northumbria.

Wild, A. (2002c). The unmanageability of construction and the theoretical psycho-social dynamics of projects. *Engineering, Construction and Architectural Management, 9,* 345-351.

Wild, A. (2003a, September 3-5). Iron triangles and holy trinities: Time or temporality in construction management. *Proceedings of the Nineteenth Annual Conference of the Association of Researchers in Construction Management,* University of Brighton.

Wild, A. (2003b). The working party report to the Minister of Works: The Phillips Report on building 1950. In M. Murray & D. Langford (Eds.), *Construction reports 1944-98*. Oxford: Blackwell.

Wild, A. (2004, March). Re-interpreting the building industry communications research project. *Construction Management and Economics, 22*(3), 303-310.

Winch, G.M. (2001). Governing the project process: A conceptual framework. *Construction Management and Economics, 19,* 799-808.

Winch, G.M. (1989). The construction firm and the construction project: A transaction cost approach. *Construction Management and Economics, 7,* 331-45.

Winch, G.M. (2000). Institutional reform in British construction: Partnering and private finance. *Building Research and Information, 28,* 141-155.

Wooster, C.E.D. (1964). Building management in the ’70s. *The Structural Engineer, 42*(3), 79-85.

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Section 2
Knowledge Management:
Development and Design Methodologies

This section provides in-depth coverage of conceptual architectures and knowledge management frameworks to provide the reader with a comprehensive understanding of the emerging technological developments within the field of knowledge management while offering research fundamentals imperative to the understanding of research processes within the knowledge management discipline. On a more global scale, many chapters explore cultural and infrastructural issues related to the management of knowledge in developing countries. From basic designs to abstract developments, this section serves to expand the reaches of development and design technologies within the knowledge management community. Included in this section are 45 contributions from researchers throughout the world on the topic of information development and knowledge sharing within the information science and technology field.

Chapter 2.1
IT in Knowledge Management

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As we trace the evolution of computing technologies in business, we can observe their changing level of organizational impact. The first level of impact was at the point work got done, and transactions (e.g., orders, deposits, reservations) took place. The inflexible, centralized mainframe allowed for little more than massive number crunching, commonly known as electronic data processing. Organizations became data heavy at the bottom, and data management systems were used to keep the data in check. Later, the management information systems were used to aggregate data into useful information reports, often prescheduled, for the control level of the organization: people who were making sure that organizational resources like personnel, money, and physical goods were being deployed efficiently. As information technology (IT) and information systems (IS) started to facilitate data and information overflow, and corporate attention became a scarce resource, the concept of knowledge emerged as a particularly high-value form of information (Grover & Davenport, 2001).

Information technology can play an important role in successful knowledge management initiatives. However, the concept of coding and transmitting knowledge in organizations is not new: training and employee development programs, organizational policies, routines, procedures, reports, and manuals have served this function for many years. What is new and exciting in the knowledge management area is the potential for using modern information technology (e.g., the Internet, intranets, extranets, browsers, data warehouses, data filters, software agents, expert systems) to support knowledge creation, sharing, and exchange in an organization and between organizations. Modern information technology can collect, systematize, structure, store, combine, distribute, and present information of value to knowledge workers (Nahapiet & Ghoshal, 1998).

According to Davenport and Prusak (1998), more and more companies have instituted knowledge repositories that support such diverse types of knowledge as best practices, lessons learned, product development knowledge, customer knowledge, human resource management knowledge, and methods-based knowledge. Groupware and intranet-based technologies have become standard knowledge infrastructures. A new set of professional job titles—the knowledge manager, the chief knowledge officer (CKO), the knowledge coordinator, and the knowledge-network facilitator—affirms the widespread legitimacy that knowledge management has earned in the corporate world.

The low cost of computers and networks has created a potential infrastructure for knowledge sharing and opened up important knowledge management opportunities. The computational power, as such, has little relevance to knowledge work, but the communication and storage capabilities of networked computers make it an important enabler of effective knowledge work. Through e-mail, groupware, the Internet, and intranets, computers and networks can point to people with knowledge, and connect people who need to share knowledge independent of time and place.

For example, electronic networks of practice are computer-mediated discussion forums focused on problems of practice that enable individuals to exchange advice and ideas with others, based on common interests. Electronic networks make it possible to share information quickly, globally, and with large numbers of individuals. Electronic networks that focus on knowledge exchange frequently emerge in fields where the pace of technological change requires access to knowledge unavailable within any single organization (Wasko & Faraj, 2005).

In the knowledge-based view of the firm, knowledge is the foundation of a firm's competitive advantage and, ultimately, the primary driver of a firm's value. Inherently, however, knowledge resides within individuals and, more specifically, in the employees who create, recognize, archive, access, and apply knowledge in carrying out their tasks. Consequently, the movement of knowledge across individual and organizational boundaries, into and from repositories, and into organizational routines and practices is ultimately dependent on employees' knowledge sharing behaviors (Bock, Zmud, & Kim, 2005).

According to Grover and Davenport (2001), most knowledge management projects in organizations involve the use of information technology. Such projects fall into relatively few categories and types, each of which has a key objective. Although it is possible, and even desirable, to combine multiple objectives in a single project, this was not normally observed in a study of 31 knowledge management projects in 1997 (Davenport & Prusak, 1998). Since that time, it is possible that projects have matured and have taken on more ambitious collections of objectives.

Regardless of definition of knowledge as the highest value of content in a continuum starting at data, encompassing information, and ending at knowledge, knowledge managers often take a highly inclusive approach to the content with which they deal. In practice, what companies actually manage under the banner of knowledge management is a mix of knowledge, information, and unrefined data—in short, whatever anyone finds that is useful and easy to store in an electronic repository. In the case of data and information, however, there are often attempts to add more value and create knowledge. This transformation might involve the addition of insight, experience, context, interpretation, or the myriad of other activities in which human brains specialize (Grover & Davenport, 2001).

Identifying, nurturing, and harvesting knowledge is a principal concern in the information society and the knowledge age. Effective use of knowledge-facilitating tools and techniques is critical, and a number of computational tools have been developed. While numerous techniques are available, it remains difficult to analyze or compare the specific tools. In part, this is because knowledge management is a young discipline. The arena is evolving rapidly as more people enter the fray and encounter new problems (Housel & Bell, 2001).

In addition, new technologies support applications that were impossible before. Moreover, the multidisciplinary character of knowledge management combines several disciplines including business and management, computer science, cybernetics, and philosophy. Each of these fields may lay claim to the study of knowledge management, and the field is frequently defined so broadly that anything can be incorporated. Finally, it is difficult to make sense of the many tools available. It is not difficult to perform a search to produce a list of more than 100 software providers. Each of the software packages employ unique visions and aims to capture its share of the market (Housel & Bell, 2001).

Ward and Peppard (2002) find that there are two dominant and contrasting views of IS/IT in knowledge management: the engineering perspective, and the social process perspective. The engineering perspective views knowledge management as a technology process. Many organizations have taken this approach in managing knowledge, believing that it is concerned with managing pieces of intellectual capital. Driving this view is the view that knowledge can be codified and stored; in essence that knowledge is explicit knowledge and therefore, is little more than information.

The alternative view is that knowledge is a social process. As such, it asserts that knowledge resides in people's heads and that it is tacit. As such, it cannot be easily codified and only revealed through its application. As tacit knowledge cannot be directly transferred from person to person, its acquisition occurs only through practice. Consequently, its transfer between people is slow, costly, and uncertain. Technology, within this perspective, can only support the context of knowledge work. It has been argued that IT-based systems used to support knowledge management can only be of benefit if used to support the development and communication of human meaning. One reason for the failure of IT in some knowledge management initiatives is that the designers of the knowledge management systems fail to understand the situation and work practices of the users and the complex human processes involved in work.

While technology can be used with knowledge management initiatives, Ward and Peppard (2002) argue that it should never be the first step. Knowledge management is, to them, primarily a human and process issue. Once these two aspects have been addressed, then the created processes are usually very amenable to being supported and enhanced by the use of technology.

What, then, is knowledge management technology? According to Davenport and Prusak (1998), the concept of knowledge management technology is not only broad, but also a bit slippery to define. Some infrastructure technology that we do not ordinarily think of in this category can be useful in facilitating knowledge management. Examples are videoconferencing and the telephone. Both of these technologies do not capture or distribute structured knowledge, but they are quite effective at enabling people to transfer tacit knowledge.

Our focus here, however, is on technology that captures, stores, and distributes structured knowledge for use by people. The goal of these technologies is to take knowledge that exists in human heads and partly in paper documents, and make it widely available throughout an organization. Similarly, Alavi and Leidner (2001) argue that information systems designed to support knowledge in organizations may not appear radically different from other forms of IT support, but will be geared toward enabling users to assign meaning to information and to capture some of their knowledge in information. Therefore, the concept of knowledge management technology in this book is less concerned with any degree of technology sophistication, and more concerned with the usefulness in performing knowledge work in organizations and between organizations.

Moffett and McAdam (2003) illustrate the variety of knowledge management technology tools by distinguishing between collaborative tools, content management, and business intelligence. Collaborative tools include groupware technology, meeting support systems, knowledge directories, and intranets/extranets. Content management includes the Internet, agents and filters, electronic publishing systems, document management systems, and office automation systems. Business intelligence includes data warehousing, decision support systems, knowledge-based systems, and workflow systems.

In addition to technologies, we also present techniques in this book. The term technique is defined as a set of precisely described procedures for achieving a standard task (Kettinger, Teng, & Guha, 1997).

KNOWLEDGE MANAGEMENT PROCESSES

Alavi and Leidner (2001) have developed a systematic framework that will be used to analyze and discuss the potential role of information technology in knowledge management. According to this framework, organizations consist of four sets of socially enacted knowledge processes: (1) creation (also referred to as construction), (2) storage and retrieval, (3) transfer, and (4) application. The knowledge-based view of the firm represents, here, both the cognitive and social nature of organizational knowledge, and its embodiment in the individual's cognition and practices as well as the collective (i.e., organizational) practices and culture. These processes do not represent a monolithic set of activities, but an interconnected and intertwined set of activities.

Knowledge Creation

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge. Through social and collaborative processes as well as individual's cognitive processes (e.g., reflection), knowledge is created. The model developed by Nonaka et al. (Nonaka, Toyama, & Konno, 2000) involving SECI, ba, and knowledge assets, views organizational knowledge creation as involving a continual interplay between the tacit and explicit dimensions of knowledge, and a growing spiral flow as knowledge moves through individual, group, and organizational levels. Four modes of knowledge creation have been identified: socialization, externalization, internalization, and combination (SECI), and these modes occur at "ba," which means place.

Nonaka et al. (2000) suggest that the essential question of knowledge creation is establishing an organization's ba, defined as a commonplace or space for creating knowledge. Four types of ba corresponding to the four modes of knowledge creation are identified:

1. Originating ba
2. Interacting ba,
3. Cyber ba
4. Exercising ba

Originating ba entails the socialization mode of knowledge creation, and is the ba from which the organizational knowledge creation process begins. Originating ba is a common place in which individuals share experiences primarily through face-to-face interactions, and by being at the same place at the same time. Interacting ba is associated with the externalization mode of knowledge creation, and refers to a space where tacit knowledge is converted to explicit knowledge and shared among individuals through the process of dialogue and collaboration. Cyber ba refers to a virtual space of interaction, and corresponds to the combination mode of knowledge creation. Finally, exercising ba involves the conversion of explicit to tacit knowledge through the internalization process. Thus, exercising ba involves the conversion of explicit to tacit knowledge through the internalization process.

Understanding the characteristics of various ba and the relationship with the modes of knowledge creation is important to enhancing organizational knowledge creation. For example, the use of IT capabilities in cyber ba is advocated to enhance the efficiency of the combination mode of knowledge creation. Data warehousing and data mining, document management systems, software agents, and intranets may be of great value in cyber ba. Considering the flexibility of modern IT, other forms of organizational ba and the corresponding modes of knowledge creation can be enhanced through the use of various forms of information systems. For example, information systems designed for support or collaboration, coordination, and communication processes, as a component of the interacting ba, can facilitate teamwork and thereby, increase an individual's contact with other individuals.

Electronic mail and group support systems have the potential of increasing the number of weak ties in organizations. This, in turn, can accelerate the growth of knowledge creation. Intranets enable exposure to greater amounts of online organizational information, both horizontally and vertically, than may previously have been the case. As the level of information exposure increases, the internalization mode of knowledge creation, wherein individuals make observations and interpretations of information that result in new individual tacit knowledge, may increase. In this role, an intranet can support individual learning (conversion of explicit knowledge to personal tacit knowledge) through provision of capabilities such as computer simulation (to support learning-by-doing) and smart software tutors.

Computer-mediated communication may increase the quality of knowledge creation by enabling a forum for constructing and sharing beliefs, for confirming consensual interpretation, and for allowing expression of new ideas. By providing an extended field of interaction among organizational members for sharing ideas and perspectives, and for establishing dialog, information systems may enable individuals to arrive at new insights and/or more accurate interpretations than if left to decipher information on their own.

Although most information repositories serve a single function, it is increasingly common for companies to construct an internal "portal" so that employees can access multiple different repositories and sources from one screen. It is also possible and increasingly popular for repositories to contain not only information, but also pointers to experts within the organization on key knowledge topics. It is also feasible to combine stored information with lists of the individuals who contributed the knowledge and could provide more detail or background on it (Grover & Davenport, 2001).

According to Grover and Davenport (2001), firms increasingly view attempts to transform raw data into usable knowledge as part of their knowledge management initiatives. These approaches typically involve isolating data in a separate "warehouse" for easier access, and the use of statistical analysis or data mining and visualization tools. Since their goal is to create data-derived knowledge, they are increasingly addressed as a part of knowledge management. Some vendors have already begun to introduce e-commerce tools. They serve to customize the menu of available knowledge to individual customers, allowing sampling of information before buying and carrying out sales transactions for knowledge purchases. Online legal services are typical examples where clients can sample legal information before buying lawyer's time.

For knowledge creation, there is currently idea-generation software emerging. Idea-generation software is designed to help stimulate a single user or a group to produce new ideas, options, and choices. The user does all the work, but the software encourages and pushes, something like a personal trainer. Although idea-generation software is relatively new, there are several packages on the market. IdeaFisher, for example, has an associative lexicon of the English language that cross-references words and phrases. These associative links, based on analogies and metaphors, make it easy for the user to be fed words related to a given theme. Some software packages use questions to prompt the user toward new, unexplored patterns of thought. This helps users to break out of cyclical thinking patterns and conquer mental blocks.

Knowledge Storage and Retrieval

According to Alavi and Leidner (2001), empirical studies have shown that while organizations create knowledge and learn, they also forget (i.e., do not remember or lose track of the acquired knowledge). Thus, the storage, organization, and retrieval of organizational knowledge, also referred to as organizational memory, constitute an important aspect of effective organizational knowledge management. Organizational memory includes knowledge residing in various component forms, including written documentation, structured information stored in electronic databases, codified human knowledge stored in expert systems, documented organizational procedures and processes, and tacit knowledge acquired by individuals and networks of individuals.

Advanced computer storage technology and sophisticated retrieval techniques, such as query languages, multimedia databases, and database management systems, can be effective tools in enhancing organizational memory. These tools increase the speed at which organizational memory can be accessed.

Groupware enables organizations to create intraorganizational memory in the form of both structured and unstructured information, and to share this memory across time and space. IT can play an important role in the enhancement and expansion of both semantic and episodic organizational memory. Semantic memory refers to general, explicit, and articulated knowledge, whereas episodic memory refers to context-specific and situated knowledge. Document management technology allows knowledge of an organization's past, often dispersed among a variety of retention facilities, to be effectively stored and made accessible. Drawing on these technologies, most consulting firms have created semantic memories by developing vast repositories of knowledge about customers, projects, competition, and the industries they serve.

Grover and Davenport (2001) found that in Western organizations, by far the most common objective of knowledge management projects involves some sort of knowledge repository. The objective of this type of project is to capture knowledge for later and broader access by others within the same organization. Common repository technologies include Lotus Notes, Web-based intranets, and Microsoft's Exchange, supplemented by search engines, document management tools, and other tools that allow editing and access. The repositories typically contain a specific type of information to represent knowledge for a particular business function or process, such as:

- "Best practices" information within a quality or business process management function
- Information for sales purposes involving products, markets, and customers
- Lessons learned in projects or product development efforts
- Information around implementation of information systems
- Competitive intelligence for strategy and planning functions
- "Learning histories" or records of experience with a new corporate direction or approach

The mechanical generation of databases, Web sites, and systems that process data are good, and have the potential to take us to a higher plane in the organization, help us understand workflows better, and help us deal with organizational pathologies and problems. The data-to-information transition often involves a low-level mechanical process that is well within the domain of contemporary information technologies, though humans are helpful in this transition as well. This information could exist in different forms throughout the organization and could even form the basis of competitive advantage or information products. For example, provision of information to customers about their order or shipment status is something that companies like Baxter and FedEx have been doing for years. But unlike knowledge, mechanically supplied information cannot be the source of sustained competitive advantage, particularly when the architectures on which it is based are becoming more open and omnipresent .

IT in knowledge management can be used to store various kinds of information. For example, information about processes, procedures, forecasts, cases, and patents in the form of working documents, descriptions, and reports can be stored in knowledge management systems. TietoEnator, a Scandinavian consulting firm, has a knowledge base where they store methods, techniques, notes, concepts, best practices, presentations, components, references, guidelines, quality instructions, process descriptions, routines, strategies, and CVs for all consultants in the firm (Halvorsen & Nguyen, 1999).

Knowledge retrieval can find support in content management and information extraction technology, which represents a group of techniques for managing and extracting knowledge from documents, ultimately delivering a semantic meaning for decision makers or learners alike. This type of computer applications is targeted at capturing and extracting the content of free-text documents. There are several tasks that fall within the scope of content management and information extraction (Wang, Hjelmervik, & Bremdal, 2001):

- Abstracting and summarizing. This task aims at delivering shorter, informative representations of larger (sets of) documents.
- Visualization. Documents can often be visualized according to the concepts and relationships that play a role. Visualization can be either in an introspective manner, or using some reference model/view of a specific topic.
- Comparison and search. This task finds semantically similar pieces of information.
- Indexing and classification. This considers (partial) texts, usually according to certain categories.
- Translation. Context-driven translation of texts from one language into another. Language translation has proven to be highly context specific, even among closely related languages. Some kind of semantic representation of meaning is needed in order to be able to make good translations.
- Question formulation and query answering. This is a task in human-computer interaction systems.
- Extraction of information. This refers to the generation of additional information that is not explicit in the original text. This information can be more or less elaborate.

A group of computational techniques are available to alleviate the burden of these tasks. They include fuzzy technology, neural networks, and expert systems. On a more application-oriented level, there are several approaches that apply one or more of the general techniques. The field is currently very dynamic, and new advances are made continuously. One novel approach is the CORPORUM system, to be presented in the section on expert systems.

Knowledge Transfer

Knowledge transfer can be defined as the communication of knowledge from a source so that it is learned and applied by a recipient (Ko, Kirsch, & King, 2005). Knowledge transfer occurs at various levels in an organization: transfer of knowledge between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups, and from the group to the organization. Considering the distributed nature of organizational cognition, an important process of knowledge management in organizational settings is the transfer of knowledge to locations where it is needed and can be used. However, this is not a simple process in that organizations often do not know what they know, and have weak systems for locating and retrieving knowledge that resides in them. Communication processes and information flows drive knowledge transfer in organizations.

Depending on the completeness or incompleteness of the sender's and the receiver's information sets, there are four representative types of information structure in knowledge transfer according to Lin, Geng, and Whinston (2005): symmetric complete information, sender-advantage asymmetric information, symmetric incomplete information, and receiver-advantage asymmetric information. Lin et al. (2005) found that because of asymmetry and incompleteness, parties seeking knowledge may not be able to identify qualified knowledge providers, and the appropriate experts may fail to be motivated to engage in knowledge transfer.

Knowledge transfer channels can be informal or formal; personal or impersonal. IT can support all four forms of knowledge transfer, but has mostly been applied to informal, impersonal means (such as discussion databases), and formal, impersonal means (such as corporate directories). An innovative use of technology for transfer is use of intelligent agent software to develop interest profiles of organizational members in order to determine which members might be interested recipients of point-to-point electronic messages exchanged among other members. Employing video technologies can also enhance transfer.

IT can increase knowledge transfer by extending the individual's reach beyond the formal communication lines. The search for knowledge sources is usually limited to immediate coworkers in regular and routine contact with the individual. However, individuals are unlikely to encounter new knowledge through their close-knit work networks because individuals in the same clique tend to possess similar information. Moreover, individuals are often unaware of what their cohorts are doing. Thus, expanding the individual's network to more extended, although perhaps weaker connections, is central to the knowledge diffusion process because such networks expose individuals to more new ideas.

Computer networks and electronic bulletin boards and discussion groups create a forum that facilitates contact between the person seeking knowledge and those who may have access to the knowledge. Corporate directories may enable individuals to rapidly locate the individual who has the knowledge that might help them solve a current problem. For example, the primary content of such a system can be a set of expert profiles containing information about the backgrounds, skills, and expertise of individuals who are knowledgeable on various topics. Often such metadata (knowledge about where knowledge resides) proves to be as important as the original knowledge itself. Providing taxonomies or organizational knowledge maps enables individuals to rapidly locate either the knowledge or the individual who has the needed knowledge, more rapidly than would be possible without such IT-based support.

Communication is important in knowledge management because technology provides support for both intraorganizational as well as interorganizational knowledge networks. Knowledge networks need technology in the form of technical infrastructure, communication networks, and a set of information services. Knowledge networks enable knowledge workers to share information from various sources.

Traditional information systems have been of importance to vertical integration for a long time. Both customers and suppliers have been linked to the company through information systems. Only recently has horizontal integration occurred. Knowledge workers in similar businesses cooperate to find optimal solutions for customers. IT has become an important vertical and horizontal interorganizational coordination mechanism. This is not only because of the availability of broadband and standardized protocols. It is also caused by falling prices for communication services, and by software programs' ability to coordinate functions between firms.

One way to reduce problems stemming from paper work flow is to employ document-imaging systems. Document imaging systems are systems that convert paper documents and images into digital form so they can be stored and accessed by a computer. Once the document has been stored electronically, it can be immediately retrieved and shared with others. An imaging system requires indexes that allow users to identify and retrieve a document when needed (Laudon & Laudon, 2005).

Knowledge Application

An important aspect of the knowledge-based view of the firm is that the source of competitive advantage resides in the application of the knowledge rather than in the knowledge itself. Information technology can support knowledge application by embedding knowledge into organizational routines. Procedures that are culture-bound can be embedded into IT so that the systems themselves become examples of organizational norms. An example according to Alavi and Leidner (2001) is Mrs. Field's use of systems designed to assist in every decision, from hiring personnel to when to put free samples of cookies out on the table. The system transmits the norms and beliefs held by the head of the company to organizational members.

Technology enforced knowledge application raises a concern that knowledge will continue to be applied after its real usefulness has declined. While the institutionalization of best practices by embedding them into IT might facilitate efficient handling of routine, linear, and predictable situations during stable or incrementally changing environments, when change is radical and discontinuous, there is a persistent need for continual renewal of the basic premises underlying the practices archived in the knowledge repositories. This underscores the need for organizational members to remain attuned to contextual factors and explicitly consider the specific circumstances of the current environment.

Although there are challenges with applying existing knowledge, IT can have a positive influence on knowledge application. IT can enhance knowledge integration and application by facilitating the capture, updating, and accessibility of organizational directives. For example, many organizations are enhancing the ease of access and maintenance of their directives (repair manuals, policies, and standards) by making them available on corporate intranets. This increases the speed at which changes can be applied. Also, organizational units can follow a faster learning curve by accessing the knowledge of other units having gone through similar experiences. Moreover, by increasing the size of individuals' internal social networks, and by increasing the amount of organizational memory available, information technologies allow for organizational knowledge to be applied across time and space.

IT can also enhance the speed of knowledge integration and application by codifying and automating organizational routines. Workflow automation systems are examples of IT applications that reduce the need for communication and coordination, and enable more efficient use of organizational routines through timely and automatic routing of work-related documents, information, rules, and activities. Rule-based expert systems are another means of capturing and enforcing well-specified organizational procedures.

To summarize, Alavi and Leidner (2001) have developed a framework to understand IS/IT in knowledge management processes through the knowledge-based view of the firm. One important implication of this framework is that each of the four knowledge processes of creation, storage and retrieval, transfer, and application can be facilitated by IT:

- Knowledge creation. Examples of supporting information technologies are data mining and learning tools that enable combining new sources of knowledge and just in time learning.
- Knowledge storage and retrieval. Examples of supporting information technologies are electronic bulletin boards, knowledge repositories, and databases that provide support of individual and organizational memory as well as intergroup knowledge access.
- Knowledge transfer. Examples of supporting information technologies are electronic bulletin boards, discussion forums, and knowledge directories that enable more extensive internal network, more available communication channels, and faster access to knowledge sources.
- Knowledge application. Examples of supporting information technologies are expert systems and workflow systems that enable knowledge application in many locations and more rapid application of new knowledge through workflow automation.

KNOWLEDGE MANAGEMENT SYSTEMS

There is no single information system that is able to cover all knowledge management needs in a firm. This is evident from the widespread potential of IT in knowledge management processes. Rather, knowledge management systems (KMS) refer to a class of information systems applied to managing organizational knowledge for use at the individual, group, and organizational level. These systems are IT applications to support and enhance the organizational processes of knowledge creation, storage and retrieval, transfer, and application.

Knowledge management systems can be classified as illustrated in Figure 1. Systems are exemplified along the axis of internal support vs.

Figure 1. Classification of knowledge management systems

Tools	Information	
Tools for external communications such as customer relationship management services	Information for external electronic cooperation such as web-based	**External**
Tools for internal work by knowledge workers	Information for internal work by knowledge workers	**Internal**

external support, and along the axis of technology support vs. content support for knowledge workers. As an example of a knowledge management system, we find customer relationship management (CRM) systems in the upper left quadrant. CRM systems support knowledge exchange between the firm and its customers.

Despite widespread belief that information technology enables knowledge management and knowledge management improves firm performance, researchers have only recently found empirical evidence of these relationships. For example, Tanriverdi (2005) used data from 250 Fortune 1000 firms to provide empirical support for these relationships.

Knowledge management systems are becoming ubiquitous in today's organizations. Knowledge management systems facilitate the efficient and effective sharing of an organization's intellectual resources. To ensure effective usage, a knowledge management system must be designed such that knowledge workers can readily find high-quality content without feeling overwhelmed (Poston & Speier, 2005).

Requirements from Knowledge Management

The critical role of information technology and information systems lies in the ability to support communication, collaboration, and those searching for knowledge, and the ability to enable collaborative learning (Ryu, Kim, Chaudhury, & Rao, 2005). We have already touched on important implications for information systems:

1. Interaction between information and knowledge. Information becomes knowledge when it is combined with experience, interpretation, and reflection. Knowledge becomes information when assigned an explicit representation. Sometimes information exists before knowledge; sometimes knowledge exists before information. One important implication of this two-way direction between knowledge and information is that information systems designed to support knowledge in organizations may not appear radically different from other forms of IT support, but will be geared toward enabling users to assign meaning to information, and to capture some of their knowledge in information (Alavi & Leidner, 2001).
2. Interaction between tacit and explicit knowledge. Tacit and explicit knowledge depend on each other, and they influence each other. The linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge are able to exchange knowledge. They suggest the existence of a shared knowledge space that is required in order for individual A to understand individual B's knowledge. The knowledge space is the underlying overlap in knowledge base of A and B. This overlap is typically tacit knowledge. It may be argued that the greater the shared knowledge space, the less the context needed for individuals to share knowledge within the group and, hence, the higher the value of explicit knowledge. IT is both dependent on the shared knowledge space and an important part of the shared knowledge space. IT is dependent on the shared knowledge space because knowledge workers need to have a common understanding of available information in information systems in the organization. If common understanding is missing, then knowledge workers are unable to make use of information. IT is an important part of the shared knowledge space because information systems make common information available to all knowledge workers in the organization. One important implication of this two-way relationship between knowledge space and information systems is that a minimum knowledge space has to be present, while IT can contribute to growth

in the knowledge space (Alavi & Leidner, 2001).

3. Knowledge management strategy. Efficiency-driven businesses may apply the stock strategy where databases and information systems are important. Effectiveness-driven businesses may apply the flow strategy where information networks are important. Expert-driven businesses may apply the growth strategy where networks of experts, work processes, and learning environments are important (Hansen, Nohria, & Tierney, 1999).
4. Combination in SECI process. The SECI process consists of four knowledge conversion modes. These modes are not equally suited for IT support. Socialization is the process of converting new tacit knowledge to tacit knowledge. This takes place in the human brain. Externalization is the process of converting tacit knowledge to explicit knowledge. The successful conversion of tacit knowledge into explicit knowledge depends on the sequential use of metaphors, analogy, and model. Combination is the process of converting explicit knowledge into more complex and systematic sets of explicit knowledge. Explicit knowledge is collected from inside and outside the organization and then combined, edited, and processed to form new knowledge. The new explicit knowledge is then disseminated among the members of the organization. According to Nonaka et al. (2000), creative use of computerized communication networks and large-scale databases can facilitate this mode of knowledge conversion. When the financial controller collects information from all parts of the organization and puts it together to show the financial health of the organization, that report is new knowledge in the sense that it synthesizes explicit knowledge from many different sources in one context. Finally, internalization in the SECI process converts explicit knowledge into tacit knowledge. Through internalization, explicit knowledge created is shared throughout an organization and converted into tacit knowledge by individuals.
5. Explicit transfer of common knowledge. If management decides to focus on common knowledge as defined by Dixon (2000), knowledge management should focus on the sharing of common knowledge. Common knowledge is shared in the organization using five mechanisms: serial transfer, explicit transfer, tacit transfer, strategic transfer, and expert transfer. Management has to emphasize all five mechanisms for successful sharing and creation of common knowledge. For serial transfer, management has to stimulate meetings and contacts between group members. For explicit transfer, management has to stimulate documentation of work by the previous group. For tacit transfer, management has to stimulate contacts between the two groups. For strategic transfer, management has to identify strategic knowledge and knowledge gaps. For expert transfer, management has to create networks where experts can transfer their knowledge. These five mechanisms are not equally suited for IT support. Explicit transfer seems very well suited for IT support as the knowledge from the other group is transferred explicitly as explicit knowledge in words and numbers, and shared in the form of data, scientific formulae, specifications, manuals, and the like. Expert transfer also seems suited for IT support when generic knowledge is transferred from one individual to another person to enable the person to solve new problems with new methods.
6. Link knowledge to its uses. One of the mistakes in knowledge management presented by Fahey and Prusak (1998) was disentangling knowledge from its uses. A major manifestation of this error is that

knowledge management initiatives become ends in themselves. For example, data warehousing can easily degenerate into technological challenges. The relevance of a data warehouse for decisions and actions gets lost in the turmoil spawned by debates about appropriate data structures.

7. Treat knowledge as an intellectual asset in the economic school. If management decides to follow the economic school of knowledge management, then intellectual capital accounting should be part of the knowledge management system. The knowledge management system should support knowledge markets where knowledge buyers, knowledge sellers, and knowledge brokers can use the system.
8. Treat knowledge as a mutual resource in the organizational school. The potential contribution of IT is linked to the combination of intranets and groupware to connect members and pool their knowledge, both explicit and tacit.
9. Treat knowledge as a strategy in the strategy school. The potential contribution of IT is manifold once knowledge as a strategy is the impetus behind knowledge management initiatives. One can expect quite an eclectic mix of networks, systems, tools, and knowledge repositories.
10. Value configuration determines knowledge needs in primary activities. Knowledge needs can be structured according to primary and secondary activities in the value configuration. Depending on the firm being a value chain, a value shop, or a value network, the knowledge management system must support more efficient production in the value chain, adding value to the knowledge work in the value shop, and more value by use of IT infrastructure in the value network.
11. Incentive alignment. The first dimension of information systems design is concerned with software engineering (error-free software, documentation, portability, modularity & architecture, development cost, maintenance cost, speed, and robustness). The second dimension is concerned with technology acceptance (user friendliness, user acceptance, perceived ease-of-use, perceived usefulness, cognitive fit, and task-technology fit). The third dimension that is particularly important to knowledge management systems is concerned with incentive alignment. Incentive alignment includes incentives influencing user behavior and the user's interaction with the system, deterrence of use for personal gain, use consistent with organizational goals, and robustness against information misrepresentation (Ba, Stallaert, & Whinston, 2001).

EXPERT SYSTEMS

Expert systems can be seen as extreme knowledge management systems on a continuum representing the extent to which a system possesses reasoning capabilities. Expert systems are designed to be used by decision makers who do not possess expertise in the problem domain. The human expert's representation of the task domain provides the template for expert system design. The knowledge base and heuristic rules that are used to systematically search a problem space, reflect the decision processes of the expert. A viable expert system is expected to perform this search as effectively and efficiently as a human expert. An expert system incorporates the reasoning capabilities of a domain expert and applies them in arriving at a decision. The system user needs little domain specific knowledge in order for a decision or judgment to be made. The user's main decision is whether to accept the system's result (Dillard & Yuthas, 2001).

Decisions or judgments made by an expert system can be an intermediate component in a larger decision context. For example, an audit expert system may provide a judgment as to the adequacy of loan loss reserves that an auditor would use as input for making an audit opinion decision. The fact that the output supports or provides input for another decision does not make the system any less an expert system, according to Dillard and Yuthas (2001). The distinguishing feature of an expert system lies in its ability to arrive at a nonalgorithmic solution using processes consistent with those of a domain expert.

Curtis and Cobham (2002) define an expert system as a computerized system that performs the role of an expert or carries out a task that requires expertise. In order to understand what an expert system is, then, it is worth paying attention to the role of an expert and the nature of expertise. It is then important to ascertain what types of expert and expertise there are in business, and what benefits will accrue to an organization when it develops an expert system.

For example, a doctor having knowledge of diseases arrives at a diagnosis of an illness by reasoning from information given by the patient's symptoms, and then prescribes medication on the basis of known characteristics of available drugs, together with the patient's history. The lawyer advises the client on the likely outcome of litigation based on the facts of the particular case, an expert understanding of the law, and knowledge of the way the courts work ,and interpret this law in practice. The accountant looks at various characteristics of a company's performance and makes a judgment as to the likely state of health of that company.

All of these tasks involve some of the features for which computers traditionally have been noted—performing text and numeric processing quickly and efficiently—but they also involve one more ability: reasoning. Reasoning is the movement from details of a particular case and knowledge of the general subject area surrounding that case to the derivation of conclusions. Expert systems incorporate this reasoning by applying general rules in an information base to aspects of a particular case under consideration (Curtis & Cobham, 2002).

Expert systems are computer systems designed to make expert-level decisions within complex domains. The business applications of this advanced information technology has been varied and broad reaching, directed toward making operational, management, and strategic decisions.

Audit expert systems are such systems applied in the auditing environment within the public accounting domain. Major public accounting firms have been quite active in developing such systems, and some argue that these tools and technologies will be increasingly important for survival as the firms strive to enhance their competitive position and to reduce their legal and business risk.

Dillard and Yuthas (2001) find that the implementation and use of these powerful systems raise a variety of significant ethical questions. As public accounting firms continue to devote substantial resources to the development of audit expert systems, dealing with the ethical risks and potential consequences to stakeholders takes on increasing significance. For example, when responsible behavior of an auditor is transferred to an audit expert system, then the system is incapable of being held accountable for the consequences of decisions.

Expert systems can be used in all knowledge management processes described earlier. For knowledge retrieval, content management, and information extraction technology represent a useful group of techniques. An example of an expert system for knowledge retrieval is the CORPORUM system. There are three essential aspects of this system (Wang et al., 2001).

First, the CORPORUM system interprets text in the sense that it builds ontologies. Ontologies describe concepts and relationships between them. Ontologies can be seen as the building blocks of knowledge. The system captures ontologies that reflect world concepts as the user of the system sees and expresses them. The ontology produced constitutes a model of a person's interest or concern. Second, the interest model is applied as a knowledge base in order to determine contextual and thematic correspondence with documents available in the system. Finally, the interest model and the text interpretation process drive an information search and extraction process that characterizes hits in terms of both relevance and content. This new information can be stored in a database for future reference.

The CORPORUM software consists of a linguistic component, taking care of tasks such as lexical analysis and analysis at the syntactical level. At the semantic level, the software performs word sense disambiguation by describing the context in which a particular word is being used. This is naturally closely related to knowledge representation issues. The system is able to augment meaning structures with concepts that are invented from the text. The core of the system is also able to extract the information most pertinent to a specific text for summary creation, extract the so-called core concept area from a text, and represent results according to ranking that is based on specified interest for a specific contextual theme set by the user. In addition, the system generates explanations that will allow the user to make an informed guess about which documents to look at and which to ignore. The system can point to exactly those parts of targeted documents that are most pertinent to a specific user's interest (Wang et al., 2001).

Like all software, CORORUM is continuously improved and revised. The Content Management Suport (CMS) system was introduced in 2005 (http://www.cognit.no). It is based on technology that applies linguistics to characterize and index document content. The ontology-based approach focuses on semantics rather than shallow text patterns. The software can be applied for intelligent search and indexing, structure content in portals, annotate documents according to content, summarize and compress information, and extract names and relations from text.

Another software created in 2005, CORPORUM Best Practice, enables organizations to structure their business and work processes and improve value creation. It is a software tool and associated methodology to build organization-wide best practice. In operation, the Web part of the system is a work portal. It embraces an ontology-based set of templates that helps to publish work-related documentation. Company resources like check lists, control plans MS Word templates, images, and e-learning material that is relevant for any process or activity described can be linked in where it is useful and intuitive (http://www.cognit.no).

A final software to be mentioned is CORPORUM Intranet Search & Navigation (SLATEWeb), which is used for indexing and categorizing corporate information sources. Featuring language detection and find-related concept search, this tool lets companies find documents that would otherwise be hard to find. Categories are available to dynamically classify documents into a taxonomy or group structure (http://www.cognit.no).

Analysis and design necessary for building an expert system differ from a traditional data processing or information system. There are three major points of distinction that prevent expert systems development being subsumed under general frameworks of systems development (Curtis & Cobham, 2002):

1. The subject matter is knowledge and reasoning as contrasted with data and processing. Knowledge has both form and content that need investigation. Form is connected with the mode of representation chosen, for instance, rules, semantic networks, or logic. Content needs careful attention as once the form is selected, it is still a difficult task to translate the knowledge into the chosen representation form.
2. Expert systems are expert/expertise orientated, whereas information systems are

decision/function/organization directed. The expert system encapsulates the abilities of an expert or expertise, and the aim is to provide a computerized replica of these facilities.

3. Obtaining information for expert systems design presents different problems from those in traditional information systems design. Many expert systems rely, partly at least, on incorporating expertise obtained from an expert. Few rely solely on the representation of textbook or rulebook knowledge. It is difficult, generally, to elicit this knowledge from an expert. In contrast, in designing an information system, the analyst relies heavily on existing documentation as a guide to the amount, type, and content of formal information being passed around the system. In the development of an expert system, the experts are regarded as repositories of knowledge.

Expert systems and traditional information systems have many significant differences. While processing in a traditional information system is primarily algorithmic, processing in an expert system includes symbolic conceptualizations. Input must be complete in a traditional system, while input can be incomplete in an expert system. Search approach in a traditional system is frequently based on algorithms, while search approach in an expert system is frequently based on heuristics. Explanations are usually not provided in a traditional system. Data and information is the focus of a traditional system, while knowledge is the focus of an expert system.

Expert systems can deliver the right information to the right person at the right time if it is known in advance what the right information is, who the right person to use or apply that information would be, and, what would be the right time when that specific information would be needed. Detection of nonroutine and unstructured change in business environment will, however, depend upon sense-making capabilities of knowledge workers for correcting the computational logic of the business and the data it processes (Malhotra, Gosain, & El Sawy, 2005).

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Ba, S., Stallaert, J., & Whinston, A. B. (2001). Research commentary: Introducing a third dimension in information systems design—the case of incentive alignment. *Information Systems Research, 12*(3), 225-239.

Bock, G. W., Zmud, R. W., & Kim, Y. G. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly, 29*(1), 87-111.

Curtis, G., & Cobham, D. (2002). *Business information systems: Analysis, design and practice.* Prentice Hall.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Dillard, J. F., & Yuthas, K. (2001). Responsibility ethic for audit expert systems. *Journal of Business Ethics, 30,* 337-359.

Dixon, N. M. (2000). *Common knowledge.* Boston: Harvard Business School Press.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Halvorsen, K., & Nguyen, M. (1999, June 17-19). A successful software knowledge base. In *Proceedings of the Eleventh International Conference on Software Engineering and Knowledge Engineering.* Germany: Kaiserslautern.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March-April). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

Housel, T., & Bell, A. H. (2001). *Measuring and managing knowledge.* Irwin, NY: McGraw-Hill Irwin.

Kettinger, W. J., Teng, J. T. C., & Guha, S. (1997, March). Business process change: A study of methodologies, techniques, and tools. *MIS Quarterly,* 55-79.

Ko, D. G., Kirsch, L. J., & King, W. R. (2005). Antecedents of knowledge transfer from consultants to clients in enterprise system implementations. *MIS Quarterly, 29*(1), 59-85.

Laudon, K. C., & Laudon, J. P. (2005). *Essentials of management information systems: Managing the digital firm* (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Lin, L., Geng, X., & Whinston, A. B. (2005). A sender-receiver framework for knowledge transfer. *MIS Quarterly, 29*(2), 197-219.

Malhotra, A., Gosain, S., & El Sawy, O. A. (2005). Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation. *MIS Quarterly, 29*(1), 145-187.

Moffett, S., & McAdam, R. (2003). Contributing and enabling technologies for knowledge management. *International Journal of Information Technology and Management, 2*(1-2), 31-49.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34.

Poston, R. S., & Speier, C. (2005). Effective use of knowledge management systems: A process model of content ratings and credibility indicators. *MIS Quarterly, 29*(2), 221-244.

Ryu, C., Kim, Y. J., Chaudhury, A., & Rao, H. R. (2005). Knowledge acquisition via three learning processes in enterprise information portals: Learning-by-investment, learning-by-doing, and learning-from-others. *MIS Quarterly, 29*(2), 245-278.

Tanriverdi, H. (2005). Information technology relatedness, knowledge management capability, and performance of multibusiness firms. *MIS Quarterly, 29*(2), 311-334.

Wang, K., Hjelmervik, O. R., & Bremdal, B. (2001). *Introduction to knowledge management.* Trondheim, Norway: Tapir Academic Press.

Ward, J., & Peppard, J. (2002). *Strategic planning for information systems.* Wiley.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly, 29*(1), 35-57.

Chapter 2.2
Using Inquiring Practice and Uncovering Exformation for Information Systems Development

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ABSTRACT

One of the oldest themes in information systems (IS) research concerns the relationship between developers and users of information systems. Over the years, IS scholars and IS practitioners have addressed the problem in a variety of ways, often focusing on how the use of social techniques can improve understanding between the two parties. Users, however, still find themselves working with systems, which do not match their requirements, needs, and expectations. We suggest that the problematic developer-user dynamic can be addressed by introducing an inquiring practice approach to information systems development. Consequently, this chapter conceptualizes a new way of understanding information systems development through the lenses of inquiring practice, Socratic dialogue, and the uncovering of exformation. We show that by applying this approach, we can enhance the inquiring capabilities of organizations, and thereby facilitate design and development of better information systems.

INTRODUCTION

One of the oldest themes in information systems (IS) research concerns the relationship between developers and users of information systems. Over the years, the theme has been addressed in a variety of ways by IS scholars and IS practitioners, for example, as a systems development problem (Fitzgerald, Russo & Stolterman, 2002; Hirschheim, Klein & Lyytinen, 1995; Mumford, 1996; Wood-Harper, Antill & Avison, 1985), as a problem that can be solved through end-user computing (Jarke, 1986), or by engaging in participatory design (Ehn, 1988; Greenbaum & Kyng, 1991). No matter how the problem is addressed, the underlying theme always seems to be how understanding between the two parties can be improved, typically through the use of various social techniques. The results, however, are not convincing. Users still find themselves working with systems which match neither their requirements nor their expectations.

We believe that attempts to address the problematic developer-user dynamic can be aided by a return to fundamental systems theory and the key questions raised by this body of knowledge. Churchman (1968) provides an example of such a key question in his book Challenge to Reason. He says, "How can we design improvement in large systems without understanding the whole system, and if the answer is that we cannot, how is it possible to understand the whole system?" (p. 3).

We argue that in aiming to develop improved information systems, we need to strive for an understanding of the whole system, and thus we pose the question: How can we facilitate a progression towards this understanding? For our part, we have chosen to focus on an inquiring practice approach to information systems development. In this chapter, we conceptualize a new way of looking at the theme through the lenses of inquiring practice, Socratic dialogue, and the uncovering of exformation. We suggest that by applying this approach, we can enhance the inquiring capabilities of organizations, and thereby facilitate the design and development of better information systems. In order to fulfill this purpose, the chapter proceeds in the following manner. First, we elaborate on the problems related to communication and understanding between developers and users of information systems, describe how conventional approaches to information systems development have dealt with the developer-user communication problem, and explain why it is appropriate to regard developers and users of information systems as belonging to different communities of practice. Second, we present the Socratic dialogue method and demonstrate how this approach to communication between different communities of practice is likely to enhance their inquiring capabilities. Third, we develop a model for how to apply Socratic dialogue method in information systems development practice, and thereafter we apply the model to a case of information systems development in order to demonstrate how developers and users can benefit from the use of Socratic dialogue method. For this purpose, we use the FX-system case, which describes the developer-user communication difficulties encountered by the Danish software firm, Unique, while developing a Foreign Exchange System for West Bank. Finally, we conclude and identify the point of arrival for our inquiring endeavor.

INQUIRING PRACTICE AND INFORMATION SYSTEMS RESEARCH

The idea of inquiring organizations originates from the works on inquiring systems by Churchman (1971). The concept of inquiring organizations has predominantly attracted attention from scholars working in the fields of organization theory (Mirvis, 1996; Richardson, Courtney & Paradice, 2001), information systems research (Courtney, 2001; Klein & Hirschheim, 2001), and, more recently, knowledge management (Malhotra, 1997). While scholars of organization theory have focused on organizational learning, scholars of information systems research have addressed decision support systems and information systems development. The decision support systems approach focuses on building inquiring information systems for inquiring organizations, whereas the information systems development approach focuses on how organizations can take on an inquiring perspective when designing and developing information systems. Although differing in their focus, both approaches share the intention of creating viable alternatives to the rational choice approach to development and use of information systems in organizations. In their seminal article on management of information systems (MIS), Mason and Mitroff (1973) suggest "that the current philosophy underlying the design of MIS has presupposed a greatly restricted view of 'knowledge', 'effectiveness', 'action' and 'purpose'" and "that to date much of the research and development work on MIS has assumed only one underlying psychological type, one class of problems, one or two methods of generating evidence, and finally, one mode or method of presentation" (p. 475). Mason and Mitroff (1973) maintain that a one thinking-sensation approach tends to dominate the design of MIS in such a way that they only produce systems for one kind of people. Accordingly they suggest other methods to explore the variables in a systematic fashion. One variable offered by Mason and Mitroff (1973) is Singerian-Churchmanian IS, also defined as learning systems.

We find that the same type of philosophy prevails in the field of design and development of information systems and suggest that a new approach to this must take its point of departure in focusing on what we have labeled the developer-user communication problem. Belardo, Ballou, and Pazer (2004) recently articulated a similar point of view, noting that one of the most significant factors in the difficulty of producing information systems that satisfactorily meet user needs "is ineffective communication between the user group and the development group" (p. 43).

DEVELOPER-USER COMMUNICATION PROBLEM

Developers and users of information systems have different backgrounds. Typically developers are employed in IS departments where they work and socialize with other IS professionals with whom they share language, concepts, and so on. Users, on the other hand, work in a context where vocation-specific languages and practices dominate. Although they may use information systems to carry out large sections of their duties, they seldom find themselves occupying the same world as IS professionals. Hence, when developers and users meet with the purpose of designing information systems, they both find themselves introduced to worlds which they have little knowledge of. Just like sellers and buyers of high-tech products who, by Darr and Talmud (2003), are found not to have a common image of product use and thus, to reach that common image, they must communicate contextual knowledge rooted in engineering practice, implying that an intense dialogue must take place between seller and buyer.

Developer-User Communication Problem in Conventional Information Systems Development Methodologies

Information systems are designed and developed for different purposes, and a variety of methodologies have been conceptualized to assist developers in designing and developing them. The methodologies are "coherent and integrated sets of methods, techniques, and tools to assist the developer" (Hirschheim, 1985, p. 80), and typically they comprise the two major tasks of systems analysis and systems development. According to Hirschheim (1985) "systems analysis is the process of collecting, organizing, analyzing facts about a particular system and the environment in which it operates" (p. 80), whereas systems development includes "requirements analysis, requirements specification, system design and systems implementation" (p. 80). Typically, a methodology includes a predetermined set of tasks, grouped into stages according to a prespecified method by use of tools and techniques. We find that the methodologies are characterized by a preoccupation with technicalities rather than with deep involvement of humans in the process.

It is possible to observe this characteristic in the methodologies even when we take into account a sample including sociotechnical methodologies (Wood-Harper et al., 1985), participatory design methodologies (Greenbaum & Kyng, 1991), and structured methodologies (Yourdon, 1989). Even within the participatory design approach, humans and the interaction between them are described at a very abstract level, for example, when describing how user participation can take place in systems design and development processes. Mumford and Weir (1979) end up with a diagrammatical representation of the process, thereby not addressing the content of the process.

From our perspective, developers and users of information systems belong to different communities of practice (Brown & Duguid, 1991, 1998; Wenger, 1998) who are unlikely to have the same view on several factors. For example, the other party, its organization, and the information system to be developed, but they share an interest in getting the information system developed. Knowledge creation and knowledge sharing within and between communities of practice have been widely discussed for some years. Brown & Duguid (1991), for example, argue that working, learning, and innovating are interrelated, and to understand this, we must study formations and changes within the communities that actually do the work. Brown and Duguid (1998) stress the difficulties with the absence of interaction between different communities of practice, and they argue that innovations, including new information systems, emerge when different communities share and discuss experiences and best practices.

THE SOCRATIC DIALOGUE

Our point of departure is the speculation about how communication and understanding between developers and users coming from two different communities of practice can be improved. Maruyama (1974) states that the difficulty in cross-disciplinary communication lies not so much in the fact that communicating parties use different vocabularies or language to talk about the same thing but rather in the fact that they use different structuring of reasoning. If they use different structures of reasoning and different terminologies, which communication method could be applied? Furthermore, Maruyama argues that when communicating parties remain unaware that they use different structures of reasoning but are aware of their communication difficulties, each party will tend to perceive communication difficulties as resulting from the other parties being illogical, lacking intelligence, or even insincerity. Consequently, we wanted to advance a method that can facilitate the development of a better understanding of this communication problem, and we found the Socratic dialogue method (Apatow, 1999; Hansen, 2000).

Background

The Socratic dialogue is a group discussion method that aims to identify hidden and taken for granted assumptions, as participants learn to think together with others and to strive to reach understanding of the others at a fundamental level, including understanding of their values and beliefs.

The idea of Socratic dialogue originates from the German philosopher Leonard Nelson who developed and used it as a pedagogical tool for adult education in the early 1920s (Hansen, 2002), and as far as we know, it has never before been applied in an information systems context. As a group discussion method, Socratic dialogue aims at creating an elaborate and deep common understanding of information and ideas from a specific context. In the dialogue, the participants advance their own thoughts, expecting others reflection to improve them rather than threaten them. Ergo, the participants in the dialogue must have an interest in expressing their own basic values, as well as in understanding the basic values of others concerning specific issues. From an existential point of view, this means that everyone involved must go back to the very basics of the problem being addressed. If the values and beliefs do not concern the participants from an existential perspective, we cannot say that they are involved in a Socratic dialogue.

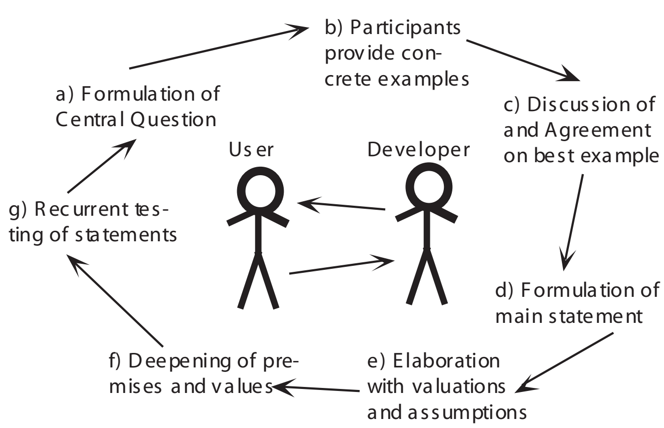
The Method of Socratic Dialogue

The Socratic dialogue begins with the formulation of a question, which all parties agree is relevant in the specific situation (Hansen, 2000). Thereafter, each participant provides a concrete example of what comes to mind when they consider the chosen question. Second, the group collectively selects the example, which it thinks provides the best outset for the dialogue. In the dialogue, the group now begins to form a main statement about the chosen question. In this process, it uses the chosen example as its point of departure. With the main statement as a background, the group then elaborates with values and assumptions underlying the statement. This inquiry into each participant's arguments and basic assumptions leads to further deepening of the premises and values that until now have been argued for. Hence, at this point in the process, the original statement has been revised several times, and more fundamental philosophical problems have been attached to the chosen question. Still, the focus of the group is on reaching the objective, namely, to find a common statement on the question. Finally, the group engages in testing the validity of the statement. This testing happens not only against the originally chosen example but also against the other examples mentioned by the participants. Thus, the testing enables the participants to reach a more general statement.

Modified Model of Socratic Dialogue Method

For several reasons, the original Socratic dialogue method needs to be modified in order to fit the information systems design and development context. First, the original method points out that the process must be given unlimited time for the parties to reach a statement that suits all. In a user-developer situation, one must face the fact that there is limited time for dialogue. Deadlines are reality, and both parties must be aware of this. Second, the original model argues that there is no need for reaching a common agreement. The

Figure 1. Socratic Dialogue Method for information systems development



objective here is the process. In our case, the objective must be more than this because users and developers need to reach a common understanding to afford product arrival. Third, in an information systems context, the starting question is unlikely to be philosophical in character. Hence, we arrived with the following picture of the Socratic dialogue method for information systems development.

Exformation: The Product of Socratic Dialogue

In relation to the Socratic dialogue, one must ask what output it produces, what is the role of this output in the information systems design and development process, and what makes the output of Socratic dialogue crucial? Using Nørretranders (1991),1 we suggest that the output take the form of exformation. "Exformation is the history of a statement, information is the product of history. Both are meaningless without each other—information without exformation is empty talk; exformation without information is not exformation, but only thrown away information" (p. 131).

The basic hypothesis is that information or knowledge exchanged between communities of practice is only a small and limited part of the knowledge creation process. The awareness of exformation as the context, the history, and the process behind the creation of information and knowledge needs as much attention as the information or knowledge itself. Exformation is an abbreviated form of explicitly discarded information. More specifically, Nørretranders (1991) states that "Exformation is everything we do not actually say but have in our heads when or before we say anything at all. Information is the measurable, demonstrable utterance we actually come out with" (p. 127).

Hence, from the information content of a message alone, there is no way of measuring how much information it contains. Nørretranders (1991) argues that exformation is produced in a process of chucking away information, and it is this process which is evident in automatic behavior of expertise (riding a bicycle, playing the piano) and which is therefore the most precious. Some might argue that exformation is similar to tacit knowledge (Nonaka, 1994). Yet, unlike tacit knowledge, exformation does not exist as something we know but cannot tell (Nonaka, 1994). Instead, exformation describes a person's nondisclosed thoughts, values, and assumptions concerning a given situation or task, and thus we maintain that talking about exformation rather than about tacit knowledge has relevance. We believe that the disclosure of exformation in the Socratic dialogue is highly beneficial for the conceptualization and design of information systems, as it enables developers and users of future information systems to produce intelligent understandings of the other party.

CASE: DESIGN AND DEVELOPMENT OF THE FX-SYSTEM

Unique is a rapidly growing Danish software firm occupied with design, development, and implementation of advanced turn-key software applications for industrial, scientific, and administrative purposes.2

In the spring in year X, salesmen in Unique discovered that West Bank wanted to purchase a Foreign Exchange System (FX-system). Yet, Unique did not have an FX-system, and West Bank wanted a ready to go FX-system. In order to address this demand, Unique decided to perceive West Bank as a potential sponsor for the development of an FX-system, which the firm subsequently could refine and sell as an off-the-shelf FX-system. Therefore, Unique initiated activities aimed at selling an FX-system to West Bank. These activities focused on explaining to West Bank that Unique knew what an FX-system was and that the firm had almost finished development of such a system. For this purpose, the manager of the Financial Services Division in Unique initiated development of a prototype of an FX-system. One of the systems developers in the division later explained how the prototype was developed:

First, we spend three days on development of a prototype generator for Presentation Manager. This generator could pick text-files and display them on a screen with fancy colors. Then, we ordered sales-material from other suppliers of FX-systems, and reproduced their user-interface. In total, we designed 20 screens with different colors and of different size. Also, they showed numbers in the different screen fields, but it was impossible to make changes in the numbers. Thereafter, we implemented the prototype as an extension to our system for online trade with stocks and bonds, because we had to have some screens with moving numbers to demonstrate a working system.

When presenting the prototype to West Bank, employees from Unique informed them that the FX-system was almost finished but that the user-interface had yet to be completed, and therefore it was impossible to demonstrate a working version of the FX-system. Also, Unique arranged that currency dealers from those customers who already used other financial systems sold by the firm answered questions from West Bank about the functionality of the FX-system. Using this approach, Unique succeeded in persuading West Bank to buy "their" FX-system, and in June, Unique and West Bank signed a contract stating that an FX-system was to be delivered to West Bank in December that very same year.

The contract signed with West Bank included some general provisions of the contract and three pages with one-liners describing the functions to be included in the FX-system. Mainly, these three pages had their outset in the sales material collected from other suppliers of FX-systems and then mixed to compose a presentation of Unique's FX-system. Hence, the contract only provided a few conceptual guidelines for design of the system.

Development and Delivery of the FX-System

Nobody in Unique knew much about foreign currency trading; also, they had no time to develop a requirement specification for the system, as the project team (six to seven systems developers) had to observe a tight deadline for delivery of the system to West Bank. Hence, the project team assumed that trade with foreign currencies was almost similar to trade with stocks and bonds, which they had some experience with. Therefore, the project team copied the source-code from Unique's systems for this activity, changed the headlines in the user-interface, and started editing the code to facilitate what they believed was FX-operations. By the end of July, the project team delivered the first modules of the FX-system to West Bank, but the delivery was not successful, as Unique did not deliver what West Bank expected. However, users in West Bank had difficulties in explaining exactly what they expected. Given the problems, the management of Unique assigned a new project manager. He discovered that no plans existed for the FX-project, that project management was almost absent, and that to some systems developers, OS/2 constituted new technology. Furthermore, representatives of West Bank explained to the new project manager that West Bank expected delivery of an FX-system similar to the one specified in the contract, which in their opinion, was not what Unique delivered. Yet, the contract did not specify the FX-system apart from stating the different subsystems to be included in the FX-system. This problem was compounded by the fact that West Bank had difficulties in specifying exactly what kind of system they wanted. Also, the new project manager realized that the schedule for the FX-project was not realistic when considering the large number of tasks to be accomplished.

A New Start on the FX-Project

With the above mentioned problems in mind, the new project manager developed a revised project plan, which divided the FX-system into subsystems and initiated development of the system from scratch. Furthermore, he explained to the top management that Unique had to perceive the project as a collaboration with West Bank. Thus, he initiated regular meetings between systems developers from Unique and users from West Bank, as he realized that Unique needed the currency dealers to tell the project team about their demands to the FX-system, since none of the system developers assigned to the project knew anything about foreign exchange. Six months later, the systems developers were in a position to produce parts of the FX-system, which were accepted by West Bank. However, at that point in time, the project was half a year behind schedule. Also, the new project manager conducted regular meetings with representatives of West Bank, as he wanted them to realize that the contract was unrealistic and to accept a revision of it. The strategy succeeded slowly as the representatives of West Bank learned that Unique did not know how to develop an FX-system. Yet, West Bank was not likely to accept a revision of the contract, as they felt that they would then have to accept a less advanced FX-system.

In the fall one year after initiation of the project, Unique faced new problems in the FX-project. The system often broke down due to problems with the software produced by Unique. The project team experienced that somehow these problems were related to the fact that West Bank did not know what they wanted and constantly changed their demands for the FX-system. In order to identify solutions to the problems, the project team intensified its meetings with users from West Bank, and thereby Unique managed to restore West Bank's confidence in the firm, as well as in persuading West Bank to stay in the project. In the end, Unique managed to develop and deliver the FX-system to West Bank, although it took more than one and a half years of extra work to finish the project, which in total meant a project which lasted for two years.

INTERPRETATION OF THE CASE

In the present paragraph, we interpret the FX-case through the Socratic dialogue model presented above. First, we identify communicative acts, which we find are representative for the case. Second, we interpret the acts with the use of the model, thereby we identify how the communicating parties acted and reacted in the process, and we seek to explain how their acting and reacting influenced the process over time. Third, we speculate how the process might have evolved if the Socratic dialogue had been applied.

Identifying Communicative Acts

For the purpose of interpretation of the case, we needed communicative acts representative for the case. Hence, we began our analysis by looking for such acts in the case. As communicative acts, we defined points in time where either of the involved parties "send messages" to the other party leading to some kind of response. As our first example, we identify the point in time where developers in Unique make contact with West Bank and suggest themselves as potential suppliers of an FX-system to West Bank. West Bank, which we now term the user, responds by agreeing to visit Unique on-site and see a presentation of the system. In total, we identified eight communicative acts. These, however, vary with regard to both content and form. Foremost, it is important to note that the form changes significantly after the first unsuccessful delivery of modules of the FX-system. We therefore talk about phase 1 initial communicative acts and phase 2 adapted communicative acts.

Initial Communicative Acts

As the first five communicative acts, we have identified the following:

Example A1:
- Developers make contact to users and suggest their firm as supplier of an FX-system
- Users accept invitation to visit developers' site and take a look at the system

Example A2:
- Developers present the proposed system to the users
- Users accept the proposed system as a suitable response to their needs

Example A3:
- Users pose questions regarding technical and functional aspects of the proposed system
- Developers answer the technical questions, and the currency dealers borrowed from existing customers answer questions about functional aspects of the system

Example A4:
- Developers write up contract about sale and delivery of the FX-system
- Users sign contract and buy the proposed FX-system

Example A5:
- Developers initiate development of the proposed FX-system
- Users passively await delivery of the FX-system

Looking at these communicative acts, it appears that they all have a similar form and content. Starting with the form, it can be observed that the communication is initiated by the developer-side as it approaches the user-side and suggests itself as an appropriate supplier of the FX-system that the user-side is looking for. From the developer-side, this gives the communicative acts a focus on convincing the user-side about the appropriateness in choosing it as the FX-system supplier. Also, it gives the communicative acts a flavor of being orchestrated by the developer-side constantly looking for the user's approval of its points of view.

As the dialogue evolves, the developer-side increasingly focuses on getting the user-side to confirm that it is on the right track regarding the proposed FX-system. This happens even though the developer-side must have some doubts about their actual capacity to deliver the proposed FX-system. In other words, no uncertainty is revealed and communicated by the developer-side. Viewing this from a Singerian perspective, it would be perceived as a highly unethical act. We do not claim that the developer-side knew that it would be difficult to deliver the system, but we assume that they must have had some doubt and that this doubt could have been articulated in an early stage of the dialogue. However, little dialogue about the users' requirements to the system took place in the initial stages of the process.

When interpreting the communicative acts in the light of the Socratic dialogue, we are afforded the following picture. The central question is formulated by the developer-side and is never tested in the dialogue with the user-side. The central question may be formulated as "We have an excellent FX-system here, don't you think?" If we then move on to Step 2 in the Socratic dialogue, the provision of concrete examples, it happens as the developer-side demonstrates the constructed FX-system to the user-side, and experiences that the user-side accepts the shown system as a suitable response to its needs, not even questioning the existence of the system. In neither of these two examples does the user-side inquire about the developer-side's understanding of its demands to such a system. Instead, "feedback" from users continuously confirmed the developers' formulation of the central question.

Adapted Communicative Acts

As the final three communicative acts, we have identified the following:

Step B1:

- Users respond to delivery by stating that this is not an FX-system
- Developers respond by assigning a new project manager who reorganizes the project team

Step B2:

- Developers begin to inquire into the users' demands to the system
- Users accept the developers' invitation to inquiring dialogue

Step B3:

- Developers suggest a step-by-step procedure for identification of the demands of the users, based on the one-liner contractual descriptions of the functionality of the FX-system
- Users engage in this activity by joining the dialogue with the developers

When looking at these three communicative acts, it appears that the initial failure by the developer-side to deliver what the user-side expected had an impact on how the dialogue evolved. In the adapted phase, far more open-ended communicative acts dominate. The weaknesses of the developer-side, which used to be hidden, are now obvious and need to be dealt with if the project is to continue. However, these inquiries from the user-side only emerged as the developer-side failed to fulfill the user-side's expectations to the delivery of the first modules of the system. The reorganization of the managerial setup following the failed delivery provided for initiation of an inquiring dialogue between the two parties.

Viewing the adapted communicative acts in the light of the Socratic dialogue, we can say that the new project manager initiates reformulation of the central question. Basically, the developer-side says: "What does an FX-system look like?" And essentially, the user-side replies: "That is actually a very good question." Here we witnesses a break point in the way the developer-side approaches the problem of developing the FX-system, and the user-side responds by accepting that this break with the prior pattern of communicative acts is highly needed. Hence, a new central question is being formulated through the involvement of both parties.

As the Socratic dialogue proceeds, the step-by-step procedure for identification of the user-side's needs implies inquiring into the meaning of the one-liner descriptions of the various functions in the proposed FX-system. If we perceive these one-liners as high-level abstractions containing a huge amount of exformation, it obviously becomes important that each party's interpretation of the one-liner is revealed, as most likely each interpretation is unknown to the other party. Hence, in this instance, the Socratic dialogue is about transforming abstractions to raw data. This happened as the involved parties provided concrete examples of how they interpret the one-liners. Examples may have been elaborated by provision of counter-examples or more detailed examples. Then, as the parties discuss and agree on best concrete examples, they obtain verification of their reciprocal understanding. Of course, the parties can never be sure of their full common understanding, and that is exactly why continuous dialogue is important.

Based on these discussions and agreements, formulation of main statements about the functionalities could take place. The main statements then serve as the basis for elaboration about the content of the functionalities to be included in the system. We cannot say much about E and F in the model, although we would expect that uncovering of crucial and case related exformation takes place here. We are however quite sure that in the FX-case testing of statements happened as modules were delivered and accepted or rejected by the users.

An important insight, which emerged in the adapted phase is that the user-side had a very vague picture of their demands to the FX-system. We see this in the fact that the user-side constantly changes its requirements to the system, and this uncertainty may have influenced them to not inquire about the presented FX-system in the initial phase.

Closure on Case Interpretation

Our interpretation of the FX-case has demonstrated that inquiring practice based on Socratic dialogue can make a difference in the quality of the output produced in IS development processes. The question that, of course, emerges is whether the developer-side had succeeded if the initial communicative acts with the user-side had started with an inquiring approach. Although we emphasize the importance of an inquiring approach in the user-developer communication, we cannot neglect that this kind of dialogue may foster uncertainty and anxiety in and among participants. However, all face-off actions demand boldness and courage, and we must take into account that our behavior may influence our counterparts to perceive us as less trustworthy. Another question is whether it was the developer-side that held the key to the initiative of inquiring practice.

Addressing the first question, we acknowledge that West Bank openly expressed that it was looking for a complete FX-system and that it would not buy a turn-key delivery. Yet, we maintain that the possibility for succeeding with an inquiring approach depends on the perspective taken by the counterpart, whether that be a developer or a user. Therefore, if West Bank had responded positively to an inquiring approach taken by Unique, we submit that the firm would have succeeded with this approach.

So, why did an inquiring approach not develop earlier on? Of course, the developers were quite street-wise in the initial phases, but on the other hand, the users did not act intelligently. They did not pose critical questions, and thereby they did not insist on engaging in an inquiring practice. In a Socratic dialogue perspective, neither the developers nor the users took responsibility for their own organization. We thus maintain that inquiring practice is always a two-way responsibility, which however might be provoked by one of the involved parties. Every stage must include inquiry, reflection, and active listening, with active listening including both listening to the counterpart and, perhaps even more important, listening to oneself.

Until now, we have argued for the Socratic dialogue method, but little has been said about how to initiate this method. From an information systems development point of view, we believe that the initiative must come from the developer-side, and in a sales context, it is probably the seller who has the greatest interest in implementing this kind of dialogue. We are aware of the problems arising when one party explicitly tries to introduce a philosophical tool in this situation, mainly, because tradition and norms tells us that this is not the way of conducting business. Therefore, we suggest that the developer-side initiates this in a manner that tells the user-side that it is important to open up ones basic thoughts and values without experiencing that these issues are too simple to highlight. Hence, the developer-side must state early on an example that is in line with the Socratic dialogue method.

CLOSURE: SOCRATIC DIALOGUE AND WISDOM

In this chapter, we have argued for a more intelligent way of organizing the cross-disciplinary dialogue between developers and users of information systems. For this purpose, we identified Socratic dialogue method and argued that it can be used in an information systems development context. The Socratic dialogue method enhances the inquiring capabilities of organizations, and thereby it allows for uncovering of exformation, which is crucial if developers and users of information systems are to obtain a more advanced understanding of one another's positions. We argue that instead of asking, "Did we get the information and knowledge we searched for?" one should ask, "Did we uncover exformation in this dialogue that can facilitate the development of this system?" Consequently, Socratic dialogue is a new way of approaching the process rather than a tool.

When organizations apply Socratic dialogue in the developer-user communication, there is a high possibility that both parties will display exformation of a far more substantial kind than the information usually being developed and exchanged. Also, viewing developers and users from the point of view of inquiring communities of practice could, in fact, produce more open flows of information in organizations and thereby provide for more innovation in organizations. Therefore, we suggest that Socratic dialogue is useful beyond the area of application dealt with in the present chapter. It could be applied both among sellers and buyers of high-tech products and in the process of creating new management practice in organizations. Because this philosophical approach opens for a new way of viewing cross-disciplinary communication, regardless of business field or vocation function, Socratic dialogue can bring about exformation being held inside people—exformation that is crucial in order to understand and share knowledge between communities. Hopefully, this dialogue can help us not only to facilitate understanding but also to develop a new type of language in management and organizations (Lundin & Rasmussen, 2002). As with information flows, flows of often used words and phrases in a community make us unaware of their meaning for other groups of people. We simply forget to reflect on it and then take it for granted. By learning and developing our choice of semantics together with others in a Socratic dialogue, we can become more aware of what we actually communicate in and between these inquiring communities.

We realize that our attempt to apply the Socratic dialogue in an information systems context is only the first move in a new endeavor aimed at formulating a new methodology for use in this context. Hopefully, further research will help refine and modify the methodology and also through experiments in real-life environments, as it is important to remember that the Socratic dialogue method was originally developed for a different context with the aim of creating a methodology that facilitates critical reflection about issues that, at the first glance, may seem obvious to us. Yet, it is by reflecting over precisely those kind of questions that we can discover exformation and thereby arrive at a better understanding of our counterparts.

REFERENCES

Apatow, R. (1999). Socratic dialogue. *Executive Excellence, 16*(5), 10-11.

Belardo, S., Ballou, D. P., & Pazer, H. L. (2004). Analysis and design of information systems: A knowledge quality perspective. In K. V. Andersen & M. T. Vendelø (Eds.), *The past and future of information systems* (pp. 43-59). Oxford: Elsevier Butterworth-Heinemann.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Towards a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Brown, J. S., & Duguid, P. (1998). Organizing knowledge. *California Management Review, 40*(3), 90-111.

Churchman, C. W. (1968). *Challenge to reason*. New York: McGraw-Hill.

Churchman, C. W. (1971). *The design of inquiring systems: Basic concepts of systems and organization*. New York: Basic Books.

Courtney, J. F. (2001). Decision making and knowledge management in inquiring organizations: Toward a new decision-making paradigm in DSS. *Decision Support Systems, 31*(1), 17-38.

Darr, A., & Talmud, I. (2003). The structure of knowledge and seller-buyer networks in markets for emergent technologies. *Organization Studies, 24*(3), 443-461.

Ehn, P. (1988). *Work-oriented design of computer artifacts*. Stockholm: Arbetslivscentrum.

Enderud, H. (1987). Dataindsamling i organisationssociologien: En note om information-sorienteret respondent-udvælgelse. In T. Broch, K. Krarup, P. K. Larsen, & Olaf Rieper (Eds.), *Kvalitative metoder i dansk samfundsforskning – Lejerbosymposiet 1978. 2. udgave* (pp. 145-159). København: Nyt fra Samfundsvidenskaberne.

Fitzgerald, B., Russo, N. L., & Stolterman, E. (2002). *Information systems development: Methods in action.* New York: McGraw-Hill.

Greenbaum, J., & Kyng, M. (1991). *Design at work: Cooperative design of computer systems*. Hillsdale: Lawrence Erlbaum.

Hansen, F. T. (2000). *Den sokratiske dialoggruppe – et værktøj til værdiafklaring.* København: Gyldendal.

Hansen, F. T. (2002). *Det filosofiske liv – et dannelsesideal for existenspædagogikken.* København: Gyldendal.

Hirschheim, R. A. (1985). *Office automation: A social and organizational perspective.* Chichester: Wiley.

Hirschheim, R., Klein, H. K., & Lyytinen, K. (1995). *Information systems development and data modeling: Conceptual and philosophical foundations.* Cambridge, MA: Cambridge University Press.

Jarke, M. (Ed.). (1986). *Managers, micros and mainframes: Integrating systems for end-users.* Chichester: Wiley.

Klein, H. K., & Hirschheim, R. A. (2001). Choosing between competing design ideas in information systems development. *Information Systems Frontiers, 3*(1), 75-90.

Lundin, M. S., & Rasmussen, L. B. (2002). A radical Scandinavian ("Øresundsk") approach to inquiring organizations: A critique of ICT in knowledge management. In K. Brunnstein & J. Berleur (Eds.). *Human choice and computers: Issues of choice and quality of life in the information society* (pp. 293-304). Dordrecht: Kluwer Academic.

Malhotra, Y. (1997, August 15-17). Knowledge management in inquiring organizations. *Proceedings of 3rd Americas Conference on Information Systems* (pp. 253-274). Indianapolis, IN.

Maruyama, M. (1974). Paradigms and communication. *Technological Forecasting and Social Change, 6,* 3-32.

Mason, R. O., & Mitroff, I. I. (1973). A program for research on management information systems. *Management Science, 19*(5), 475-487.

Mirvis, P. H. (1996). Historical foundations of organizational learning. *Journal of Organizational Change, 9*(1), 13-31.

Mumford, E. (1996). *Systems design: Ethical tools for ethical change*. Basingstoke: Macmillan.

Mumford, E., & Weir, M. (1979). *Computer systems in work design: The ETHICS method.* London: Associated Business Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nørretranders, T. (1991). *Mærk Verden – en beretning om bevidsthed.* København: Gyldendal3.

Richardson, S. M., Courtney, J. F., & Paradice, D. B. (2001). An assessment of the Singerian inquiring organizational model: Cases from academia and the utility industry. *Information Systems Frontiers, 1*(1), 49-62.

Van Maanen, J. (1988). *Tales of the field: On writing ethnography.* Chicago: University of Chicago Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge, MA: Cambridge University Press.

Wood-Harper, A. T., Antill, L., & Avison, D. E. (1985). *Information systems definition: The multiview approach.* Oxford: Blackwell.

Yourdon, E. (1989). *Modern structured analysis.* Englewood Cliffs: Prentice Hall.

ENDNOTES

1. Quotations from Nørretranders (1991) were translated from Danish to English by the authors.
2. Appendix A gives more information about the case study.
3. This book is published in English as: Nørretranders, T. (1998). The user illusion: Cutting consciousness down to size. London: Allen Lane.

APPENDIX A: CASE METHODOLOGY

The case—Design and Development of an FX-system—is borrowed from a longitudinal study of new business creation in the Danish software firm Unique. The case study took place over a period of two years and used an explorative approach to study three different cases of new business creation in the firm. One case was Financial Products, of which the present case constituted one central activity. The main source of empirical evidences in the study was qualitative data gathered on-site in the organization. Several data generation techniques of ethnographic nature (Van Maanen, 1988) were employed, such as semi-structured interviews, informal talks, direct observations, collection and review of documents, and social contact. Hence, multiple sources of evidence were used in order to collect evidences conveying the same facts. Yet, interviews with members of the organization lasting from one to two hours were the main source of empirical evidence. For the Financial Products case, a total of 12 interviews were conducted. Selection of interviewees for the case happened based on information obtained from either prior interviews or written material collected in the firm. Also, a knowledge-based sampling method was used by asking interviewees to suggest others who had knowledge of, or were involved in, certain aspects of the case. Especially, the selection focused on people believed to hold central positions in each case; that is, interviewees were selected based on their information value (Enderud, 1987). Occasionally, people, who for different reasons had left the organization, were interviewed in order to obtain information about issues which people inside the organization were reluctant to talk about. Most interviews were taped and transcribed, but occasionally tape recording did not take place. Instead, interviews were recorded in shorthand notes. After transcription interview texts were handed over to interviewees in order to ensure that they could review and correct or add information in the interviews.

Another important source of empirical evidences were written material collected in various ways. Some documents were easily accessible in the organization. Such documents included annual reports, organization charts, messages from management to the employees, memos, strategic plans, firm journals, and news clipping. Some interviewees allowed the researcher to go through their personal files and handed over to him documents related to the cases studied. Finally, a kind kitchen midden technique was used, as occasionally the researcher was moved to offices previously occupied by people who had left the organization without removing their files and collection of documents. A couple of times the researcher took the liberty to go through these files and record information of interest to the case study.

Based on the empirical evidences gathered using the different data generation techniques described above, write up of chronological case stories took place in order to reveal the progression in the processes. Before writing up the cases, the researcher went through the empirical evidences in order to get an initial impression of the data and write notes about the activities and people involved in each case. Thereafter, a write up of the first draft took place, followed by two to three revisions of each case, and a final write up occurred on completion of the collection of empirical evidences.

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Chapter 2.3
Engineering Design Knowledge Management

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INTRODUCTION

In recent years, greater global competition is pressuring organizations to produce industrial products with the shortest possible lead times, high quality, and lowest costs. The lifecycle of a product includes many phases such as requirement definition, conceptual design, production, operation, maintenance, and so forth. Each phase in the lifecycle would involve the product information, for example, using some information that comes from other phase(s) and generating some new information during the phase. Engineering design knowledge (EDK) of a product consists of the product information related to the design process of the product.

It should be noticed that modern products are complex, and their developments have increasingly become collaborative tasks among teams that are physically, geographically, and temporally separated (Caldwell et al., 2000; Szykman, Sriram, Bochenek, Racz, & Senfaute, 2000). As design becomes increasingly knowledge intensive and collaborative, traditional design databases, which merely provide access to schematics, computer-aided design (CAD) models, and documentation, are inadequate for modern product design (Szykman et al., 2000), and the need for computational design frameworks to support the representation, integration, maintenance, and use of knowledge among distributed designers becomes more critical. The representation, integration, maintenance, and use of knowledge consist of the knowledge management of engineering knowledge.

BACKGROUND

Nowadays most engineering design is a knowledge-intensive process undertaken by teams dispersed across multiple disciplines. So it needs to be supported with relevant engineering design knowledge. We call engineering design knowledge all the standards, laws, and best practices that need to affect the design decision. Engineering design knowledge attempts to integrate three fundamental facts of artifact representation: the physical layout of the artifact (structure), an indication of the artifact's overall effect (function), and a causal account of the artifact's operation (behavior) (Szykman et al., 2000). The function-behavior-structure (FBS) engineering design model has been developed in Tomiyama, Umeda, and Yoshikawa (1993) and Tomiyama, Mantyla, and Finger (1995). Based on the model, four categories of design knowledge were basically classified (Li & Zhang, 1999): artifact functions, artifact behaviors, artifact structures, and the causalities among structures, behaviors, and functions. Function knowledge is about the purpose of an artifact; behavior knowledge is about the changes of states of an artifact; structure knowledge is about a set of components and their relationships; causality knowledge is about design constraints, wishes, physical principles, heuristic rules, and so on.

Corresponding to contemporary engineering design, engineering design knowledge is structured, distributed, and evolving. It is generally already formal or can be easily formalized. It essentially consists of sets of constraints with additional references, justifications, illustrations, examples, and other documentation. This knowledge lends itself to a formal, machine-readable representation. Engineering design knowledge is typically distributed because most engineering artifacts involve a variety of domains of expertise (e.g., electrical, mechanical, styling, and manufacturing) and a variety of stakeholders (e.g., manufacturers, suppliers, servicing agents, legislators). The knowledge is distributed in the sense that each area of expertise and each stakeholder authors, publishes, and maintains their own repository. The SAE (Society of Automotive Engineers) handbook and EPA (Environmental Protection Agency) publications, for example, are published and updated independently of each other. Finally, the knowledge is rapidly evolving because it is meant to be a live reflection of the state of the art and the state of the technology relevant to the engineering domain of interest. The knowledge gets updated asynchronously, and the updated information is made immediately available to the user.

Because engineering design knowledge has a large size, rapid pace of growth and evolution, and distributed ownership, it is better managed as an independent resource rather than hard-coded within the CAD systems or their satellite tools. The management of the engineering knowledge entails its modeling (representation), maintenance, integration, and use.

ENGINEERING DESIGN KNOWLEDGE MANAGEMENT

The management of engineering design knowledge entails its modeling (representation), maintenance, integration, and use. Knowledge modeling consists of representing the knowledge in some selected language or notation. Knowledge maintenance encompasses all activities related to the validation, growth, and evolution of the knowledge. Knowledge integration is the synthesis of knowledge from related sources. The use of the knowledge requires bridging the gap between the objectives expressed by the knowledge and the directives needed to support the designer in creating valid engineering artifacts. The management of engineering design knowledge requires an adequate modeling language and an associate inferencing mechanism. So in this short article, we only focus on the modeling of engineering design knowledge.

Knowledge Modeling

Knowledge modeling and the representation of structural information have been prominent issues in artificial intelligence, knowledge representation, and advanced applications of databases. Although the design knowledge representation itself is not a new subject, there is no commonly agreed approach to the problem, and it still represents an active area of research (Vranes & Stanojevic, 1999). A number of solutions have emerged from these domains, and various researchers have developed models that attempt to capture the facts of structure, function, and behavior (Gorti, Gupta, Kim, Sriram, & Wong, 1998; Vranes & Stanojevic, 1999).

An integrated artifact metamodel was developed in BEST's knowledge representation language, Prolog/Rex (Vranes & Stanojevic, 1999). The Prolog/Rex concepts were used to define generic classes and describe the workpiece, which are instances of generic classes; Prolog/Rex relations were used to describe the relationships between the concepts. Then the knowledge used in the design process was divided into declarative and procedural knowledge. Similarly, in Gorti et al. (1998), an object model was developed which formed the basis of the design knowledge representation. Their model consists of objects, relationships among objects, and classes (object class and relationship class). An object-oriented model has been developed and applied for design knowledge modeling (Mili et al., 2001; Ma & Mili, 2003).

Class with Constraints

Knowledge units were basically constraints (Mili et al., 2001). Constraints are always associated with engineering artifacts, modeled by classes. Instances of a given class are created and modified through the direct setting and update of their parameters. These parameters, because they are the subjects of direct decisions, are called decision parameters. Most constraints on a class do not constrain directly the decision parameters. They generally refer to more complex and more abstract parameters, called performance parameters. This leads to the modeling of a class using the UML notation in which we represent four compartments: The class name in the top compartment identifies the concept of interest. The bottom compartment contains (a reference to) the constraints that class instances are bound by. These constraints typically refer to parameters of the concept. Some of these parameters are attributes directly set by the designer. They are listed under the second compartment. Most of the parameters referred to in the constraints are measures of "performance" of the class. They are not direct decision parameters, but are functions of some decision parameters. The performance parameters are included in the third compartment along with their expression in terms of decision parameters. The decision parameters used are added to the second compartment.

For example, a door panel may be represented as follows:

Door Panel
Decision parameters
    length: Real
    width: Real
    contour: Curve
Performance parameters
    top to bottom curvature = curvature
    Function (length, contour),
    corner angles = corners
    Function (contour)
Design constraints
    constraint on top to bottom curvature
    constraint on corner angles

Constraints

The most interesting elements in this model are the constraints themselves. In fact, we refer to them as constraints even though they are generally complex documents encompassing source, motivation, rationale, consequences, and a log of the various changes and updates they have undergone. Because of this existing and potential complexity, the constraints are represented within their own class. A number of attributes are used to describe the constraints. These attributes can be very useful when it comes to assessing the authority and criticality of a given constraint. For example, a constraint of type standard authored by a trusted authority from the federal agency EPA is likely to have high criticality. On the other hand, a constraint classified as best practice, whose consequence is a slightly more costly assembly procedure, can conceivably be violated in order to ensure that some other constraint is met.

Constraint
Name:
Source: {EPA, SAE, SME, …}
Author: (authority)
Classification: {standard, best practice, …}
Last updated:
Replaces: Constraint
Overrides: (Class, Constraint, Class)
Formula:
Rationale:
Consequences:
Parameters directly referenced: set of parameters
Parameters indirectly referenced: set of Parameters
Replaces older—not less recent constraints
Overrides weaker—not stronger constraints

In a word, a class with constraints representing a piece of design knowledge is defined by the quintuplet <CN, DP, PP, MT, CT>. Here, CN is the name of the class, and DP, PP, MT, and CT are the sets of decision parameters, performance parameters, methods, and constraints, respectively.

Relationships Among Design Knowledge and Comparison

Since design knowledge is represented by classes with constraints, semantic relationships among design knowledge turn out to be the semantic relationships among classes with constraints. It should be pointed out that, however, the distributed design knowledge may result in syntactic and semantic conflicts among classes with constraints, which affect the identification and determination of the relationships among design knowledge. Here we assume that all possible conflicts are identified and solved.

The following semantic relationships among classes with constraints can be classified in the knowledge model above.

- Subclass relationship
- Part-feature relationship
- Equivalence relationship
- Inclusion relationship
- Approximate equivalence relationship
- Approximate inclusion relationship

Among these relationships, some, like subclass relationship, part-feature relationship, and aggregate relationship, are common in object-oriented model; some, like assembly-component relationship, are crucial for engineering design and manufacturing; and some, like (approximate) equivalence relationship and (approximate) inclusion relationship, are very useful for design knowledge fusion and design knowledge use.

The comparison of design knowledge is a very important topic in the context of design knowledge management. During design of a product, for example, designers would usually think if there has existed a similar product designed before, if there have been some standard parts in CAD systems that could be directly used to design the product, or if some components existed in CAD systems that can be used as references to the designed product. Designers therefore would try to answer these questions by findings from CAD systems or design repositories, when the designed product is very complex or the design repositories are very large and located in heterogeneous systems. In addition, managing design knowledge federations need to integrate knowledge from different sources. In order to cerate the integrated knowledge repositories, it is necessary to identify and capture the semantic relationships among different knowledge models. The purpose of comparing design knowledge is to identify the relationships among design knowledge given above. Since design knowledge is represented by classes with constraints, comparison of design knowledge turns out to be the comparison of classes with constraints. In Ma and Mili (2003), based on the object-oriented knowledge model above, the semantic relationships among design classes with constraints were identified and the methods to determining these relationships were hereby developed. In particular, the comparison of constraints and the semantic relationships on approximate basis were investigated.

Regarding comparison of design knowledge, Tischler, Samuel, and Hunt (1995) focused on the comparison of design knowledge at the artifact structure level, where only the kinematic motion is considered in the domain of machine conceptual design. A conceptual graph (Sowa, 1999) has been used to represent the domain level of an expertise model (Dieng, 1996), and knowledge-intensive design has been represented graphically (Balazs, Brown, Bastien, & Wills, 1997). Therefore, in Li and Zhang (1999), a hybrid graph approach was proposed to represent four kinds of design knowledge: artifact functions, artifact behaviors, artifact structures, and the causalities among structures, behaviors, and functions. Then the comparison of design knowledge turned out to be the comparison of hybrid graphs. Using the Hopfield-Tank neural network algorithm, an algorithm for the graph comparison purpose was developed. Moreover, some research work has also focused on comparison of conceptual graphs (Dieng, 1996; Montes-y-Gómez, Gelbukh, López-López, & Baeza-Yates, 2001).

CONCLUSION

Most of engineering design is a knowledge-intensive process undertaken by teams dispersed across multiple disciplines. So it is essential that engineering design needs to be supported with relevant engineering design knowledge, and engineering design knowledge is better managed as an independent resource rather than hard-coded within the CAD systems or their satellite tools. In this article, we review the issues related to the modeling of engineering design knowledge. In particular, an object-oriented knowledge model to represent design knowledge associated with their categories is presented. Based on the knowledge model, the semantic relationships among design knowledge can be identified and determined. Engineering design knowledge can hereby be compared for design knowledge integration and use.

Engineering design knowledge is represented with the object-oriented model. The management of engineering design knowledge such as maintenance, integration, and use can be achieved in the context of object-oriented database management.

REFERENCES

Balazs, M.E., Brown, D.C., Bastien, P., & Wills, C.E. (1997). Graphical presentation of designs: A knowledge-intensive design approach. In M. Mantyla, S. Finger, & T. Tomiyama (Eds.), *Knowledge intensive CAD,* (Vol. II, pp. 173-188). Chapman & Hall.

Caldwell, N.H.M. et al. (2000). Web-based knowledge management for distributed design. *IEEE Intelligent Systems, 15*(3), 40-47.

Dieng, R. (1996). Comparison of conceptual graphs for modeling knowledge of multiple experts. *Proceedings of the 9th International Symposium on Foundations of Intelligent Systems* (pp. 78-87). Berlin: Springer-Verlag (LNCS 1079).

Gorti, S.R., Gupta, A., Kim, G.J., Sriram, R.D., & Wong, A. (1998). An object-oriented representation for product and design processes. *Computer-Aided Design, 30*(7), 489-501.

Lai, H.C., & Chu, T.H. (2000). Knowledge management: A review of theoretical frameworks and industrial cases. *Proceedings of the 2000 Annual Hawaii International Conference on System Sciences.*

Li, Q., & Zhang, W.J. (1999). Computer comparison of design knowledge. *Proceedings of the Institution of Mechanical Engineers Part B—Journal of Engineering Manufacturing, 212*(8), 635-645.

Ma, Z.M., & Mili, F. (2003). Knowledge comparison in design repositories. *Engineering Applications of Artificial Intelligence, 16*(3), 203-211.

Michael, S.M., & Khemani, D. (2002). Knowledge management in manufacturing technology: An A.I. application in the industry. *Proceedings of the 2002 International Conference on Enterprise Information Systems* (pp. 506-511).

Mili, F., & Ma, Z.M. (2002). Eliciting and formalizing tolerance and leniency in engineering design requirements. *Proceedings of the 2002 International Conference on Fuzzy Systems and Knowledge Discovery, 1* (pp. 96-100).

Mili, F., & Ma, Z.M. (2002). Modeling and maintaining engineering knowledge: Issues and solutions. *Proceedings of the IEEEE 2002 International Conference on Systems, Man, and Cybernetics* (Vol. 3, pp. 567-572).

Mili, F., Shen, W., Martinez, I., Noel, P., Ram, M., & Zouras, E. (2001). Knowledge modeling for design decisions. *Artificial Intelligence in Engineering, 15,* 153-164.

Montes-y-Gómez, M., Gelbukh, A., López-López, A., & Baeza-Yates, R. (2001). Flexible comparison of conceptual graphs. *Proceedings of the 12th International Conference on Database and Expert Systems Applications* (pp. 102-111). Berlin: Springer-Verlag (LNCS 2113).

OMG. (2001). *Unified Modeling Language (UML), version 1.4*. Retrieved from http://www.omg.org/technology/documents/formal/uml.htm

Sowa, J.F. (1999). *Knowledge representation: Logical, philosophical and computational foundations.* Brooks Cole Publishing Co.

Szykman, S., Sriram, R.D., Bochenek, C., Racz, J.W., & Senfaute, J. (2000). Design repositories: Engineering design's new knowledge base. *IEEE Intelligent Systems, 15*(3), 48-55.

Tischler, C.R., Samuel, A.E., & Hunt, K.H. (1995). Kinematic chain for robot hands I: Orderly number-synthesis. *Mechanisms and Machine Theory, 30*(8), 1193-1215.

Tomiyama, T., Mantyla, M., & Finger, S. (1995). *Knowledge intensive CAD*, (volume I). Chapman & Hall.

Tomiyama, T., Umeda, Y., & Yoshikawa, H. (1993). A CAD for functional design. *Annual CIRP, 42*(1), 143-146.

Vranes, S., & Stanojevic, M. (1999). Design knowledge representation in Prolog/Rex. *Engineering Applications of Artificial Intelligence, 12*(2), 221-228.

Chapter 2.4
Supporting Research and Development Processes Using Knowledge Management Methods

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EXECUTIVE SUMMARY

This chapter shows the integration of formal and informal knowledge and information exchange methodologies for an integrative product development process. It describes in detail how to transfer knowledge between organizational-related units to allow a smooth transition of development projects. Based on communities and information technology support, the concept offers a substantial way to bridge communication gaps to increase efficiency. Furthermore the authors hope that this chapter increases understanding of existing problems in manufacturing companies and enables practitioners to find a basic idea of how to solve their own challenges.

BACKGROUND

Trumpf Maschinen Austria (TAT) was founded 1990 near the city of Linz, Austria, as an independent subsidiary of the Trumpf group. TAT is a competence center for press brake and bending technology and produces TrumaBend® press brakes, the TRUMPF BendMaster®, and laser-hardened bending tools.

TAT had a turnover of 94.5 million euros and employs 168 people, and has a very low fluctuation rate. Two thirds of produced CNC machines are exported worldwide. The main focus of research and development (R&D) is on the process chain of "Blech" (sheet plates).

Currently three TrumaBend® press brakes are delivered every day and production capacities are in the process of being expanded to prepare to meet the constantly increasing demand for TRUMPF press brakes in future. Tool machines and production technology by TAT are in a leading position on the world market.

SETTING THE STAGE

The following case study is based on an information and communication problem between the R&D department and the construction department of a large machine manufacturing company with subsidiaries all over the world.

Problem Details

In the past the development of new machines was done in one big department (construction department) which also had to handle customer orders. Knowledge and experience transfer from R&D activities to order processing was an integrative part of daily business.

Later on, the fast growth of the company led to less R&D activities and required the split into an R&D department and a construction department. The R&D department was then responsible for the development of new machines, and the construction department was responsible for processing customer orders. In this department special needs of the customer concerning a machine had to be implemented within the general technical specifications. The specialization allows a more focused work and clear responsibilities for customer adoptions versus new product development.

Dividing the department caused cultural side effects. The staff of the construction team lost the status of being members of the "creative" R&D department and were very disappointed about this fact. This cultural problem resulted in a structural and emotional gap between these newly formed departments, which was reflected by less communication. Additionally, the formal information exchange has not been defined anew, so the handover happened only after the finalization of the R&D activities.

Now the big challenge is to handle the formal and informal transfer of knowledge and experience produced in the development projects within the R&D department to the construction department, which has to use the project results when processing customer orders. So the overall target of a new concept for exchanging and sharing knowledge and experience is to include know-how and experiences of all departments of the company within development projects and to bridge the emotional gap and friction between these two departments.

General Conditions

Development projects in this company are of highest complexity and last up to three years, and a normal lifetime of such a machine (including modifications) is about 10 years. A development project in this context is defined as a project that develops a machine type in several similar specifications. Additionally the machine manufacturing company required that a new concept for optimizing knowledge and information transfer among the different departments, should support

- integration of know-how of all company departments (e.g., sales, assembly, production);
- reduction of the cycle time for machine development projects;
- serial production has to start right after finishing the R&D project;
- providing up-to-date information about R&D projects for all employees;
- and should also be complementary to an overall "integrated product development process," which was worked out and applied in this company.

CASE DESCRIPTION

To solve the problems, a new concept concerning exchange and transfer of information, knowledge, experience, and know-how had to be developed. Current literature and cases only provide theoretical background and some examples for large firms, which made it necessary to adapt existing approaches and mix them with a new solution.

Current State Analysis

During the current state analysis the existing "integrated product development process" as well as the split of functions among the departments were analyzed. Additionally the employees' concerns have been integrated during an online survey about special topics, which was completed by 35 employees from several departments. This was a very good response rate (47 employees had received an invitation). Some completed questionnaires made no sense, so they had to be omitted.

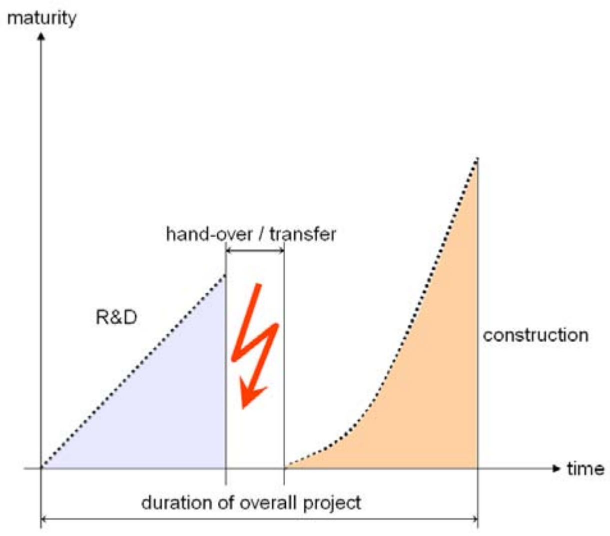
Results of the current state analysis were (including questionnaires and interviews) as follows:

- No clear work order between development and construction
- Demand for an increase of informal communication to foster the exchange (large projects involve up to 40 employees)
- Employees think that the workload of their own and their branch is very high
- A structured project result handover is needed (Figure 1)
- Reuse of essential documents is often not possible

The organizational analysis (structure, products) detected further problems caused by the strong increase of staff, no existing team or project coordination structures, and extreme pressure from market. New product development is often the starting point for a complete replacement of a whole product series. Based on the high complexity of the development process, changes during the prototype design and later on during the series production cause high efforts.

As a major point of the survey, the project handover between development and construction department had been analyzed in more details:

Figure 1. Current state of project handover



- Delivery of project results can be done by exchange of documents, but parts must be supported by communication or discussion processes.
- In principle, all results and interfaces of components or assembly groups are described as complex and time critical (for the delivery process).
- Results about new technologies are also time consuming at the delivery.
- The employees are positively motivated to use a project management tool as support for delivery.
- The construction department should be informed about the current status and content during the project to be able to bring in its know-how for optimal results.
- After delivery, there should be responsible persons at the development department for each technical aspect for assistance with various problems.

One important activity within this phase was to review existing knowledge management methods regarding their applicability within the context of this machine manufacturing company.

Theoretical Backgrounds

Before the concept is described in detail, it is important to emphasize that this solution is not an existing knowledge management approach but a combination of existing tools and instruments. In this section we explain the theory the authors used for designing the concept. Main sources are the approaches of community of practice, moderation and coaching aspects, project and team meetings, lessons learned, and aspects of organizational learning.

First of all, it is important to say that with the concept we intend to approach the existing structure of the organization to the structure of hypertext organization. This kind of organization is characterized on the one hand by a hierarchical structure, and on the other hand by the cooperation of the employees in projects in their department but also to projects with members of different departments. The advantage of this kind of organization is the contact between experts in different areas and, as a result, the exchange of their knowledge (Nonaka & Takeuchi, 1995).

We distinguish the concept of formal and informal dissemination of knowledge. For the formal spread of information, there is a start-up meeting to inform all employees about the new project. Moreover, the project manager immediately sends out important news so that all employees are "on the same page." Standardized templates support the optimal documentation during the whole development process. The existing project management tool stores these documents. One example of a template is the Project Transfer Matrix, a generated knowledge management tool for efficient planning, controlling, and managing the transfer of the project results. The matrix is described more in detail later on. Last but not least, the accomplishment of "lessons learned" in each project group is very important at the end of the project. The team members together document the positive and negative aspects of the whole project and describe how problems could have been avoided. As result, future project teams can learn from their experience (Probst, Raub, & Romhardt, 1999).

The theoretical background of the informal exchange of knowledge provides as basic principle Etienne Wenger's communities of practice concept. A community of practice is a group of people with the same interest in a certain topic, informally bound together with the aim of building and exchanging knowledge. Everyone with interest in the certain topic can participate in sharing knowledge on a Web site. The community runs as long as the members are interested (Wenger, McDermott, & Snyder, 2002). Furthermore, we distinguish between work groups and project teams. A work group has the aim of delivering a product or a service. The members are employees reporting to the same manager and work together until the next reorganization or reassignment. A project team has to accomplish a certain task, is assigned by management, and has a specific deadline. In our concept, thematic groups are built (see section on applied knowledge management methods), which are a combination of the three types.

Furthermore, regular meetings, discussions between the employees, and workshops are possibilities to generate and exchange knowledge. It is also possible to invite an external moderator to accomplish workshops with the advantage that he/she is not involved in the processes of the organization.

To encourage employees to discuss and talk about the new project, it is useful to place charts or whiteboards at meeting points in the company. Meeting points, such as a cafeteria, where members of different areas of the organization meet, facilitate contact between employees. One possibility is the creation of a "topic of the week" to enhance discussions. Possible results and new ideas can be noted on the charts.

There is one more approach of knowledge management in the concept: organizational learning. It describes how groups and so also organizations can learn from the knowledge of the individual and how the knowledge can be spread (Van Heijst et al., 1998). Learning through communication and feedback should be an additional point of this concept, which involves a combination and distribution of existing knowledge.

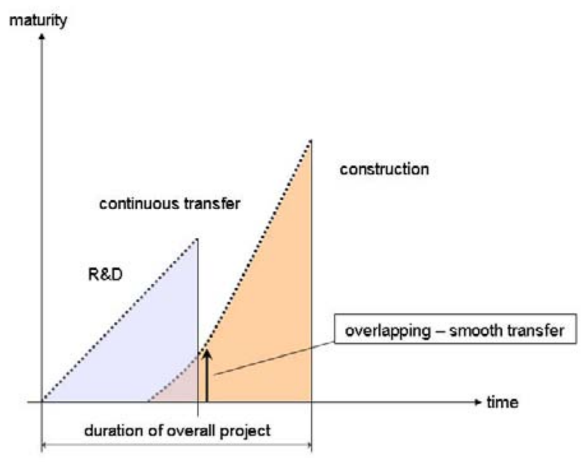
Having discussed the theoretical background in knowledge management, the concept and its development are described in detail below.

Action Plan

In a workshop with the management team and the project managers, the results of the analysis have been discussed and an optimized situation was drafted. This draft did not contain any idea about the new concept but it described the "to-be" situation within the company very clearly. Derived from this "to-be" description, a list of main goals was prepared, which is divided into three major parts: organization/structure, information/communication, and project management/documentation.

The optimization of the existing interface between development and construction cannot be taken under consideration separately from other departments of TAT. This means that there is a

Figure 2. Planned smooth project handover



higher demand for structural and organizational handling of development projects (Figure 2). The following steps have been planned:

- Definition of work distribution among involved departments in development projects
- Definition of specialized technical topic groups (a mixture of teams and communities of practice) for supporting information and communication in projects
- Standardization of documentation and storage of project documents
- Usage of a project management software

For better information and communication during the project delivery, the concept defined the following:

- Support of informal communication of employees of both departments (development and construction)
- Formal communication to grant feedback and commitment of employees to official project documentation
- Information of employees about ongoing development activities and current status of development projects

The last points of the concept handle project management and documentation. The main goal is the structured documentation of project results. To reach this, we planned the following:

- Common vision and mission in the project management
- Structured way of delivering project results

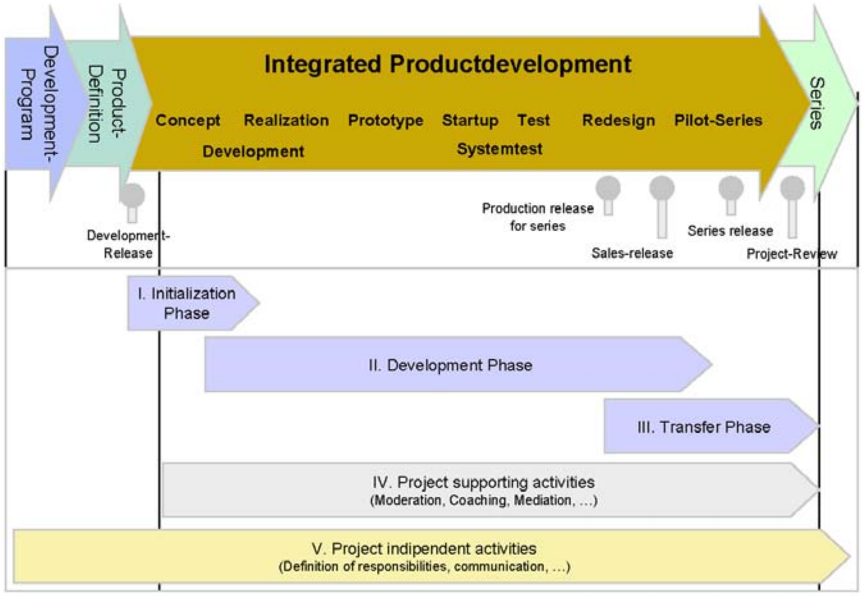
Concept Overview

To solve the existing problems, the concept is oriented along the integrated production development process of TAT (Figure 3). Project management is done very well and clearly defined by internal processes, but information and knowledge interchange must be increased and structured. As a conclusion from the analysis phase, the concept concentrates on communication via different stages, structured and informal information, know-how transfer, and documentation of relevant or critical information handover.

TAT's integrated development process follows the defined process for development of new products which is based on the strategic development program. The first two stages, "Development Program" and "Product Definition," are mainly influenced by the Trumpf Group, which defines every three years development visions for the subsidiary companies. The vague specifications of the development program define the direction of future R&D efforts. Derived from this input, the local subsidiary defines new products or product families in a more detailed way such as a functional specification and technological details, which are worked out in more details in the development department. This functional specification is a starting point for the integrated product development and provides the first input for the knowledge management concept phase — the Initialization Phase.

As shown in Figure 3, the concept consists of five main phases, of which some are partly overlapping. These overlapping parts are necessary to handle preparation activities (e.g., planning workshops), although the actual phase is not completed. Phases I (Initializing), II (Development), and III (Transfer) focus on the product development process and the ongoing interaction of all included departments (development, construction, production). Phase IV (production support) accompanies the whole development project and contains activities and measures to support tasks that are performed in phases I, II, and III. Caused by the identification of optimization potentials beside the interface of development and construction department, we developed Phase V (project-independent activi-

Figure 3. Concept overview



ties) which contains activities and measures to increase transparency and information transfer in the whole organization.

The following sections will describe the five phases of our approach and the included measures in more detail.

Procedure Model in Detail

Figure 4 shows a closer look on Phases I and II. The special task here is the target definition workshop, which is responsible for the definition of knowledge goals, responsibilities, exchange and feedback, information, and communication tasks, which are necessary for project execution (for details take a look at regarding chapter).

Initializing Phase (I)

Phase I (Initializing) handles all preparation activities for the execution of the development phase, which starts overlapping with it. Preparation means securing ongoing information exchange, communication, and exchange of experiences between all participating departments.

Subphase I.1 – Preparation

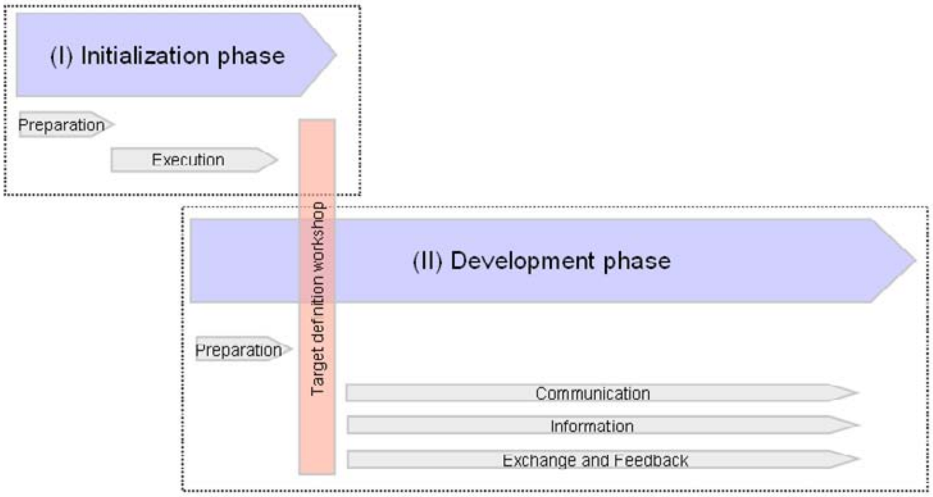
In this subphase, the project manager of the development project prepares a presentation of the idea behind a new product (e.g., machine or new series), which contains the news and makes the differences to actual products more transparent.

After this, the project manager holds a presentation in front of leaders and experienced employees of all departments of TAT to obtain initial feedback. This also fosters initial discussion processes among employees and guarantees the same amount of information to all personnel, which is highly important for motivating employees (Davenport, 1998).

Presentation of ideas:

- Participants: leaders and experienced employees of departments (selected by heads of departments)

Figure 4. Concept detail – part 1



- Responsibility: project manager and management
- Content: presentation of idea of new machine (or series), special differences to existing machines. Technological details are not presented in detail
- Goal: collecting initial feedback and initiating first discussion processes in the company

The second important activity of this subphase is the creation of a concept presentation, which can be done after finishing the concept subphase in the integrated development process (Figure 3). The presentation contains the most important facts such as technological requirements, innovations, or complex elements.

Concept presentation:

- Participants: if possible, all employees of TAT
- Responsibility: project manager
- Content: presentation of machine concept, including all defined technological details, requirements, and performance facts
- Goal: identification of all employees with new machine and motivation of employees by early involvation, intensivation of discussion processes eased by equal information level

Subphase I.2 – Execution

This subphase handles the execution of all presentations that are not part of the target definition workshop. The main idea besides the equal information level and discussion processes is the identification of employees with "their" machine.

Target Definition Workshop

The preparation of the target definition workshop is done in subphase 1 of Phase II — preparation (see section on subphase II.1). Content of this workshop is the definition of so-called "knowledge goals." These knowledge goals are relevant for co-operation of the different departments within the development project. The result of the workshop should be a way to secure the communication, information, and experience exchange and feedback between employees of these departments. It is NOT the goal of this workshop to work out technological requirements, because these are defaults already defined by product idea and concept of the new machine (series).

Participants are all heads of units and selected employees (if possible opinion leaders) of participating departments. The participants document their commitment by signing the protocol of the workshop.

As another result of this workshop, technical topic groups (see section on applied knowledge management methods) are defined to build project support structures and activities. Special technical topic groups could be electronics, mechanics, and so forth, which handle a smaller field in the development process.

Target Definition Workshop:

- Participants: leaders of participating departments and (if possible) opinion leaders
- Responsibility: project manager (for preparation and execution of workshop)
- Preparation: meeting schedule, invitations, preparation of agenda, preparation of short presentation about critical elements of the new machine. Critical means elements with "high effort for TAT," "completely new for TAT," or "success factor for TAT"
- Content: discussion of critical elements and the ongoing information and experience exchange in the development process across department borders. Definition of technical topic groups and their leaders/participants
- Goal: definition of cooperation in development process across departments. No technological goals for machine (which are already stored in the concept)

Possible goals out of such a workshop are as follows:

- Goal 1: securing feedback from all TAT departments
- Goal 2: monthly exchange of project status, experiences, and problems between development and construction staff
- Goal 3: quarterly information of all departments about project status and experiences

All defined goals are tracked with adequate measures in the development phase (see following section).

Development Phase (II)

The development phase is of great importance for the successful implementation of the procedure model, because in this phase the interaction of all participating departments occurs. Substantial for this phase is the definition of knowledge and communication goals in the target definition workshop.

The three subphases (1-3) execute and track the defined and committed goals out of the target definition workshop. This fosters efficient cooperation, successive construction of know-how in all departments, following the development department, usage of know-how of the following departments, and last but not least, securing the ongoing information about the project realization of all TAT employees.

Subphase II.1 – Preparation

As preparation work is already done before the target definition workshop, there is an overlapping part with subphase 2 of the initialization phase. A suggestion for the workshop is to take an external moderator for efficiency and meeting targets. During this preparation phase, the heads of units also select members of their departments for participation.

Subphase II.2 – Communication

Communication, meaning active and directed information transfer, is established in group meetings (see section on applied knowledge management methods) and an electronic project management tool. Van Heijst et al. (1998) described the act of organizational learning through communication. As one can see in Figure 5, the communication of experience brings an increase in organizational knowledge.

This constellation works both ways for learning out of communication (Van Heist et al., 1998): supply-driven and demand-driven learning. In supply-driven learning, the individual employee gains experience and deeper know-how and communicates this to his/her colleagues. Demand-driven learning describes the situation of an employee, who is searching for an answer for a specific problem or topic.

In TAT, the members of the service department obtained input from customers and thus learned about problems and failures. Structured meetings where this customer knowledge is spread among concerned employees led to constructive innovations and improvements during the series production.

Fostered by the heterogeneous participants of such group meetings, new and important information is spread very efficiently to all departments of TAT. The more formal communication is handled by a project management tool which is described in more detail later. This tool secures the documented information broadcast and supports feedback rules, which force people to react and provide input. As a result from former studies and projects, it is necessary to force people at a certain point to commit or to provide feedback.

Subphase II.3 – Information

Based on committed information goals, the project manager informs all participating employees by e-mail about the actual situation of the project or further news. In parallel, the same information will be published on posters or blackboards in all central areas (e.g., kitchen, coffee machine, smoking area, etc.) to keep all employees informed.

Different to the communication phase is the fact that in this phase (information), the communication runs one way. This is a push methodology, the goal of which is to spread information.

All group meetings are documented in a protocol which is published via the electronic project management tool to all relevant employees (mostly all participating employees), which grants that all involved people have the actual information about decisions, problems, or facts. The IT solution also enables employees who are not directly involved to keep in touch and stay informed, for example, marketing or purchasing department as members of the information group.

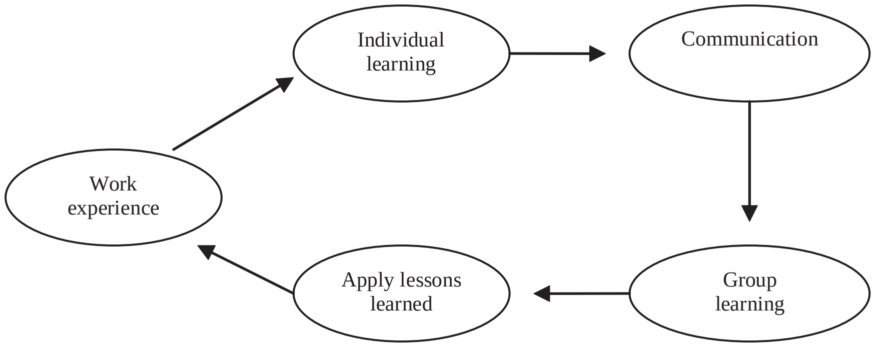
Information means, therefore, creating the possibility for facing future situations. In a special case, the purchasing department was so able to check possible suppliers in advance to obtain better conditions.

Subphase II.4 – Exchange and Feedback

The exchange process defines the interaction between all technical topic groups to prevent information gaps. In their group meetings, the technical topic groups work out important elements of their special areas of interest. Important elements include those that are of highly complex or are very time critical during the transfer between development and construction department. These elements are gathered in a structured collection which is periodically reviewed.

A possible way to increase the quality of work is to establish an internal (or if possible,

Figure 5. Organizational learning through communication (Van Heijst et al., 1998)



external) feedback group, consisting of experts or experienced people. The optional involvement of external specialists could be done by cooperations with universities or research institutes, which is an upcoming topic in Germany (Edler, 2003).

The results (relevant elements, part concepts, solution concepts, or important experiences) of a technical topic group are sent to a defined feedback group. This group reviews the results and brings in their own opinion and also experience. The main goal is here to use synergies between the knowledge of different groups and also to avoid technological or organizational blindness.

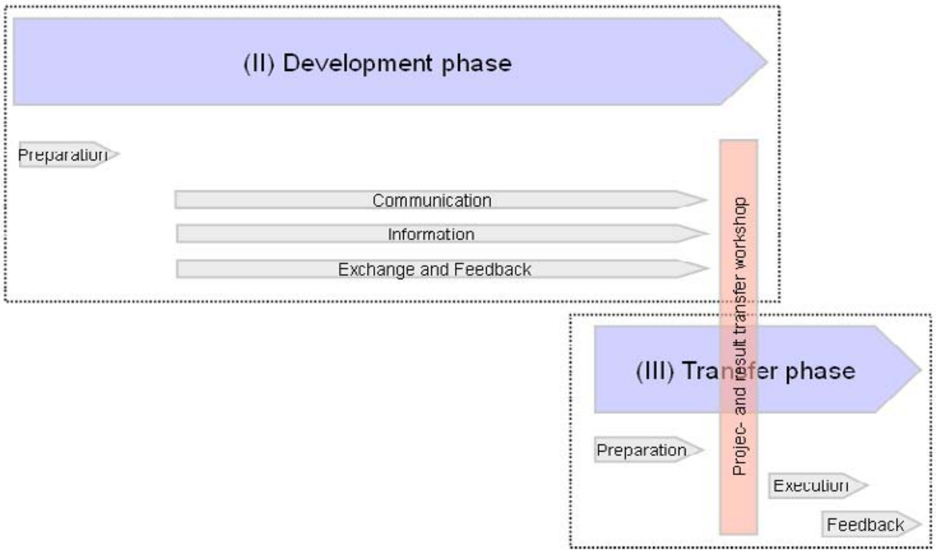
Communication, information, exchange, and feedback:

- Participants: all employees (partly), technical topic groups for communication, exchange and feedback are managed by members of the development or construction department
- Responsibility: project manager (for informing all employees) group responsible for the work in the group
- Preparation: information for all employees; in special cases (confidential information), it is useful to involve the top management, organization of technical topic groups and search for group manager (this task is performed during the target definition workshop)
- Content: information about project realization status; communication, exchange, and feedback about important (development or transfer) topics
- Goal: ongoing information of all employees during the project run time in all departments following the development department. Usage of existing know-how in following departments. Creating an increased "our product" feeling in all participating employees for securing efficient and target-oriented cooperation

Project and Result Transfer Workshop

As described in Figure 6, the concept includes also a workshop for defining how to transfer the project itself and special results between development department and construction department. This workshop initializes the transfer phase and must already be planned for in the overall project plan. The main subject of the transfer workshop is the formulation of a detailed transfer plan. Participants are largely the same as in the target definition workshop.

Figure 6. Concept detail – part 2



A moderator (external) prepares afterward a protocol and a transfer plan in digital media. The protocol and transfer plan must be committed by each participant of the workshop, which is done by using the project management software and its feedback functionality. The project transfer plan provides a summary of what, who, with whom, when, and in which way it has to be delivered. As an instrument for planning, execution, and control, a transfer matrix has been developed, which is described in more detail in another section.

A precondition of a successful application is the ongoing documentation of activities and results done by technical topic groups during the development process.

Project and result transfer workshop:

- Participants: leaders of participating departments and (if possible) opinion leaders
- Responsibility: project manager (for preparation and execution of workshop)
- Preconditions: activities and outputs are already in required form included in the project transfer matrix
- Content: specification of single elements of project transfer matrix, such as priority, start-end dates, responsible persons, and participants of transfer
- Goal: detailed planning of transfer, which is done during the execution of the transfer phase (III)

Transfer Phase (III)

The execution of this phase grants the efficient transfer of project results to following departments, for example, the construction department.

Subphase III.1 – Preparation

Like the preparation of the target definition workshop, the preparation of the transfer workshop overlaps the preliminary phase. The project manager plans with the (external) moderator the workshop to fix the essential points. The target is to grant after the workshop a detailed transfer plan (consisting of what, who, with whom, when, in which kind) is available.

Subphase III.2 – Execution

The execution this subphase handles mainly the implementation of the transfer plan and the documentation of occurring problems and responding solutions. To document these steps, a transfer protocol is used.

Subphase III.3 – Feedback

The subphase feedback is the final step of the cooperating project handling. Of importance for future projects is the documentation of gained experiences from the current development project. To grant the best possible reuse of experience, it is necessary to collect "lessons learned" of the technical topic groups, from the project manager and subproject managers. This can be done by collecting special topics, such as problem-solution combinations, or by using a storytelling, "light" approach (or something like action reviews). Resulting documents will be collected and provided in the project management software.

It is crucial to encourage or to "force" project managers to take a look at the "experience database" before they start a new project. This is a point to change organizational culture. Accepting know-how out of the experiences of others. "Moreover, they must clearly explain the rationale for their final decision, including why they chose to accept some input and advice while rejecting other suggestions. By doing so, leaders can encourage divergent thinking while building decision acceptance" (Roberto, 2002, p. X).

Project Supporting Activities (IV)

Project supporting activities are not directed to a certain stage of the project but chronological delimited by the project duration. So measures lasting the whole period such as established technical topic groups are started at the project start and finished by a structured closing. Structured closing means the collection of gained know-how, findings of lessons learned, and review of managed processes (including communication processes) as described in subphase III.3 – Feedback.

The following measures could be defined as project supporting activities:

- Establishing of technical topic groups
- Organization of group meetings
- Providing IT support
- Creation of a standardized documentation and folder structure
- Moderation, coaching, mediation (providing staff or competence)
- Information activities (e.g., topic of the week)

Information Activities

As part of the information strategy, the publication of special topics for a short period (a week) is done by publishing posters on blackboards or similar information points in central communication areas such as coffee corners, buffet area, or smoking areas. A future idea could also be the establishing of "infopoints" with specially configured PCs accessing the intranet. Such information and knowledge markets (Davenport, 1998) foster communication, information transfer, and knowledge exchange concerning this special topic. The topic responsible person is the project manager.

Project-Independent Activities (V)

Project-independent activities are institutionalized in the organization. These activities affect the organizational structure more than the virtual organization of a project management structure.

The following activities are defined as independent from a running project and can be initiated every time:

- Definition of a responsible contact person for each department

- Supply of communication means
- Clearly defined work distribution

The first two activities increase internal (and external) communication by providing methods and structures and another topic, clearly pointed out in the online survey, is the clearness of work distribution. A solution for the last point is a team around the head of unit, which describes the work of the department.

Definition of Contact Person for Each Department

To increase the efficiency of communication, especially after delivery of machines that reached the maturity phase, it is necessary to define a responsible contact person per department. Additionally, the technical topic group agents could be defined as contact persons for the individual development topics.

Communication Means

To support informal discussions (which lead to the most creative solutions), it is possible to provide whiteboards or flip charts in communication areas. Ideas could so be described more easily and worked out in more detail than only telling it. Additionally more people could take part in the discussion because it is documented.

Applied Knowledge Management Methods

To achieve the final result of a knowledge-oriented R&D process, the following knowledge management methods have been used and implemented: teams and communities of practice (CoPs) (Wenger, McDermott, & Snyder, 2002); interface handling methods such as workshops; early information system to create awareness; IT system support for decisions; information transfer; and process documentation (Maier, 2004). As a final step, a reflection step has also been integrated to obtain lessons learned and further improvements along the process.

Technical Topic Groups

These groups are a mixture of CoPs and teams, a semi-open community with a more-or-less defined goal — development of special topics of a new machine (e.g., electronics, mechanics). Like other constructs (CoPs) (Lave & Wenger, 1991), Ba (Nonaka & Konno, 1998), communities of creation (Sawhney & Prandelli, 2000), or networks of collaborating organizations (Powell, Koput, & Smith-Doerr, 1992), such technical topic groups are an extremely important issue for knowledge creation within a company.

Technical topic groups are not organizational units. They consist of participants from different departments (not only development or construction department) who are also involved in the topic of the group (e.g., technical topic group for hydraulic systems). Technical topic groups should not exceed seven members for efficiency (Fay, Garrod, & Carletta, 2000).

Each technical topic group nominates an agent who acts as feedback responder. This means the agent answers and comments all feedback inquiries from other groups. All other participants of the technical topic group will only be informed and deliver their comments to their agent.

Results and developments (including relevance) of technical topic groups are documented later on in the transfer matrix.

Organization of Group Meetings

To optimize the cross-department information and communication, it is necessary to institutionalize group meetings of technical topic groups. Each meeting should have a certain topic: development problem, development status, new technology, and so forth. These topics should be primarily suggested by development staff, and the other participants provide input and participate in discussions (bringing in their experience). Group meetings should be arranged periodically (e.g., starting with one meeting per month at the beginning up to weekly). To keep the organizational effort per meeting as small as possible, the meeting organization could be done in a rotating system. The organization could be kept simple: agenda, reservation of meeting room, sending out invitations, and documentation of meeting in meeting protocol.

Like CoPs, technical topic groups share knowledge among different departments and increase the amount of knowledge carriers (not only one person, who could get lost) and also organizational knowledge (institutionalization of know-how and best practices) (Van Heijst et al., 1998).

Project Management Tool/Software

IT support of development is split into two major parts: first is the project documentation (structured documents and folders) and second is the project management software itself. All documents and templates for protocols are provided by the project management software; that is the reason for combining these points into one topic.

Creation of Standardized Documents

The creation of a standardized documentation and folder structure should increase the efficiency in project management. The structure provides information about the point of time when documents have to be created and how they must be structured. To ease the access to these documents, it is useful to create a project-independent folder structure or to implement a document management system.

Implemented standard documents are as follows:

- Feedback document: for feedback groups to obtain feedback in structured and similar form
- Status document: designed for ongoing overview about project status and relevant results. This document is also used for the project information group. The project plan must contain points of time when such documents have to be created
- Agenda and protocol templates for technical topic groups: for a consistent documentation
- Transfer protocol template: for consistent documentation of project-result transfer among involved employees

Project Management Software

During the conceptual planning, it was necessary to plan the application of the existing project management software. As described above, the project management tool supports, additional to the provision of documents, information and feedback processes. To reach this, it was necessary to implement the following roles and dedicated functionalities:

- Project manager: person responsible for project, who accepts document release
- Project member: according to the field of activity in the development project, these persons are responsible for providing and creating documents
- Technical topic group leaders: can create documents to inform their group and project members
- Project feedback group: consists of one agent per technical topic group. The members of this group must give their feedback to documents from project management, project members, and other technical topic groups.
- Project information group: this group contains all other technical topic group members

and employees who must be kept informed about the ongoing development activities. This is necessary to prepare early upcoming activities. This information process enables employees to keep a complete overview and it also initiates an informal communication about new developments.

Project Transfer Matrix

During the transfer workshop, the team fills the project transfer matrix, which is used for planning and controlling the transfer of the development project results. The matrix contains all necessary information for the transfer of elements, responsibilities, and status (Table 1).

In detail, the complete TAT matrix consists of the following columns:

- Project steps: contains all process steps that have been executed during the product development. This column is filled out by the project members in the technical topic group meetings.
- Executing department: the current step is managed and executed by department (XY), or in combination with department (AB).
- Output: describes the output of the current project step.
- Status: current status of execution in percent.
- Transfer relevance: (priority) the definition of A (high), B (medium), or C (low) describes the importance of the transfer of these elements (and defines the order of the transferred elements).
- Transfer complexity: the definition of A (high), B (medium), or C (low) describes how difficult it is to transfer this element.
- Transfer responsibility: name of employee who is responsible for transfer of this element.
- Transfer start: date of when transfer should start.
- Transfer end: date of when transfer should be finished.
- Status of transfer (%): the transfer responsible person documents in this weekly up-

Table 1. Project transfer matrix (excerpt)

Project steps	Executing division	Output	Status (in per cent)	Transfer relevance	Transfer complexy	Transfer responsibility
List of Requirements; Functional Specification and Specification Sheet for the whole project and for the teams	D		100	C	C	
List of suppliers and possible suppliers	D		95	A	B	
List of specific assembly instructions	D		0	A	B	
Project documentation of the R&D	D		running	C	C	
Update list of risks	D		running	B	C	
Test planning and supervision	D		running	C	C	
Training Service	D/C		0	A	A	
Creation of acceptance report	C/D		10	A	A	
Creation of maintenance timetable	C/D		0	A	A	
Training Production	C/D		20	A	A	
Training Assembling	C/D		20	A	A	
Training Sales and Marketing	C/D		10	A	B	

dated column the transfer status. If a delay arises, the project manager can intervene.

- Transfer protocol (yes/no): during the transfer workshop, it is defined if it is necessary to create a protocol for this transfer element, because if the element is not important and there is only low complexity, it is not always necessary to prepare a protocol. To prepare useless protocols would lead to less motivation.
- Target department: department that gets output of current project step.
- Target responsible: employee of target department who is responsible for transfer.
- Notes: additional information for documentation, for example, reasons for delay.

The project transfer matrix is a vital document that describes not only the transfer process but also documents it.

CURRENT CHALLENGES FACING THE ORGANIZATION

Challenges During the Project and Current Status

Based on the fact that the project has been initiated under the pressure of an existing development project, at the beginning the concept could only support this project in the last phases — transfer of experiences and information. The departments used the transfer matrix and managed a structured handover. In parallel, the organization established two technical topic groups (hydraulic systems and electronic systems) and built up the reporting, information, and feedback groups within the project management software.

Current status is now a broad acceptance of the concept. The employees of the R&D and construction departments are now aware that they need each other and work more cooperatively. Company representatives lead this back to team meetings and technical topic groups, where they sit together and discuss constructively — "work is easier if we approach a challenge together." As a tool for measuring this fact, one employee told us that employees now go for coffee break together. Another result is the involvement of the service and after-sales department in the development process. Due to the good experiences with the supporting project management tool, there will be further activities to improve its functionalities. Information providers, for example, like the possibility of the tool to check who read the information and who gave feedback. Project-independent activities (e.g., posters, etc.) have also been implemented and the top-down information flows.

General Challenges

Companies have to concentrate on their own core competencies to compensate the pressure arising from the market and the increasing complexity of processes, products, or surrounding environment. Modern companies are specialized on similar fields and form work groups, work lines, or even companies for this ones. Specialization in this context means, on the one hand, highly qualified employees and very special know-how, but on the other hand, a large amount of communication work. A holistic view and a long-term plan are necessary to achieve such ambitious goals as knowledge management in a diversified or spread company.

Today, employees need not only physical material for their daily work, but also an increasing amount of information and knowledge. Codification of knowledge and dedicated sharing of this information is used for keeping knowledge within the company and to support all working steps where this information is needed. This requires also knowing more than one simple task for a further understanding of the whole process. Employees must be able to get more than a local view to notice barriers or critical interfaces to neighbor tasks. This consciousness enables innovation and further improvements on the process. The same is valid for departments and their organizational borders.

The more specialized a department, the higher the need for a common understanding of company goals and project goals. Employees from different departments work together on different projects and interact in teams. These teams form a special kind of dynamic information network cross to typical information channels of a company. Nonaka called this a "hypertext organization" (Nonaka & Takeuchi, 1995) and later an organization as organic configuration of ba (Nonaka & Konno, 2003), because the structure is dynamically formed on demand and changes over time.

REFERENCES

Davenport, T. (1998). *Working knowledge.* Cambridge, MA: Harvard University Press.

Edler, J. (2003). *Knowledge management in German industry. Study in the framework of an OECD initiative of the Centre for Educational Research and Innovation (CERI).* Karlsruhe: Fraunhofer Institute for Systems and Innovation Research (ISI).

Fay, N., Garrod, S., & Carletta, J. (2000). Group discussion as interactive dialogue or serial monologue: The influence of group size. *Psychological Science, 11*(6), 487-492.

Lave, J., & Wenger, E. (1991). *Situated learning – Legitimate peripheral participation.* Cambridge, UK: Cambridge University Press.

Maier, R. (2004). *Knowledge management systems* (2nd ed.). Berlin: Springer.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40,* 40-54.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford: Oxford University Press.

Nonaka, I., & Toyama, R. (2003). The knowledge-creating theory revisited: Knowledge creation as a synthesizing process. *Knowledge Management Research and Practice, 1*(1), 2-10.

Powell, W., Koput, K., & Smith-Doerr, L. (1996). Inter-organizational collaboration and the focus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41,* 116-146.

Probst, G., Raub, S., & Romhardt, K. (1999). *Managing knowledge.* John Wiley & Sons.

Roberto, M. (2002). *Lessons from Everest: The interaction of cognitive bias, psychological safety, and system complexity.* Harvard Business School Press.

Sawhney, M., & Prandelli, E. (2000). Communities of creation: Managing distributed innovation in turbulent markets. *California Management Review, 41,* 63-74.

van Heijst, G. et al. (1998). Organizing corporate memories. In U. Borghoff & R. Pareschi (Eds.), *Information technology for knowledge management.* Berlin: Springer.

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice.* Harvard Business School Press.

FURTHER READING

Bohm, D. (1996). *On dialogue.* Routledge.

Brown, J., & Duguid, P. (2000). *The social life of information.* Harvard Business School Press.

Firestone, J. (2003). *Enterprise information portals and knowledge management.* Butterworth-Heinemann.

Holsapple, C. (Ed.). (2003). *Handbook on knowledge management.* Berlin: Springer.

McDermott, R. (1999a). The role of communities of practice in team organizations. *Knowledge Management Review,* May/June.

McDermott R. (1999b). Nuturing three dimensional communities of practice: How to get the most out of human networks. *Knowledge Management Review,* Fall.

Pfeffer, J., & Sutton, R. (1999). *The knowing-doing gap: How smart companies turn knowledge into action.* Harvard Business School Press.

Rogers, E. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Scharmer, O. (2000, May 25-26). Presencing: Learning from the future as it emerges: On the tacit dimension of leading revolutionary change. *Conference on Knowledge and Innovation,* Helsinki School of Economics, Helsinki, Finland.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal.*

Chapter 2.5
E-mail and Knowledge Creation:
Supporting Inquiring Systems and Enhancing Wisdom

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ABSTRACT

The real promise of organizational communication technologies may lie in their potential to facilitate participative discourse between knowledge workers at all levels in distributed locations and time zones. Such discourse enables the exchange of sometimes conflicting viewpoints through which resolution and symbiosis, organizational knowledge can be built. This chapter presents a case study of a Singerian inquiring organization which illustrates how a fluid dynamic community of employees can use email to build knowledge, learn, make decisions, and enhance wisdom through a cycle of knowledge combination (divergence) and knowledge qualification (convergence). The chapter offers new theoretical perspectives on the enhancement of wisdom in inquiring organizations and provides practical insights into the use of email for supporting effective knowledge creation in inquiring organizations.

INTRODUCTION

In today's globalized business environment, many companies recognize the strategic role of the generation, capture, and dissemination of knowledge in developing inimitable competencies, innovations, and competitive advantages. In particular, the constant creation of new knowledge has been identified as a key business objective. While some experts see the value of ongoing knowledge creation in terms of accelerating innovation (Sharkie, 2003), others focus on its value for enhancing a firm's ability to act—the hallmark of a learning organization (Loermans, 2002; Senge, 1990). When such an approach uses a systematic method for justifying knowledge claims about complex social alternatives, the company evolves into an inquiring organization, employing inquiring systems.

Inquiring systems were originally conceptualized by the pragmatist philosopher Churchman (1971), who strongly believed that knowledge should be created for practical problem-solving purposes and that its creation should be ethically grounded. He specified five archetypal inquiring systems to assist with complex problem solving, each corresponding to a particular philosophy for discovering knowledge truth. A comprehensive view of inquiring systems proposes that they systematically generate knowledge, resolve complex problems, and enhance organizational learning capability, leading to continuous learning and improvement (Courtney, Chae & Hall, 2000).

In the past decade, a diverse body of knowledge has accumulated around identifying, understanding, and linking the key concepts of inquiring systems and organizations. Some of this work has focused on the development of design frameworks for inquiring systems. In a recent development, Hall, Paradice, and Courtney (2003) described a conceptual model for a Learning Organization Knowledge Management System (LOKMS) that portrays a design for an environmentally aware extended inquiring system. Their model shows how key information and knowledge can be continuously and systematically captured and employed to hypothesize and select new states or goals. To achieve these goals, alternative solutions are generated, each based on a recognized mode of inquiry. From among the alternatives, the best option is selected in a decision-making process. A key feature of LOKMS is its reliance on an organizational memory comprising a constantly verified and updated knowledge base and a store of extraneous accumulated knowledge which, while not immediately useful, may acquire validity at some future time. Monitoring of the external environment introduces new and updated knowledge into the organization.

While such designs appear promising, we still lack ways to support such organizations and systems and also need a greater understanding of the underlying concepts. One way to explore and understand the constructs and their support is to study environments where the systems are in evidence. We noticed in the discourse of the ubiquitous organizational tool electronic mail (email), the enactment of some of the key processes appearing in LOKMS—in particular, information and knowledge discovery, the creation of organizational knowledge from the resolution of multiple perspectives, decision support, and the building of organizational memory.

These knowledge processes were discovered in email conversations between people collaborating in distributed networks to solve practical problems. The linchpin knowledge process identified in the conversations was knowledge creation, suggesting to us that in the group appropriation of email for collaboratively solving problems, characteristics of inquiring systems might emerge through the patterns of discourse. We wondered whether discourse found in the simple tool, email, could support some of the components of inquiring systems and organizations. Reaching for wisdom, it was also worth considering whether email could support the enhancement of wisdom.

In this chapter, we explore the potential of email for supporting inquiring organizations and enhancing wisdom. We begin the chapter by looking at an information hierarchy that shows how data can be transformed into knowledge and wisdom. Knowledge creation and other key concepts of inquiring organizations and systems are then reviewed, guided by a simplified conceptual model of inquiring systems in inquiring organizations that incorporates wisdom development structures.

We then analyze how knowledge creation takes place in a collection of email conversations and how inquiring system characteristics emerge. A cycle of collaborative knowledge creation found in email conversations is described, highlighting a pattern of discourse interaction that may enhance wisdom. The chapter provides insights into how inquiring systems and wisdom can be enabled in organizations through specific discourse structures supported by email. This understanding highlights a previously overlooked value in email and also suggests potentially valuable design elements and interventions for inquiring organizations.

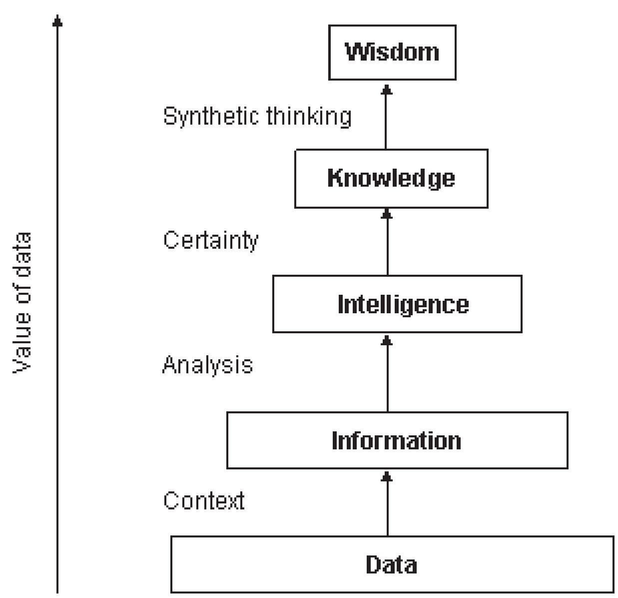
KNOWLEDGE CREATION IN ORGANIZATIONS

The Information Hierarchy

To understand how knowledge is created in organizations, we must first settle the meaning of knowledge in terms of its position within an information hierarchy. In Figure 1, we illustrate an information hierarchy developed by Barabba and Zaltman (1991) and Haeckel and Nolan (1993). According to Barabba and Zaltman, many codified observations or data are obtained from a marketplace of data which, when placed in a decision context, become information. By analyzing information, intelligence is developed. In developing high levels of certainty in intelligence (not necessarily 100%), we create knowledge. Through synthetic thinking about knowledge, a wise outcome is reached—that is, wisdom is achieved. Synthetic thinking involves synthesis, or the combining of ideas in such a way as to create a whole that is greater than the aggregation of its parts.

The value of data increases along the transformation path from data to wisdom, while the volume decreases. There are two distinct stages described: In the creation of collections of data, information is provided. When people use this information for a purpose, intelligence, knowl-

Figure 1. Information hierarchy (based on Barabba & Zaltman, 1991; Haeckel & Nolan, 1993)



edge, and wise decisions may be developed. What is emphasized in this model is Churchman's key observation that how users react to a collection of information alters outcomes and their meanings. Later in the chapter, we show how different modes of inquiry can systematically guide users in the way they create knowledge and even enhance wisdom.

We now proceed to explore how knowledge is created in organizations, how this is often linked with decision-making, and how, simultaneously, learning occurs.

How Knowledge is Created in Organizations

According to Nonaka (1994), knowledge is created from the interplay and transformations between the various knowledge types—individual or collective; tacit or explicit. The four basic transformations are socialization (the conversion of tacit knowledge to tacit knowledge); combination (the conversion of explicit knowledge to explicit knowledge); externalization (the conversion of tacit to explicit knowledge); and internalization (the conversion of explicit to tacit knowledge). This remains the most well known model of knowledge creation, although many others exist.

Various scenarios stimulate knowledge creation. First, within and across the boundaries of organizations, knowledge can be created when insights and intuitions are shared, combined, or gleaned during social processes that typically involve discourse. Second, through regular sampling of external environmental data (for example, scanning the World Wide Web), new knowledge can be brought into the firm and existing organizational knowledge thus validated, updated, and extended. Third, new knowledge may be discovered through a knowledge discovery process from databases. As we have highlighted in the information hierarchy, knowledge originates with people who use information. Thus, most knowledge creation models show the expansion of a knowledge base through collective human activity and are fundamentally social models.

Clearly, participatory organizational groups and networks are particularly useful for this purpose. Such structures are increasingly prevalent in organizations, given the need to coordinate and/or integrate temporally and geographically distributed specialist knowledge for wider purposes, such as projects, and the trend toward participatory work practices. Increasingly, emerging network structures support self-organizing groups whose members cluster around programs, practices, projects, and tasks.

Social Knowledge Creation and Decision Making

The creation of organizational knowledge through collective human activity is closely related to decision making. Knowledge from different people must be assembled to solve problems and make decisions because the likelihood that one person will contain all the relevant knowledge is miniscule—given the current paradigm of specialized knowledge and the limitations (bounded rationality) of the human mind (Jensen & Meckling, 1992).

As today's organizations are plagued by complex changing circumstances and destabilized authority, there are often many considerations and alternatives when resolving associated wicked decision problems (Rittel & Webber, 1973; Weick, 2001). According to Courtney's (2001) new paradigm for decision making in such settings, the interplay of diverse perspectives may assist in resolving wicked decision problems by producing new insights and updating the mental models of stakeholders with one another's perspectives and unspoken assumptions. Dialogue is an important medium that enables diverse views to be heard and resolved.

Social Knowledge Creation and Learning

The link between social knowledge creation and learning is also important to note. Dialogue plays a critical role, in that valuable learning occurs as a result of the interactions occurring in group discourse and collaboration (Bakhtin, 1986; Roschelle, 1992; Stahl, 2002). According to Bakhtin, learning is closely linked to the process of multiple voices coming into contact with one another via verbalized utterances. He suggests that in an utterance, both speaker and listener learn. Stahl describes how social and individual learning are enhanced through discursive debate and a negotiated outcome. Highlighting the nature of interactions needed, Roschelle suggests that effective learning occurs through patterns of divergence and convergence in discourse during collaborative problem solving. Convergence is associated with processes of analysis—for example, testing concepts and solving problems; while divergence is associated with processes of synthesis—for example, generating alternatives and recognizing problems.

Various well known learning models incorporate the ideas of analysis/convergence and synthesis/divergence--for example, Carlsson, Keane, and Martin (1976) and Kolb (1985). Roschelle and other researchers report how the presence of authority in a problem-solving/decision-making conversation can force early convergence and stifle learning (Hubscher-Younger & Narayanan, 2003; Roschelle, 1992), suggesting more generally that conversations require cooperative conditions for optimal learning to take place. Learning is also enhanced in situ (e.g., Lave & Wenger, 1991). Amalgamating these findings:

"Collaborative conversations based around pragmatic problem solving and decision making can be highly valuable for learning purposes, if skills of synthesis and analysis are employed, and if authority does not intervene."

As organizations aim not only for new knowledge and learning but also wisdom in decisions and people, we now discuss the role that knowledge creation can play in leading to wise decisions and, more generally, wisdom.

From Knowledge Creation to Wisdom Enhancement

We review two perspectives of wisdom enhancement: making wise decisions and enhancing wisdom through an attitude of fallible knowing.

In order to make wise decisions, the information hierarchy suggests that analysis (convergence) and synthesis (divergence) are needed (Barabba & Zaltman, 1991; Haeckel & Nolan, 1993). Considering also the value to learning of collaborative problem-solving/decision-making conversations involving cycles of convergence and divergence as discussed previously, we propose a cycle of wisdom enhancing problem solving and decision making in discourse, as shown in Figure 2. The knowledge processes involved are knowledge sharing, creation, convergence and divergence. Wisdom is not indefinitely increased through this cycle, however, because, for example, too many cycles will lessen commitment to continue or follow through with a decision at the end.

Weick (2001) views wisdom as a balanced attitude of fallible knowing, a conceptualization originally espoused by Meacham (1990). Weick suggests that the influx of knowledge in dialogue adds to overly cautious participants' knowledge while removing some of the existing doubt, thereby increasing wisdom. Conversely, doubt raised by the input of new knowledge provided to overly confident participant attitudes increases wisdom. This effect is illustrated in Figure 3. Remaining mindful of ongoing fallibility in knowing during knowledge creation through a combination of acts of doubt and acts of confidence will ultimately lead, according to Weick, to wisdom.

We argue that in today's organizations, where specialization is the norm for distribut-

Figure 2. Enhancing wisdom in decision making in discourse

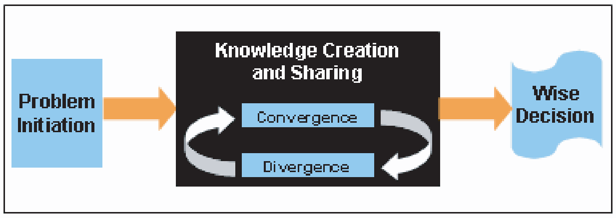
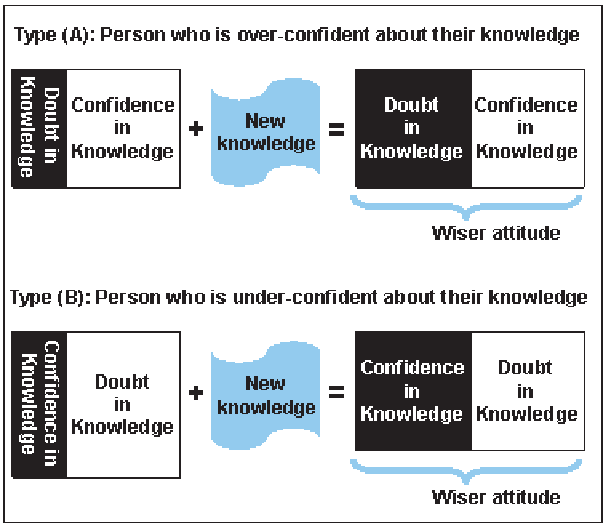


Figure 3. Wisdom as fallible knowing



ing knowledge among workers, there tends to be greater doubt than confidence in domains that lie outside one's area of specialization. In such settings, gathering knowledge from others offsets excessive doubt by imbuing the recipient with new confidence once such knowledge is internalized. Confidence is also increased when knowledge creation is situated in practice, and the new knowledge created is highly relevant, accordingly. Furthermore, if this knowledge is collaboratively created, it can later be defended by those who constructed it, providing greater confidence in the validity of the knowledge within the organizational context.

KNOWLEDGE CREATION IN INQUIRING ORGANIZATIONS

In this chapter, we are particularly concerned with social knowledge creation, decision making, and wisdom enhancement in inquiring systems. As we wish to review the concepts of inquiring systems and organizations, we begin by summarizing a complex design model of an inquiring system, LOKMS, introduced earlier and fully described in Hall, Paradice, and Courtney (2003). LOKMS comprises a staged view of how an inquiring system can reach a decision while simultaneously building and refreshing an organizational memory. The system aims to have verified knowledge in its memory, thus storing only concrete types of knowledge. Softer knowledge including semi-abstract types of knowledge, such as stories and artifacts, and abstract knowledge, such as organizational structure, roles, and culture, is not stored.

Simon's (2003) Intelligence-Design-Choice model underpins the three basic stages of LOKMS, comprising Intelligence—information discovery, hypothesis generation, and goal selection; Design--generation and analysis of alternatives developed from different modes of inquiry; and Choice—selection of the best option by a decision maker. In the Intelligence phase, key information and knowledge are continuously and systematically captured from knowledge sources and employed to hypothesize and select new states or goals. In the Design phase, alternative solutions and analyses are generated, each based on a different inquiry paradigm. In the Choice phase, one of the candidate solutions is selected. Feedback loops—and environmental and time-space checks for currency—are built in throughout. The model is fully explained in Hall, Paradice, and Courtney (2003).

LOKMS is a specific and complex design for an inquiring system. Our objective in this chapter is to show how discourse in email can support the basic elements of inquiring systems and enhance wisdom. For this purpose, in Figure 4 we provide a simplified conceptual model of how inquiring systems operate inside inquiring organizations, incorporating the wisdom enhancement principle of convergence-divergence in discourse, introduced in the previous section. This model encompasses the external environment and internal environment, which is comprised of the organizational memory, inquiring system knowledge flow domain, and philosophies guiding knowledge claim justification (knowledge creation) in the domain. We review each of these elements in more detail.

Organizational Memory

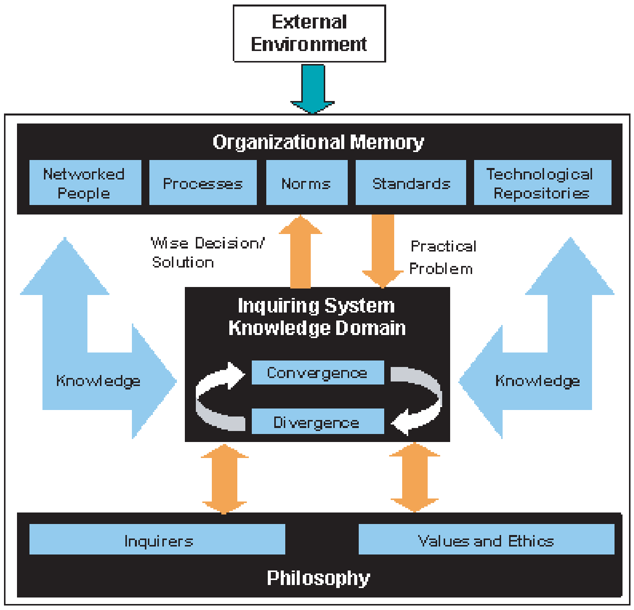
An organizational memory (OM) is a place to retain, integrate, and provide access to organizational knowledge. Most modern definitions for OM include people, processes, norms, standards, and technological repositories. Wickramasinghe (2003) found that although ideally OM should be composed of objective components (explicit knowledge), such as recorded knowledge in repositories, and subjective components (tacit knowledge), such as personal knowledge, the subjective component is typically missing in practice. In inquiring organizations, as shown in Figure 4, subjective knowledge is made available through interpersonal interaction in the group and participation in norms, processes, and standards. Knowledge that has been created in the inquiring system knowledge domain is returned to the OM, while knowledge in the OM is continually validated against scanned external knowledge.

The codified component of OM faces significant problems, such as its potential for sustaining indefinite growth. Another problem is that nowadays codified OM is often fractured into localized repositories (e.g., intranets) that grow in isolation and, to be useful at a broader level at a future time, need reintegration or coordination. In inquiring systems, knowledge held in the OM is coordinated and/or integrated through pragmatic knowledge creation.

Inquiring System Knowledge Domain and Inquirers

A practical problem requiring a solution will lead problem solvers to tap into knowledge from OM and/or the external environment in order to develop a solution/decision. This knowledge creation activity occurs inside a knowledge work domain. Inquiring systems that support inquiring organizations in order to arrive at solutions or decisions are composed of inputs, operators,

Figure 4. Supporting inquiring organizations and wisdom enhancement



outputs, and inquirers that define particular modes of inquiry for ascertaining the truth of knowledge claims. Each inquirer represents a specific philosophy for determining knowledge—inductive and consensual (Locke); deductive and analytic (Leibniz); multiple realities (Kant); conflicting and dialectic (Hegel); and multiple perspectives (Singer).

Courtney, Chae, and Hall (2000) describe five types of inquiring organizations. Liebnizian and Lockean organizations are basically scientific with the first determining truth through theory and the second determining truth through empirics. A Liebnizian organization argues with formal logic, assumes cause and effect, and uses predetermined axioms. In contrast, a Lockean organization is empirically focused, valuing group observation, discourse, and validation in a social context in which group consensus is sought in order to meet group needs. Majority support provides validation of any given observation, input or other information, with an efficient solution sought to meet a group's current needs.

In the Kantian organization, the elements of Liebnizian (truth by theory) and Lockean (truth by empirics) are combined and enhanced through an analytical approach where various alternative models of meaning, explaining the data through a particular theory, are constructed and evaluated. A best fit is obtained through judgment in the particular context. The Hegelian organization takes a dialectic approach that assumes that through conflict of opposing views—thesis and antithesis—a solution better than either view can be synthesized.

Finally, the Singerian organization encompasses all the other types of inquiring organizations by enabling and resolving multiple competing viewpoints, aiming for the common good. Existing knowledge is challenged, and new information representing technical, organizational/social, personal, ethical, and aesthetic perspectives is swept in whenever current models fail to explain a particular situation. Discrepancies are analyzed using methods from the four previous inquirer styles with an emphasis on an ethical and practical approach.

The model depicted in Figure 4 also illustrates knowledge creation and learning as well as the wisdom enhancement cycle of convergence and divergence processes introduced earlier, which, we have argued, can enhance wisdom.

Level of Complexity of Knowledge Work Domain

The level of complexity of a knowledge work domain (Snowden, 2002) shapes and is shaped by the inquirer employed in that domain. In complicated domains, the relationships between cause of knowledge outcome and the outcome itself (that is, cause and effect) are already known, or knowable given sufficient resources. There is high predictive ability for knowledge outcomes in such domains, suggesting that the Liebnizian or Lockean inquiry approaches may be successful.

In complex domains, there are many interacting human agents, each with multiple identities. The interactions form patterns whose outcomes are unpredictable. However, the patterns can be recognized, disrupted, and reoriented, suggesting the potential for Kantian, Hegelian, or Singerian inquirers. In chaotic domains, while patterns of interaction are not emergent, they can be imposed as interventions. According to Snowden, people can mold complex or chaotic domains into known or knowable domains through applying regulation and order. The problem does not determine the inquiry style but rather, people do. Thus, there is always some opportunity to organize all these types of knowledge domains through appropriate management. Snowden further suggested that different managerial and leadership approaches are needed for each domain type.

Values and Ethics

Recent sociopolitical pressures have highlighted the role of ethical values in global healing (Simon, 2003), and ethical values are considered important to inquiring organizations. The values of an organization are embedded in knowledge work through the participants, whose individual values are recreated or reinforced as a result. Internally, a morally sound framework will contribute to increased intraorganizational trust with positive ramifications for open and cooperative team functioning, as required for collective inquiry. Network structures that enable equitable participation and addressing of diverse concerns are suggested.

Ethical organizations exhibit and reinforce values in all activities, including knowledge work. As there is often more than one set of personal values at play in collaborative problem solving, people with values lying outside the boundary of common or majority may be excluded and marginalized. However, with reflection upon this situation by a decision maker, group, or other agent, their views can be accommodated. This reflective process is termed system intervention by Midgley (2000), who suggests that the particular "boundary critique" policy adopted will affect the ethical nature of the organization.

We now proceed to explore these concepts empirically through a study of knowledge creation in discourse in email.

SUPPORT OF KNOWLEDGE CREATION AND INQUIRING SYSTEMS IN E-MAIL DISCOURSE

We conducted a case study involving the knowledge creation activities of a community of practice in a large Australian university, as found in email discourse. The results of this qualitative research are primarily based on a qualitative content analysis of the patterns of discourse involved in knowledge creation in 300 complete email conversations collected from a Eudora email archive in the community under study. Each conversation analyzed contained more than 10 messages and featured the creation of new organizational knowledge. Two of the authors were participants in the academic community while one was the archive owner. Thus, an ethnographic understanding of the context of the conversations was present during analysis, helping us to develop greater insights.

Knowledge Creation Cycle in E-mail Discourse

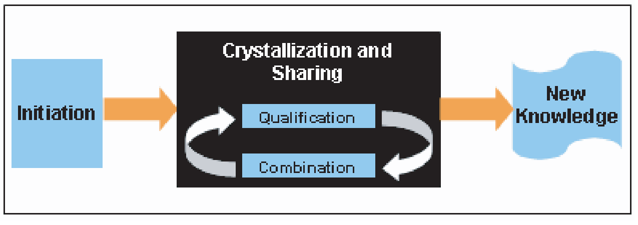
In LOKMS, the three basic stages are intelligence, design, and choice. In the email discourse studied, knowledge was created incrementally through discourse interactions that interwove the elements of intelligence, design, and choice. We identified a pattern of collaborative knowledge development and creation in the conversations studied, described in depth in Lichtenstein (2004) and shown in Figure 5. There are five underlying processes—initiation, crystallization, sharing, qualification, and combination--leading to the creation of new organizational knowledge. The life cycle is illustrated by the email conversation shown in Figure 6.

To summarize, transient virtual teams, operating more like microcommunities, are summoned through an initial message inspired by a need perceived to be of mutual interest to others in the group. This message becomes part of a knowledge trail consisting of successive related emails in one or more threads emanating from the first knowledge seed email. In the conversations, selected because knowledge development took place, knowledge is crystallized along the knowledge trail through processes of knowledge qualification and combination with reference to knowledge resources, including authorities, documents, contributions of insights, ideas, suggestions, and context by participants.

New participants are co-opted as needed for their decision-making power, interest, or additional knowledge. From time to time, participants are omitted from the circulation list. By the end of the knowledge trails, the tacit knowledge of participants has been shared and combined in useful ways, and new organizational knowledge has been created in the form of organized plans and innovation, decisions, and actions. As a result of the continuous learning occurring concurrently, new social and intellectual capital has also been created at individual and collective levels. Thus, there has been knowledge integration in which the specific knowledge held by individual participants has been combined, imbued with collective meaning, and integrated into the group members' tacit knowledge in a potentially valuable way.

In the conversations studied, we observed that the impetus for the cycle of inquiry and knowledge creation arose from an individual (alone, or on behalf of a collective) raising issues for discussion, such as new directions, problems, challenges, or opportunities. These issues had diverse origins including the environment external

Figure 5. Collaborative knowledge creation life cycle in e-mail (Lichtenstein, 2004)



to the organizational unit (for example, competitive threats and mandates from elsewhere in the organization, or outside the organization), the individual's own needs, or a perceived need of the organizational unit.

From Knowledge to Wisdom in E-mail Discourse

It is important to assess the value of the knowledge created in this way. A key advantage of email in this respect is its ability to access a wide variety of people's knowledge through its great reach. Thus, knowledgeable people were co-opted into discussions through the copy or forward facilities, when access was sought to newly needed knowledge. People were included in the initiating message or called upon during email discussions only when needed, including peers, decision makers, knowledge experts, administrators, and knowledge archivists. This may have enabled key people with little time and attention to con-

Figure 6. Sample of knowledge creation in e-mail discourse

Ray (initiation): "I am planning to teach Subject A next year on week nights, instead of weekends. In order to do that, I need a free week night when there are no other classes for students. Bob, can you swap times with me for Subject B, and teach on weekends?"

Bob (crystallization, sharing, combination): "I wish I could help, Ray, but I can't do weekends, either. I've been thinking though of changing the teaching for Subject B. I've noticed students don't get much out of Tutorials in Subject B, so I might omit those and have a two hour seminar which I can put on at 4pm. You can then teach three hours of Subject A afterward at 6pm, Ray. What do you all think?"

Sue (crystallization, sharing, qualification): "As I recall, Marcia says all postgraduate subjects need three hours of class contact."

Marcia (crystallization, sharing, qualification): "Colleagues, yes, the students like three hours of class contact a week, to provide the understanding they need in the subject."

Ray (crystallization, sharing): "Maybe it is time to look at alternative ways that provide even better value?"

Marcia (crystallization, sharing, qualification): "Well, perhaps Bob can find an innovative way of doing that? Bob, I will leave it to you to come up with something."

Bob (crystallization, sharing, combination): "After some discussions with others about this, I suggest we have a two hour workshop each week at 4pm, and a two day workshop during the mid-semester break."

Marcia (crystallization, sharing, qualification): "Sounds good to me. What do you think, Sue and Ray?"

Sue (crystallization, sharing, qualification): "Good idea!"

Ray (crystallization, sharing, qualification): "Yup. Thanks, Bob."

tribute in a timely and economical fashion. The participation of decision makers also meant there was an extremely high likelihood that the created knowledge would have a practical immediate outcome—thereby motivating participants to develop a good solution, quickly.

The raising of a variety of viewpoints allowed assumptions and other issues to surface in the form of disagreement, for resolution. The time available for reflection between attendances on email enabled an important issue to be identified off-line, then raised in email discussion on the next attendance. Finally, issues could be relatively easily brought to the attention of key decision makers without the need for scheduled appointments, providing motivation for raising a concern in email that might otherwise remain unvoiced.

Over and above the advantages discussed above, we suggest that the main value of the knowledge generated is to be found in the method of resolution of multiple perspectives. This resolution was driven by the emerging inquiry mode (as discussed later) as well as the cycles of qualification and combination.

Comparing the cycle in Figure 6 with the cycle of wise decision making in Figure 2 (and shown again in Figure 4), we observe a correspondence between the qualification and convergence processes in that current alternatives are being considered and judged, hastening decision closure. Similarly, there is a correspondence between the combination and the divergence processes in that new alternatives are offered for consideration, showing expansion. We suggest that in general, the greater the number of cycles of qualification and combination, the wiser the resulting solution. A caveat to this is that there will be a point of diminishing returns in repeating the cycle in that, eventually, cooperation in problem solving will diminish under perceived group dissonance.

According to the second perspective of wisdom as fallible knowing, expressed in Figure 3, it is through such combinations in email that an attitude of wisdom can be nurtured, in adding knowledge that balances doubt or confidence in knowing. An attitude of fallible knowing through email discourse is also encouraged at a collective level.

Mode of Inquiry and Decision Making

The mode of inquiry drove the resolution of diverse perspectives. We observed an eclectic array of inquirers: Hegelian (for example, new academic programs in development were considered both with and without particular content); Kantian (for example, reasoning about possible causes for enrolment trends); Singerian (for example, the synthesis of academic content for new units being developed from multiple contributions); Lockean (for example, analyzing enrollment information to make key enrollment decisions); and Leibnizian (for example, an analysis of the number of cars needed to transport employees to an event). We found the Singerian cycle to be the dominant inquirer for knowledge truth in the email conversations studied, with other inquirers utilized as needed. Importantly, the multiple discordant voices appearing in discourse acted as stimuli for the cycle of knowledge creation described.

However, we observed examples where more was needed to achieve closure in the email conversations. There were challenges to the knowledge base—or assumptions or problems—that were difficult to resolve. An impasse, in which no decision was possible as a consensual outcome was required, necessitated moving a discussion off-line. At times, a decision-making authority was brought into a conversation to guarantee resolution in an act of power (Lichtenstein, 2004), or this person simply observed the conversation until the “dust had settled” and then pronounced the outcome, providing a rationale based on assessment of the conversation.

Domain Complexity

We noticed significant disorder in the patterns of knowledge processes occurring, with chaotically (rather than linearly) ordered employee contributions to knowledge development. It is impossible in email, as it presently exists, to ensure linear development of a threaded discussion. After an initiator sent an initial message, a number of people responded at different times, possibly without reading the most current response. This resulted in quite fragmented discussions, which may have reduced the effectiveness of email-based decision making and knowledge creation. On the other hand, this may have encouraged the submission of diverse views, as the protocol of turn taking was simply not possible.

Yet, despite this obstacle, most conversations still resulted in successful outcomes. We recognized that the knowledge work in our email sample resembled the domain of complexity reviewed earlier. This pattern was observed in many of the conversations studied and ties into our finding that the dominant mode of inquiry was Singerian. As mentioned previously, Snowden (2002) suggests that complex domains are managed and led by the early identification of pattern formation, followed by disruption of any undesirable patterns, and stabilization of those desired. We observed signs of this type of management and leadership in the discourse interactions, although this did not appear to be planned. The leadership which emerged seemed to be based mainly on natural authority of a patriarchal or matriarchal nature and was obtained through the process of knowledge qualification, although at times an act of power was clearly linked to an actor with designated authority, as we discuss in the next section.

Organizational Memory and External Knowledge Resources

In our study, the important role that was played by an organization's memory and the external environment was observed because email participants often included knowledge resources of high quality to inform the decision-making process. For example, documents and hyperlinks from sources in organizational memory or outside the organization were included in emails and, in some cases, participants prepared documents over the course of the email conversation if needed. The knowledge of the participants themselves was available through email discourse—as far as participants were prepared to share and able to articulate such knowledge. The tacit knowledge of experts and decision makers who were not initially included in the conversation was accessed when needed. Similarly, affected knowledge stakeholders could be accessed when needed for their opinions or authorization by adding them to the list of email recipients.

The email discourse itself resulted in new codified knowledge being added to organizational memory because participants used the quote function to generate a knowledge trail. This trail provided a record of the way in which the issues and knowledge had developed over a conversation and acted as a reminder of the state of play, considering the lack of continuity inherent in communicating with an asynchronous medium. Possibly, it was an attempt to mimic threaded conversations on a message board in which entire discussions are always viewable. However, there was some confusion experienced whenever participants chose to respond without including the previously maintained knowledge trail.

A major concern with organizational memory repositories is the issue of ensuring that the knowledge retained is accurate. In the organizational unit studied, we found that key people "in the know"—as well as recent credible external information—were accessed for the most recent knowledge and information, while some current participants brought this knowledge with them as they were also participants in other groups (as mentioned earlier, such people can be termed knowledge integrators). Indeed, the degree of accuracy within the email conversations was largely dependent on participants' awareness of who was "in the know" in order to co-opt those experts or peers into the discussion (for example, via the copy feature of email).

A danger thus exists in that if current participants lack accurate knowledge as well as the knowledge of who has the accurate knowledge and is accessible to share it, inaccurate knowledge could be accepted and employed as fact. This is a likely advantage of the LOKMS model, which attempts to link explicit knowledge to individuals who possess the requisite tacit knowledge. However, it was certainly true that in the email conversations in our empirical study there was usually an attempt to co-opt the needed people and thus correct possible errors in the knowledge being shared (and hence ensure that the resulting knowledge created had a greater chance of accuracy).

In some respects, we saw accuracy as enhanced through email via the rationales and results of the additional "information gathering" (the first phase of the LOKMS model) provided by participants. Even stored presumably static knowledge was not always taken as commonly agreed but rather consulted, queried, debated, and sometimes revised when arising in discussion—suggesting that such static knowledge is merely a starting point for developing a situated form of the knowledge. Because participants could view the rationale provided, for instance, they could assess more openly the accuracy of the facts or explicit knowledge on which a decision was being made. Further, we found that accuracy problems in email discourse were reduced to some extent because errors could be detected quite late in the cycle and be relatively easily corrected.

Values and Ethics in Knowledge Creation in E-mail

Importantly, in email, compared with face-to-face meetings and various synchronous collaborative tools, we discovered a strong sense of participatory and democratic involvement in decision making, with all participants given plenty of opportunity to reflect, formulate, and contribute individual opinions, as well as consider at leisure the other perspectives offered and formulate and contribute responses. Furthermore, the fact that key decision makers were accessible and accountable loaned credibility and weight to the decision-making processes involved—in particular, the qualification processes—as well as to the final knowledge outcome.

Participants clearly cooperated and collaborated in their efforts to build knowledge for a team-driven common purpose. There was generalized team spirit and determination to find a solution, however.

A further finding was that email encouraged only participants who felt they had "something genuine to say," or those who read their email in a timely manner, to contribute. Other participants effectively excluded themselves from the process by choosing to remain passive. This questions the true extent of participation provided by email.

CONCLUSION

This chapter aimed to explore the potential of email for supporting inquiring organizations and enhancing wisdom. We first reviewed how knowledge can be created when solving problems and making decisions in organizations during social processes involving discourse and circumstances in which this may lead to the enhancement of wisdom. In particular, the chapter highlights the value of a cycle of convergence and divergence in discourse for the promotion of learning and wisdom and the wisdom of maintaining an attitude of fallible knowing throughout knowledge creation and decision making. We also reviewed key concepts of inquiring organizations, highlighting the influences of different inquiry modes for guiding knowledge creation and decision making and introducing a conceptual model for supporting inquiring organizations (Figure 4) that incorporates the wisdom enhancement principle of cycles of convergence-divergence.

We reported an empirical study of knowledge creation in email from which emerged some of the key characteristics of inquiring systems. More specifically, we observed a cyclic knowledge creation life cycle (Figure 5) that highlights cycles of qualification (convergence) and combination (divergence), suggesting that wisdom may be enhanced through this email-enabled knowledge creation cycle.

The potential of email for supporting pragmatic collaborative knowledge creation, learning, and wisdom enhancement has been highlighted in this chapter. In looking for ways to promote the valuable patterns found, the structuring of collaborative spaces with negotiation discourse templates is one avenue to explore (Ing & Simmonds, 2000; Turoff et. al, 1999). A simpler idea is to train employees in the types of conversations that best promote learning, wise decisions, and wisdom in general. Leadership provides yet another path for influencing domains by modifying the complexity of knowledge work, thus encouraging different patterns of discourse.

We saw that the interplay of perspectives enabled the coordination and integration of tacit knowledge between organizational participants who, possessing only specialized knowledge, otherwise tended to remain isolated and unable to contribute to the larger goals of the organization. Participants also integrated their tacit knowledge with codified knowledge in knowledge trails and internal repositories. These findings are important because, as noted earlier, OM is piecemeal, and its fragments require integration or coordination, while it is generally difficult to access the subjective component of OM. An emerging key role for people possessing integrated knowledge was highlighted by the study. Such people can be termed knowledge integrators, and their increasing importance for collaborative learning and decision making suggests a shift away from valuing specialist knowledge toward valuing people with interdisciplinary and "big picture" understanding.

In closing, we remark an increasing need, in our times, for wisdom. The way forward may lie in giving people voices that are genuinely heard, as people strive to achieve their individual goals, together. This chapter has suggested that it is in the resulting symbiosis of individual ideas and judgments that wisdom, so greatly needed, may well be found.

REFERENCES

Bakhtin, M. (1986). *The problem of speech genres. In Speech genres and other late essays* (V. McGee, Trans.). Austin: University of Texas Press.

Barabba, V. P., & Zaltman, G. (1991). *Hearing the voice of the market: Competitive advantage through creative use of market information.* Boston: Harvard Business School Press.

Carlsson, B., Keane, P., & Martin, J. B. (1976). R&D organizations as learning systems. *Sloan Management Review, 17*(3), 1-15.

Churchman, C. W. (1971) *The design of inquiring systems: Basic concepts of systems and organization*. New York: Basic Books.

Courtney, J. F. (2001). Decision making and knowledge management in inquiring organizations: Toward a new decision-making paradigm for DSS. *Decision Support Systems, 31*(1), 17-38.

Courtney, J. F., Chae, B., & Hall, D. (2000). Developing inquiring organizations. *Knowledge and Innovation, 1*(1), 132-145.

Haeckel, S. H., & Nolan, R. L. (1993). Managing by wire. *Harvard Business Review, 71*(5), 122-132.

Hall, D., Paradice, D., & Courtney, J. F. (2003). Building a theoretical foundation for a learning-oriented knowledge management system. *Journal of Information Technology Theory and Application, 5*(2), 63-89.

Hubscher-Younger, T., & Narayanan, N. H. (2003). Authority and convergence in collaborative learning. *Computers & Education, 41*(4), 313-334.

Ing, D., & Simmonds, I. (2000, May). *Managing by wire, revisited* (White Paper). IBM Advanced Business Institute.

Jensen, M. C., & Meckling, W. H. (1992). Specific and general knowledge, and organizational structure. In L. Wering & H. Wijkander (Eds.), *Contract economics* (pp. 251-274). Oxford: Basil Blackwell.

Kolb, D. A. (1985). *LSI Learning Style Inventory*. Boston: McBer and Company.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lichtenstein, S. (2004, January 5-8). Knowledge development and creation in email. In *Proceedings of the 37th Annual Hawaii International Conference on System Sciences* (HICSS'04), Big Island, HI, USA. IEEE Computer Society.

Loermans, J. (2002). Synergizing the learning organization and knowledge management. *Journal of Knowledge Management, 6*(3), 285-294.

Meacham, J. A. (1990). The loss of wisdom. In R. J. Sternberg (Ed.), *Wisdom: Its nature, origins, and development* (181-212). Cambridge: Cambridge University Press.

Midgley, G. (2000). *Systemic intervention: Philosophy, methodology and practice.* New York: Kluwer Academic/Plenum.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5*(1), 14-37.

Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences, 4,* 155-169.

Roschelle, J. (1992). Learning by collaborating: Convergent conceptual change. *Journal of the Learning Sciences, 2*(3), 235-276.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization.* New York: Currency Doubleday.

Sharkie, R. (2003). Knowledge creation and its place in the development of sustainable competitive advantage. *Journal of Knowledge Management, 7*(1), 20-31.

Simon, P. (2003). *Healing America: Values and vison for the 21st century.* Orbis Books.

Snowden, D. (2002). Complex acts of knowing: Paradox and descriptive self-awareness. *Journal of Knowledge Management, 6*(2), 100-111.

Stahl, G. (2002). Rediscovering the collaboration. In T. Koschmann, R. Hall, & N. Miyaki (Eds.), *Carrying forward the conversation: Proceedings of CSCL2*. Mahwah, NJ: Lawrence Erlbaum.

Turoff, M., Hiltz, S. R., Bieber, M., Fjermestad, J., & Rana, A. (1999, January 5-8). Collaborative discourse structures in computer mediated group communications. In *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences (HICSS'99),* Maui. IEEE Society Press.

Weick, K. E. (2001). *Making sense of the organization*. Malden, MA: Blackwell Publishers.

Wickramasinghe, N. (2003). Do we practice what we preach: Are knowledge management systems in practice truly reflective of knowledge management systems in theory? *Business Process Management Journal, 9*(3), 295-316.

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Chapter 2.6
Stages of Knowledge Management Systems

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Knowledge management systems refer to a class of information systems applied to manage organizational knowledge. These systems are IT applications to support and enhance the organizational processes of knowledge creation, storage and retrieval, transfer, and application (Alavi & Leidner, 2001).

The knowledge management technology stage model presented in this chapter is a multistage model proposed for organizational evolution over time. Stages of knowledge management technology are a relative concept concerned with IT's ability to process information for knowledge work. The knowledge management technology stage model consists of four stages (Gottschalk, 2005). When applied to law enforcement in the following chapters, the stages are labeled officer-to-technology, officer-to-officer, officer-to-information, and officer-to-application.

KNOWLEDGE TECHNOLOGY STAGES

Stages-of-growth models have been used widely in both organizational research and information technology management research. According to King and Teo (1997), these models describe a wide variety of phenomena: the organizational life cycle, product life cycle, biological growth, and so forth. These models assume that predictable patterns (conceptualized in terms of stages) exist in the growth of organizations, the sales levels of products, and the growth of living organisms. These stages are (1) sequential in nature, (2) occur as a hierarchical progression that is not easily reversed, and (3) involve a broad range of organizational activities and structures.

Benchmark variables are often used to indicate characteristics in each stage of growth. A one-dimensional continuum is established for each benchmark variable. The measurement of benchmark variables can be carried out using Guttman scales (Frankfort-Nachmias & Nachmias, 2002). Guttman scaling is a cumulative scaling technique based on ordering theory that suggests a linear relationship between the elements of a domain and the items on a test.

In the following main part of this chapter, a four-stage model for the evolution of information technology support for knowledge management is proposed and empirically tested. The purpose of the model is both to understand the current situation in an organization in terms of a specific stage, and to develop strategies for moving to a higher stage in the future. We are concerned with the following question: Do organizations move through various stages of growth in their application of knowledge management technology over time, and is each theoretical stage regarded as an actual stage in an organization?

STAGES-OF-GROWTH MODELS

Various multistage models have been proposed for organizational evolution over time. These models differ in the number of stages. For example, Nolan (1979) introduced a model with six stages for IT maturity in organizations that later was expanded to nine stages. Earl (2000) suggested a stages-of-growth model for evolving the e-business consisting of the following six stages: external communication, internal communication, e-commerce, e-business, e-enterprise, and transformation. Each of these models identifies certain characteristics that typify firms in different stages of growth. Among these multistage models, models with four stages seem to have been proposed and tested most frequently (King & Teo, 1997).

In the area of knowledge management, Housel and Bell (2001) described a knowledge management maturity model. The knowledge management maturity (KMM) model is used to assess the relative maturity of a company's knowledge management efforts. The KMM model defines the following five levels (Housel & Bell 2001, p. 136):

1. Level one is the default stage in which there is low commitment to managing anything other than essential, necessary survival-level tasks. At level one, formal training is the main mechanism for learning, and all learning is taken to be reactive. Moreover, level-one organizations fragment knowledge into isolated pockets that are not explicitly documented.
2. Level two organizations share only routine and procedural knowledge. Need-to-know is characteristic, and knowledge awareness rises with the realization that knowledge is an important organizational resource that must be managed explicitly. Databases and routine tasks exist, but are not centrally compiled or managed.
3. Level three organizations are aware of the need for managing knowledge. Content fit for use in all functions begins to be organized into a knowledge life cycle, and enterprise knowledge-propagation systems are in place. However, general awareness and maintenance are limited.
4. Level four is characterized by enterprise knowledge sharing systems. These systems respond proactively to the environment, and the quality, currency, utility, and usage of these systems are improved. Knowledge processes are scaled up across the organization, and organization knowledge boundaries become blurred. Benefits of knowledge sharing and reuse can be explicitly quantified, and training moves into an ad hoc basis as the technology infrastructure for knowledge sharing is increasingly integrated and seamless.
5. Level five is where knowledge sharing is institutionalized and organizational boundaries are minimized. Human know-how and content expertise are integrated into

a seamless package, and knowledge can be most effectively leveraged. Level-five organizations have the ability to accelerate the knowledge life cycle to achieve business advantage.

According to Kazanjian and Drazin (1989), the concept of stages of growth is widely employed. A number of multistage models have been proposed that assume that predictable patterns exist in the growth of organizations, and that these patterns unfold as discrete time periods best thought of as stages. These models have different distinguishing characteristics. Stages can be driven by the search for new growth opportunities, or as a response to internal crises. Some models suggest that firms progress through stages, while others argue that there may be multiple paths through the stages.

Kazanjian (1988) applied dominant problems to stages of growth. Dominant problems imply that there is a pattern of primary concerns that firms face for each theorized stage. In the area of IT maturity, dominant problems can shift from lack of skills to lack of resources to lack of strategy associated with different stages of growth.

Kazanjian and Drazin (1989) argue that either implicitly or explicitly, stage-of-growth models share a common underlying logic. Organizations undergo transformations in their design characteristics that enable them to face the new tasks or problems that growth elicits. The problems, tasks, or environments may differ from model to model, but almost all suggest that stages emerge in a well-defined sequence, so that the solution of one set of problems or tasks leads to the emergence of a new set of problems or tasks that the organization must address. Growth in areas such as IT maturity can be viewed as a series of evolutions and revolutions precipitated by internal crises related to leadership, control, and coordination. The striking characteristic of this view is that the resolution of each crisis sows the seeds for the next crisis. Another view is to consider stages of growth as responses to the firm's search for new growth opportunities once prior strategies have been exhausted.

Stages-of-growth models may be studied through organizational innovation processes. Technological innovation is considered the primary driver of improvements in many businesses today. Information technology represents a complex organizational technology, that is, technology that, when first introduced, imposes a substantial burden on would-be adopters in terms of the competence needed to use it effectively (Levina & Vaast, 2005). According to Fichman and Kemerer (1997), such technology typically has an abstract and demanding scientific base, it tends to be fragile in the sense that it does not always operate as expected, it is difficult to test in a meaningful way, and it is unpackaged in the sense that adopters cannot treat the technology as a black box.

Embodying such characteristics, organizational learning and innovation diffusion theory can be applied to explain stages-of-growth models. Organizational learning is sometimes placed at the center of innovation diffusion theory through a focus on institutional mechanisms that lower the burden of organizational learning related to IT adoption. Organizations may be viewed, at any given moment, as possessing some bundle of competence related to their current operational and managerial processes. In order to successfully assimilate a new process technology, an organization must somehow reach a state where its bundle of competence encompasses those needed to use the new technology (Fichman & Kemerer, 1997).

Innovations through stages of growth can be understood in terms of technology acceptance over time. Technology acceptance has been studied for several decades in information systems research. Technology acceptance models explain perceived usefulness and usage intentions in terms of social influence and cognitive instrumental processes. For example, Venkatesh and Davis (2000) found that social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use) significantly influenced user acceptance. Similarly, Venkatesh (2000) identified determinants of perceived ease of use, a key driver of technology acceptance, adoption, and usage behavior.

Stages-of-growth models have been criticized for a lack of empirical validity. Benbasat et al. (Benbasat, Dexter, Drury, & Goldstein, 1984) found that most of the benchmark variables for stages used by Nolan (1979) were not confirmed in empirical studies. Based on empirical evidence, Benbasat et al. (1984) wrote the following critique of Nolan's stage hypothesis:

The stage hypothesis on the assimilation of computing technology provides one of the most popular models for describing and managing the growth of administrative information systems. Despite little formal evidence of its reliability or robustness, it has achieved a high level of acceptance among practitioners. We describe and summarize the findings of seven empirical studies conducted during the past six years that tested various hypotheses derived from this model. The accumulation of evidence from these studies casts considerable doubt on the validity of the stage hypothesis as an explanatory structure for the growth of computing in organizations.

For example, Nolan (1979) proposed that steering committees should be constituted in later stages of maturity. However, an empirical study showed that of 114 firms, 64 of which had steering committees, the correlation between IT maturity and steering committees was not significant. In practice, organizations adopt steering committees throughout the development cycle rather than in the later stages.

Another example is charge-back methods. In a survey, approximately half of the firms used charge-back systems and the other half did not. In the Nolan (1979) structure, as firms mature through later stages, they should have adopted charge-back systems. Yet, in the empirical analysis, there were no significant correlations between maturity indicators and charge-back system usage, according to Benbasat et al. (1984). Benchmark variables such as steering committees and charge-back systems have to be carefully selected and tested before they are applied in survey research.

The concept of stages of growth has created a number of skeptics. Some argue that the concept of an organization progressing unidirectionally through a series of predictable stages is overly simplistic. For example, organizations may evolve through periods of convergence and divergence related more to shifts in information technology than to issues of growth for specific IT. According to Kazanjian and Drazin (1989), it can be argued that firms do not necessarily demonstrate any inexorable momentum to progress through a linear sequence of stages, but rather that observed configurations of problems, strategies, structures, and processes will determine a firm's progress.

Kazanjian and Drazin (1989) addressed the need for further data-based research to empirically examine whether organizations in a growth environment shift according to a hypothesized stage of growth model, or whether they follow a more random pattern of change associated with shifts in configurations that do not follow such a progression. Based on a sample of 71 firms, they found support for the stage hypothesis.

To meet the criticism of lacking empirical validity, this research presentation describes the careful development, selection, and testing of a variety of instrument parts to empirically validate a knowledge management technology stage model.

Guttman Scaling for Cumulative Growth

Benchmark variables in stages-of-growth models indicate the theoretical characteristics in each stage of growth. The problem with this approach is that not all indicators of a stage may be present in an organization, making it difficult to place the organization in any specific stage.

Guttman scaling is also known as cumulative scaling or scalogram analysis. Guttman scaling is based on ordering theory, which suggests a linear relationship between the elements of a domain and the items on a test. The purpose of Guttman scaling is to establish a one-dimensional continuum for a concept to measure. We would like a set of items or statements so that a respondent who agrees with any specific question in the list will also agree with all previous questions. This is the ideal for a stage model, or for any progression. By this we mean that it is useful when one progresses from one state to another, so that upon reaching the higher stage, one has retained all the features of the earlier stage (Trochim, 2002).

For example, a cumulative model for knowledge transfer could consist of six stages: awareness, familiarity, attempt to use, utilization, results, and impact. Byers and Byers (1998) developed a Guttman scale for knowledge levels consisting of stages by order of learning difficulty. Trochim (2002) developed the following cumulative six-stage scale for attitudes towards immigration:

1. I believe that this country should allow more immigrants in.
2. I would be comfortable with new immigrants moving into my community.
3. It would be fine with me if new immigrants moved onto my block.
4. I would be comfortable if a new immigrant moved next door to me.
5. I would be comfortable if my child dated a new immigrant.
6. I would permit a child of mine to marry an immigrant.

Guttman (1950) used scalogram analysis successfully during the war in investigating morale and other problems in the United States Army. In scalogram analysis, items are ordered such that, ideally, organizations that answer a given question favorably all have higher ranks than organizations that answer the same question unfavorably. According to Guttman (1950, p. 62), the ranking of organizations provides a general approach to the problem of scaling:

We shall call a set of items of common content a scale if an organization with a higher rank than another organization is just as high or higher on every item than the other organization.

Kline (1998, p. 75) discusses three problems with Guttman scales that may, he claims, render them of little scientific value:

1. The underlying measurement model. The first concerns the fact that items correlate perfectly with the total scale score or the attribute being measured. This is unlikely of any variable in the real world. In general terms, it means the measurement model does not fit what is being measured. This is not dissimilar to the difficulty that in psychological measurement, it is simply assumed that the attribute is quantitative.
2. Unidimensionality of the scale. It has been argued that all valid measuring instruments must be unidimensional. Now the construction of a Guttman scale does not ensure unidimensionality. It would be perfectly possible to take items from different scales, each item of a considerably different level of difficulty, and these would form a Guttman scale. This is because the scaling characteristics of Guttman scales are dependent only on difficulty levels. Thus, Guttman scales may not be unidimensional. The only practical way round the problem is to factor the items first, but then it may prove difficult to make a Guttman scale with so restricted an item pool.

3. Ordinal measurement. The construction of Guttman scales may only permit ordinal measurement. This severely restricts the kinds of statistical analyses that can be used with Guttman scales.

These problems also occurred in the conducted empirical tests of the knowledge management technology stage model in Norway and Australia, as is evident in the book by Gottschalk (2005).

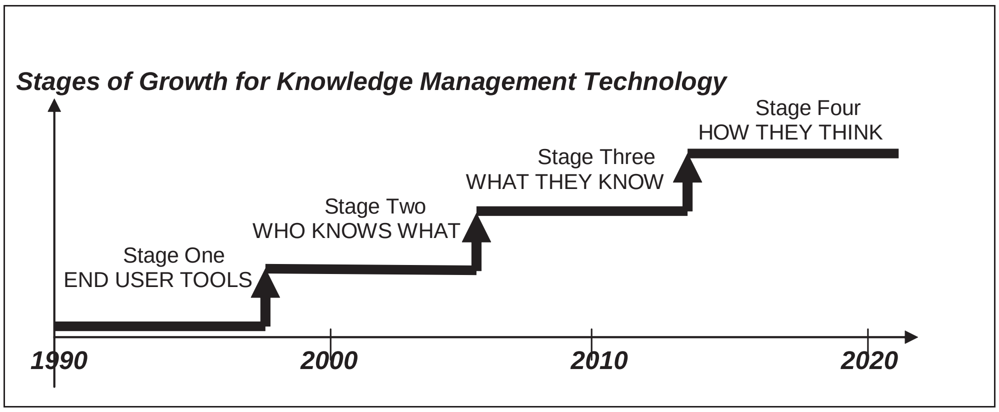
THE KMT STAGE MODEL

Stages of knowledge management technology are a relative concept concerned with IT's ability to process information for knowledge work. IT at later stages is more useful to knowledge work than IT at earlier stages. The relative concept implies that IT is more directly involved in knowledge work at higher stages, and that IT is able to support more advanced knowledge work at higher stages. The knowledge management technology (KMT) stage model consists of four stages. The first stage is general IT support for knowledge workers. This includes word processing, spreadsheets, and e-mail. The second stage is information about knowledge sources. An information system stores information about who knows what within the firm and outside the firm. The system does not store what they actually know. A typical example is the company intranet. The third stage is information representing knowledge. The system stores what knowledge workers know in terms of information. A typical example is a database. The fourth and final stage is information processing. An information system uses information to evaluate situations. A typical example here is an expert system.

The contingent approach to firm performance implies that Stage 1 may be right for one firm, while Stage 4 may be right for another firm. Some firms will evolve over time from Stage 1 to higher stages, as indicated in Figure 1. The time axis, ranging from 1990 to 2020 in Figure 1, suggests that it takes time for an individual firm and a whole industry to move through all stages. As an example applied later in this chapter, the law-firm industry is moving slowly in its use of information technology.

Stages of IT support in knowledge management are useful for identifying the current situation, as well as planning for future applications in the firm. Each stage is described in the following:

Figure 1. The knowledge management technology stage model



1. Tools for end users are made available to knowledge workers. In the simplest stage, this means a capable networked PC on every desk or in every briefcase with standardized personal productivity tools (word processing, presentation software) so that documents can be exchanged easily throughout a company. More complex and functional desktop infrastructures can also be the basis for the same types of knowledge support. Stage 1 is recognized by widespread dissemination and use of end-user tools among knowledge workers in the company. For example, lawyers in a law firm will, in this stage, use word processing, spreadsheets, legal databases, presentation software, and scheduling programs.

   Stage 1 can be labeled end-user-tools or people-to-technology, as information technology provides knowledge workers with tools that improve personal efficiency.
2. Information about who knows what is made available to all people in the firm and to selected outside partners. Search engines should enable work with a thesaurus, since the terminology in which expertise is sought may not always match the terms the expert uses to classify that expertise.

   According to Alavi and Leidner (2001), the creation of corporate directories, also referred to as the mapping of internal expertise, is a common application of knowledge management technology. Because much knowledge in an organization remains uncodified, mapping the internal expertise is a potentially useful application of technology to enable easy identification of knowledgeable persons.

   Here we find the cartographic school of knowledge management (Earl, 2001), which is concerned with mapping organizational knowledge. It aims to record and disclose who in the organization knows what by building knowledge directories. Often called Yellow Pages, the principal idea is to make sure knowledgeable people in the organization are accessible to others for advice, consultation, or knowledge exchange. Knowledge-oriented directories are not so much repositories of knowledge-based information as gateways to knowledge, and the knowledge is as likely to be tacit as explicit.

   Information about "who knows what" is sometimes called metadata, representing knowledge about where the knowledge resides. Providing taxonomies or organizational knowledge maps enables individuals to rapidly locate the individual who has the needed knowledge, more rapidly than would be possible without such IT-based support.

   One starting approach in Stage 2 is to store curriculum vitae (CV) for each knowledge worker in the firm. Areas of expertise, projects completed, and clients helped may, over time, expand the CV. For example, a lawyer in a law firm works on cases for clients using different information sources that can be registered on yellow pages in terms of an intranet.

   At Stage 2, firms apply the personalization strategy in knowledge management. According to Hansen et al. (Hansen, Nohria, & Tierney, 1999), the personalization strategy implies that knowledge is tied to the person who developed it, and is shared mainly through direct person-to-person contact. This strategy focuses on dialogue between individuals; knowledge is transferred mainly in personal e-mail, meetings, and one-on-one conversations.

   The creation of a knowledge network is an important part of Stage 2. Unless specialists can communicate easily with each other across platform types, expertise will deteriorate. People have to be brought together both virtually and face-to-face to exchange and build their collective knowledge in each of the specialty areas. The knowledge management effort is focused on bringing the experts together so that important knowledge can be shared and amplified, rather than on mapping expertise or benchmarking, which occurs in Stage 3.

Electronic networks of practice are computer-mediated discussion forums focused on problems of practice that enable individuals to exchange advice and ideas with others based on common interests. Electronic networks have been found to support organizational knowledge flows between geographically dispersed coworkers and distributed research and development efforts. These networks also assist cooperative open-source software development and open congregation on the Internet for individuals interested in a specific practice. Electronic networks make it possible to share information quickly, globally, and with large numbers of individuals (Wasko & Faraj, 2005).

The knowledge network is built on modern communication technology. Advance in portable computers such as palmtops and laptops, in conjunction with wireless network technologies, has engendered mobile computing. In a mobile computing environment, users carrying portable computers are permitted to access the shared computing resources on the network through wireless channels, regardless of their physical locations.

According to Earl (2001), knowledge directories represent more of a belief in personalized knowledge of individuals than the codified knowledge of knowledge bases, and may demonstrate organizational preferences for human, not technology-mediated, communication and exchange. The knowledge philosophy of firms that settle in Stage 2 can be seen as one of people connectivity. Consequently, the principal contribution from IT is to connect people via intranets, and to help them locate knowledge sources and providers using directories accessed by the intranet. Extranets and the Internet may connect knowledge workers to external knowledge sources and providers.

Communication competence is important at Stage 2. Communication competence is the ability to demonstrate skills in the appropriate communication behavior to effectively achieve one's goals. Communication between individuals requires both the decoding and encoding of messages (Ko, Kirsch, & King, 2005). Lin et al. (Lin, Geng, & Whinston, 2005) found that knowledge transfer depends on the completeness or incompleteness of the sender's and the receiver's information sets.

The dramatic reduction in electronic communication costs and ease of computer-to-computer linkages has resulted in opportunities to create new channel structures, fueling interest in interorganizational systems. Interorganizational systems are planned and managed ventures to develop and use IT-based information exchange systems to support collaboration and strategic alliances between otherwise independent actors. These systems allow for the exchange of information between partners for the purpose of coordination, communication, and cooperation (Malhotra, Gosain, & El Sawy, 2005).

Stage 2 can be labeled who-knows-what or people-to-people, as knowledge workers use information technology to find other knowledge workers.

3. Information from knowledge workers is stored and made available to everyone in the firm, and to designated external partners. Data-mining techniques can be applied here to find relevant information and combine information in data warehouses. On a broader

basis, search engines are Web browsers and server software that operate with a thesaurus, since the terminology in which expertise is sought may not always match the terms used by the expert to classify that expertise.

One starting approach in Stage 3 is to store project reports, notes, recommendations, and letters from each knowledge worker in the firm. Over time, this material will grow fast, making it necessary for a librarian or a chief knowledge officer (CKO) to organize it. In a law firm, all client cases will be classified and stored in databases using software such as Lotus Notes.

An essential contribution that IT can make is the provision of shared databases across tasks, levels, entities, and geographies to all knowledge workers throughout a process (Earl, 2001). For example, Infosys Technologies—a U.S. $1 billion company with over 23,000 employees and globally distributed operations—created a central knowledge portal called KShop. The content of KShop was organized into different content types, for instance, case studies, reusable artifacts, and downloadable software. Every knowledge asset under a content type was associated with one or more nodes (representing areas of discourse) in a knowledge hierarchy or taxonomy (Garud & Kumaraswamy, 2005).

According to Alavi and Leidner (2001), one survey found that 74% of respondents believed that their organization's best knowledge was inaccessible, and 68% thought that mistakes were reproduced several times. Such a perception of failure to apply existing knowledge is an incentive for mapping, codifying, and storing information derived from internal expertise.

However, sifting though the myriad of content available through knowledge management systems can be challenging, and knowledge workers may be overwhelmed when trying to find the content most relevant for completing a new task. To address this problem, system designers often include rating schemes and credibility indicators to improve users' search and evaluation of knowledge management system content (Poston & Speier, 2005).

According to Alavi and Leidner (2001), one of the most common applications is internal benchmarking, with the aim of transferring internal best practices. To be successful, best practices have to be coded, stored, and shared among knowledge workers.

In addition to (1) best practices knowledge within a quality or business process management function, other common applications include (2) knowledge for sales purposes involving products, markets, and customers, (3) lessons learned in projects or product development efforts, (4) knowledge around implementation of information systems, (5) competitive intelligence for strategy and planning functions, and (6) learning histories or records of experience with a new corporate direction or approach (Grover & Davenport, 2001).

In Stage 3, access both to knowledge (expertise, experience, and learning) and to information (intelligence, feedback, and data analyses) is provided by systems and intranets to operatives, staff, and executives. The supply and distribution of knowledge and information are not restricted. Whereas we might say in Stage 1, "give knowledge workers the tools to do the job," we now add, "give knowledge workers the knowledge and information to do the job." According to Earl (2001), this is another way of saying that the philosophy is enhancing the firm's capabilities with knowledge flows.

Although most knowledge repositories serve a single function, Grover and Davenport (2001) found that it is increasingly common for companies to construct an internal portal so that employees can access multiple, different repositories and sources from one screen. It is also possible and increasingly popular for repositories to contain information as well as pointers to experts within the organization on key knowledge topics. Often called Knowledge Yellow Pages, these systems facilitate contact and knowledge transfer between knowledgeable people and those who seek their knowledge. Stored, codified knowledge is combined with lists of individuals who contributed the knowledge and could provide more detail or background on it.

An enterprise information portal is viewed as a knowledge community. Enterprise information portals are of multiple forms, ranging from Internet-based data management tools that bring visibility to previously dormant data so that their users can compare, analyze, and share enterprise information to a knowledge portal that enables its users to obtain specialized knowledge that is related to their specific tasks (Ryu, Kim, Chaudhury, & Rao, 2005).

Individuals' knowledge does not transform easily into organizational knowledge even with the implementation of knowledge repositories. According to Bock et al. (Bock, Zmud, & Kim, 2005), individuals tend to hoard knowledge for various reasons. Empirical studies have shown that the greater the anticipated reciprocal relationships are, the more favorable the attitude toward knowledge sharing will be.

Electronic knowledge repositories are electronic stores of content acquired about all subjects for which the organization has decided to maintain knowledge. Such repositories can comprise multiple knowledge bases, as well as the mechanisms for acquisition, control, and publication of the knowledge. The process of knowledge sharing through electronic knowledge repositories involves people contributing knowledge to populate repositories (e.g., customer and supplier knowledge, industry best practices, and product expertise) and people seeking knowledge from repositories for use (Kankanhalli, Tan, & Wei, 2005).

In Stage 3, firms apply the codification strategy in knowledge management. According to Hansen et al. (1999), the codification strategy centers on information technology: knowledge is carefully codified and stored in knowledge databases, and can be accessed and used by anyone. With a codification strategy, knowledge is extracted from the person who developed it, is made independent from the person, and stored in form of interview guides, work schedules, benchmark data, and so forth, and then searched and retrieved and used by many employees.

According to Grover and Davenport (2001), firms increasingly view attempts to transform raw data into usable knowledge as part of their knowledge management initiatives. These approaches typically involve isolating data in a separate warehouse for easier access, and the use of statistical analysis or data mining and visualization tools. Since their goal is to create data-derived knowledge, they are increasingly addressed as part of knowledge management in Stage 3.

Stage 3 can be labeled what-they-know or people-to-docs, as information technology provides knowledge workers with access to information that is typically stored in documents. Examples of documents are contracts and agreements, reports, manuals and handbooks, business forms, letters, memos, articles, drawings, blueprints, photographs, e-mail and voice mail messages, video clips, script and visuals from presentations, policy statements, computer printouts, and transcripts from meetings.

Sprague (1995) argues that concepts and ideas contained in documents are far more valuable and important to organizations than facts traditionally organized into data records. A document can be described as a unit of recorded information structured for human consumption. It is recorded and stored, so a speech or conversation for which no transcript is prepared is not a document. A document is a snapshot of some set of information that can incorporate many complex information types, exist in multiple places across a network, depend on other documents for information, change as subordinate documents are updated, and be accessed and modified by many people simultaneously.

4. Information systems solving knowledge problems are made available to knowledge workers and solution seekers. Artificial intelligence is applied in these systems. For example, neural networks are statistically oriented tools that excel at using data to classify cases into one category or another. Another example is expert systems that can enable the knowledge of one or a few experts to be used by a much broader group of workers requiring the knowledge.

   According to Alavi and Leidner (2001), an insurance company was faced with the commoditization of its market, and declining profits. The company found that applying the best decision-making expertise via a new underwriting process, supported by a knowledge management system based on best practices, enabled it to move into profitable niche markets and, hence, to increase income.

   According to Grover and Davenport (2001), artificial intelligence is applied in rule-based systems, and more commonly, case-based systems are used to capture and provide access to resolutions of customer service problems, legal knowledge, new product development knowledge, and many other types of knowledge.

   Biodiversity is a data-intense science, drawing as it does on data from a large number of disciplines in order to build up a coherent picture of the extent and trajectory of life on earth. Bowker (2000) argues that as sets of heterogeneous databases are made to converge, there is a layering of values into the emergent infrastructure. This layering process is relatively irreversible, and it operates simultaneously at a very concrete level (fields in a database) and at a very abstract one (the coding of the relationship between the disciplines and the production of a general ontology).

   Knowledge is explicated and formalized during the knowledge codification phase that took place in Stage 3. Codification of tacit knowledge is facilitated by mechanisms that formalize and embed it in documents, software, and systems. However, the higher the tacit elements of the knowledge, the more difficult it is to codify. Codification of complex knowledge frequently relies on information technology. Expert systems, decision support systems, document management systems, search engines, and relational database tools represent some of the technological solutions developed to support this phase of knowledge management. Consequently, advanced codification of knowledge emerges in Stage 4, rather than in Stage 3, because expert systems and other artificial intelligence systems have to be applied to be successful.

   Stage 4 can be labeled how-they-think or people-to-systems, where the system is intended to help solve a knowledge problem. The label how-they-think does not mean that the systems, as such, think. Rather, it means that the thinking of people has been implemented in the systems.

Stage 1 is a technology-centric stage, while Stage 2 is a people-oriented stage, Stage 3 is a technology-driven stage, while Stage 4 is a process-centric stage. A people- oriented perspective draws from the work of Nonaka et al. (Nonaka, Toyama, & Konno, 2000). Essential to this perspective of knowledge sharing and knowledge creation is that people create knowledge, and that new knowledge, or the increasing of the extant knowledge base, occurs as a result of human cognitive activities and the effecting of specific knowledge transformations (Wasko & Faraj, 2005). A technology-driven perspective to knowledge management at Stage 3 is often centered on the computerized technique of data mining, and the many mathematical and statistical methods available to transform data into information and then meaningful knowledge (e.g., Poston & Speier, 2005). A process-centric approach tries to combine the essentials of both the people-centric and the technology-centric and technology-driven perspectives in the earlier stages. It emphasizes the dynamic and ongoing nature of the process, where artificial intelligence might help people understand how to proceed in their tasks. Process-centered knowledge generation is concerned with extraction of critical and germane knowledge in a decision-making perspective (Bendoly, 2003).

The stages-of-growth model for knowledge management technology is mainly a sequential and accumulative model. However, in practice, the model can also be applied in a cyclical mode. For example, when a firm reaches 2020 in Figure 1, the firm might return to Stage 3 from Stage 4 to improve information sources and information access at Stage 3 that will improve the performance of systems applied at Stage 4. Therefore, in a short-term perspective, the stages model is sequential, while in a long-term perspective it consists of several cycles.

When companies want to use knowledge in real-time, mission-critical applications, they have to structure the information base for rapid, precise access. A Web search yielding hundreds of documents will not suffice when a customer is waiting on the phone for an answer. Representing and structuring knowledge is a requirement that has long been addressed by artificial intelligence researchers in the form of expert systems and other applications. Now their technologies are being applied within the context of knowledge management. Rule-based systems and case-based systems are used to capture and provide access to customer service problem resolution, legal knowledge, new product development knowledge, and many other types of knowledge. Although it can be difficult and labor-intensive to author a structured knowledge base, the effort can pay off in terms of faster responses to customers, lower cost per knowledge transaction, and lessened requirements for experienced, expert personnel (Grover & Davenport, 2001).

Expert systems are in Stage 4 in the proposed model. Stewart (1997) argues for Stage 2, stating that knowledge grows so fast that any attempt to codify all is ridiculous; but the identities of in-house experts change slowly. Corporate yellow pages should be easy to construct, but it's remarkable how few companies have actually done this. A simple system that connects inquirers to experts saves time, reduces error and guesswork, and prevents the reinvention of countless wheels.

What may be stored in Stage 3, according to Stewart (1997), are lessons learned and competitor intelligence. A key way to improve knowledge management is to bank lessons learned, in effect, prepare checklists of what went right and wrong, together with guidelines for others undertaking similar projects. In the area of competitor intelligence, companies need to organize knowledge about their suppliers, customers, and competitors.

Information technology can be applied at four different levels to support knowledge management in an organization, according to the proposed stages of growth. At the first level, end-user tools are made available to knowledge workers. At the second level, information on who knows what is made available electronically. At the third level, some information representing knowledge is stored and made available electronically. At the fourth level, information systems capable of simulating human thinking are applied in the organization. These four levels are illustrated in Figure 2, where they are combined with knowledge management tasks. The entries in the figure only serve as examples of current systems.

One reason for Stage 3 emerging after Stage 2 is the personalization strategy vs. the codification strategy. The individual barriers are significantly lower with the personalization strategy, because the individual professional maintains the control through the whole knowledge management cycle. According to Disterer (2001), the individual is recognized as an expert and is cared for.

Knowledge management strategies focusing on personalization could be called communication strategies, because the main objective is to foster personal communication between people. Core IT systems with this strategy are yellow pages (directories of experts, who-knows-what systems, people finder database) that show inquirers who they should talk to regarding a given topic or problem. The main disadvantages of personalization strategies are a lack of standards, the high dependence on communication skills, and the will of the professionals. Such disadvantages make firms want to advance to Stage 3. In Stage 3, independence, in time, among knowledge suppliers and knowledge users is achieved (Disterer, 2002).

When we look for available computer software for the different stages, we find a variety of offers from software vendors. At Stage 1, we find Microsoft software such as Word, Outlook, Excel, and Powerpoint. At Stage 2, we find knowledge software such as Knowledger from Knowledge Associates (http://www.knowledgeassociates.com). The Knowledger 4.0 helps companies collect and categorize internal and external information. It allows individuals to capture information, together with its context, into a knowledge repository.

At Stage 3, we find Novo Knowledge Base Enterprise (http://www.novosolutions.com), Confluence the Enterprise Wiki (http://www.atlassian.com), and Enterprise Edition X1 Technologies (http://www.x1.com). While Novo's KnowledgeBase provides Web support and documentation solutions, Atlassian's JIRA is tracking and managing the issues and bugs that emerge during a project.

Figure 2. Examples of IS/IT in different knowledge management stages

STAGES TASKS	**I END USER TOOLS people-to-technology**	**II WHO KNOWS WHAT people-to-people**	**III WHAT THEY KNOW people-to-docs**	**IV WHAT THEY THINK people-to-systems**
Distribute knowledge	Word Processing Desktop Publishing Web Publishing Electronic Calendars Presentations	Word Processing Desktop Publishing Web Publishing Electronic Calendars Presentations	Word Processing Desktop Publishing Web Publishing Electronic Calendars Presentations	Word Processing Desktop Publishing Web Publishing Electronic Calendars Presentations
Share knowledge		Groupware Intranets Networks E-mail	Groupware Intranets Networks E-mail	Groupware Intranets Networks E-mail
Capture knowledge			Databases Data Warehouses	Databases Data Warehouses
Apply knowledge				Expert systems Neural networks Intelligent agents

Finally, at Stage 4, we find DecisionScript by Vanguard Software Corporation (http://www.vanguardsw.com) and CORVID Knowledge Automation Expert System Software by Xsys (http://www.exsys.com). Vanguard provides decision-support system software ranging from desktop tools for managing decision-making to server-based systems that help the entire organization work smarter. Vanguard's desktop software, DecisionPro, is designed for managers, consultants, and analysts who make business decisions based on uncertain estimates and imperfect information. Exsys argues that their software and services enable businesses, government, and organizations to distribute a company's most valuable asset-expert knowledge-to the people who need it, through powerful interactive Web-enabled systems.

Benchmark variables have been developed by Gottschalk (2005) for the stages-of-growth model. Benchmark variables indicate the theoretical characteristics in each stage of growth. Examples of benchmark variables include trigger of IT, management participation, critical success factor, and performance indicator.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Benbasat, I., Dexter, A. S., Drury, D. H., & Goldstein, R. C. (1984). A critique of the stage hypothesis: Theory and empirical evidence. *Communications of the ACM, 27*(5), 476-485.

Bendoly, E. (2003). Theory and support for process frameworks of knowledge discovery and data mining from ERP systems. *Information & Management, 40,* 639-647.

Bock, G. W., Zmud, R. W., & Kim, Y. G. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly, 29*(1), 87-111.

Bowker, G. C. (2000). Biodiversity datadiversity. *Social Studies of Science, 30*(5), 643-683.

Byers, C., & Byers, W. A. (1998, June). *Sliding scale: A technique to optimize the assessment of knowledge level through ordering theory.* Annual Conference of the International Personnel Management Association Assessment Council, Chicago. Retrieved from http://www.ipmaac.org/conf98/byers.pdf

Disterer, G. (2001). Individual and social barriers to knowledge transfer. In *Proceedings of the 34th Hawaii International Conference on Systems Sciences (HICSS-34).* IEEE.

Disterer, G. (2002). *Veränderungen der Rechtsberufe durch neue Technologien. Beispiel: Wissensmanagement bei Anwälten.* Arbeidspapier 68/2002, Fachbereich Wirtschaft, Fachhochschule Hannover, Germany.

Earl, M. J. (2000). Evolving the e-business. *Business Strategy Review, 11*(2), 33-38.

Earl, M. J. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Fichman, R. G., & Kemerer, C. F. (1997). The assimilation of software process innovations: An organizational learning perspective. *Management Science, 43*(10), 1345-1363.

Frankfort-Nachmias, C., & Nachmias, D. (2002). *Research methods in the social sciences* (5th ed.). Arnold.

Garud, R., & Kumaraswamy, A. (2005). Vicious and virtuous circles in the management of knowledge: The case of Infosys Technologies. *MIS Quarterly, 29*(1), 9-33.

Gottschalk, P. (2005). *Strategic knowledge management technology.* Hershey, PA: Idea Group Publishing.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Guttman, L. (1950). The basis for scalogram analysis. In S. A. Stouffer, L. Guttman, E. A. Suchman, P. F. Lazardsfeld, S. A. Star, & J. A. Clausen (Eds.), *Measurement and prediction, studies in social psychology in World War II, IV,* (pp. 60-90). Princeton University Press.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March-April). *What's your strategy for managing knowledge?* Harvard Business Review, 106-116.

Housel, T., & Bell, A. H. (2001). *Measuring and managing knowledge.* New York: McGraw-Hill Irwin.

Kankanhalli, A., Tan, B. C. Y., & Wei, K. K. (2005). Contributing knowledge to electronic knowledge repositories: An empirical investigation. *MIS Quarterly, 29*(1), 113-143.

Kazanjian, R. K. (1988). Relation of dominant problems to stages of growth in technology-based new ventures. *Academy of Management Journal, 31*(2), 257-279.

Kazanjian, R. K., & Drazin, R. (1989). An empirical test of a stage of growth progression model. *Management Science, 35*(12), 1489-1503.

King, W. R., & Teo, T. S. H. (1997). Integration between business planning and information systems planning: Validating a stage hypothesis. *Decision Sciences, 28*(2), 279-307.

Kline, P. (1998). *The new psychometrics: Science, psychology and measurement.* Routledge.

Ko, D. G., Kirsch, L. J., & King, W. R. (2005). Antecedents of knowledge transfer from consultants to clients in enterprise system implementations. *MIS Quarterly, 29*(1), 59-85.

Levina, N., & Vaast, E. (2005). The emergence of boundary spanning competence in practice: Implications for implementation and use of information systems. *MIS Quarterly, 29*(2), 335-363.

Lin, L., Geng, X., & Whinston, A. B. (2005). A sender-receiver framework for knowledge transfer. *MIS Quarterly, 29*(2), 197-219.

Malhotra, A., Gosain, S., & El Sawy, O. A. (2005). Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation. *MIS Quarterly, 29*(1), 145-187.

Nolan, R. L. (1979, March-April). Managing the crises in data processing. *Harvard Business Review,* 115-126.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34

Poston, R. S., & Speier, C. (2005). Effective use of knowledge management systems: A process model of content ratings and credibility indicators. *MIS Quarterly, 29*(2), 221-244.

Ryu, C., Kim, Y. J., Chaudhury, A., & Rao, H. R. (2005). Knowledge acquisition via three learning processes in enterprise information portals: Learning-by-investment, learning-by-doing, and learning-from-others. *MIS Quarterly, 29*(2), 245-278.

Sprague, R. H. (1995, March). Electronic document management: Challenges and opportunities for information systems managers. *MIS Quarterly,* 29-49.

Stewart, T. A. (1997). *Intellectual capital: The new wealth of organizations.* Nicholas Brealy Publishing.

Trochim (2002). *Guttman scaling.* Retrieved from http://trochim. human.cornell.edu/kb/scalgutt.htm

Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. *Information Systems Research, 11*(4), 342-365.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186-204.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly, 29*(1), 35-57.

Zack, M. H. (1999). Developing a knowledge strategy. *California Management Review, 41*(3), 125-145.

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Chapter 2.7
Knowledge Management Systems

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INTRODUCTION

Knowledge management systems (KMSs) are seen as enabling technologies for an effective and efficient knowledge management (KM). However, up to date the term knowledge management system has often been used ambiguously. Examples are its use for specific KM tools, for KM platforms, or for (a combination of) tools that are applied with KM in mind. So far, investigations about the notion of KMS remain on the abstract level of what a KMS is used for, for example, "a class of information systems applied to managing organizational knowledge" (Alavi & Leidner, 2001, p. 114). The following two sections define the term KMS and obtain a set of characteristics that differentiates KMS from traditional information systems, such as intranet infrastructures, document- and content-management systems, groupware, or e-learning systems. Then, two ideal architectures for KMS are contrasted. It is discussed which KMS architecture fits what type of KM initiatives, and some empirical findings on the state of practice of KMS are summarized. The last sections give an outlook on future trends and conclude the article.

BACKGROUND

A review of the literature on information and communication technologies to support KM reveals a number of different terms in use, such as knowledge warehouse, KM software, KM suite, KM (support) system, and KM technology as well as learning-management platform, learning-management portal, learning-management suite, learning-management system, or organizational-memory (information) system (e.g., Alavi & Leidner, 2001; Maier, 2004; McDermott, 1999; Mentzas, Apostolou, Young, & Abecker, 2001; Nedeß & Jacob, 2000; Schwartz, Divitini, & Brasethvik, 2000; Seifried & Eppler, 2000; Stein & Zwass, 1995). In addition to these terms meaning a comprehensive platform in support of KM, many authors provide more or less extensive lists of individual tools or technologies that can be used to support KM initiatives as a whole or for certain processes, life-cycle phases, or tasks thereof (e.g., Allee, 1997; Binney, 2001; Borghoff & Pareschi, 1998; Hoffmann, 2001; Jackson, 2003; Meso & Smith, 2000; Ruggles, 1998).

TOWARD A DEFINITION OF KNOWLEDGE MANAGEMENT SYSTEMS

Recently, the terms KM tools and KMS have gained wide acceptance both in the literature and on the market. Consequently, we use the term KMS being well aware that there are a number of similar conceptualizations that complement the functionality and architectures of KMS. In the following, we will summarize the most important characteristics of KMS as found in the literature.

Goals

The primary goal of KMS is to bring knowledge from the past to bear on present activities, thus resulting in increased levels of organizational effectiveness (Lewin & Minton, 1998; Stein & Zwass, 1995). Thus, a KMS is the technological part of a KM initiative that also comprises person-oriented and organizational instruments targeted at improving the productivity of knowledge work (Maier, 2004). KM initiatives can be classified according to the strategy in human-oriented personalization initiatives and technology-oriented codification initiatives (Hansen, Nohria, & Tierney, 1999). They can further be distinguished according to the scope into enterprise-specific initiatives and initiatives that cross organizational boundaries. According to organizational design, initiatives can establish a central organizational unit responsible for KM, or they can be run by a number of projects and/or communities. The initiatives can focus on a certain type of content along the knowledge life cycle, for example, ideas, experiences, lessons learned, approved knowledge products, procedures, best practices, or patents. Finally, the organizational culture can be characterized as open, trustful, or collective where willingness to share knowledge is high; or as confidential, distrustful, or individual where there are high barriers to knowledge sharing (see Maier, 2004, for a definition of and empirical results about this typology of KM initiatives). The type of initiative determines the type of KMS for its support.

Processes

KMSs are developed to support and enhance knowledge-intensive tasks, processes, or projects (Detlor, 2002; Jennex & Olfmann, 2003) of, for example, knowledge creation, organization, storage, retrieval, transfer, refinement and packaging, (re)use, revision, and feedback, also called the knowledge life cycle, ultimately to support knowledge work (Davenport, Jarvenpaa, & Beers, 1996). In this view, a KMS provides a seamless pipeline for the flow of explicit knowledge through a refinement process (Zack, 1999).

Comprehensive Platform

Whereas the focus on processes can be seen as a user-centric approach, an IT-centric approach provides a base system to capture and distribute knowledge (Jennex & Olfmann, 2003). This platform is then used throughout the organization. In this case, a KMS is not an application system targeted at a single KM initiative, but a platform that can be used either as is to support knowledge processes or as the integrating base system and repository on which KM application systems are built. Comprehensive in this case means that the platform offers functionality for user administration, messaging, conferencing, and the sharing of (documented) knowledge, that is, publishing, searching, retrieving, and presenting.

Advanced Knowledge Services

KMSs are ICT platforms on which a number of integrated services are built. The processes that have to be supported give a first indication of the types of services that are needed. Examples are rather basic services, for example, collaboration, work-flow management, document and content management, visualization, search, and retrieval (e.g., Seifried & Eppler, 2000); or more advanced services, for example, personalization, text analysis, clustering and categorization to increase the relevance of retrieved and pushed information, advanced graphical techniques for navigation, awareness services, shared work spaces, and (distributed) learning services as well as the integration of and reasoning about various (document) sources on the basis of a shared ontology (e.g., Bair, 1998; Borghoff & Pareschi, 1998; Maier, 2004).

KM Instruments

KMSs are applied in a large number of application areas (Tsui, 2003) and specifically support KM instruments, such as (a) the capture, creation, and sharing of good or best practices, (b) the implementation of experience-management systems, (c) the creation of corporate knowledge directories, taxonomies, or ontologies, (d) competency management, (e) collaborative filtering and handling of interests used to connect people, (f) the creation and fostering of communities or knowledge networks, or (g) the facilitation of intelligent problem solving (e.g., Alavi & Leidner, 2001; McDermott, 1999; Tsui, 2003). Thus, KMSs offer a targeted combination and integration of knowledge services that together foster one or more KM instruments.

Specifics of Knowledge

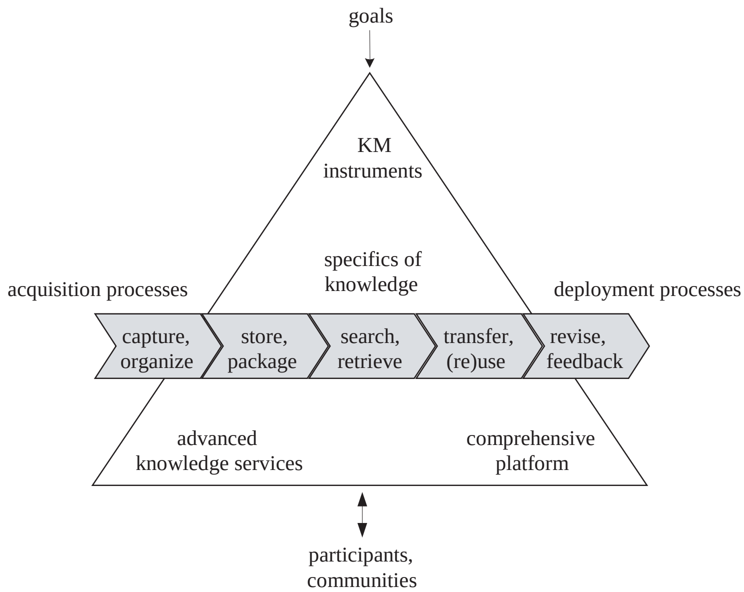
KMSs are applied to managing knowledge that is described as "personalized information…related to facts, procedures, concepts, interpretations, ideas, observations, and judgements" (Alavi & Leidner, 2001). From the perspective of KMS, knowledge is information that is meaningfully organized, accumulated, and embedded in a context of creation and application. KMSs primarily leverage codified knowledge, but also aid communication or inference used to interpret situations and to generate activities, behaviour, and solutions. KMSs help to assimilate contextualized information, provide access to sources of knowledge, and, with the help of shared context, increase the breadth of knowledge sharing between persons rather than storing knowledge itself (Alavi & Leidner, 2001).

Participants

The internal context of knowledge describes the circumstances of its creation. The external context relates to the retrieval and application of knowledge (Barry & Schamber, 1998; Eppler, 2003). Contextualization is one of the key characteristics of KMS (Apitz, Lattner, & Schäffer, 2002) that provides a semantic link between explicit, codified knowledge and the persons that hold or seek knowledge in certain subject areas. Thus, it creates a network of artifacts and people, of memory and of processing (Ackerman & Halverson, 1998). Decontextualization and recontextualization turn static knowledge objects into knowledge processes (Ackerman & Halverson, 1998). Metaknowledge in a KMS is sometimes as important as the original knowledge itself (Alavi & Leidner, 2001). Therefore, users play the roles of active, involved participants in the knowledge network fostered by KMS.

In addition to the previous characteristics, a KMS has to be aligned with the specifics of its

Figure 1. Characteristics of KMS



application environment, the goals, and the types of KM initiatives as well as the acquisition and deployment processes required for managing knowledge (see Figure 1).

Consequently, a KMS is defined as a comprehensive ICT platform for collaboration and knowledge sharing with advanced knowledge services built on top that are contextualized and integrated on the basis of a shared ontology, and personalized for participants networked in communities. KMSs foster the implementation of KM instruments in support of knowledge processes targeted at increasing organizational effectiveness.

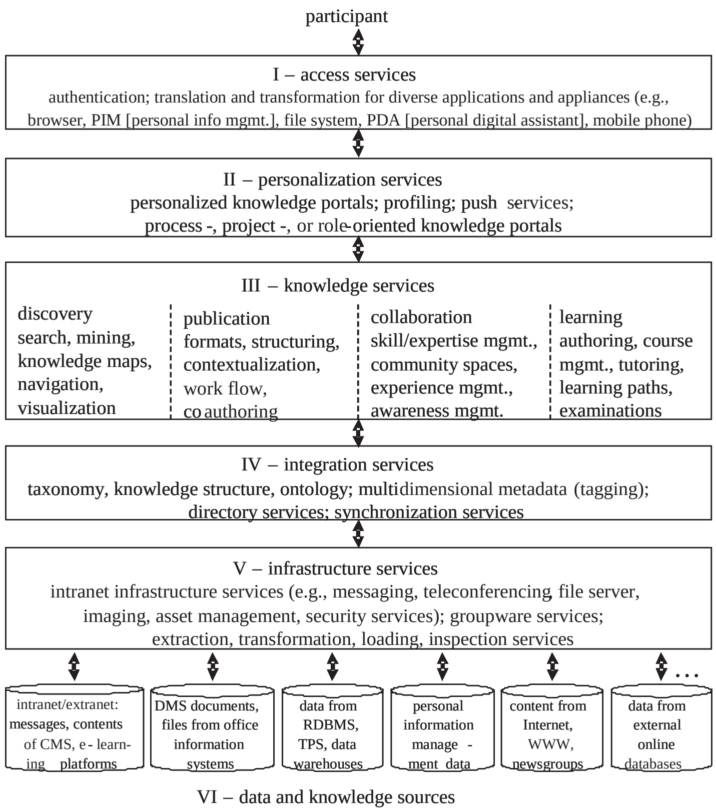
Actual implementations of ICT systems certainly fulfill the characteristics of an ideal KMS only to a certain degree. Thus, a continuum between traditional IS and advanced KMS might be imagined with minimal requirements providing some orientation (see Maier & Hädrich, 2004).

ARCHITECTURES FOR KNOWLEDGE MANAGEMENT SYSTEMS

There are basically two ideal types of architectures of KMS: centralistic KMS and peer-to-peer (p2p) KMS.

Many KMS solutions implemented in organizations and offered on the market are centralistic client-server solutions (Maier, 2004). Figure 2 shows an ideal layered architecture for KMS that represents an amalgamation of theory-driven (e.g., Apitz et al., 2002; Zack, 1999), market-oriented (e.g., Applehans, Globe, & Laugero, 1999; Bach, Vogler, & Österle, 1999), and vendor-specific architectures (e.g., Hyperwave, Open Text Livelink). A thorough analysis of these architectures and the process of amalgamation can be found in Maier, 2004. The ideal architecture is oriented toward the metaphor of a central KM server that integrates

Figure 2. Architecture of a centralized KMS



all knowledge shared in an organization and offers a variety of services to the participant or to upward layers (see Figure 2).

Data and knowledge sources include organization-internal as well as organization-external sources, and sources of structured as well as semi-structured information and knowledge.

Infrastructure services provide basic functionality for synchronous and asynchronous communication, sharing of data and documents as well as the management of electronic assets. Extraction, transformation, and loading tools provide access to data and knowledge sources. Inspection services (viewers) are required for heterogeneous data and document formats.

Integration services help to meaningfully organize and link knowledge elements from a variety of sources by means of an ontology. They are used to analyze the semantics of the organizational knowledge base and to manage metadata about knowledge elements and users. Synchronization services export and (re)integrate a portion of the knowledge work space for work off-line.

Knowledge services provide intelligent functions for discovery, that is, the search, retrieval, and presentation of knowledge elements and experts; publication, that is, the structuring, contextualization, and release of knowledge elements; collaboration, the joint creation, sharing, and application of knowledge; and learning, the authoring that is supported by tools and tools for managing courses, tutoring, learning paths, and examinations as well as the reflection on learning and knowledge processes established in the organization (commonly referred to as double-loop learning; see Argyris & Schön, 1978).

Personalization services provide more effective access to the large amounts of knowledge elements. Subject-matter specialists or managers of knowledge processes can organize a portion of the KMS contents and services for specific roles or develop role-oriented push services. The services can be personalized with the help of, for example, (automated) interest profiles, personal category nets, and personalized portals.

Access services transform contents and communication to and from the KMS to fit heterogeneous applications and appliances. The KMS has to be protected against eavesdropping and unauthorized use by tools for authentication and authorization.

Recently, the peer-to-peer (p2p) metaphor has gained increasing attention from both academics and practitioners (e.g., Barkai, 1998; Schoder, Fischbach, & Teichmann, 2002). There have been several attempts to design information-sharing systems or even KMSs to profit from the benefits of this metaphor (Benger, 2003; Maier & Sametinger, 2004; Parameswaran, Susarla, & Whinston, 2001; Susarla, Liu, & Whinston, 2003). This promises to resolve some of the shortcomings of centralized KMS, for example:

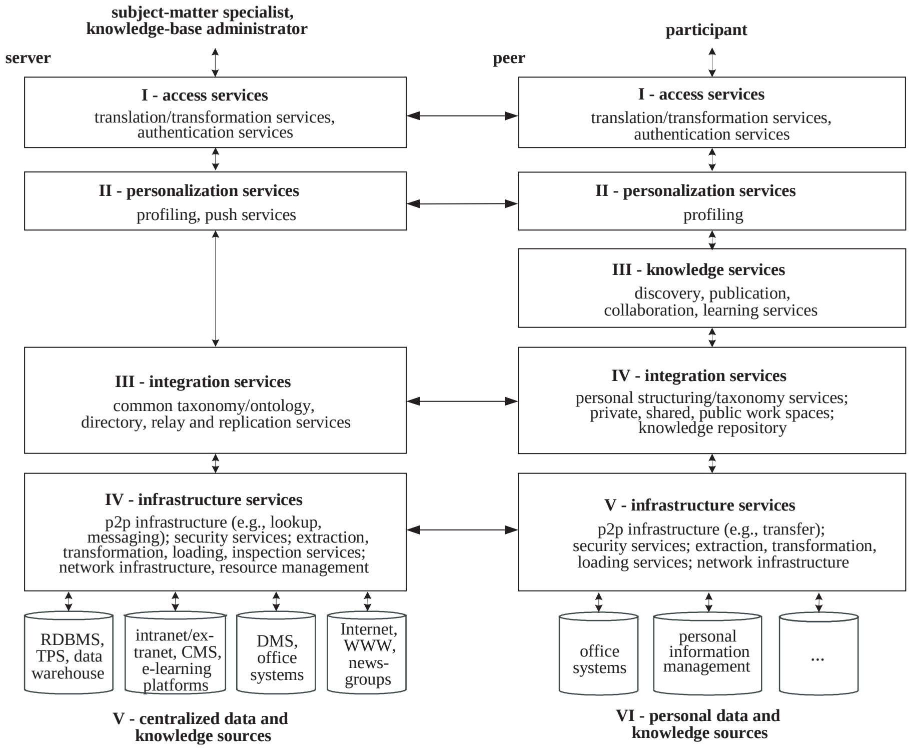
- to reduce the costs of the design, implementation, and maintenance of a centralized knowledge server,
- to overcome the limitations of a KMS that focuses on organization-internal knowledge whereas many knowledge processes cross organizational boundaries,
- to reduce the barriers to actively participate and share in the benefits of a KMS, and
- to seamlessly integrate the shared knowledge work space with personal knowledge work spaces and messaging objects.

However, there is no common architecture or an agreed list of functions yet for this type of KMS. Generally, the p2p label is used for different architectures, for example, pure p2p architectures or hybrid architectures such as assisted and super p2p architectures (e.g., Dustdar, Gall, & Hauswirth, 2003). The more functionality for central coordination that is required in a p2p system, as is the case in a KMS, the more likely it is that some kind of assistance by a server is needed to coordinate the system (hybrid architecture). Still, the difference to the centralized architecture is that p2p systems allow users to develop personal knowledge bases locally and to directly share knowledge with other peers without the need to design a shared space on a server. Figure 3 depicts the architecture of a peer and a server to assist the network. Both architectures basically consist of the same layers as the architecture of the centralized KMS.

The differences between a single peer's architecture and the centralistic architecture are the following:

- Infrastructure services handle personal data and knowledge sources and provide the p2p infrastructure for locating peers, exchanging data with other peers, and assuring the security of the personal knowledge base.
- Integration services handle the meta-data of the knowledge objects in the personal knowledge base and establish a personal ontology. Private work spaces contain information that is only accessible by its owner. Public work spaces hold knowledge objects that are published via the Internet. Protected work spaces contain knowledge objects that are accessible by a single peer or a group of peers that the owner explicitly grants access to.
- Knowledge services build upon the knowledge base, just as in the centralized case.

Figure 3. Architecture of server and peer



The knowledge repository is now spread across a number of collaborating peers.

- Personalization services build on individual user profiles and on centralized personalization services provided by the server.
- Access services are similar to those in the centralized KMS architecture.

The differences between a server's architecture and the centralistic architecture are the following:

- Infrastructure services enable a server to access a number of additional shared data and knowledge sources. He provides services for lookup and message handling that improve the efficiency of the p2p infrastructure.
- Integration services offer a shared ontology for the domain handled by, for example, a network of subject-matter specialists. This addresses the challenge in a distributed KMS that the personal knowledge bases cannot be integrated without a mapping of ontologies. The server might offer replication services to peers that sometimes work off line.
- There are no central knowledge services in addition to the peers' services.
- Personalization services include profiles and push services that ease in accessing the organized collection of (quality-approved or even-improved) knowledge that the subject-matter specialists administer.
- Access services are restricted to the administration of the server, the central knowledge

structure, and the profiles for personalization.

DISCUSSION

Centralized KMSs offered on the market differ with respect to the extent and intensity with which they cover the services included in the centralized architecture. Some focus on learning management (e.g., Hyperwave), integration (e.g., Lotus Notes/Workspace), discovery (e.g., Verity K2 Enterprise), publication (e.g., Open Text Livelink), collaboration (e.g., Quovix CommunityBuilder), or on access and personalization (portal solutions, e.g., Plumtree Corporate Portal, SAP Enterprise Portal). In addition to several research prototypes (e.g., Benger, 2003; Maier & Sametinger, 2004), Groove Networks Groove is an example for a p2p collaboration tool that is readily available on the market and at least offers some of the functions that are needed in KM (Maier & Hädrich, 2004).

Table 1 shows for what type of KM initiative centralized and p2p KMSs are suited. Consequently, a centralized KMS seems to be more adequate for a KM initiative that can be described as a codification initiative restricted to the organization's boundaries and managed by a central organizational unit that fosters the handling of all types of knowledge. A p2p information-sharing system targets a KM initiative that can be described as a personalization initiative involving members from a number of institutions. Thus, the initiative is managed decentrally, requiring an open, trustful, collective organizational culture and a focus on the exchange of individual knowledge, ideas, and experiences.

However, there are still serious technical challenges that have to be overcome in p2p computing in general. These challenges concern connectivity, security, and privacy, especially the risk of spreading viruses, unauthorized access to confidential and private information, the installation of unwanted applications, fault tolerance, availability, and scalability (Barkai, 1998). There are also organizational issues that have to be resolved before a p2p KMS can be fully deployed in an organization, for example, the coordination issue, meaning that structuring and quality management of the knowledge contained in a p2p network have to be supported.

In the following, the state of practice of KMS is summarized in the form of theses that describe activities concerning KMS in German-speaking countries as investigated in an empirical study conducted by one of the authors (Maier, 2004).

1. Almost all large organizations have an intranet and/or groupware platform in place that offers a solid foundation for KMS. These platforms, together with a multitude

Table 1. Type of KMS and type of KM initiative

characteristics	centralized KMS	p2p KMS
strategy	codification	personalization
organizational design	central	decentralized
content	primarily lessons learned, (approved) knowledge products, and secured knowledge, but also ideas, experiences, and individual contents	individual contents, ideas, and results of group sessions and experiences
organizational culture	both types of culture (restrictive or loose user privileges)	open, trustful culture

of extensions and add-on tools, provide good basic KM functionality, for example, the easy sharing of documents and access to company information.

2. Large organizations have also already implemented KM-specific functions. Most rely on the centralized KMS architecture, but many experiment with p2p solutions. Many of the implemented functions are not used intensively, in some cases due to technical problems, but mostly because they require substantial organizational changes and significant administrative effort.
3. The majority of organizations relies on organization-specific developments and combinations of tools and systems rather than on standard KMS solutions. The market for KMS solutions is a confusing and dynamic one, and integration with existing systems is often difficult. Organizations might also fear the loss of strategic advantages if they exchange their homegrown KMS solutions for standard software.
4. There has been a strong emphasis on explicit, documented knowledge. This is not surprising as in many cases large amounts of documents have already existed in electronic form, and improved handling of documents and the redesign of corresponding business processes can quickly improve organizational effectiveness. Recently, there has been a trend toward collaboration and learning functions because technical requirements for media-rich electronic communication can now be met at reasonable costs.
5. Comprehensive KMSs are highly complex ICT systems because of (a) the technical complexity of advanced knowledge services and of large volumes of data, documents, messages, and links as well as contextualization and personalization data, (b) the organizational complexity of a solution that affects business and knowledge processes throughout the organization, and (c) human complexity due to the substantial change in habits, roles, and responsibilities that is required as KMSs have to be integrated into daily practices of knowledge work.
6. In many organizations, a multitude of partial systems is developed without a common framework that could integrate them. Some organizations also build enterprise knowledge portals that at least integrate access to ICT systems relevant for the KM initiative. Only recently have comprehensive and integrated KMSs offered functionality integrated within one system and realized the vision of an enterprise knowledge infrastructure (Maier, Hädrich & Peinl, 2005).

FUTURE TRENDS

Generally, there has been a shift in the perspective of KMS vendors as well as organizations applying those systems from a focus on documents containing knowledge, and thus from a pure codification strategy, to a combination and integration of functions for handling internal and external contexts, locating experts, managing competency, and so forth that bridges the gap to a personalization strategy (Maier, 2004). Advanced functions supporting collaboration in teams and communities, tools linking knowledge providers and seekers, and e-learning functionality have been integrated into many centralized KMSs. This trend will continue as many organizations strive to profit from the promised benefits of comprehensive ICT platforms for the increase of productivity of knowledge work and, consequently, of organizational effectiveness.

CONCLUSION

This article has studied the notion of the term KMS. Ideal architectures for centralized and peer-to-peer KMSs were contrasted. Each of these architectures targets a different type of KM initiative. Summing up, it seems that centralized KMSs offered on the market more and more live up to the expectations of organizations ready to apply ICT to support a KM initiative. Peer-to-peer KMSs promise to resolve some of the shortcomings of centralized KMS, especially concerning the time-consuming effort to build and maintain a central knowledge repository. However, major challenges still lie ahead until peer-to-peer systems can truly be called KMSs and can be used to support the still-growing share of users involved in knowledge work.

There seem to be four main approaches to deploying KMSs in organizations: (a) A KMS can be seen as a general infrastructure that supports knowledge work throughout the organization, (b) business processes, projects, and/or theme-oriented activities are the nexus of knowledge and thus are specifically targeted by KMSs, (c) communities and knowledge networks can be fostered by ICT, which aids knowledge sharing throughout the life cycle of these organizational entities, and (d) certain types of knowledge, for example, lessons learned and best practices, can be at the core of the design of a KMS.

REFERENCES

Ackerman, M. S., & Halverson, C. (1998). Considering an organization's memory. *Proceedings of ACM 1998 Conference on Computer Supported Cooperative Work* (pp. 39-48).

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Allee, V. (1997). *The knowledge evolution: Expanding organizational intelligence.* Boston: Butterworth-Heinemann.

Apitz, R., Lattner, A., & Schäffer, C. (2002). Kontextbasiertes Wissensmanagement in der Produktentwicklung als Grundlage für anpassungsfähige Unternehmen. *Industrie Management, 18*(3), 32-35.

Applehans, W., Globe, A., & Laugero, G. (1999). *Managing knowledge: A practical Web-based approach.* Reading, MA: Addison-Wesley.

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action perspective.* Reading, MA: Addison-Wesley.

Bach, V., Vogler, P., & Österle, H. (Eds.). (1999). *Business Knowledge Management: Praxiserfahrungen mit Intranet-basierten Lösungen.* Berlin, Germany: Springer.

Bair, J. (1998). *Dimensions of KM technology selection* (Rep. No. T-05-0592). Stamford, CT: Gartner Group.

Barkai, D. (1998). *Peer-to-peer computing: Technologies for sharing and collaborating on the Net.* Hillsboro, OR: Intel Press.

Barry, C. L., & Schamber, L. (1998). Users' criteria for relevance evaluation: A cross-situational comparison. *Information Processing & Management, 34*(2-3), 219-236.

Benger, A. (2003). Dezentrales, selbstorganisierendes Wissensmanagement. In N. Gronau (Ed.), Wissensmanagement: Potenziale, Konzepte, Werkzeuge. *Proceedings of the 4th Oldenburg Conference on Knowledge Management* (pp. 155-170). Berlin, Germany: Gito.

Binney, D. (2001). The knowledge management spectrum: Understanding the KM landscape. *Journal of Knowledge Management, 5*(1), 33-42.

Borghoff, U. M., & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management.* Berlin, Germany: Springer.

Davenport, T. H., Jarvenpaa, S. L., & Beers, M. C. (1996). Improving knowledge work processes. *Sloan Management Review, 37*(4), 53-65.

Detlor, B. (2002). An informational perspective towards knowledge work: Implications for knowledge management systems. In D. White (Ed.)*, Knowledge mapping and management* (pp. 195-205). Hershey, PA: IRM Press.

Dustdar, S., Gall, H., & Hauswirth, M. (2003). Peer-to-Peer-Architekturen. In S. Dustdar, H. Gall, & M. Hauswirth (Eds.), *Software-Architekturen für verteilte Systeme* (pp. 161-198). Berlin, Germany: Springer.

Eppler, M. J. (2003). *Managing information quality: Increasing the value of information in knowledge-intensive products and processes*. Berlin, Germany: Springer.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(3-4), 106-116.

Hoffmann, I. (2001). Knowledge management tools. In K. Mertins, P. Heisig, & J. Vorbeck (Eds.), *Knowledge management: Best practices in Europe* (pp. 74-94). Berlin, Germany: Springer.

Jackson, C. (2003). *Process to product: Creating tools for knowledge management.* Retrieved October 15, 2004, from http://www.brint.com/members/online/120205/jackson/

Jennex, M., & Olfmann, L. (2003). Organizational memory. In C. W. Holsapple (Ed.), *Handbook on knowledge management: Vol. 2. Knowledge directions* (pp. 207-234). Berlin, Germany: Springer.

Lewin, A. Y., & Minton, J. W. (1998). Determining organizational effectiveness: Another look, and an agenda for research. *Management Science, 32*(5), 514-553.

Maier, R. (2004). *Knowledge management systems: Information and communication technologies for knowledge management* (2nd ed.). Berlin, Germany: Springer.

Maier, R., & Hädrich, T. (2004). *Centralized versus peer-to-peer knowledge management systems.* Paper presented at the 5th European Conference on Organizational Knowledge, Learning and Capabilities (OKLC), Innsbruck.

Maier, R., Hädrich, T., Peinl, R. (2005). *Enterprise Knowledge Infrastructures.* Berlin, Germany: Springer.

Maier, R., & Sametinger, J. (2004). Peer-to-peer information workspaces in Infotop. *International Journal of Software Engineering and Knowledge Engineering, 14*(1), 79-102.

McDermott, R. (1999). Why information technology inspired but cannot deliver knowledge management. *California Management Review, 41*(4), 103-117.

Mentzas, G., Apostolou, D., Young, R., & Abecker, A. (2001). Knowledge networking: A holistic solution for leveraging corporate knowledge. *Journal of Knowledge Management, 5*(1), 94-106.

Meso, P., & Smith, R. (2000). A resource-based view of organizational knowledge management systems. *Journal of Knowledge Management, 4*(3), 224-234.

Nedeß, C., & Jacob, U. (2000). Das Knowledge Warehouse vor der Gefahr der Komplexitätsfalle. In H. Krallmann (Ed.), *Wettbewerbsvorteile durch Wissensmanagement: Methodik und Anwendungen des Knowledge Management* (pp. 91-116). Stuttgart, Germany: Schäffer-Poeschel.

Parameswaran, M., Susarla, A., & Whinston, A. B. (2001). P2P networking: An information sharing alternative. *IEEE Computer, 34*(7), 1-8.

Ruggles, R. L. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Schoder, D., Fischbach, K., & Teichmann, R. (Eds.). (2002). *Peer-to-peer.* Berlin, Germany: Springer.

Schwartz, D. G., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D. G. Schwartz, M. Divitini, & T. Brasethvik (Eds.)*, Internet-based organizational memory and knowledge management* (pp. 1-23). Hershey, PA: IGP.

Seifried, P., & Eppler, M. J. (2000). *Evaluation führender Knowledge Management Suites: Wissensplattformen im Vergleich.* St. Gallen, Switzerland: Net Academy Press.

Stein, E., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Susarla, A., Liu, D., & Whinston, A. B. (2003). Peer-to-peer enterprise knowledge management. In C. W. Holsapple (Ed.), *Handbook on knowledge management: Vol. 2. Knowledge directions* (pp. 129-139). Berlin, Germany: Springer.

Tsui, E. (2003). Tracking the role and evolution of commercial knowledge management software. In C. W. Holsapple (Ed.), *Handbook on knowledge management: Vol. 2. Knowledge directions* (pp. 5-27). Berlin, Germany: Springer.

Zack, M. H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 2.8
Conceptual Confusions in Knowledge Management and Knowledge Management Systems:
Clarifications for Better KMS Development

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ABSTRACT

Knowledge Management and Knowledge Management Systems are slowly but surely capturing the attention of many organisations in a quest for competitive advantage. Like many other computing fads before them, there is no shortage of recipes by its proponents. This chapter discusses the emerging discipline of Knowledge Management in computing and explains the concepts underlying Knowledge Management Systems that will lead to a better development and implementation of these systems. In particular, it tackles the conceptual confusion about data, information, and knowledge, which appears to be finding its way into the Knowledge Management literature. The terms, 'capta' (Checkland, Howell, 1998) and 'constructed data' (Flood, 1999), are used in analysing these concepts to clear some of the confusion surrounding them. The use of these terms also highlights our (the IT community) taking for granted assumptions about the hierarchical relationship and the more insightful emergent relationships.

INTRODUCTION

Every few years, the IT community comes up with a promised panacea to cure all ills. There was once the push for office automation, artificial intelligence, decision support, groupware, reverse engineering, MIS, B2B, B2C and now, it is KM - Knowledge Management. These are often brilliant concepts and while they all find their level of utility, usually more modest than their proponents' claims, they have by and large been misunderstood and misapplied, to the disadvantage of some stakeholders and, ultimately, investors. This misunderstanding is often characterised by a lack of foundational concepts about the development and management of information systems, of which knowledge management systems are now a particular type.

Knowledge Management Systems (KMS) are now being touted as yet another silver bullet. How can a would-be investor in a KMS realise its anticipated benefits and how would an implementor know they are on the right path, thereby avoiding this characteristic confusion that may inevitably snuff out the promise shown by this idea? The urgency for such a conceptual cleansing is echoed by White and Sutton (2001, p. 180) who note that, "the kinds of rationalist assumptions about knowledge creation and use, which characterise Knowledge Management, are inadequate." They suggest the need for a broader approach to, and definition of, knowledge as an essential pre-requisite to attempts to harness and exploit it: otherwise, the emerging discipline may also be consigned to the ranks of yet another 'management fad'.

This chapter looks at some concepts underlying Knowledge Management and suggests some ways of bringing the concepts to bear on Knowledge Management Systems. Following this introduction, the chapter first highlights the current state of affairs and then some of the conceptual confusion in the area of Knowledge Management. This is followed by a brief overview of a target environment, which Knowledge Management Systems are supposed to serve (i.e., help organise and manage). The chapter then continues by presenting a critical analysis of some terms which KMS thrives on. The chapter then presents a conceptual cleansing that will lead to the realisation of a better KMS.

Our analysis follows a systemic account that draws heavily on concepts and insights originating from the works of Hirschheim et al. (1995) concerning information systems development methodologies, Checkland's (1998) work concerning the nature of information systems and Flood (1999) and Senge's (1995) work concerning the organisation and management of complex systems.

Current State of Affairs

The implementation of Knowledge Management Systems has generally focused on the technological capabilities of data representation and access, to the detriment of foundational concepts about the generation of data itself. As noted by Yen (2001), of the many vital issues in knowledge management, knowledge representation has been studied more thoroughly than others. However, without a foundationally coherent and consistent understanding of data, information, knowledge and the organisation and the management of complexity within the target environment (Boahene, Ditsa, 2001), all the technological sophistication is unlikely to guarantee the realisation of any anticipated benefits.

By far, the literature on KMS has focused on the categorisation, classification and processing of invariances, assuming some relationship between data, information and knowledge. Hence, we have categorisations such as tacit and explicit knowledge, objective and subjective knowledge, certain and uncertain knowledge and so on. These categorisations—while interesting—are, however, of little value in providing insights into the conception and development of Knowledge Management Systems. The problem is that such categorisations do not distinguish between data originating from observations in the target environment, on one hand, and the 'knowledge-base' needed to make sense of the observations, on the other. As such, any given set of data may have characteristics of both.

White and Sutton (2001), in their inquiry into knowledge management in clinical practice within the NHS in Britain, make a similar observation when they note that no work was found which analysed types of clinical knowledge in such a way as to define which phenomena fell into which category and what the relative percentages were.

The Conceptual Confusion

A relationship between data, information and knowledge is widely recognised in the literature. This relationship is popularly recognised as a hierarchy where data, being plentiful, sits at the base, followed by information and then knowledge. However, the distinction often seems arbitrary. These terms are often used inter-changeably, making it difficult to make sense of the emergent relationships that exist between them. This confusion has found its way into the knowledge management literature, where a diverse range of application systems lay claim to being Knowledge Management Systems.

Further, organisation and management are underpinned by thinking, which can be categorised in philosophical and sociological terms. From a philosophical perspective, there is positivism and phenomenology at opposite ends of a continuum. The positivist stance refers to a philosophical position characterised by a readiness to concede primacy to the given world as known through experimental evidence. The phenomenological stance, on the other hand, refers to the position characterised by a readiness to concede primacy to the mental processes of observers rather than to the external world (Checkland, 1981).

From a sociological perspective, there are functionalist and interpretivist views at polar ends of a continuum, yielding 'hard' and 'soft' systems thinking approaches to the organisation and management of phenomena (e.g., problem of choice in a dynamic environment). The functionalist view adopts a realist ontology and assumes that facts about the world exist and are waiting to be discovered; hence, knowledge is perceived as an immutable object that exists in a variety of forms (e.g., tacit, explicit) and reside in a variety of locations (e.g., individuals, culture, work routines). The interpretivist perspective maintains that reality is socially constructed; hence, knowledge is perceived as a process of knowing that is continually emerging, indeterminate and closely linked with practice (Detlor, 2001).

These philosophical and sociological viewpoints form the basis of all thinking and practice in the inquiry into a target environment, the selection of relevant data and the development of information systems that serve systems of purposeful action (e.g., managing complexity).

Can both viewpoints be right or is one right and the other wrong? Or, more importantly, how can each be leveraged off the other to deepen our understanding and reduce uncertainty in inquiries concerning the development of Knowledge Management Systems? To answer these questions we first need to understand the nature of the phenomena (i.e., data, information and knowledge) that fuels the creation, access, use and sustenance of Knowledge Management Systems.

Target Environment

Little attention has been paid to the nature of a target environment, which invariably gives rise to the management and organisational functions, which a Knowledge Management system is supposed to serve. To understand the emergent relationships between data, information and knowledge, we need to take a closer look at organisation and management, the reason for the generation of data in any target environment. A target environment being any bounded area in which we set out to intervene in a problem situation. In this environment, problem situations that arise do not come neatly packaged to fit into any predetermined classifications. These are messy, real world problems, as Checkland (1981) puts it. A target environment is characterised by complexity with elements exhibiting dynamic behaviour. According to Flood (1999, p. 86), "dynamic behaviour is capable of producing unexpected variety and novelty through spontaneous self-organisation. … a complex of variables interrelates with multiple feedback, which spontaneously creates a new order."

Senge (1990), however, makes an important contribution to understanding complexity in a target environment by distinguishing between two kinds of complexity in management situations, reflecting the nature of the target phenomena that Knowledge Management Systems aim to support. These he classifies as detail complexity and dynamic complexity. Detail complexity refers to situations where there are many variables; however, outcomes are predictable. Dynamic complexity refers to situations where cause and effect are subtle and where the outcomes of interventions over time are not obvious. As he points out, mixing many ingredients into a stew involves detail complexity, as does taking inventory in a retail store. But balancing market growth and capacity expansion or improving quality while reducing total costs and satisfying customers in a sustainable manner are examples of dynamic complexity problems.

In problems involving detail complexity, cause and effect are closely linked; therefore, it is possible to predict outcomes based on a given set of variables relevant to the problem situation. For instance, it is relatively easy to predict the composition and even taste of a hamburger given the proportionate mix and the order of introducing the ingredients (a problem of detail complexity). Using the taste of the hamburger, it is a lot more uncertain, if at all reliable, to predict if it would attract customers and, therefore, increase sales or the market share for the hamburger (a problem of dynamic complexity), because other factors such as market conditions and consumer behaviour may be at play in influencing the outcome.

Detail and dynamic complexity are the challenges that Knowledge Management Systems and, for that matter, all other information systems aim to help users organise and manage in problem situations.

The following section presents an analysis of the terms (data, capta, information, knowledge and organisation and management) on which Knowledge Management Systems thrive.

ANALYSIS OF TERMS IN KNOWLEDGE MANAGEMENT SYSTEMS

Data

Hirschheim et al. (1995, p. 14) defines data as "invariances with potential meaning to someone who can interpret them." According to Hirschheim et al., the basis of all communication technically, biologically or socially are invariances encoded in some medium and transmitted in many forms (e.g., waves, electrical currents).

The encoded invariances are received through our senses (e.g., vision, hearing, smell, touch, taste). It is important to note that following the receipt of invariances, via a communication medium through our senses, what is expressed as data may be represented as a word, sentence, number, sign, symbol or some other form of representation.

Hirschheim et al. distinguish between invariances that occur naturally, such as bird markings, and invariances created by humans for some purpose, such as letters and graphics. In this chapter, we shall concentrate on the invariances created by humans through observations (with our senses) or cognitive capabilities.

Also, through his analysis of Systems Thinking, Checkland (1981) makes an important contribution to the understanding of the nature of data. He distinguishes between two types of data. One that is independently verifiable (that which positivists and functionalists propose as a reality outside ourselves which actually exists) and one that is perceptive and, therefore, within oneself (that which phenomenologists and interpretivists propose as the continually negotiated truth).

Consider the following examples of data. If I observe an object (e.g., a dog), which other observers that I am not in collusion with can confirm, or a camera can record the same object as a dog, then I am prepared to say there is an immutable invariance that may be expressed as data (e.g., "This is a dog" or dog) which exist outside of ourselves and is real. This type of invariance seems to be what the functionalists refer to as data.

However, if I observe a dog and describe it as cute or beautiful or ugly, then while the fact remains that it is a dog (which agrees with the functionalists view of data), it can hardly be argued that 'a beautiful dog' is an immutable invariance, since it is my perception of the dog which may or may not be confirmed by any other observer. This type of invariance seems to be what the interpretivists refer to as data.

Capta

As Checkland and Howell (1998) point out, there could be a multitude of data (or invariances) pertaining to any particular object or phenomenon, but we choose, for one reason or another, to focus on a subset which is of interest to us at any time. They make a defining distinction between the multitude of data attributable to an object or phenomenon and the subset we choose to pay attention to. This, they refer to as 'capta'.

Flood (1999) complements this line of reasoning. He uses the term 'data construction' instead of 'data collection' to distinguish between the mass of data that could be attributed to a phenomenon or item of interest and the portion that is considered and chosen to be of interest. He points out rather understatedly that, "data is not waiting out there in volumes to be reaped like corn in an autumn harvest, but it is rather the product of a process of investigation" (p. 145).

For instance, of all the invariances that may be observed about dogs and represented as data, a breeder may choose to pay attention to (i.e., 'capta') colour, breed and origin rather than size, age or sex, as a result of some interests (e.g., breeding exotic dogs) that the breeder may have and the environment (e.g., locality, regulations, etc.) within which the inquiry is conducted. It is, however, possible that at some future time the breeder may choose to pay attention to a different subset of data if the environment or his/her interests change.

This distinction is important as it draws attention to the fact that the selection of a subset of all possible data about an object or phenomenon should not be taken for granted, since it defines boundaries of the target environment. More importantly, it also limits the subsequent insights that may be generated about the object or phenomenon. Therefore, the current assumption that 'data-warehouses' could be the repository of all data about an object or phenomenon in advance and 'mined' for insights is not very well grounded, because the bounded environment keeps changing.

In summary, data are the starting point in our mental processing. That is, invariances about an object or a phenomenon that could be paid attention to. 'Capta', on the other hand, are the result of selecting some for attention. The emergent property in the relation between data and capta being the decision to pay attention to the data that is selected because of a perceived interest.

Information

Having constructed data (through the process of investigation) or chosen to pay attention to a subset of the mass of possible data (capta) about an object or a phenomenon, we put it into context or attribute meaning to it. Hirschheim et al. (1995) contends that by themselves these invariances have no intrinsic meaning. The invariances acquire meaning through social conventions of individuals and communities. The invariances received are transformed through a process of meaning attribution (or interpretation) into information, which then triggers a behaviour. Attribution of meaning to 'capta' is a creative act and it may be argued that no two interpretations are ever quite the same. In other words, there is no guarantee that the same meaning will be attributed to the same observation by two individuals or even the same individual on different occasions.

For instance, at a dog show the dog breeder may observe, for argument sake, a red, white and blue striped chihuahua from France and attribute meaning such as, 'cute but not exotic', which triggers a 'don't buy' behaviour. Another may make the same observation, but attribute meaning such as, 'interesting, worth trying' and trigger a 'buy' behaviour.

This complements the observations of Sutton and White (2001) when they point out that, technically, clinical observations can be readily translated into data and that data can be shared. However, accurate technical performance does not necessarily equate to transfer of knowledge. It rather gives a partly illusory and misleading representation.

In summary, information is created through the attribution of meaning (by individuals) to 'capta'. Information, therefore, is a far more personal, variable, esoteric and ephemeral concept, dependent on the receiver's point of interest and 'knowledge-base', which is private and only available to the individual. Information, however, should not be confused with knowledge.

Knowledge

'Capta' that has been generated as a result of a process of inquiry or observation, the meaning attributed to it and the behaviour that follows can all be transformed into a new 'form' exhibiting different emergent properties. This new 'form', also 'capta', is stored as part of a 'knowledge-base'. It enriches the 'knowledge-base' and may be used for further meaning attribution to new 'capta' on another occasion.

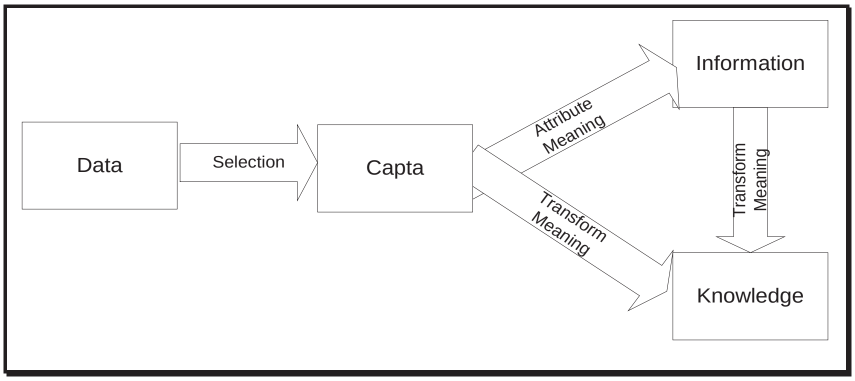
From the previous statements, we assert that there are two types of 'capta': one that is about observations, ephemeral meaning and behaviour pertaining to a target environment and one that enriches the 'knowledge-base'. The first type of 'capta' referred to as 'observation induced capta' is transformed into the second type of capta referred to as 'transformed capta'. The 'transformed capta' is represented as concepts, methods, beliefs, values and normative principles, forming a filter through which we perceive events and observations, thereby enabling us to attribute particular meanings to new 'observation induced capta'. This, however, does not preclude the 'garbage-in garbage-out' principle. If the 'knowledge-base' is unreliable, it is unlikely to support the effective attribution of meaning to new 'observation induced capta'.

This concept complements what White and Sutton (2001) noted as a process of knowledge generation and decision making by one of the participants in their study. The participant explains that, "following the initial discussion with the patient, I take the data collected [i.e., 'observation induced capta'] and put it in my knowledge base [i.e., transformed 'capta'] and conclude a number of things [i.e., further meaning attribution to 'observation induced capta'] about the present state of the individual" (p. 179).

With respect to 'capta', Hirschheim et al. (1995, p. 14) cite four types of speech acts (cf. Deitz, Widdershoven, 1992, cited in Hirschheim et al., 1995) following from Habermas' Theory of Communicative Action:

- To express how one feels or thinks (expressiva), e.g., I love pink dogs;

Figure 1. "Capta" relationships



- To get someone to do something (orders, imperativa), e.g., When you see a pink dog, buy one;
- To appeal to others to obey accepted social norms (regulativa), e.g., Dogs should be well cared for; and
- To get someone to accept something as true (assertions about the external world, also called constantiva), e.g., Pink dogs are a money spinner.

'Observation induced capta', which may be captured in a raw form or deduced, manifest as expressiva or imperativa speech acts, while 'transformed capta', stored as part of a 'knowledge-base', manifest as regulativa or constantiva speech acts – accepted social norms and assertions of truth about the external world.

As a further example, let's go back to the information created by the breeder's observation. In speech acts, the information created is expressiva (i.e., 'cute' and 'not exotic') and the behaviour triggered, i.e., 'don't buy', is imperativa. But why does the breeder come to this conclusion? Perhaps the breeder, knowing that his/her clients are only attracted to mono colour, pure-bred dogs originating from hard-to-reach countries or higher profit margins for such dogs. Whatever the reasons (i.e., the 'Whys'), this knowledge expresses the breeder's assertions of truth about a perceived external world (i.e., constantiva).

In summary, knowledge is a reserve of 'transformed capta', expressed as constativa or regulativa that can be applied to new 'observation induced capta'. Knowledge may be personal or collective, but definitely more stable than information.

From the discussion so far, we recognise an emergent relationship between data, capta, information and knowledge as shown in the following diagram. The question then is, can computers automatically undertake the transformation of 'capta' into knowledge?

In the next section we present a conceptual cleansing which we hope will lead to a better understanding of the conception, development and implementation of Knowledge Management Systems.

Conceptual Cleansing

We have so far been laying the foundation from which to clarify the competing claims about knowledge management and the confusing manifestations of Knowledge Management Systems.

Knowledge Management Systems have been popularly defined by different writers from either a structural or functional perspective. From a structural point of view, Morse (2001) defines Knowledge Management Systems as follows: "Knowledge [management] systems take a large, diverse collection of document-based knowledge, provide a physical infrastructure for storing those documents and provide a logical structure for retrieving information" (p. 230). He also provides a functional definition as follows. "Knowledge [management] systems are centralised computer systems that store, structure and provide access to the corporation's document-based knowledge" (p. 230).

We find the structural perspective somewhat deficient, because of the variety of possible compliant components which do not particularly contribute to either a necessary or sufficient condition for the attainment of an effective knowledge management system. The functional perspective, although it gets us closer to a unifying definition, does not surface fundamental assumptions (e.g., beliefs and values) made about content which is necessary for the KMS to function adequately.

Knowledge management in any target environment may be viewed as an ongoing 'journey' rather than an end or a destination in itself. Knowledge changes over time since it is a synthesis of the perceptions of a target environment, which is in a constant state of flux. Further, in knowledge-intensive working environments where people deal with dynamic complexity, consensus building as an approach to decision-making is rarely the norm. However, most conventional KMS implementations assume and model interventions around consensus (as the dominant cultural approach to decision-making) and determinism – a characteristic of detail complexity.

Following from our earlier discussion about the philosophical and sociological perspectives of organisation and management of phenomena (and objects) and its relationship to data, it is apparent that the ontology and epistemology of systems developed to support problem situations will contain an indeterminate mixture of positivist (functionalist) and phenomenologist (interpretivist) stances. The ontology is concerned with the fundamental units (or elements) which are assumed to exist in a target environment. The units may be composed of hard tangible structures (e.g., dog, building, car) with a concrete material base (realism), or composed of malleable, vague phenomena (e.g., sale, agreement, service), which are socially constructed through an intellectual or cultural base of values and concepts (nominalism or idealism). The epistemology is concerned with how an investigator inquires into a target environment and sees phenomena (observation 'capta') in them (Hirschheim et al., 1995).

These will reflect the relative mix of detail and dynamic complexity requiring management in the problem situation. In practice, each polar end of the continuum is unlikely to capture the relevant nature of the target environment or managing complexity (detailed and dynamic) of problem situations arising within them.

To support the organisation and management of the requisite mix of detail and dynamic complexity in a target environment, we distinguish between four categories of information systems:

- Transaction Processing Systems – Capturing observation, observation induced and transformed capta.
- Information Management Systems – Consisting of observations and observation induced 'capta'. A base of expressiva speech acts, mainly supporting the recall of meaning-attribution.
- Knowledge-based Systems – Consisting of 'observation induced capta'. A base of codified meaning representing imperativa speech acts. Mainly to support the organisation and management of detail complexity.
- Knowledge Management Systems – Consisting of 'transformed capta'. A base of concepts representing regulativa and con-

stantiva speech acts. Mainly to support the organisation and management of dynamic complexity.

As a consequence of this distinction, we assert that there is only one type of Knowledge Management system. Defined from a content perspective, a Knowledge Management system is an organised collection of concepts, methods, beliefs, values and normative principles (i.e., 'knowledge-base') supported by material resources (e.g., technology). Our definition is similar to Hirschheim et al's (1995) definition of an information systems development methodology. A 'knowledge-base' is used to make sense of invariances (i.e., 'observation capta'), not to provide codified meaning about an object or phenomenon that has been chosen for attention. A 'knowledge-base' is the source of our 'know-why' (Boahene, 1999), used to organise and manage uncertainty in complex problem situations, which is an essential property of knowledge.

As a rule of thumb, Information Management Systems have the capability to provide answers to questions of 'Where', 'Who', 'When' and What', while Knowledge-based Systems go a step further, providing answers to questions of 'How', but Knowledge Management Systems will have the capability to provide answers to questions of 'Why' and, in some cases, 'How'.

Notwithstanding the dizzying array of application systems that claim to support knowledge management, if the system does not articulate a 'knowledge-base' that supports dynamic complexity, then it is not a KMS.

Since dynamic behaviour is characterised by unexpected variety and novelty through spontaneous self-organisation, solutions to issues and problems cannot be known a priori. We learn our way into the unknown. The 'knowledge-base' in a knowledge management system ought to provide the frame of reference that will be consistently used to provide insights that support the organisation and management of dynamic complexity in a target environment, that is, new and deeper understandings of problem situations and how to intervene in them.

Concepts in a 'knowledge-base' are structures used to classify, explain and give order to phenomena or an object in a target environment. As an example, Flood (1999) provides an insightful conceptual structure for deepening systemic appreciation of a problem situation. According to Flood, any investigation into a problem situation will use ideas from systems of processes, structure, meaning and knowledge-power. These different views may be combined to provide a panoramic view, which he terms prismatic thought.

Beliefs are inferences of 'truth' that we hold in esteem and values help us to justify and uphold those beliefs. These beliefs affect our attitude toward, and our perception of, phenomena and the environment in which it occurs. Truth, however, should not be viewed as unchanging. As Flood's concept of prismatic thought suggests, a target environment is determined by boundary judgment. Boundaries are mental constructs, which determine what is in view (and might be taken into account at the moment) and what is out of view (and thus excluded from consideration). As

Table 1. Rule of thumb

System Type	Problem Situation	Typical Capability	Speech Act
Information Management	Detail complexity	Where,Who, When, What,	Expresiva
Knowledge-based	Detail complexity	How	Impreratíva
Knowledge Management	Dynamic complexity	How, Why	Constantiva Regulativa

such, the determination of a target environment (i.e., bounded action area) and what is taken to be relevant and worthy of having knowledge about is influenced by beliefs and values, both of which may change (in space and time) as different complex mixes of variables come into view and others drop out of view. It, therefore, follows that knowledge also changes as truth is continually renegotiated.

Concepts, beliefs and values can be organised into coherent sets of technical and behavioural rules which guide an approach to investigating problem situations in a target environment. These rules may be expressed as methods and normative principles. These elements of a 'knowledge-base' are what transformed 'capta' is about.

The 'knowledge-base' so constructed with the support of material resources can then be used to make sense of the nature of what is known about a target phenomenon (e.g., problem situation and possible insights that can be acquired through different types of inquiry) and alternative methods of investigation (i.e., observation capta) and thereby intervene more effectively.

While computers may be used to deduce expresiva and imperativa speech acts, it is unlikely that they can be used to deduce regulativa or constantiva speech acts. However, a computer will be perfectly capable of capturing and storing all speech acts.

CONCLUSION

This chapter has discussed the emerging discipline of Knowledge Management in computing and explained the concepts underlying Knowledge Management Systems which we believe will lead to a better understanding for the development and implementation of these systems. An attempt has been made to clear some of the conceptual confusion surrounding data, information, and knowledge which appears to be finding its way into the Knowledge Management literature.

REFERENCES

Boahene, M. (1999). Information systems development methodologies: Are you being served? *Proceedings of 1999 Australasian Conference on Information Systems*, Wellington, New Zealand (pp. 88-99).

Boahene, M., & Ditsa, G. (2001). The conception of an information system*, Proceedings of 2001 Information Resources Management Association International Conference*, Toronto, Canada (pp. 81-84).

Checkland, P. B. (1981). *Systems thinking, systems practice.* John Wiley & Sons.

Checkland, P. B., & Howell, S. (1998). *Information, systems and information systems: Making sense of the field.* John Wiley & Sons.

Detlor, B. (2001). An informational perspective towards knowledge work: Implications for knowledge management systems. *Proceedings of 2001 Information Resources Management Association International Conference,* Toronto, Canada (pp. 463-466).

Flood, R. L. (1999). *Rethinking the fifth discipline: Learning within the unknowable.* Routledge.

Hirschheim, R., Klein, H. K, & Lyytinen, K. (1995). *Information systems development and data modeling: Conceptual and philosophical foundations.* Cambridge University Press.

Morse, R. (2001). Applying level of technology use models to knowledge systems use*. Proceedings of 2001 Information Resources Management Association International Conference*, Toronto, Canada (pp. 230-234).

Senge, P. (1995). *The fifth discipline - The art and practice of the learning organization.* Random House.

White, D. A. & Sutton, Y.M. (2001). Knowledge management: A telling oxymoron? *Proceedings* *of 2001 Information Resources Management Association International Conference,* Toronto, Canada (pp. 177-181).

Yen, V.C. (2001). A hybrid knowledge mapping structure and its applications. *Proceedings of 2001 Information Resources Management Association International Conference,* Toronto, Canada (pp. 671-673).

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Chapter 2.9
Internet Support for Knowledge Management Systems

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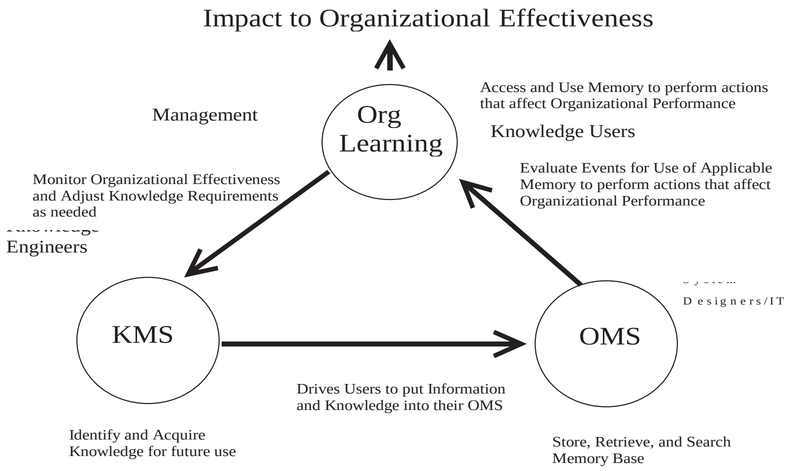
INTRODUCTION

Organizations are building and maintaining systems for managing organizational knowledge and memory. Users of these systems may not be at the same location; in many cases they are distributed across large geographical distances and multiple offices. Key to this task is developing an infrastructure that facilitates distributed access and utilization of the retained knowledge and memory. Connectivity and easy to use interfaces are main concerns. Jennex (2000) found that using the Internet as a common communications platform (either as an Intranet or an Extranet) and Web browsers as an interface is a viable, low cost solution. Newell, et al. (1999) found that Intranets not only supported distributed knowledge processes but also enhanced users' abilities to capture and control knowledge. Stenmark (2002) proposes that using a multiple perspective of the Internet— information, awareness, and communication—allows developers to build successful Internet-based knowledge management systems, KMS. This article discusses how the Internet can be effectively used as an infrastructure for knowledge management/organizational memory systems, KMS/OMS.

BACKGROUND

The OMS consists of the processes and information system components used to capture, store, search, retrieve, display, and manipulate knowledge. The KMS consists of the tools and processes used by knowledge workers to interface with the knowledge contained in the OMS. Knowledge is managed and used through a combination of the KMS and OMS. Jennex and Olfman (2002) identified the KMS-OMS model in Figure 1 as a representation of the relationships between the OMS, KMS, and organizational learning. Organizational learning, OL, is identified as a quantifiable improvement in activities, increased available knowledge for decision-making, or sustainable competitive advantage (Cavaleri, 1994; Dodgson, 1993; Easterby-Smith, 1997; Miller, 1996).

Figure 1. The Jennex-Olfman KMS-OMS model



There are two approaches to building a KMS as discussed by Hansen et al. (1999), Morrison and Weiser (1996), and Stenmark (2002). These can be described as a process/task approach and the infrastructure/generic approach. The process/task approach focuses on the use of knowledge/OM by participants in a process, task or project in order to improve the effectiveness of that process, task or project. This approach identifies the information and knowledge needs of the process, where they are located, and who needs them. This approach requires the KMS to capture less context, as users are assumed to understand the knowledge that is captured and used.

The infrastructure/generic approach focuses on building a system to capture and distribute knowledge/OM for use throughout the organization. Concern is with the capturing of context to explain the captured knowledge and the technical details needed to provide good mnemonic functions associated with the identification, retrieval, and use of knowledge/OM. The approach focuses on network capacity, database structure and organization, and knowledge/information classification.

Both approaches may be used to create a complete KMS. The process/task approach supports specific work activities, while the infrastructure/generic approach integrates organizational knowledge into a single system that can be leveraged over the total organization instead of just a process or project.

Jennex and Olfman (2001) developed a set of design recommendations for enabling KM/OM in systems. The recommendations, Table 1, are based on studies of KMS/OMS success factors. One recommendation calls for use of a common infrastructure. The Internet is suggested for this due to its widespread availability, open architecture, and developed interfaces. This also assists in standardizing software across the organization through the use of browsers and Web applications.

The Internet meets several of these recommendations. It provides a common network that is global. Use of common browsers aids in

Table 1. KMS design recommendations

- Use a common network structure, such as the Internet.
- Add KM/OM skills to the tech support skill set.
- Use high-end PCs and/or clients.
- Standardize hardware and software across the organization.
- Incorporate the KMS into everyday processes and IS.
- Use an enterprise-wide data dictionary to design knowledge base.
- Allocate maintenance resources for KMS.
- Train users on use and content of the KMS.
- Create and implement a KM strategy/process for identifying/maintaining the knowledge base.
- Expand system models/life cycles to include the knowledge process.
- Assess system/process changes for impact to the KMS.
- Automate data capture.
- Design security into the knowledge base.
- Incorporate KM into personnel evaluation processes.
- Implement KMS use/satisfaction metrics.
- Identify organizational culture concerns that could inhibit KMS usage.

Table 2. Internet features/technologies that support KMS

- Common Architecture and Interfaces
- Easy to Use Front-end Systems (Browser User Interface)
- Trends Towards Internet-Based Processes
- Back-end Systems that Provide Database Access to Users
- XML wrapping of documents and other data
- Powerful Search Engines
- Virtual Private Networks
- Internet Opportunities Include:
  - Ability to push time-sensitive data quickly to a wide audience
  - To answer frequently asked questions
  - To create 24-hour service
  - To make knowledge additions/updates available quickly
  - To allow feedback from users
  - To service both specialized teams/users and generic users

standardizing software. Ease of use of browsers and in building and maintaining Internet-based systems empowers users (Newell et al., 1999) and simplifies incorporating the KMS into everyday processes. Ease in handling unstructured data as well as databases simplifies knowledge representation, capture, and dissemination. Table 2 lists Internet tools and features that expand the ability of the Internet to serve as the infrastructure for a KMS. Some of these features are expanded in the following.

Gandon et al. (2000) propose using XML to encode memory and knowledge, and suggest using a multi-agent system that can exploit this technology. The proposed system would have improved search capabilities and would improve the disorganization and poor search capability normally associated with Web pages. Chamberlin et al. (2001) and Robie et al. (1998) discuss using XML query language to search and retrieve XML encoded documents.

Dunlop (2000) proposes using clustering techniques to group people around critical knowledge links. As individual links go dead due to people leaving the organization, the clustered links will provide a linkage to people who are familiar with the knowledge of the departed employee. Lindgren (2002) proposes the use of Competence Visualizer to track skills and competencies of teams and organizations.

Te'eni and Feldman (2001) propose using task-adapted Web sites to facilitate searches. This approach requires the site be used specifically for a KMS. Research has shown that some tailored sites, such as those dedicated to products or communities, have been highly effective.

Eppler (2001), Smolnik and Nastansky (2002), and Abramowicz et al. (2002) use knowledge maps to graphically display knowledge architecture. This technique uses an intranet hypertext clickable map to visually display the architecture of a knowledge domain. Knowledge maps are also known as topic maps and skill maps. Knowledge maps are useful, as they create an easy to use standard graphical interface for the Intranet users and an easily understandable directory to the knowledge.

The use of ontologies and taxonomies to classify and organize knowledge domains is growing. Zhou et al. (2002) propose the use of

Table 3. A summary of issues for future trends of Internet-based KMS

Bandwidth Restrictions and Latency Improving transmission and methods to enable large numbers of users to receive knowledge from the KMS
Organizing Knowledge Creating standard ontologies and taxonomies to enable standard knowledge structures
Flooding of the Web with content Improving knowledge acquisition so that content not helpful to the users is captured
Maintenance and integrity of data Keeping Web maintenance up-to-date and accurate knowledge on the site for users
Exposure Points/Security Creating secure systems that allow remote access yet keep unauthorized user access out
System incompatibilities Improving cross-platform compatibility to improve system integrations and access

ROD, rapid ontology development, as a means of developing an ontology for an undeveloped knowledge domain.

FUTURE TRENDS

Although there is strong support for using the Internet as a knowledge infrastructure, there are areas that current research is improving. Chief among these is the difficulty in organizing and searching large quantities of knowledge in varying knowledge formats and structures. Knowledge can be stored as documents, audio, images, databases, and spreadsheets. Lack of standard structure can make organizing knowledge difficult, while the lack of standard terms and naming conventions makes searching difficult. An example is Ernst & Young UK, who in early 2000 had in excess of one million documents in its KMS (Ezingeard et al., 2000). Another concern is the tendency to not to use the system. Jennex and Olfman (2002) fount that voluntary use is enhanced if the system provides near and long-term job benefits, is not too complex, and the organization's culture supports sharing and using knowledge and the system. Other significant issues requiring resolution are summarized in Table 3 and include security, having adequate bandwidth for the expected use, maintaining content in large sites, and system incompatibilities between distributed offices/users.

CONCLUSION

The conclusion is that the Internet is an effective infrastructure for a KMS. However, there are issues associated with using the Internet that KMS designers need to be aware of. Chief among these are knowledge representation and search. Several tools such as knowledge maps, XML, adaptive Web sites, clustering, and examples of effective Internet-based KMSs were discussed that addressed these issues. However, as knowledge bases grow, designers need to be aware of increasing search times as well as a variety of knowledge artifacts. This is perhaps the most important area for future research. Developing ontologies and taxonomies to aid in classifying and structuring knowledge domains is critical.

Maintaining a site is critical. User, organizational, and/or project needs for knowledge change over time, requiring the KMS to change its knowledge content. Also, knowledge has a life cycle and eventually reaches a point where it is no longer useful. Organizations must allocate resources to update and maintain every KMS.

Securing the KMS is also critical, as knowledge is valuable. KMS/OMS designers need to ensure the security of captured knowledge and use of secure connections is a viable alternative. This may be the greatest impediment to the development of Internet-based KMSs.

The final issue is the tendency of people not to use the computer portion of a KMS. Jennex and Olfman (2002) found that this is a tendency of new members and suggest that this is a matter of context. New members do not understand the context under which the knowledge was created and stored so do not know how to retrieve and use the knowledge. As these members gain experience they gain context and rely more upon the computer and less upon their peers.

REFERENCES

Abramowicz, W., Kowalkiewicz, M., & Zawadzki, P. (2002). Tell me what you know or I'll tell you what you know: Skill map ontology for information technology courseware. *Proceedings of the 2002 Information Resources Management Association International Conference*.

Cavaleri, S. (1994). Soft systems thinking: A pre-condition for organizational learning. *Human Systems Management*, *13*(4), 259-267.

Chamberlin, D., Clark, J., Florescu, D., Simon, J., Robie, J., & Stofancscu, M. (2001). *Xquery 1.0: An XML Query Language*. WSC Working Draft 2001. www.w3.org/TR/xquery/

Davenport, T.H., & Prusak, L. (1998). *Working knowledge.* Harvard Business School Press.

Dodgson, M. (1993). Organizational learning: A review of some literatures. *Organization Studies, 14*(3), 375-394.

Dunlop, M.D. (2000). Development and evaluation of clustering techniques for finding people. *Proceedings of the 3rd International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Easterby-Smith, M. (1997). Disciplines of organizational learning: Contributions and Critiques. *Human Relations, 50*(9), 1085-1113.

Eppler, M.J. (2001). Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. *Proceedings of the 34th Hawaii International Conference on System Sciences.* IEEE Computer Society.

Ezingeard, J.-N., Leigh, S., & Chandler-Wilde, R. (2000). Knowledge management at Ernst & Young UK: Getting value through knowledge flows. *Teaching Case,* 807-822.

Gandon, F., Dieng, R., Corby, O., & Giboin, A. (2000). A multi-agent system to support exploiting an XML-based corporate memory. *Proceedings of the 3rd International Conference on Practical Aspects of Knowledge Management, PAKM2000.*

Hansen, M.T., Nohria, N., & Tierney, T. (1999, March-April). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

Jennex, M.E. (2000). *Using an intranet to manage knowledge for a virtual project team. Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Jennex, M.E., & Olfman, L. (2001). Development recommendations for knowledge management/organizational memory systems. *Contemporary trends in IS development.* Kluwer.

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity, a longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Jennex, M.E., & Olfman, L. (2003). Organizational memory. In C.W. Holsapple (Ed.), *Handbook on knowledge management (*pp. 207-234). Berlin, Heidelberg: Springer.

Lindgren, R. (2002). Competence visualizer: Generating competence patterns of organizational groups. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Malhotra, Y. (1998). *Knowledge management for the new world of business.* www.brint.com/km/whatis.htm

Miller, D. (1996). A preliminary typology of organizational learning: Synthesizing the literature. *Journal of Management, 22*(3), 485-505.

Morrison, J., & Weiser, M. (1996). A research framework for empirical studies in organizational memory. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society Press.

Newell, S., Scarbrough, H., Swan, J., & Hislop, D. (1999). Intranets and knowledge management: Complex processes and ironic outcomes. *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Robie, J., Lapp, J., & Schach, D. (1998). XML Query Language (XQL). *WWW The Query Language Workshop (QL).*

Smolnik, S., & Nastansky, L. (2002). K-discovery: Using topic maps to identify distributed knowledge structures in groupware-based organizational memories. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Stenmark, D. (2002). Information vs. knowledge: The role of intranets in knowledge management. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Te'eni, D., & Feldman, R. (2001). Performance and satisfaction in adaptive Websites: An experiment on searches within a task-adapted Website. *Journal of the Association for Information Systems, 2*(3), 1-30.

Zhou, L., Booker, Q.E., & Zhang, D. (2002). ROD – toward rapid ontology development for underdeveloped domains. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

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Chapter 2.10
Developing and Maintaining Knowledge Management Systems for Dynamic, Complex Domains

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ABSTRACT

An effective knowledge-based organization is one that correctly captures, shares, applies and maintains its knowledge resources to achieve its goals. Knowledge Management Systems (KMS) enable such resources and business processes to be automated and are especially important for environments with dynamic and complex domains. This chapter discusses the appropriate tools, methods, architectural issues and development processes for KMS, including the application of Organizational Theory, knowledge-representation methods and agent architectures. Details for systems development of KMS are provided and illustrated with a case study from the domain of university advising.

INTRODUCTION

An effective knowledge-based organization is one that correctly captures, shares, applies, and maintains its knowledge resources to achieve its goals. Knowledge Management Systems (KMS) enable such resources and business processes to be automated. Possibly the greatest benefits, but with the biggest challenges, emerge from creating KMS for environments with dynamic and complex domains (DCD). If knowledge is viewed as information applied in a particular context, then a dynamic domain is one in which information such as policies and procedures are subject to frequent change. A complex domain is one in which many interrelated policies exist with informally defined and tacit exceptions.

Typical parameters used to describe or classify organizational structures in any environment are centralization, hierarchy, and standardization. Dynamic and complex environments tend to coerce organizations into highly centralized, hierarchical structures with many strictly enforced standards-based rules of operation. This environment results in organizations wherein only a few experienced individuals have the knowledge and experience to cope with frequent change, exceptions, and their complex interrelationships. The rest of the organization is thus poorly informed and subject to making errors when employees must make decisions. Obviously, this highly centralized, hierarchical structure is the wrong approach for a knowledge-based organization. The organizational goal is to get the right knowledge to the right person at the right time so better decisions and fewer mistakes will be made. The knowledge management challenge is to support this goal through the development of KMS that can readily adapt to change while dealing with complexity. The emerging science of knowledge management should preserve and build upon literature that exists in other fields (Alavi & Leidner, 2001). We believe, and research on knowledge as a contingency variable (Birkinshaw, Nobel et al., 2002) indicates, that any KMS will benefit from the application of Contingency Theory (CT) and Information Processing Theory (IPT), both well established in the field of Organizational Theory (OT).

The chapter begins with the role of CT and IPT in examining the organizational aspects of dynamic, complex environments, followed by an overview of classic knowledge management and tools for KMS development. Next, the organizational, domain, development, maintenance, and KMS issues for dynamic, complex domain environments are presented. The recommended strategies and tools are illustrated through a case study of a recently developed university advising system, a classic case in which a few knowledgeable individuals (departmental advisors) attempt to serve a large population (students) in a dynamic, complex domain. Additional recommendations and future trends conclude the chapter.

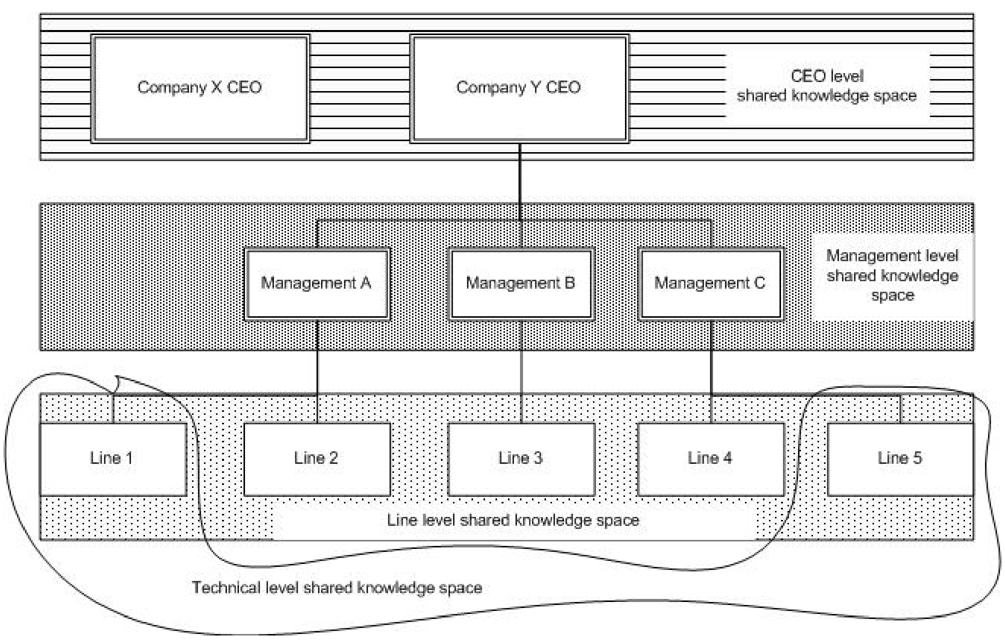
CONTINGENCY THEORY

A basic tenet of CT is that organizations are structured according to their situational environment. OT is a field of study that examines an organization's structure, constituencies, processes, and operational results in an effort to understand the relationships involved in creating effective and efficient organizations. Countering the "one best" organizational structure approach of classical organization theory, the subfield known as CT (Galbraith, 1973; Pfeffer & Salanick, 1978; Dess & Beard, 1984; Thompson, 1967) recognizes that environment influences appropriate structure. CT has been applied to a wide variety of fields including software design (Lai, 1999). In CT an organization's environmental context may be described by two characteristics: (1) the complexity and heterogeneity of the entities in the environment and (2) their rate and predictability of change (dynamicism). Successful organizations survive by adapting to the demands of their task environments (March & Simon, 1958). There may be more than one equally effective organizational design, as each varies by degree of centralization, hierarchy, and standardization. Fortunately, due to interdependencies between components, organizational configurations tend to fall into a limited number of coherent patterns, and thus the set of possibilities is limited. In proposing IPT-aiding application of this theory, Galbraith proposed that complexity, predictability, and interdependence actually measure one underlying concept, that of task information processing requirements (Galbraith, 1973; Galbraith, Downey et al., 2001). Thus, the basic concept to be analyzed is the task and its information processing requirements. A task may be defined as a relatively independent sequence of activities that serves a purpose for some user.

The more heterogeneous, unpredictable, and dependent upon other environmental resources a task is, the greater the information processing that the organization must be able to do in order to successfully accomplish it. IPT shows that as diversity and unpredictability increase, uncertainty increases due to incomplete information. As diversity of resources, processes, or outputs increase, inter-process coordination requirements and system complexity increase. As uncertainty increases, information-processing requirements increase because of management's inability to predict every situation. Thus, the basic premise of IPT is that the greater the uncertainty in the overall tasks in an organizational system, the greater the amount of information that the system must process. When a task environment is stable with few or no exceptions, then standard operating procedures, hierarchical control, and specific goal-setting can be used to coordinate activities. When a task environment is less stable or more diverse, alternative organizational structures must be used either to reduce information processing requirements or raise information processing capability. Organizational structures are therefore a result of attempts to deal with uncertainty, the result of which is complexity and dynamicism.

As an example of how organizational structures can limit the effectiveness of KMS, consider the situation in Figure 1 in which the worker at Line 1 needs knowledge held by the employee at Line 5. In this simplified example using a traditionally structured, hierarchical organization, the knowledge request would have to be propagated up the organizational hierarchy until a common departmental shared knowledge space was reached (in this example, the CEO) then

Figure 1. Knowledge vocabularies based on shared knowledge spaces



down to the employee, and then back up through the hierarchy. This communication sequence is lengthy primarily because it relies only on tacit knowledge and hierarchical control. However, following IPT guidelines allows the use of this "exception" to create a much more direct path using a technical-level knowledge space. Once this vocabulary is encoded into the KMS by either a human or by the KMS's learning module, future communication is greatly facilitated.

As shown in the above example, a conceptual transformation must take place in order to apply CT and IPT to the design of KMS in a dynamic, complex environment. The technological complexity-information processing relationship from the viewpoint of the IS and KMS as a whole must be examined. Among the factors a designer should consider are: (1) how this interaction affects organizational control structure, (2) how this interaction is affected by organizational control structure, (3) the importance of the development groups, (4) the time constraints on the results, and (5) management's viewpoint. This complex analysis is aided by first developing the basic relationship, then examining limitations and effects by the listed factors one at a time.

A series of questions must be considered related to the individual concepts and their interactions. What exactly does technological complexity mean when it is considered as part of a KMS rather than as a separate construct? How does the nature of information processing in a KMS change when it is part of a single team, which is part of other organizational systems? How long has this level of technological complexity been used in this industry, and how well standardized is its infrastructure? All of these questions relate to the constraints that are placed on this one system by other systems within the organization.

The primary determinants in this relationship are the environmental variables of heterogeneity and stability. In distributed IS design for KMS the concept of heterogeneity can be measured in terms of output requirements, IS familiarity and ability, physical location, connectivity method and type of device; data — in terms of location, source, rate of change; and processes — in terms of both business and software; and system hardware. These indicators, along with the stability or predictability of each constituency, provide a means for concept categorization.

In the following sections the knowledge management and KBS tools overviews provide the necessary background and then the case study demonstrates how these concepts are applied to a real project. Additional details on the application of CT and IPT to KMS design, along with examples, may be found in Durrett, Burnell and Priest (2003, 2002a, 2002b, 2001).

KNOWLEDGE MANAGEMENT OVERVIEW AND CHALLENGES

Knowledge management focuses on knowledge creation, storage, sharing, and application. Knowledge management systems are then developed to support these tasks. The specific types of knowledge needed will determine the organizational structure. A full review of knowledge management and KMS are beyond the scope of this chapter. The focus is on how KM and KMS can improve knowledge in a dynamic, complex environment. Properly implemented KMS can provide the following benefits to an organization: (1) fewer mistakes, (2) less redundancy, (3) quicker problem-solving, (4) better decision-making, (5) increased worker independence, (6) enhanced customer relations, and (7) improved products and services.

KMS are a class of information systems used to manage organizational knowledge (Alavi & Leidner, 2001). While information systems are not absolutely required in KM, they can be an important enabler for finding, storing, and distributing information quickly and efficiently throughout the organization. KMS can extend an individual's knowledge beyond formal communication lines (Alavi & Leidner, 2001).

Knowledge management classifies knowledge into two types:

- Tacit Knowledge (informal) — knowledge held by an individual or organization, but which has not been documented and is not widely known.
- Explicit Knowledge (formal) — information that has been documented and shared for others to use. This type includes procedures, manuals, policies, guides, and customer databases.

The goals of transfer, creation, and expansion of knowledge require that knowledge be transformed from tacit to explicit and back to tacit again as it is utilized. Unfortunately in a DCD environment the amount of tacit information is widespread, large, complex, and constantly changing. In this environment, a KMS needs to (Tiwana, 2000):

- Have a shared knowledge space which provides a consistent, well-understood vocabulary;
- Be able to identify, model, and explicitly represent their knowledge;
- Share knowledge among employees and re-use knowledge between differing applications; and
- Create a culture that encourages knowledge sharing.

Databases (DB) and other technologies such as data mining, bulletin boards, best practices, expert directories, expert systems, and case-based reasoning are just some of the methods used. However, knowledge does not thrive by IT alone. The challenges of a dynamic, complex environment require the organization to recognize change and complexity as normal and use these technologies accordingly. A review of the knowledge literature shows several mentions of flexibility and scalability as development objectives but almost no mention of "designing for change and complexity."

TOOLS FOR KMS DEVELOPMENT

In order to develop software that manages change and complexity, sophisticated methods and data representations need to be applied appropriately. A number of these tools are summarized in this section. The three basic categories described are Data Base Management Systems (DBMS), Artificial Intelligence (AI), and distributed communication. For each, recommendations and limitations are given.

DBMS

Much of the basic data needed for creating a knowledge-based organization will reside in databases. A DBMS takes care of concurrent access, security, and data integrity, and can handle large data items, such as audio or video. Processing can be performed by small programs (triggers) to respond to events like deleting a row in a table. Database design and performance-tuning methods are well developed, and personnel with such skills are readily available. Most companies will already have, and should use, a relational DBMS. Pure object-oriented DBMS have essentially found use in a small number of niche markets. Furthermore, major relational DBMS vendors are continuing to expand the capabilities of their products to include object-oriented support.

Not all data is best suited for storage in a DBMS. While a particular DB design can accommodate moderate amounts of change over time, such as adding new tables or attributes, large changes to the schema or processing requirements are difficult to accommodate. While standard relational databases should be employed for some domain knowledge and facts, declarative representations such as rules are the better choice for dynamic or complex policies and procedures. When trying to represent complex policies, a database solution (commonly attempted) becomes too complex or incomprehensible for system designers to understand or for anyone to try to modify. The same is true for hard-coding business logic into programs, which not only creates a confusing system, but also possesses great inflexibility to change. A combination of rules and relational database management systems, sometimes called an active DBMS, allows both declarative and relational representations to be defined using a single product. While this model can be useful, it is not required to integrate both paradigms into one solution. Later, in the case study, we show how separate DBMS and knowledge-based tools are integrated to provide a solution. But first we discuss powerful tools and methods from Artificial Intelligence (AI) that are used to capture an organization's knowledge.

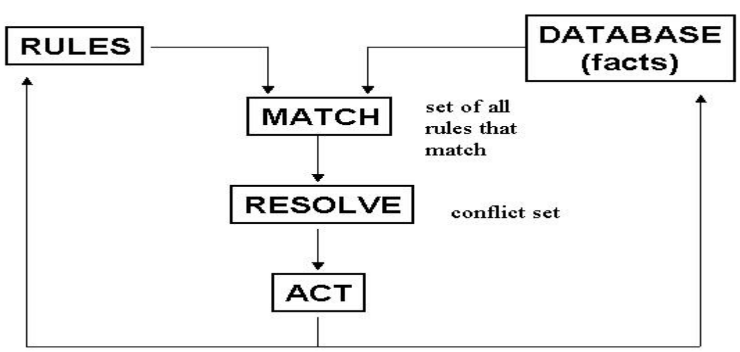
Knowledge-Based and Expert Systems

Systems that represent and reason with knowledge are generally referred to as knowledge-based systems (KBS). While the term KBS can be used to describe any system that uses or delivers knowledge in some way, a KBS is traditionally defined to be a program or collection of programs that represents and reasons with declaratively specified knowledge. Current KBS often integrate the knowledge component with other processing so that the knowledge-based part of the system is hidden from the user and may be a small, though critical, part of overall system functionality. Within this section, the term KBS will refer to the specific knowledge component or components within a larger system. A KBS is sometimes referred to as an Expert System if the performance matches or exceeds that normally found in experts within a discipline.

A number of methods for constructing KBS are available. We will discuss a few of these. Developing KBS typically requires advanced training and experience, but some vendor tools provide specific support for staff without such training. A given problem may require combining multiple KBS methods to obtain a satisfactory solution. Some important methods are rules, cases, belief networks, fuzzy systems and business-rule systems.

Rule-based systems represent knowledge in an IF-THEN format. The inputs for solving a problem are the rules plus facts that represent a current situation. An inference engine executes

Figure 2. Execution cycle in a rule-based system



by finding patterns in the rules that match the facts, "firing" (executing) the rule, and repeating these two steps until no more patterns match facts (Figure 2). Each cycle through the rules may result in changes to current facts, so dynamic behavior can be achieved. As an example, with facts that state that a student has a GPA of 3.7 and has taken a DB course, the following rule will fire.

IF the student has a GPA>3.5 AND has taken the DB course
THEN approve student for the AI course

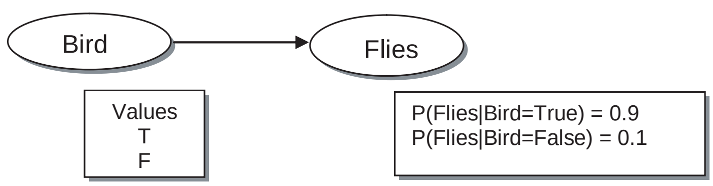
A number of commercial and free shells exist that provide the inference engine, supporting functions for string and numeric processing, and required format for creating rules. Examples include JESS (JESS, 2002) and CLIPS (CLIPS, 2002).

Case-based reasoning (CBR) attempts to solve problems by comparing them to those that have previously been solved. The reasoner searches a case-base of problems and their solutions to find those that best match the description of a current problem, then attempts to adapt the stored solution to the new problem. The new problem and its solution may be stored into the case-base for future reference. A common application of CBR is to support help-desks.

Belief nets, also known as Bayesian belief networks, are used to represent uncertainty, specifically the probabilistic causal relationship between objects or attributes. For example, the relationship between a person's age, weight, blood pressure, and other factors influences the belief that the person is at risk for heart disease in the future. An extension to belief nets, called influence diagrams, adds decision nodes to the representation to recommend a choice among actions that maximizes value to the decision-maker. Using the same example above, a decision node could be added to recommend if the person should undergo the expense of a stress test. Rather than trying to represent a complete model of some phenomena, probabilities are used to summarize knowledge. The result is that computationally tractable large models can be constructed. Taking another example, consider the need to represent that most birds fly. Using a logic-based representation, we would need to describe all the exceptions to the most likely case that if something is a bird, then it flies. Exceptions include the species, if the bird is dead, or has its wings clipped. We can group these exceptions into one or more belief net nodes, depending on how the knowledge is to be used in the overall system. A belief net for the simplest case is shown in Figure 3.

Fuzzy systems, which can extend the representational power of rule-based systems, commonly are used to represent vagueness, not uncertainty, such as is found in the statement "Elton is tall." Here, the statement is certain, but the term "tall" is vague. A fuzzy calculus is used to map natural language terms to numbers, and to combine those numbers in a meaningful way to determine if a rule should fire.

Figure 3. A belief net for the simplest case



Business-rules systems (BRS) are a subcategory of KBS that encode particular kinds of knowledge. BRS capture, disseminate, and enforce the current explicit and tacit policies, procedures, and guidelines of an organization. Because such knowledge must be adaptable to changing market and economic demands, business rules must be easily identifiable and maintainable. While the term "rules" is part of the BRS acronym, and standard expert system style "If-Then" rules are often used, this encoding is not a requirement. Other declarative knowledge-representation systems, such as cases (as in case-based reasoning systems), are appropriate. The rationale for choosing a declarative representation is to give end-users (knowledge-workers) the ability to comprehend and modify the business logic.

Other Techniques from AI

Two important techniques that can be used with the methods of the previous section are neural networks and machine-learning methods. By adding the capability to learn autonomously from past data, these methods can be used to create knowledge components or to adapt the behavior of a system to changes over time. This capability allows tacit knowledge to be more easily encoded into explicit knowledge.

Complex problems with multiple input and output values can also be modeled using neural networks. Patterned conceptually after the human brain, this technique allows weighted linkages between value nodes to transform input data to output knowledge. Neural nets (networks) learn a mathematical function that describes the relationship between variables by using example data. Common uses include classification, speech, and vision tasks. Complex functions can be learned that, unlike statistical models, do not require the user to specify the expected type of function. Unlike the other representations discussed here, neural nets are a "black box"—it is not possible to uncover the model learned. In a rule-based system, for example, a user can view the chain of reasoning (rule firings) used to solve a problem. Despite this disadvantage, neural nets are powerful problem solvers that can tackle problems the other reasoning methods have difficulty solving.

Machine learning methods can be employed with many representations, including databases, precise and fuzzy rule-based systems, belief nets, and case-based reasoning. The learning can be used to enhance system capabilities (be able to create new explicit knowledge) or performance (solve problems faster). In data mining, machine learning and statistical methods can be used to discover new knowledge. For example, a grocery store could discover that customers who buy lots of fresh fruit also tend to buy soy milk. Using knowledge of buyer patterns of behavior, product selection and display can then be adjusted to maximize profits. Rules can be learned by supplying past data, for example, to classify the creditworthiness of persons seeking loans. Belief net learning algorithms either learn the basic structure of the belief net or improve the accuracy of the results. CBR learning algorithms, often integrated within the CBR tool, learn new cases or combine several specific cases into general ones that can solve a wider range of problems.

Web Services and Distributed Communication

More systems development is becoming distributed across computers. Part of the reason for this shift is a desire to take advantage of the trend in using many computers instead of one big mainframe. Systems have become developed by individual departments or divisions that need to work together. This trend toward distributed computing is necessary because the systems being developed are much too complex to consider as one monolithic system, and must be decomposed into subsystems so developers can understand them. Further, the trend is towards piecing together components, some custom developed, some purchased, where each component performs some specific tasks, such as credit card processing. Finally, intercompany processing means that disparate computing systems need to communicate. A Web service is a software entity that is capable of inter-application communication over any local or wide area network. Web services enable the creation of dynamic intra- and intercompany systems.

Standards exist, and are continuing to be developed. There is a confusing and overwhelming array of communications protocols. The old EDI (Electronic Data Interchange) for intercompany communication is giving way to many other standards, including but not limited to XML. WSL, CORBA, KQML, FIPA, SOAP, UPNP are a few of the standards. Some of the newest standards target security (XML Signature), requirements (Web Services Description Usage Scenarios), and design (Web Services Architecture and Descriptions Requirements). These and other standards documents are published by the World Wide Web Consortium (W3C).

Currently, XML and some of the protocols built on top of it are reasonably safe choices. XML can be used to share data between databases and programs running across the Internet. Unlike HTML, which simply describes the formatting of data within a web browser, XML describes what data items are. Like a database scheme, an XML tag describes what a piece of data is, for example <price>$19.99</price> uses the <price> tag to identify the data $19.99 as the price of some item. In order to use XML for communication, the programs sharing the XML data must agree on what the tags mean. Some communities, like medicine, have created XML vocabularies, with the expectation that any program wishing to communicate about medical data will use this standard vocabulary. Creating these standards, and then using with existing programs and databases, is a major challenge.

Having reviewed CT/IPT and key software technologies, the following section shows how these concepts and methods can be used in the development of a KMS in a DCD. Software development phases, each with specific issues when applied to dynamic and complex domains, are presented, then demonstrated by the example KMS currently being developed.

DEVELOPING KMS FOR DCD

There are a number of fundamental work phases, each with issues and choices, in the development of a complete KMS solution. The domain analysis phase involves acquiring an accurate model of business processes including data elements, policies, and their stability over time. The requirements phase entails eliciting, analyzing, and specifying the system behavior, including interaction with users and other systems. In architectural design, the blueprint for the system is constructed to define major components and their interactions. In detailed design, the components are fully specified, including data representation and algorithm selection. Implementation translates the design into executable code. Testing is an integral part of each phase and continues throughout the lifecycle of the product. Once the system is in place, maintenance is necessary to correct errors and to respond to changes in the domain and operational environment. This process is especially important for a DCD where needed changes are frequent. The goal of designing for systems in DCD is to reduce the maintenance burden, which accounts for up to 80% of system lifecycle costs in many instances.

The work phases are performed within a software engineering methodology and generally require a number of iterations through each phase. For DCD systems, an agile methodology, such as FDD (Palmer & Felsing, 2000) or XP (Beck, 2000), should be considered because it provides better support for change throughout development. The standard notation for describing artifacts of software development is the Unified Modeling Language (UML). An easy-to-use guide to the UML is Fowler and Scott (2000). Computer Aided Software Engineering (CASE) tools are available to support collaborative development of one or more phases. Commercial and free tools include products from Rational, TogetherSoft, and Gentleware.

Domain Analysis

Knowing your domain is vital to successful knowledge management. For DCD, it is not enough to only look at your current operation. The best thing to do is to collect three types of data from (1) your current domain, (2) your domain history, and (3) other organizations. The data you should collect includes the language (terms used and their precise definitions), business policies and processes, and specific overrides to those policies and processes. A primary benefit of CT/IPT-based KMS is the utilization of situations not covered by existing policy. In traditional systems, such exceptions are propagated up a control hierarchy to eventually land in a log file and thus on a human's desk. In a KMS utilizing IPT's organizational model, common exceptions are sent to a learning module and are used to create new knowledge. This structure allows tacit knowledge to be more easily encoded into explicit knowledge. For example, the policy for offering a book discount may be that the discount is only given if a person presents a discount card, with a learned exception to offer a discount if the person spends more than $100 on their first purchase and turns in an application for a new discount card at the cash register.

Following this advice obviously will take more time, but the result in a DCD will be much easier maintenance. Designers must understand which items are likely to change and which can be abstracted. For example, terms may change over time. What is called a "general education requirement" may later be called an "undergraduate core requirement." Abstract the term in the ontology to use internally, and add specific terms as synonyms for display to users (each synonym can be augmented with an audience and date range to determine when appropriate to use). Users need to see the terms they know, but finding and changing them throughout a database and programs is time consuming and error prone. Policies and processes also change over time, often with more frequency than language.

Policies are the guiding principles by which the organization operates. These principles can be stated succinctly in a single statement or a series of if-then-else clauses. An example policy is, "Senior level electives require completion of the software engineering course and a GPA greater than 3.2." A more complex policy is, "If the student has the course prerequisites, then they may take the course; else if they get departmental approval, then they may take the course; else they may not take the course." Notice the many terms used within these two simple examples — course, prerequisite, departmental approval, GPA, elective, (course) completion.

Processes describe steps that need to be performed. These steps may involve many data changes or the execution of multiple policies and can be quite complex. Example processes are purchasing books online or getting approval for a college degree plan.

Within all these three areas — language, policies, processes — the domain can change. In a DCD, the goal is to develop systems that can be easily modified when needed.

Requirements

There are three major tasks in the requirements phase. These are elicitation, in which you get the requirements from the users; specification, in which you record these requirements; and analysis, in which you organize and correct the specification. Each is discussed in this section, including how to deal with change during and after initial requirements are gathered.

Eliciting requirements is a similar process to domain modeling, but the focus is different. In

Figure 4. Example use case with multiple scenarios for buying groceries

Buy Groceries using self check-out
1. Customer goes to check out with items to purchase
2. Customer scans each item and places it in a bag
3. Customer indicates last item has been scanned
4. System displays total
5. System requests payment information (credit, debit)
6. Customer inputs payment information
7. System confirms purchase

Alternative: Card authorization failure
At step 7, system requests customer to reenter information up to two more times, then notifies store employee for assistance.
Other Possible Alternatives: dealing with coupons, discount cards and scan failures are described in alternative scenarios.

domain modeling, designers are trying to understand the domain — what the users do and how they do it. This process facilitates communication with the users, in their language, to determine what they need the system to do. There are many structured and unstructured methods for requirements elicitation, including interviews, process tracing, and user interface prototyping (McGraw & Harbison, 1989). Prototyping is a particularly powerful method for eliciting requirements that have significant user interaction, since it is generally easier for a user to critique a simulation than to construct a comprehensive list of their needs. The process almost always starts with interviewing and some initial specification before the prototype is developed. Further elicitation and specification then proceed iteratively.

A powerful technique for capturing functional requirements is the use-case model. A use case describes the interaction of a user with the system to perform a task of value to that user. For example, entering a PIN number into an ATM is not of value to the user; getting cash from a bank account is. Use cases specify the external systems and types of users, collectively called actors; preconditions that stipulate the required system state for the use case to be valid; and possibly post-conditions, or changes to system state after the steps of the use case have been completed. Use case scenarios describe particular sequences of steps involving interaction with the system. A use case with multiple scenarios for buying groceries is shown in Figure 4. Nonfunctional requirements that do not fit into a single use case, such as specification of platform or performance needs, are recorded in a supplementary document. The use-case model and supplementary documentation together form the requirements specification.

An important facet of using use cases for requirements determination in DCDs is that they allow an analysis of the potential exceptions that will be generated out of a particular process. In use cases where there are a great many alternative scenarios, the IPT guidelines tell us that support objects and rules created should be very flexible, containing more functionality and thus minimizing the inter-object communication requirements. In some cases, these guidelines can dictate violations to traditional software development models.

In requirements analysis, the specification is examined to identify missing, conflicting, or incorrect requirements and to organize the specifications to aid understanding and communication with potential users (Priest & Sanchez, 2001). Use cases that perform similar tasks may be combined, or complex use cases may be decomposed into multiple user cases. Another analysis task is to find steps that occur in multiple use cases and extract them into a single use case. This process often results in the specification of basic system utilities like retrieving student transcript data. The collection of use cases, actors, and their relationships may be represented in a graphical format to communicate a high-level view of the total system capabilities. While early analysis aims to capture all the requirements, this goal is not usually possible, especially in DCD environments. As in all the phases of development, dealing with change must be built into the process.

To account for later change, the analysis model must be readily maintainable. Extremely detailed and large numbers of use cases are too hard to keep current. Instead, limit use-case specification to major functions. Alternative scenarios can be summarized as brief text statements instead of a detailed sequence of steps. Identify each use case using a project standard identification scheme. As development progresses, each developer should know which use case she is designing, implementing, or testing. Each artifact produced and each milestone scheduled should be tied to specific use cases. Each use case should also reference any related artifacts produced in domain analysis. This traceability is key to maintaining a live requirements specification — one that accurately reflects the current purpose of the system.

Design and Architectural issues for DCD

With maintainability as a major design goal for DCD, general software design principles are just the first consideration in selecting an appropriate architecture. Two important general principles are high cohesion, where each component is responsible for a related set of tasks, and low coupling, where the communication between components is small. Using these principles provides a starting point from which CT and IPT principles are applied to examine the concepts, and their interactions, stability and heterogeneity. In the resulting architecture, the number of required specialized components (agents) increases with the number of dynamic and/or unique processes. While this negatively effects coupling, the advantage is that policy and language changes are simpler to implement.

Two design issues of particular relevance to design for DCD are ontology creation and agent-based architectures. Ontology creation, begun in domain and requirements analysis, is fully developed during design to create a central repository for the domain language. Agent-based architectures are a means for structuring a software system that adhere to Contingency Theoretic principles. Contingency-theoretic system development (CTSD) adapts contingency theory to development and maintenance of software systems (Burnell, Durrett, & Priest, 2002; Durrett, Burnell, & Priest, 2001). A summary of CTSD is given in Table 1.

Ontologies are specifications of conceptualizations, used to help programs and humans share knowledge. They are sets of concepts — such as things, events, and relations — that are in some way congruous (such as specific natural language) and thereby create an agreed-upon vocabulary for exchanging information. They allow one group's knowledge to be understood by and shared with other groups. The DCD environment requires the ontology to be a continuously evolving effort.

Table 1. CTSD design principles

Design Principle	Rational
Isolate dynamic concept names in ontology	As terms change over time or across organizations, updating only needs to be performed in the ontology.
Isolate external systems connections	Subsystems that interface with external databases and systems tend to be highly dynamic, both in connection method and format of returned data.
Create agents for specialized complex processing; each agent performs a tightly related set of tasks	Changes to processes are localized into specialist agents, thereby aiding reuse of components.
Software Teams	IPT suggests to minimize communication requirements by combining agents into "teams"
Exception Management	To follow CT guidelines and quickly identify exceptions to existing policy, overrides are propagated to human and AI-based knowledge creation modules.
Do not use DBMS for dynamic policies or processes	Makes DBMS structure overly complex and difficult to modify, especially after system has gone into production
Incrementally design and deliver fully tested functionality	Waiting for a complete system can result in delivery of an obsolete system.

Keeping a well maintained ontology facilitates the continued use of and even allows the expansion of existing knowledge spaces

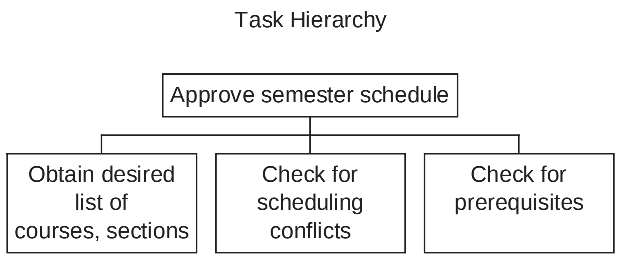
There are many definitions of and arguments over agents. Agents can be autonomous, mobile and/or intelligent. A generally agreed upon viewpoint is that an agent is a program or collection of programs that lives (continuously runs) for some purpose (is goal-based) in a dynamic environment (changing access to resources) and can make decisions to perform actions to achieve its goals. Agents have been created to schedule meetings, to find and filter news items, and to perform military reconnaissance. To illustrate how an agent operates, consider meeting scheduling. I simply notify my agent that I need to meet with my staff this week about a new project. My agent then automatically contacts the agents of each of my staff members, coordinates a suitable time, arranges the meeting room, places the meeting on my calendar, and notifies me at the appropriate time. Like the best administrative assistants, agents both know and adapt to their boss.

Multi-agent systems are those in which multiple agents (usually) cooperate to perform some task. In the meeting example above, the agents for each employee communicate directly to negotiate a time to meet. The agents may or may not be developed together. A vision for the future is that agents will seek out other agents anywhere on the Internet to find the information or resources they need to achieve a goal. This interaction will all be transparent to the user and completely secure. A less ambitious goal for multi-agent systems is to decompose a complex task into a collection of interacting agents that together solve some problem. In a military reconnaissance application, separate agents may be responsible for collecting images, navigation, and detecting threats.

The design of an individual agent is flexible. It may be object-oriented, a rule-based expert system, a neural net, or any other design. Legacy software may be "wrapped" with an agent interface. The key point is to design the agent using good design principles. This requirement means that the interfaces to the agent are clearly defined and the internal operation is hidden from all external software.

A thorough analysis of tasks and the environment are used to guide architectural design

Figure 5. Example task hierarchy for approving a semester schedule



issues. Tasks capture the actions that need to be performed by the system. Often, it is necessary to create a task hierarchy (Figure 5) so that the appropriate level of task is assigned to a computational component (or software team of multiple components), which is performed later. For each task, a predictability metric is assigned to indicate the expected stability of the task over time. This predictability metric allows us to follow IPT guidelines and create components for high predictability tasks and software teams for low predictability tasks. From domain analysis in our case study, approving a semester schedule is dynamic — the process changes over time and across universities. Conversely, checking for scheduling conflicts is static — the task of checking if there are time conflicts between two courses must always be done. Maintenance is driven by measuring the frequency with which manager (exception-handling) modules are employed to complete processing tasks.

Testing

The test effort should demonstrate that the product satisfies the customer, meets the design requirements, performs properly under all conditions, and satisfies the interface requirements of the hardware and other software components. The product is incrementally validated using the use-case scenarios. Since each scenario provides a complete description and can be immediately prototyped, this testing allows user validation to begin very early in the development process. The validation process also uses scenarios for documentation, training, and user manual purposes. Feedback is gathered from users as they learn to use the system. Issues are efficiently defined within the scenario task context and task ontology and problems can be automatically traced back to the appropriate design area. Analysis of the system by users may result in new scenarios. The best approach is to use several test methods continuously throughout design and coding. Testing rules adapted from Myers (1976) are shown below:

- A good test is one that discovers an undiscovered error.
- The biggest problem in testing is knowing when enough testing has been done.
- A programmer cannot adequately test his or her own program.
- Every test plan must describe the expected results.
- Avoid unpredictable testing.
- Develop tests for unexpected conditions as well as expected conditions.
- Thoroughly inspect all test results.
- As the number of detected errors increases, the probability that more errors exist also increases.

- Assign the most creative programmers to the test group.
- Testability must be designed into a program. Do not alter the program to make tests.

Well designed code and a development process that recognizes the importance of near-continuous testing will result in fewer schedule delays and software that performs to its specifications. One of the tenets of extreme programming is to write the test cases before writing code and to perform regression testing as part of frequent code integration.

CASE STUDY: A VIRTUAL ADVISOR

A recently designed expert advising system will be used to illustrate the process for developing a KMS for a DCD application. The student advising process found at most universities is an example of a knowledge-intensive process within a dynamic, complex environment. The process can prove to be tedious, time-consuming, inconsistent, and error-prone. From a student's perspective, the task of deciding what courses to take and when to take them can leave many students frustrated and confused. Students only need advising a limited number of times throughout their college experience, so their level of knowledge varies and is often incomplete. Designing a degree plan for a given time period and creating a schedule for each semester requires an understanding of all the policies and regulations within a university, college, and department. Student objectives and preferences mean that some semester schedules or degree plans are preferred over others, i.e., optimization. These users want a quick, effective process with limited training required.

From a faculty member's perspective, the advising process includes not only an understanding of the documented policies and rules of the university, i.e., explicit knowledge, but also an understanding of the rules and exceptions or choices that may not be explicitly stated within her own department. Many of the interrelationships between the rules are confusing, and many exceptions are often not documented. Because of this dynamic complexity, most departments identify a few individuals as departmental advisors. The departmental advisors become the knowledge center for the advising process. This organizational structure results in tacit knowledge only being known by a few individuals. The overall goal is to ensure that a student takes the appropriate courses mandated for his graduation and appropriate for his capabilities, interests, and scheduling constraints. However the level of knowledge both tacit and explicit between different faculty and faculty advisors can vary greatly. Faculty objectives focus on time management, consistency, and minimizing mistakes. Students depend on faculty advisors to know all of the rules and exceptions, as well as the students' preferences, in order to guide them appropriately.

Administrators have to manage data for each student, each semester, and each degree plan. With numerous rules and the exceptions and interrelationships between rules that are constantly changing, complexity increases exponentially. Administrators need up-to-date information about each student's course schedule and transcript, departmental schedules, lists of classes that are full, and degree, course, or section changes. Their objectives are time management, responsiveness, and maintenance.

The purpose of the Virtual Advisor (VA) system is to quickly and accurately aid students and faculty advisors in selecting courses for a semester and planning courses needed for graduation. Furthermore, the system is end-user customizable across departments and universities. Because the data, policies and procedures change frequently, are heavily interrelated, and vary widely across universities and departments, the environment is dynamic and complex. Any system built with hard-coding constraints will become obsolete within a matter of months after implementation.

A university or department cannot rely upon inflexible and non-customizable systems in adapting to the dynamic nature of curriculum changes and university rules. In the following, the major KMS development tasks are described. These tasks are performed in an iterative, not purely sequential fashion, for reasons discussed in the prior section.

Domain Analysis

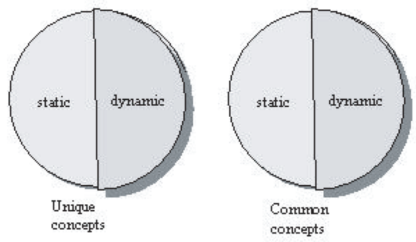
In domain analysis, we first analyzed several existing departmental advising systems, including those we had used ourselves as advisors. This analysis yielded a number of important insights. First, the existing systems were either tightly integrated with external systems, in which calls to external databases were embedded within processing code, making maintenance difficult, or they were not integrated at all, requiring downloading and manual reformatting of data before use in the system. Second, maintenance, if it occurred at all, was passed around to novice personnel with heavy workloads resulting in shoddy patches just to keep the code running. One system analyzed was so brittle that only a few of the many functions worked at all, and these required much manual effort to input and maintain accurate data. Finally, none of the systems had the capability that students want, including the ability to specify preferences for course times, or spreading difficult courses evenly over multiple semesters.

According to CTSD principles, a domain with frequent changes like this one requires a measure of the type and frequency of changes. We examined two departments at two universities, then looked at the changes that had occurred at each over the past five years. We found that an initial decomposition of terms and policies was useful (Table 2). Static concepts are those that are not subject to change. These concepts describe the fundamental terms and processes within a domain, e.g., students, instructors, and courses. This data is generally already represented in a database system. Dynamic concepts are those that have shown to change over time or are new concepts. The stability of such concepts is uncertain, and therefore the representation needs to be amenable to change. In education, policies for curriculum and admissions requirements change over time. New programs for distance education, which may have little or no history, might be categorized as dynamic, since changes are likely after the organization gains experience with the new model for education delivery. Static and dynamic concepts may be either common or unique. Common concepts are those found widely across organizations, whereas unique concepts are specific to a small percentage of organizations. Looking at these two dimensions by which a concept can be categorized, a student is a static, common concept. A requirement for an undergraduate thesis may be a static, unique concept. How the four decompositions are related is shown in Figure 6.

Table 2. Categories of domain concepts

Decomposition of Domain Concepts	Example
Static	A student ID; classification (e.g., freshman)
Dynamic	General curriculum requirements and exceptions
Common	Courses have prerequisites
Unique	Requirements for admittance into upper division technical program

Figure 6. Relationship of domain concept categories



An important task for ontology development was the creation of abstract names for common concepts. The prior concept analysis activity showed that some concepts change slightly over time within departments, and others are static, but are named differently by different organizations. In order to support maintainability, we needed to represent these differences in the ontology. For a simple example that illustrates both these characteristics, consider the static concept of a set of courses that are required for all students graduating from a particular university. In one university, the name for this concept changed from UCR to CUE. The same concept was called GEC or had no specific name at two other universities. Previous systems hard coded these names into databases, variable names, and user interfaces. The better approach is to use the abstracted name wherever invisible to the user and translate to the appropriate specific term for display. Changes are thus isolated to changing the ontology, a key tenet for supporting maintainability.

Based on the understanding gained from the domain analysis and additional interviews with domain experts, the use-case model was then prepared. Here the focus is on clearly demarcating the desired functions of the system. Since

Figure 7. Use case for checking student degree plan

USE CASE: USER DEFINED DEGREE PLAN CHECKER

Use Case ID: A13

Priority: 1   Implementation difficulty: 3

Description: The student can chose to create their degree plan for a selected number of semesters. The student is given a list of courses offered within the university. The student can then assign courses to specific semesters. The student then submits the degree plan created for system verification.

Precondition: Student logged in; in academic good-standing

Actors: Student, Online Enrollment System

Primary Scenario:

1. Student selects Degree Planner option
2. Student selects what type of degree plan he/she wants to perform
3. Student enters desired number of semesters to plan for and college/major info
4. System retrieves information on student courses and displays them
5. Student assigns desired courses into appropriate semesters
6. Student repeats step 5 as often as desired
7. Student submits created degree plan for verification
8. System checks rules and prerequisites
9. System returns with approval or an error message for any conflicts

each use case describes an interaction with the system to perform a task of value, a use case can be assigned measures to rank its priority and implementation difficulty. Analyzing the preconditions and post-conditions, a graph showing the dependencies between use cases is also developed to show, for example, that checking a degree plan is dependent upon being able to select courses for a single semester. The dependency graph and ranking measures are then used to prepare an implementation schedule, in which major milestones result in the delivery of a core set of functionality to the user. A sample use case for the virtual advisor is shown in Figure 7.

Design

To transition to design, two major activities occur that shift the focus from the external, or behavioral, view of the system, to the internal system construction. One activity is the construction of an initial class model containing only the objects and attributes that describe the major entities and their relationships. The other activity is the extraction of tasks, which will become the object methods. A useful technique for extracting these items from the use cases is to use Class-Responsibility-Collaboration (CRC) cards. A card is filled out that contains a class name, the major tasks this class is responsible for, and the other classes with which this class interacts. The strength of CRC cards is that, when utilized by a team, the interaction between the members (in simulating the execution of the system) can highlight missing or incorrect fields in a class, whether attributes or methods (Schach, 2002).

Following CTSD for the design of VA, the design grouped related classes from the CRC cards according to the considerations given below. The related classes are implemented as major modules in the systems and, if processing or communications requirements are complex, are designated to be implemented as "employee" or "manager" agents. Factors to consider when selecting the grouping of tasks, classes, and modules are:

1. the predictability/stability of the task environment and business processes involved;
2. the diversity of the task environment in terms of each relevant constituency;
3. scope or granularity of "line-level" software teams;
4. inter-team coordination techniques used and business knowledge involved; and
5. "management-level" control teams.

In the system architecture design phase CT design guidelines tell us that domain policies must be specified declaratively and grouped according to predictability to minimize the impact of change. We used relational database tables to store raw data, downloaded from external systems. This design choice isolates legacy system interface tasks. Domain policies are categorized and stored as rules. These rules are implemented in JESS. JESS rules represent and check prerequisites, degree requirements and other university rules. The Java degree planner manager interfaces with the rules and internal database to provide a degree of isolation of policy and implementation. The degree-planner manager controls the mechanics of supplying data to and storing data supplied by the degree planner rules. Thus, individual rule bases that behave as employee specialists are strictly focused on solving specific domain problems, such as creation of a degree plan based on student and university constraints. Managers handle the mundane tasks of acquiring and distributing resources (data) from the appropriate sources. A separate user interface again isolates domain policies and procedures from mechanics of implementation. Graphical rule editors, templates and parameter-setting forms allow an administrator, typically a department chair or lead advisor, to maintain the system to meet their needs and to provide portability across departments and

Figure 8. Virtual advisor architecture

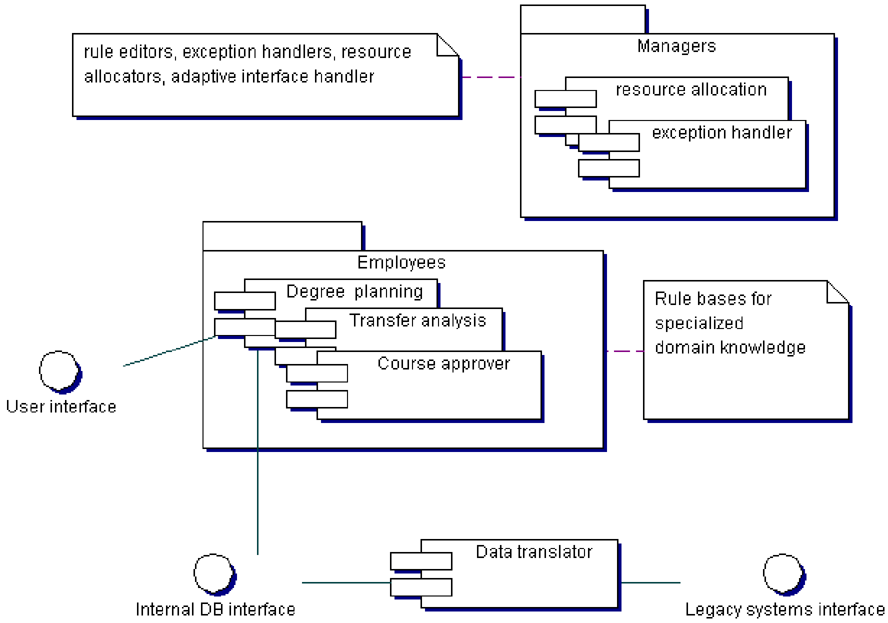


Figure 9. Semester scheduler with student preferences

universities. The resulting architecture for the system is shown in Figure 8.

Figure 9 shows one option for the semester scheduler that allows the student to select courses that match a set of preferences, and for which the student has prerequisites. As courses in the desired subject areas are selected, they are checked for time conflicts with those already selected. In the display, generic terms used internally within the system have been mapped to the specific terms used at this student's university, as specified in the ontology.

FURTHER RECOMMENDATIONS AND CONCLUSION

The development of an effective knowledge management system in any organization is a complex process. This fact is especially true in an environment subject to rapid and unpredictable changes and with many differing and interrelated resource, processing, and output requirements. However, in this type of dynamic complex environment, KMS can be extremely beneficial and can be used to create a true knowledge-based organization.

The initial design steps in any project are especially important. In developing tools to support an organization's evolution toward a flexible, knowledge-based organization the first and most important step is the creation of a vision. The vision statement for our example advising system is:

To provide accurate, timely, specific guidance to students, faculty, support staff, and others about the services provided by and the rules, requirements, and procedures of the university while remaining flexible to changing requirements and as easy to learn and use as possible.

As with all such statements, one stating the motivation for a KMS should be in terms of benefits to company, customers, and other stakeholders, not in terms of technology. It should motivate designers and users of the system toward cooperation in the realization of a greater goal. This motivation is potentially the most important part of the design of a KMS.

Equipped with the right processes, methods, and tools, it is the people that create a knowledge-based organization. It takes an upper-management champion for the system vision, the right team of developers, a good team leader, and enthusiastic users, all within an environment that encourages and rewards knowledge sharing. Developers, chosen for their creativity and flexibility as well as their technical talent, should be given the resources to learn and experiment. A team leader acts primarily in the role of coach, i.e., providing guidance, motivation, resources, and a common vision. An upper-management champion works to keep the projects funded and to garner support for larger scale efforts. Enthusiastic users are critical as well, for without their knowledge and feedback, developed products will not solve the correct problems, nor will they be used.

REFERENCES

Alavi, M., & Leidner, D.E. (2001, March). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Beck, K. (2000). *Extreme programming explained.* Reading, MA: Addison Wesley.

Birkinshaw, et al. (2002). Knowledge as a contingency variable: Do the characteristics of knowledge predict organization structure? *Organization Science, 13*(3), 274-289.

Bukowitz, W. R., & Williams, R. (2000). *Knowledge management fieldbook.* Upper Saddle River, NJ: Prentice Hall.

Burnell, et al. (2002, May 14-16). A business rules approach to departmental advising. *Proceedings of the 15th International Florida Artificial Intelligence Research Society Conference (FLAIRS-2002)*, Pensacola Beach, Florida (pp. 305-309).

CLIPS: C Language Integrated Production System. (2002). Retrieved March 29, 2002, from http://www.ghg.net/clips/CLIPS.html

Davenport, T., & Probst, G. (2000). *Knowledge management case book, Siemans best practices.* New York: John Wiley & Sons.

Dess, G.G., & Beard, D.W. (1984). Dimensions of organizational task environments. *Administrative Science Quarterly, 29*(1), 52-73.

Dixon, N. M. (2000). *Common knowledge.* Boston: Harvard Business School Press.

Durrett, J.R., Burnell, L.J., & Priest, J.W. (2001, July/August). An organizational behavior approach for managing change in information systems. *Proceedings of PICMET, Vol. 1.* Portland, Oregon (pp. 74-75). CD-ROM.

Durrett, J.R., Burnell, L.J., & Priest, J.W. (2002). A hybrid analysis and architectural design method for development of smart home components. *IEEE Wireless Communications Special Issue on Smart Homes, 19*(5), 85-91.

Durrett, J.R., Burnell, L.J., & Priest, J.W. (2002, May 19-22). SARA: Smart, agent-based resource for virtual advising. *Proceedings of 2002 International Resources Management Association International Conference Issues and Trends of Information Technology Management in Contemporary Organizations.* Seattle, Washington (pp. 344-348).

Durrett, J.R., Burnell, L.J., & Priest, J.W. (2003). A virtual advisor utilizing multi-agent software teams and contingency theoretic coordination models. In F. Albalooshi (Ed.), *Virtual education: Cases in learning and teaching technologies* (pp. 50-62). Hershey, PA: IRM Press.

Fowler, M., & Scott, K. (2000). *UML Distilled Second Edition* (page 40). Reading, MA: Addison-Wesley.

Galbraith, et al. (2001). *Designing dynamic organizations: A hands-on guide for leaders at all levels.* New York: Amacom.

Galbraith, J.R. (1973). *Designing complex organizations.* Reading, MA: Addison-Wesley.

JESS: Java Expert System Shell. (2002). Retrieved July 22, 2002, from http://herzberg.ca.sandia.gov/jess/

Krough, G. V., Ichijp, K., & Nonaks, I. (2000). *Enabling knowledge creation.* New York: Oxford Press.

Lai, V. S. (1999). A contingency examination of CASE-task fit on software developer's performance. *European Journal of Information Systems, 8*(1), 27-39.

Levesque, H. J., & Lakemeyer, G. (2000). *Logic of knowledge bases.* Cambridge, MA: MIT Press.

Loshin, D. (2001). *Enterprise knowledge management.* San Mateo, CA: Morgan Kaufmann.

March, J.G., & Simon, H.A. (1958). *Organizations.* New York: John Wiley & Sons.

McGraw, K., & Harbison, K. (1989). *Knowledge acquisition: Principles and huidelines.* Englewood Cliffs, NJ: Prentice Hall.

Palmer, S.R., & Felsing, J.M. (2002). *A practical guide to feature-driven development.* Englewood Cliffs, NJ: Prentice Hall.

Pfeffer, J., & Salanick, G.R. (1978). *The external control of organizations* (Chapters 1, 3, and 6). New York: Harper and Row.

Priest, J. W., & Sanchez, J.M. (1998). Design for producibility: A key concept in product live-cycle engineering (Chapter 15). In A. Molina, J.M. Sanchez, & A. Kusiak (Eds.), *Handbook of life cycle engineering.* Dordrecht: Kluwer Academic Publishers.

Priest, J. W., & Sanchez, J.M. (2001). *Product development and design for manufacturing: A collaborative approach for producibility and reliability.* New York: Marcel Dekker.

Schach, S.R. (2002). *Object-oriented and classical software engineering.* Boston: McGraw-Hill.

Sowa, J. F. (2000). *Knowledge representation.* Pacific Grove, CA: Brooks/Cole.

Thompson, J. D. (1967). *Organizations in action: Social science bases of administrative theory.* New York: McGraw-Hill.

Tiwana, A. (2000). *The knowledge management toolkit.* Englewood Cliffs, NJ: Prentice Hall.

W3C. (2002). *World Wide Web Consortium*. Retrieved August 13, 2002, from www.w3c.org

Chapter 2.11
Interesting Knowledge Patterns in Databases

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INTRODUCTION

Knowledge management (KM) transforms a firm's knowledge-based resources into a source of competitive advantage. Knowledge creation, a KM process, deals with the conversion of tacit knowledge to explicit knowledge and moving knowledge from the individual level to the group, organizational, and interorganizational levels (Alavi & Leidner, 2001). Four modes—namely, socialization, externalization, combination, and internalization—create knowledge through the interaction and interplay between tacit and explicit knowledge. The "combination" mode consists of combining or reconfiguring disparate bodies of existing explicit knowledge (like documents) that lead to the production of new explicit knowledge (Choo, 1998). Transactional databases are a source of rich information about a firm's processes and its business environment. Knowledge Discovery in Databases (KDD), or data mining, aims at uncovering trends and patterns that would otherwise remain buried in a firm's operational databases. KDD is "the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data." (Fayyad, Piatetsky-Shapiro, & Smyth, 1996). KDD is a typical example of IT-enabled combination mode of knowledge creation (Alavi & Leidner, 2001).

An important issue in KDD concerns the glut of patterns generated by any knowledge discovery system. The sheer number of these patterns makes manual inspection infeasible. In addition, one cannot obtain a good overview of the domain. Most of the discovered patterns are uninteresting since they represent well-known domain facts. The two problems—namely, rule quality and rule quantity—are interdependent. Knowledge of a rule's quality can help in reducing the number of rules. End-users of data mining outputs are typically managers, hard pressed for time. Hence, the need for automated methods to identify interesting, relevant, and significant patterns. This article discusses the interestingness of KDD patterns. We use the association rule (AR) (Agrawal, Imielinski, & Swami, 1993) in a market-basket context as an example of a typical KDD pattern. However, the discussions are also applicable to patterns like classification rules.

BACKGROUND

The Rule Quantity Problem: Solution Perspectives

The rule quantity problem may be a result of the automated nature of many KDD methods, such as AR mining methods. In one study, Brin, Motwani, Ullman, and Tsur (1997) discovered 23,712 rules on mining a census database. Approaches to alleviate this problem aim at reducing the number of rules required for examination while preserving relevant information present in the original set. Redundancy reduction, rule templates, incorporation of additional constraints, ranking, grouping, and visualization are some of the techniques that address the rule quantity problem.

In AR mining, additional constraints in conjunction with support and confidence thresholds can reveal specific relationships between items. These constraints reduce the search space and bring out fewer, relevant, and focused rules. Rule templates (Klemettinen, Mannila, Ronkainen, Toivonen, & Verkamo, 1994) help in selecting interesting rules by allowing a user to pre-specify the structure of interesting and uninteresting class of rules in inclusive and restrictive templates, respectively. Rules matching an inclusive template are interesting. Such templates are typical post-processing filters. Constraint-based mining (Bayardo, Agrawal, & Gunopulos, 2000) embeds user-specified rule constraints in the mining process. These constraints eliminate any rule that can be simplified to yield a rule of equal or higher predictive ability. Association patterns like negative ARs (Savasere, Omiecinski, & Navathe, 1998; Subramanian, Ananthanarayana, & Narasimha Murty, 2003), cyclic ARs (Ozden, Sridhar, & Silberschatz, 1998), inter-transactional ARs (Lu, Feng, & Han, 2000), ratio rules (Korn, Labrinidis, Kotidis, & Faloutos, 1998), and substitution rules (Teng, Hsieh, & Chen, 2002) bring out particular relationships between items. In the market-basket context, negative ARs reveal the set of items a customer is unlikely to purchase with another set. Cyclic association rules reveal purchases that display periodicity over time. Thus, imposition of additional constraints offers insight into the domain by discovering focused and tighter relationships. However, each method discovers a specific kind of behaviour. A large number of mined patterns might necessitate the use of other pruning methods. Except for rule templates, methods that enforce constraints are characterized by low user-involvement.

Redundancy reduction methods remove rules that do not convey new information. If many rules refer to the same feature of the data, then the most general rule may be retained. "Rule covers" (Toivonen, Klemettinen, Ronkainen, Hatonen, & Mannila, 1995) is a method that retains a subset of the original set of rules. This subset refers to all rows (in a relational database) that the original ruleset covered. Another strategy in AR mining (Zaki, 2000) is to determine a subset of frequently occurring closed item sets from their supersets. The magnitude of cardinality of the subset is several orders less than that of the superset. This implies fewer rules. This is done without any loss of information. Sometimes, one rule can be generated from another using a certain inference system. Retaining the basic rules may reduce the cardinality of the original rule set (Cristofor & Simovici, 2002). This process being reversible can generate the original ruleset if required. Care is taken to retain the information content of the basic unpruned set. Redundancy reduction methods may not provide a holistic picture if the size of the pruned ruleset is large. Further, the important issue of identification of interesting patterns is left unaddressed. For example, a method preserving generalizations might remove interesting exceptions.

Visualization techniques take advantage of the intuitive appeal of visual depiction that aids in easy understanding (Hilderman, Li, & Hamilton, 2002). Various features like use of graphs, colour, and charts help in improved visualization. Rules depicted in a visual form can be easily navigated to various levels of detail by iteratively and interactively changing the thresholds of rule parameters. The main drawback in visualization approaches is the difficulty of depicting a large rule/attribute space. In addition, understandability of visual depiction decreases drastically with increase in dimensions. Hence, a user might fail to detect an interesting phenomenon if it is inlaid in a crowd of mundane facts. However, for browsing a limited rule space, visualization techniques provide an intuitive overview of the domain.

A user might be able to get a good overview of the domain with a few general rules that describe its essentials. Mining generalized association rules using product/attribute taxonomies is one such approach (Srikant & Agrawal, 1995). If all items at lower levels of a product taxonomy exhibit the same relationship, then rules describing them may be replaced by a general rule that directly relates product categories. General Rules, Summaries, and Exceptions (GSE) patterns introduced by Liu, Hu, and Hsu (2000) is an approach to summarization. The general rules, along with summaries, convey an overview while exceptions point to cases differing from the general case. Another approach is to group rules on the basis of exogenous criteria such as economic assessment, profit margin, period of purchase, and so forth (Baesens, Viaene, & Vanthienen, 2000). Clustering techniques group "similar" rules (Gupta, Strehl, & Ghosh, 1999) by imposing a structure on them. Rules within each group can then be studied and evaluated based on this structure. Most of the techniques stated help in consolidating existing knowledge rather than identifying new/latent knowledge.

The Rule Quality Problem: Solution Perspectives

The "rule-quality" problem is a consequence of most of the discovered patterns referring to obvious and commonplace domain features. For example, Major and Mangano (1995) mined 529 rules from a hurricane database of which only 19 were found to be actually novel, useful, and relevant. The most common and obvious domain facts are easily discovered since they have strong presence in databases. In addition, such facts form a core component of the user's domain knowledge due to repeated observation and application. Examination of these patterns is a waste of time since they do not further a user's knowledge. Ranking rules based on their interestingness is one approach that may address the rule-quality problem.

INTERESTINGNESS MEASURES

Interestingness measures try to capture and quantify the amount of "interest" that any pattern is expected to evoke in a user. Interesting patterns are expected to arouse strong attention from users. "Interestingness," an elusive concept, has many facets that may be difficult to capture and operationalize. Some of them may be domain and user-dependent. In other cases, depending on the context, the same features may be domain and user-independent. Capturing all features of interestingness in one single measure simultaneously is an arduous task. Therefore, researchers typically concentrate on those features that are important and relevant for a particular application. Thus, operationalization of interestingness may be context-dependent. Information retrieval and KM literature allude to "relevance ranking" schemes that bring out the relevance of a particular piece of knowledge such as document and Web site. Interestingness in KDD is a much more complex concept with many facets in addition to relevance. Although relevance contributes to interestingness, a relevant pattern may not be interesting if it is commonplace knowledge. Thus, the interplay of various facets like relevance, novelty, unexpectedness, surprisingness, user knowledge, and others together determine the interestingness of a KDD pattern. A broad classification of interestingness measures may be based on user-involvement.

Objective Measures of Interestingness

Objective measures quantify a pattern's interestingness in terms of its structure and the underlying data used in the discovery process. Researchers have used measures developed in diverse fields such as statistics, social sciences, machine learning, information theory, and others to measure specific data characteristics. These include statistical measures like confidence, support (Agrawal, Imielinski, & Swami, 1993), lift (Piatetsky-Shapiro & Steingold, 2000), conviction (Brin, Motwani, Ullman, & Tsur, 1997), rule interest (Brin et al., 1997), and others. Information theoretic measures such as entropy, information content, the Kullback and the Hellinger measures have also been used in other data mining studies (Hilderman & Hamilton, 1999). Occurrence of odd events/phenomena such as Simpson's paradox is also deemed interesting (Freitas, 1998). Freitas (1999) has adopted a multi-criteria approach for evaluation of objective interestingness. Incorporation of rule-quality factors such as disjunct size, imbalance of class distributions, misclassification costs, and asymmetry help in the objective evaluation of a rule's "surprisingness." With A→B denoting an AR, P(A) and P(B) denoting the probabilities of occurrence of sets A and B, respectively, we have the following key properties (Piatetsky-Shapiro & Steingold, 2000) that should satisfy a good objective measure of interestingness (RI)

1. RI=0, if A and B are statistically independent, that is, P(A,B)=P(A).P(B)
2. RI monotonically increases with P(A,B), other parameters such as P(A) and P(B) being fixed.
3. RI monotonically decreases with P(A) (or P(B)), other parameters (i.e., P(A,B) and P(B) or P(A)) being constant.

It may be observed that these properties are tied to the co-occurrence of A and B. The interestingness of A→B increases with increase in the co-occurrence of A and B relative to individual occurrences of A or B.

Objective measures are strongly domain- and user-independent. They reveal data characteristics that are not tied to domain/user-related definitions. However, this property may limit their power of discrimination. Since any objective measure has to hold across domains, it takes care of a limited aspect of data that is common across domains. Hence, objective measures cannot capture all complexities of the discovery process (Silberschatz & Tuzhilin, 1996). Many objective measures are based on strength of the dependence relationship between items (Shekar & Natarajan, 2004b). Conventionally, interestingness is regarded as being directly proportional to strength of the dependence relationship. However, this view may lead to erroneous results (Brin et al., 1997). For example, while "Support" is useful in measuring the statistical significance of a rule, rules that are most obvious to the user have high support values. Similarly, other objective measures have their own limitations and biases.

It is also common for different objective measures to convey contradictory evaluation or conceal certain facts about a domain. Therefore, it is not only important to select the appropriate measure(s) for each domain, but also specify the correct order of application (Tan, Kumar, & Srivastava, 2004). Only then, the truly interesting rules would get revealed. An important application of objective measures is their use as initial filters to remove definitely uninteresting or unprofitable rules. Rules that reflect insignificant presence of transactions do not warrant further attention and hence may be removed by objective measures.

Subjective Measures of Interestingness

Users play an important role in the interpretation and application of KDD results. Therefore, interestingness measures need to incorporate user-views in addition to data-related aspects. Users differ in their beliefs and interests since they may have varied experience, knowledge, and psychological makeup. In addition, they also may have varying goals and difference of opinions about the applicability and usefulness of KDD results. This variation in interest enhances the importance of injecting subjectivity into interestingness evaluation (Silberschatz & Tuzhilin, 1996). "Actionability" and "Unexpectedness" are two facets that determine subjective interestingness (Silberschatz & Tuzhilin, 1996). Interesting rules may be unexpected (i.e., surprising to the user) or actionable (translating results into actions).

Actionability is an important criterion in KM because organizational performance often depends more on the ability to turn knowledge into effective action, rather than on knowledge itself (Alavi & Leidner, 2001). Actionable patterns are interesting since they offer opportunity for direct action. However, operationalization of "actionability" has proved to be an extremely difficult task due to the inherent difficulty in associating patterns with actions. Also, it may not be possible to pre-specify all possible actions. Studies centered on actionability tend to be domain-specific (Silberschatz & Tuzhilin, 1996). The demand that patterns be related to actions is one difficult task in all but the narrowest of domains where actions are clearly defined. The KEFIR system (Matheus, Piatetsky-Shapiro, & McNeill, 1996) is a typical example. Adomavicius and Tuzhilin (1997) propose an approach to defining actionability, using "action hierarchy." An action hierarchy is a tree (Deo, 1989) of actions with patterns and pattern templates (KDD queries) assigned to its nodes. This approach provides a framework for operationalizing actionability with some domain independence.

Roddick and Rice (2001) bring out the temporal and dynamic nature of interestingness. Using events in the sporting arena as a running example, they show how "anticipation" has a critical effect on both: selection of interesting events and variation of interestingness threshold as events unfold. However, the concept of anticipation needs to be further explored. Information about a subject is interesting if the user has some prior knowledge about it and also if this knowledge is relevant to user-goals (Ram, 1990). Accordingly, interestingness may be defined as a heuristic that measures relevance of the input to a person's knowledge goals. "Knowledge goals" (Ram, 1990) is related to acquiring some piece of information required for a reasoning task. If a piece of information is relevant to "knowledge goals," interest toward it increases.

Silberschatz and Tuzhilin (1996, p. 971) argue that "the majority of actionable patterns are unexpected and that the majority of unexpected patterns are actionable." Hence, they hypothesize that unexpectedness is a good approximation for actionability and vice-versa. Since unexpectedness is easier to operationalize than actionability, most studies concerning subjective interestingness employ "unexpectedness" as the main subjective criterion. Approaches to determination of subjective interestingness using "unexpectedness" tend to follow the general approach given below:

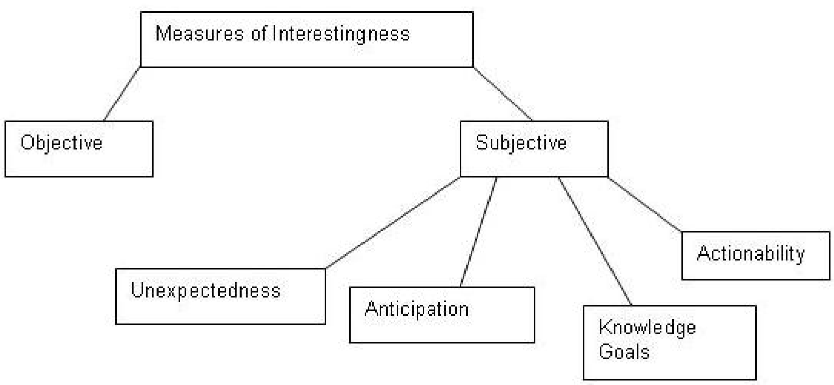
- Eliciting user-views
- Representing user-views in a form suitable for computation
- Mining the database to extract rules about the domain
- Comparing mined rules with user-views to determine the degree of conflict
- Presenting and labeling, rules that conflict user-views (on attributes such as relationship, strength, and direction), as interesting

However, methods using unexpectedness may differ in implementation details such as representation schema, method of comparison, and interestingness measures (Padmanabhan & Tuzhilin, 1999; Liu, Hsu, Mun, & Lee, 1999, Shekar & Natarajan, 2004a). One limitation of this methodology is the knowledge acquisition issue. Eliciting views from users is difficult, and acquired knowledge could be incomplete. Users may not be able to completely specify all their views about a domain. This may result in a large number of rules having high interestingness scores. Many of these rules might concern attributes, relationships, and beliefs, the user has failed to specify. Other limitations are more approach-specific, such as specifying a priori probabilities in the Bayesian approach (Silberschatz & Tuzhilin, 1996) and fuzzy membership functions (Liu et al., 1999). Figure 1 displays a partial classification of the approaches toward interestingness in KDD. Pruning and ranking of patterns on the basis of interestingness measures is an intuitive approach to rule quality and rule quantity problems.

FUTURE TRENDS

Interestingness, an elusive concept, may have many facets intrinsic to a particular domain. A combination of objective and subjective measures may be necessary to reveal interesting patterns. Some issues concerning application of interestingness measures may be generic while others may be domain-specific. One important issue is the genesis of interestingness and its constituent features. Unexpectedness and actionability do not characterize interestingness in its totality. There might be other domain-dependent features worthy of consideration and incorporation. A detailed study of interestingness in specific domains and across domains can help in capturing and operationalizing subtle features. These features could then form the basis for more comprehensive interestingness evaluation.

Figure 1. Partial classification of interestingness measures (based on Silberschatz and Tuzhilin, 1996)



Another issue concerns the joint application of objective and subjective measures. Objective measures could be used as a first filter to remove rules that are definitely uninteresting. This should be based on certain requirements, such as significance and predictive ability. Subjective measures can then bring in user-biases and beliefs into interestingness evaluations. Interaction between objective and subjective measures has not been sufficiently explored. In addition, few studies have considered the appropriateness of applying a specific interestingness measure across domains. The effect of changing the order of application of interestingness measures and the interaction between them are issues worthy of future study. Some relationships are a logical consequence of a firm's operational business rules. Such knowledge, being intuitive and tacit due to daily application, may not be specified during the knowledge elicitation phase. Incorporating such logical inferences in subjective measures is another issue for future research.

An important consideration with storing knowledge in KM systems is context inclusion (Alavi & Leidner, 2001). Without contextual information, knowledge may not be efficiently and effectively operationalized. Interestingness may be strongly domain and user-dependent and hence highly subjective. On the other hand, if objective measures can be made context-dependent by infusing them with domain-related data definitions, then the user-dependence may be reduced. This might allow sharing of KDD results across an organization.

Application of interestingness measures during the various phases of knowledge discovery has its own advantages and disadvantages. If the dataset is large, then it may be advantageous to mine rules and then apply interestingness measures. On the other hand, for a small one, application of interestingness measures during the mining phase may be preferable. Ideally, a data mining system should contain a repository of interestingness measures, both objective and subjective. Choice of measures could be based on the patterns mined, application, and purpose of the user. Here, the importance of integrating mining methods with interestingness evaluation cannot be over-emphasized.

Another problem with rule ranking concerns the possible lack of relationship among interesting rules. Thus, two consecutive interesting rules could pertain to different domains/sub-domains. Hence, it may be difficult for a user to connect them and obtain an overview of the domain. Combining methods that address the rule quantity problem with interestingness might partially address this problem. Clustering of similar rules could possibly be studied as a pre-processing step followed by a ranking scheme based on interestingness. Thus, a user might be able to obtain an overview of the domain and also discover implicit hidden knowledge brought out by interesting rules. Visualization techniques that display interestingness evaluations in an intuitive and understandable manner may be helpful.

CONCLUSION

Initial focus in the KDD community was with respect to algorithm development—toward newer and faster methods operating on large datasets. This resulted in a large number of patterns—sheer numbers of which contributed to incomprehensibility. The importance of understandability of discovered patterns, especially with respect to practical applications has been acknowledged. Recent literature in KDD has focused on various approaches to alleviate the rule quality and rule quantity problem. Ranking patterns according to interestingness is an important approach to addressing the rule quality problem. Interestingness is both data-driven and user-view driven. Correspondingly, patterns may be evaluated on the basis of objective and subjective measures. However, interestingness is an elusive concept, whose many facets are both difficult to capture and difficult to operationalize. Many of these facets are yet to be identified. Future research pertaining to interestingness is expected to yield results with respect to more complete characterizations. KM deals with the creation, storage/retrieval, transfer, and application of relevant knowledge in any organization. Interestingness measures and other methods, which address the problem of immensity of mined patterns are vital contributors to knowledge creation processes in KM. It is not uncommon to find organizations struggle to make sense of data captured through automated processes. Frameworks and methodologies for selecting relevant and significant patterns that add to organizational knowledge are expected to feature as important issues in KM.

REFERENCES

Adomavicius, G., & Tuzhilin, A. (1997). Discovery of actionable patterns in databases: The action hierarchy approach. *Proceedings of the 3rd International Conference on Data Mining and Knowledge Discovery (KDD 1997),* Newport Beach, California (pp. 111-114). AAAI Press.

Agrawal, R., Imielinski, T., & Swami, A. (1993). Mining association rules between sets of items in large databases. *Proceedings of the 1993 ACM SIGMOD International Conference on Management of Data*, Washington, DC. (pp. 207-216). ACM Press.

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Baesens, B., Viaene, S., & Vanthienen, J. (2000). Post-processing of association rules. *Proceedings of the Workshop on Post-Processing in Machine Learning and Data Mining: Interpretation, Visualization, Integration, and Related Topics Within The 6th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD 2000)*, Boston (pp. 20-23). Retrieved from www.cas.mcmaster.ca/~bruha/kdd2000/kddrep.html

Bayardo Jr., R.J., Agrawal, R., & Gunopulos, D. (2000). Constraint-based rule mining in large, dense databases. *Data Mining and Knowledge Discovery, 4*(2/3), 217-240.

Brin, S., Motwani, R., Ullman, J.D., & Tsur, S. (1997). Dynamic itemset counting and implication rules for market basket data. *Proceedings of the ACM SIGMOD International Conference on Management of Data*, Tucson, AZ (pp. 255-264). ACM Press.

Choo, C.W. (1998). *The knowing organization.* New York: Oxford University Press.

Cristofer L., & Simovici D. (2002). Generating an informative cover for association rules. *Proceedings of the 2002 IEEE International Conference on Data Mining (ICDM 2002)*, Maebashi City, Japan (pp. 597-600). IEEE Computer Society Press.

Deo, N. (1989). *Graph theory with wpplications to engineering and computer science.* India: Prentice Hall of India Private Limited.

Fayyad, U.M., Piatetsky-Shapiro, G., & Smyth, P. (1996). From data mining to knowledge discovery: An overview. In U. M. Fayyad, G. Piatetsky-Shapiro, P. Smyth, & R. Uthurusamy (Eds.), *Advances in knowledge discovery and data mining* (pp. 1-34). AAAI/MIT Press.

Freitas, A.A. (1998). On objective measures of rule surprisingness. *Proceedings of the Second European Symposium on Principles of Data Mining and Knowledge Discovery, (PKDD-98),* Lecture Notes in Artificial Intelligence. (LNAI 1510), Nantes, France (pp. 1-9). Springer-Verlag.

Freitas, A.A. (1999). On rule interestingness measures. *Knowledge-Based Systems, 12*, 309-315.

Gupta, G.K., Strehl, A., & Ghosh, J. (1999). Distance based clustering of association rules.

Proceedings of Intelligent Engineering Systems through Artificial Neural Networks, (ANNIE 1999) (Vol. 9, pp. 759-764). ASME Press.

Hilderman, R.J., Li, L., & Hamilton, H.J. (2002). Visualizing data mining results with domain generalization graphs. In U. M. Fayyad, G. G. Grinstein, & A. Wierse Andreas (Eds.), *Information visualization in data mining and knowledge discovery* (pp. 251-270). Academic Press.

Hilderman, R.J., & Hamilton, H.J. (1999). *Knowledge discovery and interestingness measures: A survey.* Technical Report, Department of Computer Science, University of Regina, Canada.

Klemettinen, M., Mannila, H., Ronkainen, P., Toivonen, H., & Verkamo, I.A. (1994). Finding interesting rules from large sets of discovered association rules. *Proceedings of the 3rd International Conference on Information and Knowledge Management (CIKM 1994)* (pp. 401-407). ACM Press.

Korn, F., Labrinidis, A., Kotidis, Y., & Faloutos, C. (1998). Ratio rules: A new paradigm for fast, quantifiable data mining. *Proceedings of the 24th International Conference on Very Large Databases (VLDB 1998),* New York (pp. 582-593). Morgan Kaufmann Publishers.

Liu, B., Hsu, W., Mun, L., & Lee, H. (1999). Finding interesting patterns using user expectations. *IEEE Transactions on Knowledge and Data Engineering, 11*(6), 817-832.

Liu, B., Hu, M., & Hsu, W. (2000). Multi-level organization and summarization of the discovered rules. *Proceedings of the ACM SIGKDD International Conference on Knowledge Discovery & Data Mining (KDD 2000),* Boston (pp. 208-217). ACM Press.

Lu, H., Feng, L., & Han, J. (2000). Beyond intra-transaction association analysis: Mining multi-dimensional inter-transaction association rules. *ACM Transactions on Information Systems, 18*(4), 423-454.

Major, J.A., and Mangano, J.J. (1995). Selecting among rules induced from a hurricane database. *Journal of Intelligent Information Systems, 4,* 39-52.

Matheus, C., Piatetsky-Shapiro, G., & McNeill, D. (1996). Selecting and reporting what is interesting: The KEFIR application to healthcare data. In U. M. Fayyad, G. Piatetsky-Shapiro, P. Smyth, & R. Uthurusamy (Eds.), *Advances in knowledge discovery and data mining* (pp. 495-516). AAAI/MIT Press.

Ozden, B., Sridhar, R., & Silberschatz, A. (1998). Cyclic association rules. *Proceedings of the 14th International Conference on Data Engineering (ICDE 1998)* (pp. 412-421). IEEE Computer Society Press.

Padmanabhan, B., & Tuzhilin, A. (1999). Unexpectedness as a measure of interestingness in knowledge discovery. *Decision Support Systems, 27*(3), 303-318.

Piatetsky-Shapiro, G., & Steingold, S. (2000). Measuring lift quality in database marketing. *ACM SIGKDD Explorations Newsletter, 2*(2), 76-80.

Ram, A. (1990). Knowledge goals: A theory of interestingness. *Proceedings of the 12th Annual Conference of the Cognitive Science Society,* Cambridge, MA.

Roddick, J.F., & Rice S. (2001). What's interesting about Cricket?: On thresholds and anticipation in discovered rules. *ACM SIGKDD Explorations Newsletter, 3*(1), 1-5, ACM Press.

Savasere, A., Omiecinski, E., & Navathe, S. (1998). Mining for strong negative associations in a large database of customer transactions. *Proceedings of the 14th International Conference on Data Engineering (ICDE 1998)* (pp. 494-502). IEEE Computer Society Press.

Shekar, B., & Natarajan, R. (2004a). A framework for evaluating knowledge-based interestingness of association rules. *Fuzzy Optimization and Decision Making, 3*(2), 157-185.

Shekar, B., & Natarajan, R. (2004b). A transaction-based neighbourhood-driven approach to quantifying interestingness of association rules. *Proceedings of the 4th IEEE International Conference on Data Mining (ICDM 2004),* Brighton, UK (pp. 194-201). IEEE Computer Society Press.

Silberschatz, A., & Tuzhilin, A. (1996). What makes patterns interesting in knowledge discovery systems. *IEEE Transactions on Knowledge and Data Engineering, 8*(6), 970-974.

Srikant, R., & Agrawal, R. (1995). Mining generalized association rules. *Proceedings of the 21st International conference on Very Large Databases (VLDB 1995),* Zurich, Switzerland (pp. 407-419). Morgan Kaufmann Publishers.

Subramanian, D.K., Ananthanarayana, V.S., & Narasimha Murty, M. (2003). Knowledge-based association rule mining using AND-OR taxonomies. *Knowledge-Based Systems, 16,* 37-45.

Tan, P., Kumar, V., & Srivastava, J. (2004). Selecting the right interestingness measure for association patterns. *Information Systems, 29*(4), 293-331.

Teng, W., Hsieh, M., & Chen, M. (2002). On the mining of substitution rules for statistically dependent items. *Proceedings of IEEE International Conference on Data Mining (ICDM 2002)* (pp. 442-449). IEEE Computer Society Press.

Toivonen, H., Klemettinen, M., Ronkainen, P., Hatonen, K., & Mannila, H. (1995). Pruning and grouping discovered association rules. *Proceedings of the Mlnet Workshop on Statistics, Machine Learning and Knowledge Discovery in Databases*, Herakhion, Crete, Greece.

Zaki, M.J. (2000). Generating non-redundant association rules. *Proceedings of the 6th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining (KDD 2000)* (pp. 34-43). ACM Press.

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Chapter 2.12
User Modelling and Personalisation of Knowledge Management Systems

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ABSTRACT

This chapter focuses on the role of user models and user modelling for enhanced, personalised user support within knowledge management systems (KMSs). Personalisation can bring a utility function as well as a conviviality function with "high touch" impact for the users. From this utility and conviviality perspective, various personalised services enable KMSs to adapt their functionality, structure, and content to match the needs and preferences of users based on a user model that is stored and updated dynamically. The chapter presents a set of examples, different types of adaptations and personalised services specific to KMSs.

INTRODUCTION

User modelling is a multidisciplinary and broad area of research. Amongst many objectives related to user modelling research, in the last few years, personalisation emerges as an important strand. In general, the goal of personalisation is to improve the efficiency of interaction with the users, to simplify the interaction, and to make complex systems more usable. Important application areas of personalisation include: customer relationship management (Kobsa, Koenemann, & Pohl, 2001; Fink & Kobsa, 2001; Schafer, Konstan, & Riedl, 2001; Ardissono, Goy, Petrone, & Segnan, 2003), educational software (Brusilovsky, 1998, 2001), and Web search and retrieval (Tanudjaja & Mui, 2002; Ardissono et al., 2003; Kurki, Jokela, Sulonen, & Turpeinen, 1999). Personalisation has already proved its utility in e-commerce and e-learning. For example Clark and Mayer (2002) emphasise the role of personalisation in e-learning. In this sense, they are quoting studies conducted by Moreno et al. (2001) and Atkinson (2002) which prove the role of the coaching agents for learning. In the domain of customer relationship management, Kobsa et al. (2001) provide data from communication reports showing that personalisation based on purchased data and personal data has a considerable payoff.

This chapter focuses on the role of user models and user modelling for enhanced, personalised user support within KMSs. Building and maintaining users' models enable one to capture their competencies, their expertise, their interests, and implicitly to better manage the tacit knowledge and the human capital. User models and user modelling are the key elements in the management of tacit knowledge, but they have a much broader scope that is not limited to human resource management and expertise finding. The user model is extended with certain characteristics of the users (level of activity, type of activity, level of knowledge sharing, etc.), and the rationale for extending the user model is explained.

The main contribution of this work is to emphasise the role of user modelling in KMSs. The chapter presents the different ways in which user modelling can be applied to KMSs. User model and user modelling are identified as key components for supporting: expertise finding, personalisation, collaboration and networking, learning, and change (Razmerita, Angehrn, & Nabeth, 2003a). Examples of specific types of adaptations and personalised services for KMSs are given.

The chapter is structured as follows. The second section introduces briefly the context of the research. It presents some issues, problems, and challenges associated with the design of actual KMSs. KMSs are high functionality systems with limited personalisation features. Personalisation has two main roles. It has utility and conviviality functionality. The main thrust of the chapter is constituted of the third, fourth, and fifth section. The third section introduces the structure of the user ontology and describes specific user modelling processes. The fourth section elaborates on the role of user models and user modelling for enhanced user support and personalisation in KMSs. Personalisation mechanisms specific to KMSs are described and some specific examples are provided. The fifth section overviews various personalised services. Finally, the sixth section includes conclusions and future research work.

TRENDS AND CHALLENGES FOR KMSS

KMSs can be defined as a "class of information systems applied to managing organisational knowledge" (Leidner & Alavi, 2001). KMSs are designed to allow their users to access and utilise the rich sources of data, information, and knowledge stored in different forms, but also to support knowledge creation, knowledge transfer, and continuous learning for the knowledge workers. Knowledge in the context of KMSs consists of experience, know-how, and expertise of the people (tacit knowledge), and different information artefacts and data stored in documents and reports available within and outside the organisation (explicit knowledge).

Even if traditional KMSs tend to provide more functionality, they are still mainly centred on content manipulation (storing, searching, and retrieving). In the last few years, various researchers have pointed out that information technology dimension is a crucial success factor, but not the most important one. Organisational culture aspects and a human-centred perspective need also to be addressed (O'Leary & Studer, 2001; Nabeth Angehrn, & Roda, 2002). Following this stream of thinking, we also believe that designing effective KMSs requires not only a view that is achieved by considering organisational imperatives and technological solutions, but it also requires taking into account a more user-centred perspective, by considering the real individual needs of the users (work tasks, responsibilities), usability and ergonomics issues, and so forth. In that sense, we agree with Prusak (2001), who emphasises that the user satisfaction is more important than the performance of technology: "Knowledge management shares information management's user perspective; a focus on value as a function of user satisfaction rather than the efficiency of the technology that houses and delivers the information." To a certain extent, user satisfaction depends on how useful and how usable the system is perceived to be. More high-touch features — such as personalisation, providing users with experience fitting their background knowledge, and task to handle — could be a plus in the acceptance and impact of KMSs.

Recently KMSs are challenged to address ambitious goals. They aim to go beyond the mere administration of electronic information; they aim to support complex business processes. These complex business processes include: learning processes, knowledge sharing, and collaboration between knowledge workers irrespective of their location, with the ultimate goal of increasing the productivity of its knowledge workers.

The complexity of business processes implies capturing, storing, and deploying a lot of knowledge. The amount of knowledge available requires an enhanced support of business processes and better mechanisms of structuring knowledge.

Actual KMSs featuring intelligence are implemented as Web-enabled environments. Ontologies, software agents, and user modelling are emerging technologies to be integrated in KMSs to help in handling this complexity. Ontologies are knowledge representation mechanisms for better structuring the domain model. Existing knowledge sources (documents, reports, images, videos, etc.) are mapped into the domain ontology and semantically enriched. This semantically enriched information enables better knowledge indexing and searching processes, and implicitly a better management of knowledge. The distributive nature of tasks to be handled in a KMS determines a natural choice for the use of multi-agent systems. Societies of agents can act with the purpose of helping the user or solving problems on behalf of the users. Specialised agents are cooperating, negotiating, and communicating in order to achieve various functions such as: discovery and classification of new knowledge, search and retrieval of information, the automatic evolution of the domain ontology, and so forth.

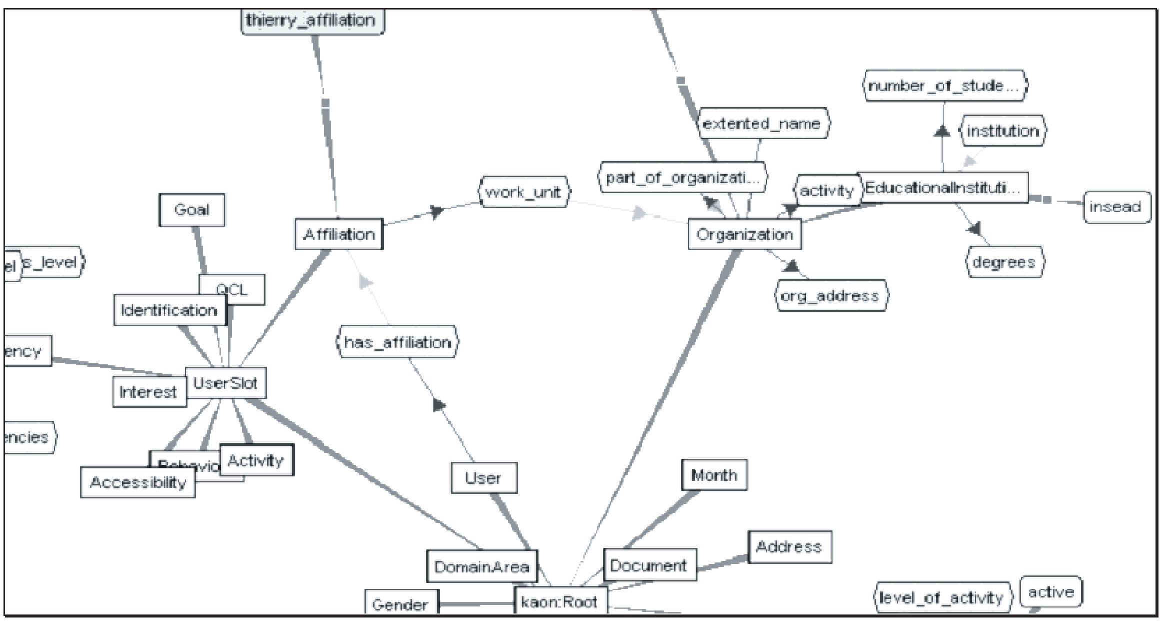
In Web-based applications personalisation is usually obtained by dynamically tailoring the content of the Web pages according to the user's model characteristics. "Adaptation decisions in adaptive systems are based taking into account various characteristics of the users represented in the user model" (Brusilovsky, 2001). Many of the Web personalisation techniques and especially adaptive hypermedia techniques methods can be successfully applied to the context of KMSs. An important strand of research in user modelling aims to enhance the interaction between the users and the systems. Numerous researchers have reported on: human-agent interaction, how to construct adaptive systems, how to tailor and filter information, how to personalise help and dialogue systems, and how to personalise interaction in e-commerce and e-learning. All these traditional application areas of user modelling brought us insights on how user modelling can contribute to enhanced features of KMSs. There clearly exist adaptation methods and personalisation techniques that are specific to KMSs. These adaptation methods and personalisation techniques relate to specific objectives of KMSs. Amongst these objectives are: how to motivate people to create knowledge and to submit new knowledge assets in the system, how to stimulate collaboration and knowledge sharing between knowledge workers irrespective of their location, how to alleviate information overload, how to simplify business processes and work tasks, and so forth. Personalisation techniques rely on the user's characteristics captured and named user models or user profiles. Building a user model, or knowing more about a user, is a first step for achieving personalised interaction. The following section presents the user ontology, including the different characteristics. These characteristics relate to personalised user support in a KMS.

BUILDING A USER ONTOLOGY FOR KMSS

The user model is defined as a user ontology describing the different characteristics of a user and the relationships between the different concepts. The first ideas of using ontologies for learner modelling have been reported by Chen and Mizoguchi (1999). Kay (1999) also argues for the use of ontologies for reusable and "scrutable" student models. More recently, the idea of using sharable data structures containing the user's features and preferences are proposed in order to enable personalised interactions with different devices for the benefit of the users. For this purpose, a user modelling mark-up language for ubiquitous computing built on XML technology has been proposed as a platform for communication by Heckmann and Krueger (2003).

The definition of the user ontology captures rich metadata about the employee's profiles comprising different characteristics such as: name, e-mail, address, competencies, cognitive style, preferences, and so forth, but also a behavioural profile specific to the user interaction with a KMS. The proposed user model is extending the Information Management System Learner Information Package specification (IMS LIP, 2001). IMS LIP is structured into 11 groupings, including: Identification, Goal, QCL (Qualifications, Certifications, and Licenses), Accessibility, Activity, Competence, Interest, Affiliation, Security Key, and Relationship. These groupings are implemented as abstract concepts in the user ontology. The concept Identification contains attributes and other sub-concepts that help to identify an individual (name, address, e-mail, etc.) within the system. Affiliation includes information on the descriptions of the organisations associated with the user/learner. QCL contains concepts related to the different qualifications, certifications, and licenses the user has. Competence contains skills associated with formal or informal training or work history. Activity includes activities related

Figure 1. A partial graph-based view of the user ontology



to the education/training work of the user. Accessibility contains concepts related to: user preferences, language information, disabilities, and so forth. The concept Interest contains information on hobbies and other recreational activities. The concept Goal contains a learner's/user's goals. The user ontology contains a set of concepts, a set of taxonomic relations (User, Learner), and a set of non-taxonomic relations ('User works_on Project', 'User has_affiliation Affiliation').

The user ontology has been implemented using KAON. A partial view of the user ontology using

Table 1. User model components and enhanced features of KMSs

User model	Functions of the KMSs
Identification first_name, email, address, etc.	Achieve access on the platform Achieve access to the user's data through the user profile editor Search for people/experts Contact people/experts
Affiliation title work_unit	Search for experts-contact units of expertise Personalize the layout Customize the user interface
Competency/QCL knowledge interests level of expertise	Filter content Use agent/event-based notification Customize an ontology/taxonomy Personalize the content
Activity working papers projects white papers documentations prototypes	Share a document Manage contributions Provide incentives for contributors Manage the "usability" of the different documents Infer the activity of the users in KMSs ProvideResources - publish ProvideMetadata -comments documents, etc.
Behavior level_of_activity type_of_activity level_of_knowledge_ sharing	Infer the user's behavior Provide incentives for change management Acknowledge the active users/provide rewards Provide incentives for knowledge sharing
Accessibility languages small/ large fonts likes/ dislikes interface agents learning style	Customize the user interface Personalize the layout Select documents based on the language criteria
Interest hobbies classical /modern music	Organize social activities Provide social networking facilities
Goal search for docs/case studies learn search for people contact people	Search/Query Retrieve documents ProvideResources - Publish ProvideMetadata Manage Documents and Folders Manage Links Manage Index/Taxonomies/Ontologies Contact people/experts Communicate and collaborate

a graph-based representation using OI-Modeler is represented in Figure 1. KAON is a tool suite for ontology management and for the development of ontology-based applications (Maedche, Motik, Stojanovic, Studer, & Volz, 2002).

KMSs aim to support people to codify their experience, to share their knowledge, and to be active in the system. For this purpose the IMS LIP groupings are extended with the Behaviour concept (see the fifth row of Table 1).

The Behaviour concept describes some characteristics of a user interacting with a KMS such as: type_of_activity, level_of_activity, level_of_knowledge_sharing. The Behaviour concept and its sub-concepts were introduced to "measure" two processes that are important for the effectiveness of a KMS, namely knowledge sharing and knowledge creation. The user modelling systems classify the users into three categories: readers, writers, or lurkers. The description of the ontology-based user-modelling system and its integration into the KMS is presented in Razmerita et al. (2003b). These categories are properties of the type_of_activity concept. The level_of_activity comprises four attributes that can be associated with the users: very active, active, passive, or inactive. The classification of users according to the type_of_activity or level_of_activity is based on heuristics. The user ontology also includes a representation of the user's level of knowledge sharing. Through the level_of_knowledge_sharing feature (Table 1), the level of adoption of knowledge sharing practices is captured. The level of adoption of knowledge sharing is defined using Near's terminology and mapping it into Roger's theory (see Angehrn & Nabeth, 1997). The user states in relation to the level of knowledge sharing are: unaware, aware, interested, trial, and adopter.

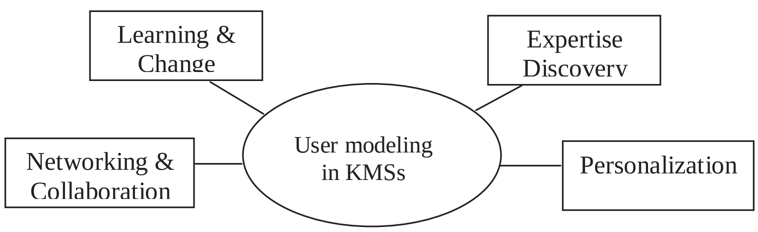
An analysis of the user's characteristics reveals the different functions that need/could be integrated in the KMS (Table 1). The components of the user model can be correlated either with the different functions required by a KMS, with enhanced user support or other personalised services.

ROLES OF USER MODELLING IN KMSS

The integration of user modelling processes in a KMS can enhance their functionality in several ways: expertise discovery, networking and collaboration, learning and change, and personalisation as represented in Figure 2.

Expertise discovery, expert finding, skill mining, or intellectual capital management are widely discussed topics in knowledge management. Making the competencies, the qualifications, and the domains of interests of the users explicit enables location of domain experts, knowledgeable

Figure 2. User modelling in KMSs facilitates enhanced functionality in four domains



persons, and how to contact them. This is also a valuable option not only for the knowledge workers who need to complete different job-related tasks, but also for human resource management units, especially for big, distributed organisations.

The use of ontologies for the user model's representation seems to be a more powerful approach for expertise discovery. Let's have a look at a more specific example of applying ontologies for user modelling and expertise finding in the context of KMSs. The user ontology describes various properties and concepts relevant for the user model. The concepts of the user ontology are bridged with the concepts of the domain ontology through properties. Figure 3 depicts in a graph-based representation a part of the concepts and properties of the user ontology. Concepts are represented with green ovals, while properties of the concepts are represented with orange ovals. The application scenario includes the followings relationships between the concepts: User, Project, and Topic described as RDFS tuples:

(User, works_on, Project)
(Project, related_to, Topic)

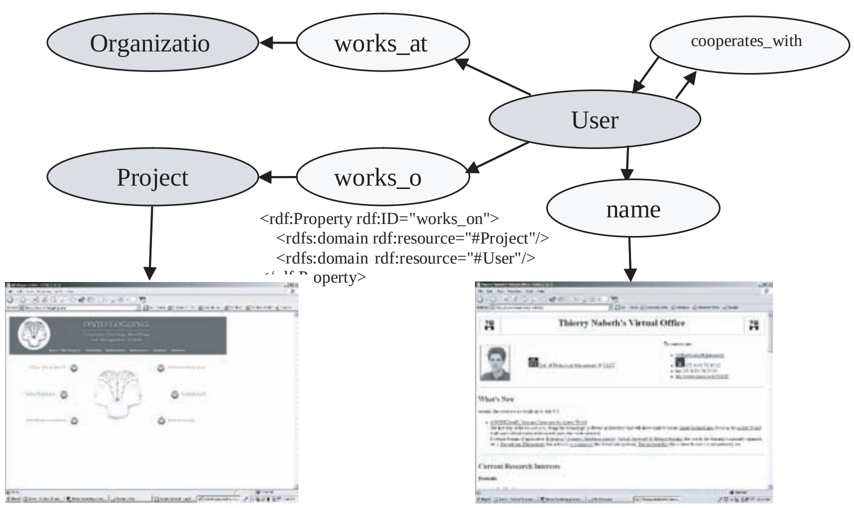
In our examples the previous RDFS tuples are instantiated as the following:

(Thierry, works_on, Ontologging)
(Ontologging, related_to, Knowledge Management)
(Ontologging, related_to, Ontology)
(Ontologging, related_to, User modelling)

The properties and the relationships between the different concepts such as: 'works_at', 'works_on', 'cooperates_with' enable us to make further inferences. Consider, for instance, the fact that: 'Thierry works_on Ontologging project'. Ontologging is described as a project about: knowledge management, user modelling, and ontologies. The range of the property 'works_on' is restricted to the concept Project. Based on these facts the system automatically infers that Thierry might have expertise in: ontology, knowledge management, and user modelling.

An Ontobroker-specific syntax (Decker, Erdmann, Fensel, & Studer, 1999) written in F-logic (Kifer, 1995) enables one to query all the people

Figure 3. Application scenario of the user ontology



working in knowledge management. This query looks like:

FORALL Y, Z <- Y: User [works_on ->>Z] and Z: Project [related_to->>KnowledgeManagement]

Thus without requiring people to keep their profiles updated, in our example the expertise, an ontology-based KMS can facilitate making the domain experts visible.

Networking and Collaboration

The dynamic exchange of tacit knowledge can be facilitated through networking and collaborative tools. In the last few years, computer-mediated collaboration or computer-supported collaborative work has developed a lot. Different types of communication systems, from e-mail to more advanced groupware systems (shared workspaces, discussion forums, chat systems, instant messaging systems, etc.), enable virtual interactions, knowledge exchanges, collaboration, and learning in distributed working environments. Social processes can facilitate networking and collaboration, and can be organised to take into account the user's characteristics (hobbies, interests). In certain systems, communities are built based on the user's domain of interests (Snowdon & Grasso, 2002).

Learning and Change

Learning is not only a process of acquiring new pieces of knowledge, but it often involves a behavioural change for the user at the individual level. From this perspective a system can also provide feedback and stimulus for behavioural change at the individual level. A KMS facilitates storing, searching, and retrieving of knowledge assets, but it also needs to promote users' participation in knowledge sharing and knowledge creation. Therefore the system tracks a series of "behavioural" characteristics of the user interaction with the system (such as level of activity, level of adoption of knowledge sharing, type of activity, etc.). These elements make the user aware of his behaviour in the system and are intended to motivate the user to be active in the system. Moreover, based on the identified stages of the users, different types of agents can intervene to stimulate and coach a user towards the adoption of a set of desired behaviours (adopters of knowledge sharing behaviour) (Angehrn, Nabeth, Razmerita, & Roda, 2001; Roda, Angehrn, Nabeth, & Razmerita, 2003).

Personalisation is an opportunity to provide more 'high-touch' features for users. It has a utility function and a conviviality function. Issues related to personalisation of KMSs will be elaborated in the following section.

PERSONALISATION OF KMSS

In the last few years, personalisation has started to become an important issue in Web-based applications. Hypermedia systems are Web-based applications consisting of various hypermedia objects (text, images, video/audio, etc.). A personalised hypermedia application is defined as a hypermedia system that adapts the content, structure, or/and presentation of networked hypermedia to each individual user's characteristics, usage behaviour, and/or usage environment (Kobsa et al., 2001).

Personalisation is obtained by dynamically tailoring the content of the Web pages according to the user's characteristics. Personalisation of hypermedia presentations has already been proved to be beneficial in learning environments, customer relationship management, or e-commerce. Nevertheless aspects of personalisation are important in most Web-based applications. The widespread integration of personalisation techniques in Web-based applications could be hindered by two main issues: (1) the complexity and implicitly of the increased cost of developing such a system, and (2) the specificity of personalisation of the different applications.

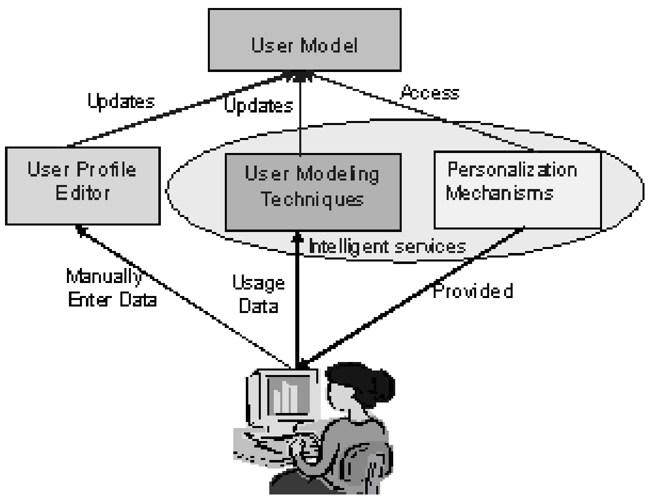
The following definition is proposed for personalisation of a KMS:

"Personalisation of a KMS as the process that enables interface customisation, adaptations of the functionality, structure, content and modality in order to increase its relevance for its individual users."

Blom (2000) distinguishes between two main roles of personalisation: (1) to facilitate the work, and (2) to accommodate social requirements. In the first category he includes enabling access to information content, accommodating work goals, and accommodating individual differences, while the second category contains eliciting an emotional response and expressing identity. These two main roles of personalisation apply to the context of KMSs, and both of them are important. A utility function that personalisation could bring to the users of a system, as well as a conviviality function with high-touch impact for the users can be differentiated. Moreover, significant differences between the role and the associated work tasks of the different knowledge workers in an organisation can be distinguished. Most of the actual KMSs include certain customisation features based on the user's preferences. Personalisation is similar to interface customisation and is usually initiated by the user. Some systems give the possibility of filtering the knowledge assets corresponding to the domain of interest of the user. Adaptive KMSs can automatically adapt to the inferred user's preferences, needs, and goals. User modelling processes enable KMSs to change their structure and content to match the needs and preferences of users based on a user model that is stored and updated dynamically.

A simplified form of a user modelling system including personalisation mechanisms is represented in Figure 4. The user modelling server acquires and maintains the user's data through a user profile editor (explicitly) and through different user modelling techniques (implicitly). The user modelling techniques and the personalisation mechanisms are named intelligent services. Under the term of personalisation mechanisms are grouped various adaptive techniques or agent-based interactions, as will be presented in subsequent sections.

Figure 4. User modelling and personalisation mechanisms



Such personalisation mechanisms are based on the user's characteristics and could include:

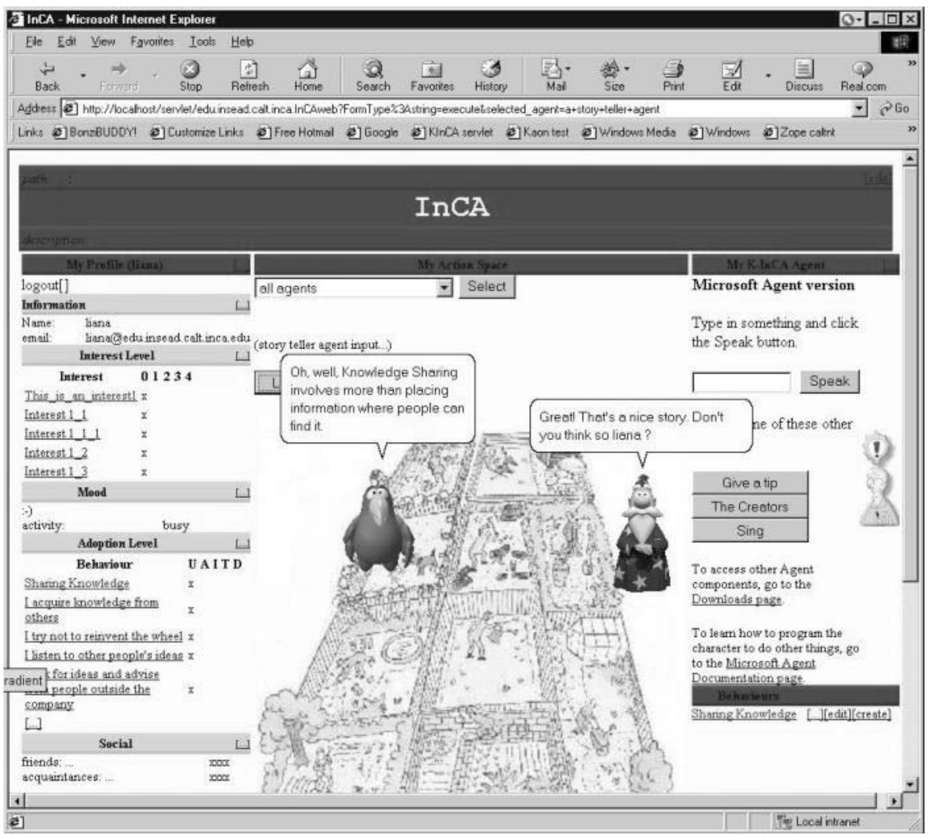
- direct access to customised relevant knowledge assets;
- provide unobtrusive assistance;
- help to find/recall information needed for a task; and
- offer to automate certain tasks through implicit or explicit interventions.

Even certain agent-based interactions can be fit into the process of adaptation; personalised interaction based on agents' intervention is presented as a distinctive type of personalisation. From this perspective personalisation can be achieved in two different ways:

- based on the agent's intervention; and
- based on various types of intelligent services that are transparent for the users also addressed as adaptive features in the user modelling literature.

Software agents possess attractive features including autonomy, proactiveness, intelligence (reasoning capability), social ability (interaction with the environment, user, and other agents), and mentalist characterisation (beliefs, desires, motivations, etc.) that can be used to build advanced adaptive, distributed systems. Agent-based systems have been used with a wide range of purposes. The agent-based approach offers a much greater opportunity for tailoring to the individual user. For this purpose the agent needs to

Figure 5. Story telling agents in KInCA



have access to information about the user (goals, objectives, preferences, interests, etc.). Agents can intervene beyond adaptation: they can support users to perform different tasks or they can be delegated to perform tasks by the users. They can reduce work and information overload (intelligent information agents, personal assistants), they can search and guide users to find different knowledge assets (filtering agents), or they can enhance learning processes (pedagogical agents, story-telling agents) (Maes,1994; Thomas & Fischer, 1996; Decker & Sycara, 1997; Klusch, 2001; Lieberman, 1996; Greer et al., 1998, Brna, Cooper, & Razmerita, 2001).

Some prototypes of the agents mentioned above have been implemented in the KInCA (Knowledge Intelligent Conversational Agents) system described in Angehrn et al. (2001) and Roda et al. (2001). KInCA is an agent-based system designed to support the adoption of knowledge sharing practices within organisations. The system observes the user's actions and, whenever appropriate, it makes suggestions, introduces concepts, proposes activities, and, in general, encourages the user in the adoption of the desired knowledge sharing behaviours.

Conversational agents aim at providing personalised guidance through the whole adoption process, from the introduction of the behaviours to the user (explaining what the desired behaviours are and why they should be adopted) to their practice within the community. Story telling has recently emerged as a practical, efficient technique for knowledge disclosure and communication in knowledge management. For instance, the story telling agents, represented in Figure 5, address the novices in the domain of knowledge sharing, namely unaware users, who get some basic ideas about the importance of sharing knowledge through entertaining conversation which takes place between two synthetic characters Peeddy and Merlin. In the following section a set of adaptive features specific to KMSs are presented.

ADAPTIVE FEATURES FOR KMSS

A flexible, adaptive system would enable the adaptation of its functionality and its hypermedia content to the basic needs of the different users. The functionality of the system is presented through the user interface. Well-designed interfaces present orderly and attractive views to the users. Bannon (1986) points out that more usable human computer interfaces can be built based on a thorough understanding of the users and of their task domain.

The main objective of the integration of adaptive features in KMSs is the dynamic generation of hypermedia spaces tailored to the characteristics and preferences of the different users. In a comprehensive overview of adaptive hypermedia systems, Brusilovky (2001) classifies the adaptive hypermedia technologies into two main groups, based on the type of adaptation provided: adaptive presentation or content-level adaptation, and link-level adaptation or adaptive navigation support.

In the following, a set of adaptive features that can be integrated in KMSs are identified and classified using Kobsa's (2001) taxonomy of adaptation. From this perspective, the adaptation techniques, at the level of the user interface, can be classified into three categories: adaptation of structure, adaptation of content, adaptation of modality and presentation.

Adaptation of Structure

Adaptation of structure refers to the way in which the hypermedia space is structured and presented to the different groups of users. Fischer (2001) provides some insights in the design of human-centred systems supported by user modelling techniques. He emphasises that high functionality applications must address three problems: (1) the unused functionality must not get in the way; (2) unknown existing functionality must be accessible or delivered at times when it is needed; and (3) commonly used functionality should be not too difficult to be learned, used, and remembered.

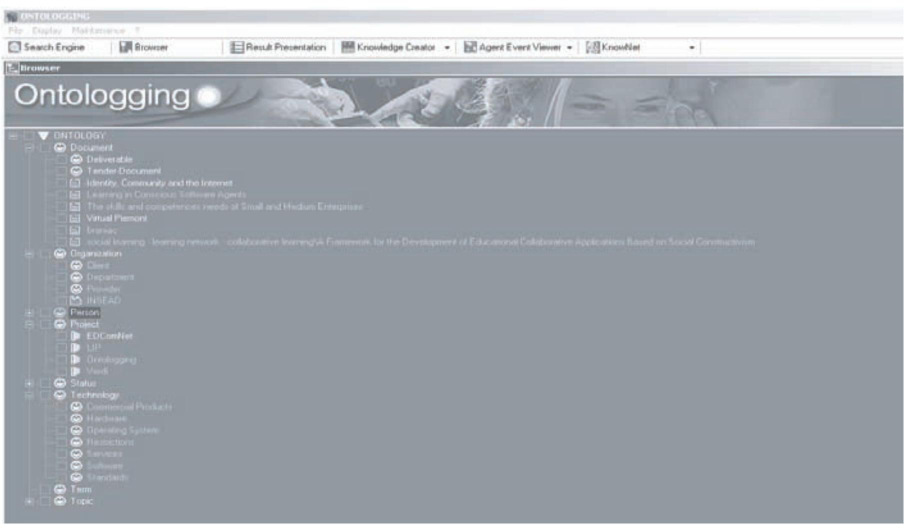
Taking into account these principles and applying them in the context of KMSs as part of a global, default view, several types of personalised views of KMSs can be designed and integrated into the system.

"Personalised views are a way to organise an electronic workplace for the users who need an access to a reasonably small part of a hyperspace for their everyday work." (Brusilovsky, 1998)

For a KMS two main types of personalised views are proposed. These personalised views can be designed as domain-oriented subsystems of the KMS. Fischer (2001) argues that high functionality applications have often migrated to a collection of domain-oriented subsystems containing their own forms, templates. For instance the system can offer a personalised view of the corporate knowledge based on the interest areas and the knowledge of the users or based on the role and competencies of the users.

- Personalised views based on the job title: Based on the role of the users and the associated work tasks, different views on the systems can be designed. Taking into account the job titles and the most important associated work tasks, several stereotyped views can be designed. A set of richer features and complex functionality can be associated with certain jobs. Similar to a system administrator, a knowledge manager or a knowledge engineer has access to a richer functionality than a normal end user. Simplified views with limited functionality can be offered to other categories of users.
- Personalised views based on the interest areas and the knowledge of the users: Implies the possibility of selecting different views or subdomains of the domain ontology/taxonomies. In an ontology-based KMS, the domain ontology or the corporate memory can be made up of different sub-ontologies. For example, financial experts could have the possibility of selecting the finance ontology, ignoring other parts of the domain ontology.

Figure 6. Ontologging system: A view of the tendering process ontology



> The DUI (Distributed User Interface) of an Ontologging system is designed using XML-driven components. The interface includes a 'template mechanism' to customise a personalised view. The DUI includes two main layers: the user interface layer and the component layer. The user interface layer consists of: search interface, browse interface, property edition and upload, result presentation interface, document download' and agent management interface. Thus through this template mechanism the different work units can personalise their view of the organisational memory, or select parts of it that are related to their expertise, interests, and so forth.

Figure 6 represents the 'tendering process' ontology of the Ontologging (www.ontologging.com) system. In a more sophisticated approach, the system is in charge with the selection of relevant knowledge assets for the user (the most suited items). The system evaluates how closed the knowledge assets match the user's background and interests, and it presents the best ones. In an ontology-based KMS, the system selects the concepts that match the user's background and interests. A sub-ontology of the domain ontology is further displayed to the user. Such techniques for selection of relevant items according to the user's profiles were described by Ardissono and Goy (2000).

Adaptation of Content

The users give different relevance to information and knowledge assets according to their goals, interests, backgrounds, or hobbies. Adaptation of content refers to the process of dynamically tailoring the information that is presented to the different users according to their specific profiles (needs, interests, level of expertise, etc.). The adaptation of content is an added value service as it facilitates the process of filtering and retrieval of relevant information. These techniques of adaptations enable users to spend less time searching and retrieving relevant knowledge. Techniques for adaptation of content are often inspired by the research on intelligent tutoring systems and adaptive explanations. The main objective of intelligent tutoring systems is to tailor and adapt the content of the presented material according to the learner's needs and goals in order to maximise the learning benefits. The user's characteristics and the process of cognitive modelling are the basis for providing support for the learners, for suggesting learning material, and for adapting the learning content to the user's needs. A large range of techniques for adaptation of content for improving online customer relationship are overviewed by Kobsa et al. (2001).

In a KMS, recommender systems, information filtering agents, and collaborative filtering techniques can be explored with the purpose of adaptation of content. More appropriate for the use within KMSs are the following techniques:

- Filtering of content: Techniques for filtering the content help the user to select and retrieve information. Different systems integrate various filtering mechanisms. Amongst the well-known engines enabling filtering and automatic classification of content are: Verity (2003) and Autonomy (2003). For example Autonomy integrates techniques such as: 'active matching and content matching'. Active matching enables users to enter the task and to extract a list of relevant documents for the task at hand. Content matching extracts conceptually related documents.
- Personalised recommendations: Inform users about available relevant information in the system. Recommendations can be provided via human (collaborative filtering) or artificial agents. In the category of recommender systems based on collaborative filtering, Xerox research park developed systems such as KPump and CWall (Snow-

don & Grasso, 2002). KPump allows users to submit recommendations of URLs, local files (via upload), or text. A recommendation consists of a rating and, preferably, a comment, along with the user's classification of the item into one or more communities. In turn, the Knowledge Pump calculates a personalised set of recommendations for a user for each community to which s/he belongs. Communities are built based on domains of interest: "A community is a set of domains of interest plus the people in the organisation with that set of interests."

- Personalised hints for marking presumed interests. Different types of agents can acknowledge to the users new knowledge assets available in the system related to their interests and expertise (notification agents, etc.). Different relevant events can also be delivered to the users based on their interests and hobbies.

Let's have a look at some specific examples. All users interested in a certain domain (knowledge management) can be notified by the agents about various events related to their domain of interests. The domain of interest corresponds to the Interest_area in the user ontology. For instance, let's consider the following event: Mr. Popescu is in charge of a new project in the area of knowledge management. The notification agent system tells all users interested in KM (via a pop-up or via e-mail, depending on their preferences) that:

"George Popescu from Competence Centre team has started a new project in the area of knowledge management."

Another example: when Mr. Ionescu submits a new document into the system, all users interested in KM are notified that:

"A new document related to Knowledge Management authored/submitted by Adrian Ionescu is available in the system."

- Optional detailed information and automatic summarisation: Filtering certain parts of the documents could be provided based on semantic annotations included in the document. For example paragraphs of HTML documents can be annotated in order to enable to adapt the content of the displayed pages according to the user's interests and preferences. Such techniques for tailoring Web pages to the user's needs and interests are presented by many researchers (Signore, Bartoli, & Fresta, 1997; Calvi & De Bra, 1997; Milosavljevic & Oberlander, 1998).

Techniques of automatic summarisation enables the automatic generation of summary from a certain piece of content. Autonomy (2003) is an example of knowledge management system embedding techniques of automatic summarisation. This summary can be displayed by default to the users based on his preferences.

ADAPTATION OF PRESENTATION AND MODALITY

The adaptation of presentation empowers the users to choose between different presentation styles, such as different layouts, skins, or fonts. Other preferences can include the presence or absence of anthropomorphic interface agents, the preferred languages, and so forth. Different types of sorting, bookmarks, and shortcuts can also be included in a high functional system. Adaptation of presentation overlaps in a certain extent with interface customisation. New modalities of information visualisation have recently emerged. These new forms of information visualisation try to go beyond a tree-based view of documents or knowledge assets. Intelligent information portals bring new designs of the user interface with a graphical view representation (Kartoo, Brain, ClusterMap, etc.). The adaptation of modality enables changes from text to other types of media to present the information to the user (image, video, animations, or audio) if they are available in the system. In modern adaptive hypermedia, different types of media can present the same content. The adaptation of modality enables the automatic selection of the media type based on various criteria such as: cognitive style, learning style, preferences, and so forth. The Avanti system (Fink & Kobsa, 2000) explores such changes of modality and different types of adaptations to the user's preferences and to the user's physical abilities.

CONCLUSIONS AND FUTURE TRENDS

Knowledge management systems tend to become high functionality systems as they need to integrate complex business processes. The research on user modelling is motivated by four main reasons: (1) the users are the key element in the management of tacit knowledge; (2) the characteristics and the needs of the individual users are very different (work tasks, expertise, responsibilities, backgrounds); (3) the heterogeneity of the different groups of people (i.e., work units, teams); and (4) user models and user modelling are the basis for achieving personalised interaction and enhanced user support.

Knowledge workers want convivial, simple systems adapted to their specific needs. Personalisation and adaptive features for KMSs are becoming inescapable features of the current KMSs. Personalisation has a utility function and a conviviality function.

From the utility perspective:

- personalisation helps fitting the functionality of the system to the user's needs; and
- personalisation reduces the information overflow by providing users with the most relevant information.

From the conviviality perspective:

- personalisation helps to bridge the gap between the 'designer's view of the system' and the end-user's view of the system, and to take into account the user's preferences.

The main contribution of this work is to demonstrate the role of user modelling in KMSs. This chapter has emphasised the different ways in which user modelling can be applied in a KMS. User modelling has an essential role for enhanced user support within KMSs. Different types of adaptations and personalised services have been presented. It has been shown how user modelling can be used for: personalisation, expertise discovery, networking, collaboration, and learning.

ACKNOWLEDGMENTS

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REFERENCES

Angehrn, A., & Nabeth, T. (1997). Leveraging emerging technologies in management-education:

Research and experiences. *European Management Journal, 15*, 275-285.

Angehrn, A., Nabeth, T., Razmerita, L., & Roda, C. (2001, August). KInCA: Using artificial agents for helping people to learn new behaviours. *Proceedings of the IEEE International Conference on Advanced Learning Technologies (ICALT 2001),* Madison, WI.

Ardissono, L., & Goy, A. (2000). Tailoring the interaction with users in Web stores. *User Modelling and User-Adapted Interaction, 10*(4), 251-303.

Ardissono, L., Goy, A., Petrone, G., & Segnan, M. (2003). A multi-agent infrastructure for developing personalised Web-based systems. *ACM Transactions on Internet Technology (TOIT).* ACM Press.

Autonomy. (2003). *Autonomy white paper.* Retrieved September 27, 2003, from www.autonomy.com

Blom, J. (2000). Personalisation—a taxonomy. *Proceedings of CHI'00 Conference on Human Factors in Computing Systems,* The Hague, The Netherlands.

Brna, P., Cooper, B., & Razmerita, L. (2001). Marching to the wrong distant drum: Pedagogic agents, emotion and student modelling. *Proceedings of the Workshop on Attitude, Personality and Emotions in User-Adapted Interaction in Conjunction with User Modelling,* Sonthofen, Germany.

Brusilovsky, P. (1998). Adaptive educational systems on the World Wide Web: A review of available technologies. *Proceedings of the 4th International Conference in Intelligent Tutoring Systems,* San Antonio, TX.

Brusilovsky, P. (2001). *Adaptive hypermedia, user modelling and user-adapted interaction* (pp. 87-110). The Netherlands: Kluwer Academic Publishers.

Calvi, L., & De Bra, P. (1997). Using dynamic hypertext to create multi-purpose textbooks. In T. Mtildner & T.C. Reeves (Eds.), *ED-MEDIA'97* (pp. 130-135). AACE Press.

Chen, W., & Mizoguchi, R. (1999). Communication content ontology for learner model agent in multi-agent architecture. In G. Cumming, T. Okamoto, & L. Gomez (Eds.), *Advanced Research in Computers and Communications in Education, Proceedings of ICCE'99* (pp. 95-102).

Clark, R.C., & Mayer, R.E. (2003). *E-learning and the science of instruction: Proven guidelines for consumers and designers of multimedia learning.* John Wiley & Sons.

Decker, S., Erdmann, M., Fensel, D., & Studer, R. (1999). Ontobroker: Ontology-based access to distributed and semi-structured information. In R. Meersman et al. (Eds.), *Database semantics: Semantic issues in multimedia systems* (pp. 351-369). Kluwer Academic Publishers.

Fink, J., & Kobsa, A. (2000). A review and analysis of commercial user modelling servers for personalisation on the World Wide Web. *User Modelling and User Adapted Interaction, Special Issue on Deployed User Modelling, 10,* 204-209.

Fischer, G. (2001). User modelling in human-computer interaction. *User Modelling and User Adaptive Interaction,* 69-85.

Greer, J., McCalla, G., Vassileva, J., Deters, R., Bull, S., & Kettel, L. (2001). Lessons learned in deploying a multi-agent learning support system: The I-Help experience. *Proceedings of AIED 2001* (pp. 410-421). San Antonio, TX.

Heckmann, D., & Krueger, A. (2003). A user modelling markup language (UserML) for ubiquitous computing. *Proceedings of the Ninth International*

Conference on User Modelling (pp. 393-397). Berlin: Springer-Verlag.

IMS LIP, IMS Learner Information Package. (2001). Retrieved November, 22, 2001, from www.imsproject.org/aboutims.html

Kay, J. (2001). Scrutability for personalised interfaces. *ERCIM NEWS, Special Theme Issue on Human Computer Interaction, 46*, 49-50.

Kobsa, A., Koenemann, J., & Pohl, W. (2000). Personalised hypermedia presentation techniques for improving online customer relationships. *The Knowledge Engineering Review, 16*, 111-155.

Kurki, T., Jokela, S., Sulonen, R., & Turpeinen, M. (1999). Agents in delivering personalised content based on semantic metadata. *Proceedings of the 1999 AAAI Spring Symposium Workshop on Intelligent Agents in Cyberspace* (pp. 84-93). Stanford, CA.

Lieberman, H. (1995). Letizia: An agent that assists Web browsing. *Proceedings of the International Joint Conference on Artificial Intelligence (IJCAI'95)* (pp. 924-929), Montreal, Canada.

Maedche, A., Motik, B., Stojanovic, L., Studer, R., & Volz, R. (2002). Ontologies for enterprise knowledge management. *IEEE Intelligent Systems, (November-December)*, 12-22.

Maes, P. (1998). Modelling adaptive autonomous agents. *Artificial Life Journal, 1*(1&2), 135-162.

Nabeth, T., Angehrn, A., & Roda, C. (2002). Towards personalised, socially aware and active knowledge management system. *Proceedings of the E-Business and E-Work Annual Conference (E-2002),* Prague, Czech Republic.

O'Leary, D., & Studer, R. (2001). Knowledge management: An interdisciplinary approach. *IEEE Intelligent Systems Journal,* (January/February), 44-49.

Prusak, L. (2001). Where did knowledge management come from? *IBM Systems Journal, 40*(4), 1002.

Razmerita, L., Angehrn, A., & Nabeth, T. (2003a). On the role of user models and user modelling in knowledge management systems. *Proceedings of HCI International* (Volume 2, pp, 450-456), Greece.

Razmerita, L., Angehrn, A., & Maedche, A. (2003b). Ontology-based user modelling for knowledge management systems. *UM2003 User Modelling: Proceedings of the Ninth International Conference* (pp. 213-217). Pittsburgh, PA: Springer-Verlag.

Roda, C., Angehrn, A., Nabeth, T., & Razmerita, L. (2003). *Using conversational agents to support the adoption of knowledge sharing practices. Interacting with computers* (pp. 57-89). Elsevier.

Schafer, J.B., Konstan, J.A., & Riedl, J. (2001). E-commerce recommendation applications. *Data Mining and Knowledge Discovery.*

Signore, O., Bartoli R., & Fresta, G. (1997). Tailoring Web pages to users' needs. In T. Mtildner & T.C. Reeves (Eds.), *ED-MEDIA'97.* AACE Press.

Snowdon, D., & Grasso, A. (2002). Diffusing information in organisational settings: Learning from experience. *Proceedings of the Conference on Human Factors and Computing Systems* (pp. 331-338), Minnesota.

Tanudjaja, F., & Mui, L. (2002). Persona: A contextualized and personalised Web search. *Proceedings of the 35th Hawaii International Conference on System Science (HICSS).*

Thomas, C., & Fischer, G. (1996). Using agents to improve the usability and usefulness of the World Wide Web. *Proceedings of the 5th International Conference on User Modelling* (pp. 5-12).

Verity. (2003). Retrieved October 10, 2003, from www.verity.com

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Chapter 2.13
Integrating Knowledge Management with the Systems Analysis Process

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INTRODUCTION

Information systems research has clearly recognized that knowledge management systems (KMSs) have different characteristics and requirements than those of a classic management information system (MIS). Beginning with the relationship drawn between data, information, and knowledge (Alavi & Leidner, 1999, 2001; Bhatt, 2001; Ulrich, 2001; Spiegler, 2000, 2003; Tuomi, 2000), through to the essential nature of unstructured and semi-structured information vs. structured information (Wu, Ling, Lee, & Dobbie, 2001; Lai, Carlsen, Christiansson, & Svidt, 2003; Fensel et al., 2002; Chou & Chow, 2000), there are many elements and areas in which the two diverge.

However although the definition, description, and implementation of a KMS has been recognized as sufficiently distinct from an MIS (Alavi & Leidner, 2001; Hahn & Subramani, 2000; Plass & Salisbury, 2002; Malhotra, 2002), there is no single clear approach to develop a systems analysis and development process that is tailored specifically for a KMS (Alavi & Leidner, 2001; Hahn & Subramani, 2000; Plass & Salisbury, 2002). While the first generation of KMS has been developed as add-on or parallel systems living alongside pre-existing structured management information systems, the next generation of systems development needs to deal with fusion systems. A fusion system (Gray et al., 1997) is a system that integrates structured and unstructured knowledge in real time, allowing for full situational assessment based on both information and knowledge resources.

MIS has a long and illustrious history of research and development focusing on creating and refining the systems analysis process. KMS has no such legacy other than what it has inherited directly from MIS. The purpose of this article is to articulate the unique systems analysis and development issues presented by KMS in organizations, explain why tight integration between MIS and KMS development processes is desirable, and illustrate how such integration can be achieved through a modified Knowledge Integrated Systems Analysis (KISA) process for knowledge management.

The KISA process evolved from a series of action research cycles conducted over an information system development project within the Information Systems Development Department and the Chief Information Office of the Israeli Navy. Beginning with a classic IS development approach, each development cycle added new modifications to the process, until a fully integrated process was reached and then applied, without modification, to new integrated KMS-MIS development. The result is a process that is tailored to the needs of fusion systems. The result is an integrated (knowledge and process) system to support the Navy mission lifecycle.

BACKGROUND

According to Demarco (1978):

Analysis is the study of a problem, prior to taking some action. In the specific domain of computer systems development, analysis refers to the study of some business area or application, usually leading to the specification of a new system. (p. 4)

Whitten, Bentley, and Dittman (2001) state that the systems analyst will study "the problems and needs of an organization to determine how people, data, processes, communications, and information technology can best accomplish improvement for the business" (p. 14). No matter what methodology of system analysis is chosen—structured, information modeling or object-oriented methodology—this statement by Demarco made over 25 years ago is still correct. Although methodology changes, still the systems analyst as specified by Yourdon (1989) is the key member of any systems development project and, in fact, this role has not changed. Sircar, Nerur, and Mahapatra (2001) showed that a controversy exists in the literature about the magnitude and nature of the differences between object-oriented (OO) and structured systems development methods. Some authors, as cited by these researchers, believe that the OO approach is merely an evolution from the structured systems development approaches. Others cited by these researchers claim that OO requires an entirely new approach and mindset; still the researchers' emphasize that the primary task of system analysis within the systems development process is to capture the essence of a real-world system through models. This fundamental task has been incorporated into both the structured and the OO development approaches.

Knowledge in an organization can be characterized as unstructured or semi-structured, whereas information and data are fully structured and can be managed by common information management methods. Estimates show that unstructured and semi-structured information account for about 80% of the information volume within organizations (Corp, 2001; Lindvall, Rus, & Sinha, 2003; Ferrucci & Lally, 2004). Therefore, a structured MIS that aids organizational processes will only be addressing 20% of the information management needs. KM flourishes in this gap. Within this gap, most KM projects place an emphasis on knowledge "stock," which tends to dominate an organization's thinking about knowledge (Fahey & Prusak, 1998). According to Schwartz and Te'eni (2000) and Fisher (1999), the problem is "getting the right knowledge to the right person at the right time," or in other words, "delivery of the knowledge to the point of action where it can be applied to the issue at hand" (Schwartz, Divitini, & Brasethvic, 2000).

However, the "right knowledge" is not necessarily the sole property of the knowledge management domain, nor is it to be wholly found in the management information systems domain. The right knowledge is often a fusion of what resides within an MIS with what resides within a KMS. To produce a full knowledge-based situational assessment, fusion between the different systems is required. We need to look beyond placing knowledge management systems alongside our management information systems and strive to have them tightly integrated or intertwined.

The need to utilize new or revised systems analysis methods is founded upon few basic phenomena. First, over time, systems analysis methods have evolved in response to the growing complexity of software systems (Booch, 1994). The two main methods of systems analysis—the Structured (Demarco, 1978; Gane & Sarson, 1979; Yourdon 1989) and Object Oriented (Rumbaugh, Blaha, Premerlani, Eddy, & Lorensen, 1991; Jacobson, Christerson, Jonsson, & Overgaard, 1992; Booch, 1994)—are mainly focused on the structured information as part of the business process. Considering the increase in complexity caused by KM mainly from a technical point of view—the dominant unstructured or semi-structured nature—new or revised methods of system analysis methods are indicated.

Second, as suggested by Jayaratna and Sommerville (1998), current methods and techniques for classic systems analysis lack the ability to close the gap between the ordered world of formality and the complex real world. Adding the lack of structure found in KM to this equation only widens this gap. Since the real world has become more complex, it is the formal methods and techniques that are to be changed.

Third, KM is intended to be viewed as a natural extension of the IS function, and studies show that IS remains responsible for most KM implementation and management (King, Marks, & McCoy, 2002). However, approaching the new field of KMS with the old tools of systems analysis is a recipe for failure. This confusion leads to facts mentioned by researchers, that there is no single clear approach to the development of KMS (Alavi & Leidner, 1999), and that KMSs are developed in ad-hoc and trial-and-error modes (Plass & Salisbury, 2002; Nissen, 2001). The classic system analysis process tends to ignore organizational knowledge and KM process, focusing instead on the organizational processes that involve data and information.

NIMSAD (Normative Information Model-based Systems Analysis and Design) is a systemic framework created by Jayaratna (1994). It is used to understand and evaluate methodologies. Using this framework to examine the structured analysis methodology shows clearly that the classic systems methodology focuses on the flows and structures of formal data and data-related activities, while any aspect beyond this remains outside the area of the practitioner concern (Jayaratna, 1994).

KISA: KNOWLEDGE INTEGRATED SYSTEMS ANALYSIS

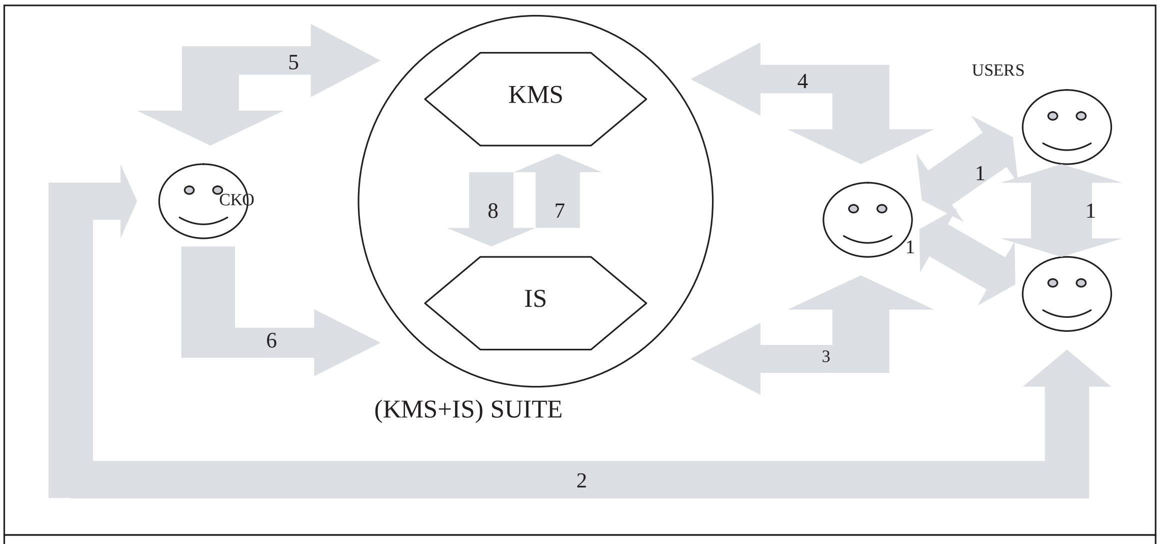
One strategy to accomplish this tight coupling between KMS and MIS is to specifically integrate knowledge items (or knowledge artifacts) into the information system. The approach illustrated here is based on the popular UML (Unified Modeling Language) methodology for systems analysis and design. The modified system analysis phases include building the KMS as part of the system analysis process, and adding the knowledge items into the UML charts. The final product of this approach is a unified system that contains two cooperative but independent subsystems, which allow the users to accomplish their processes and use knowledge artifacts at the right time, in the right way. UML is a unification of three methods (Jacobson, Booch, & Rumbaugh, 1999); the unified process is use-case driven, which is a piece of functionality in the system that gives a user (or another system) a result of value. All the use cases together make up the use-case model, which describes the complete functionality of the system. The main reasons for using the use-case model (and the UML as a whole) are the ability of reuse (since use case offers systematic and intuitive means of capturing functionality) and the ability to support the whole development process (most activities such as analysis, design, and testing are performed starting from use cases). According to Fowler and Kendall (2000), the fundamental reason to use the UML involves communication: "I use the UML because it allows me to communicate certain concepts more clearly than the alternatives" (p. 7).

Macro-Level KISA

An Integrated IS + KMS Suit

Information systems cannot be viewed as stand-alone systems, but as interrelated systems that need continuous management rather then one-time planning (Lindgren, Hardless, Pessi, & Nulden, 2002). A system analysis process for a single system that ignores the overall picture is strategically wrong. In other words, planning a system should be part of the information strategy and needs to integrate with the present and future systems. Therefore a KMS should always be part of the overall picture, and a KMS analysis process is part of an overall analysis process. Only the planning of KMS+IS will lead to streamlined, seamless business processes. Today, because most organizations have already established procedural information systems, a new KMS analysis process should be part of the strategy and lead to integration with the organizations' legacy systems. Davenport and Glaser (2002) call this approach "just-in-time delivery," stating that the key to success is "to bake specialized knowledge

Figure 1. KMS+IS suite and user roles



1. Communication and collaboration of the individuals within the organization.
2. Communication of individuals with the CKO with respect to the organization's knowledge needs.
3. A user approaches the suite to fulfill the structured organizational procedural activities (use the IS module).
4. A user approaches the suite to acquire knowledge for unstructured activities (use the KMS module).
5. The CKO organizes, formalizes, and stores the knowledge to the suite (to the KMS module).
6. The CKO is actively part of changes in the suite (the procedures within the IS), to align with the knowledge used by the process.
7, 8. The IS module "calls" the KMS module for knowledge at the moment it is the most valuable.

into the jobs of highly skilled workers—to make the knowledge so readily accessible that it can't be avoided."

The integrated suit is illustrated in Figure 1. It should be emphasized that the KMS component or module within the suit allows not only integrated knowledge within the process, but also allows free retrieval of knowledge. For example, knowledge as lessons learned should be available while performing an organizational procedure, like preparing the next week work plan, and also available for a new worker learning the job, by using free retrieval of knowledge.

A Moderated System Analysis Process

Our point of departure is that the IS+KMS suit (as illustrated in Figure 1) is the product of combining IS and KMS methodologies. A classic system analysis process contains the following phases (Whitten et al., 2001; Yourdon, 1989; Demarco, 1978; Gane & Sarson, 1979; Booch, 1994; Pressman, 2000):

1. initial problem/opportunity identification (including feasibility testing)
2. study of the current system
3. requirements discovery and analysis
4. data modeling
5. information modeling
6. process modeling

In order to emphasize the main modifications of the integrated system analysis process, we will discuss it from both macro-moderation and micro-moderation points of view.

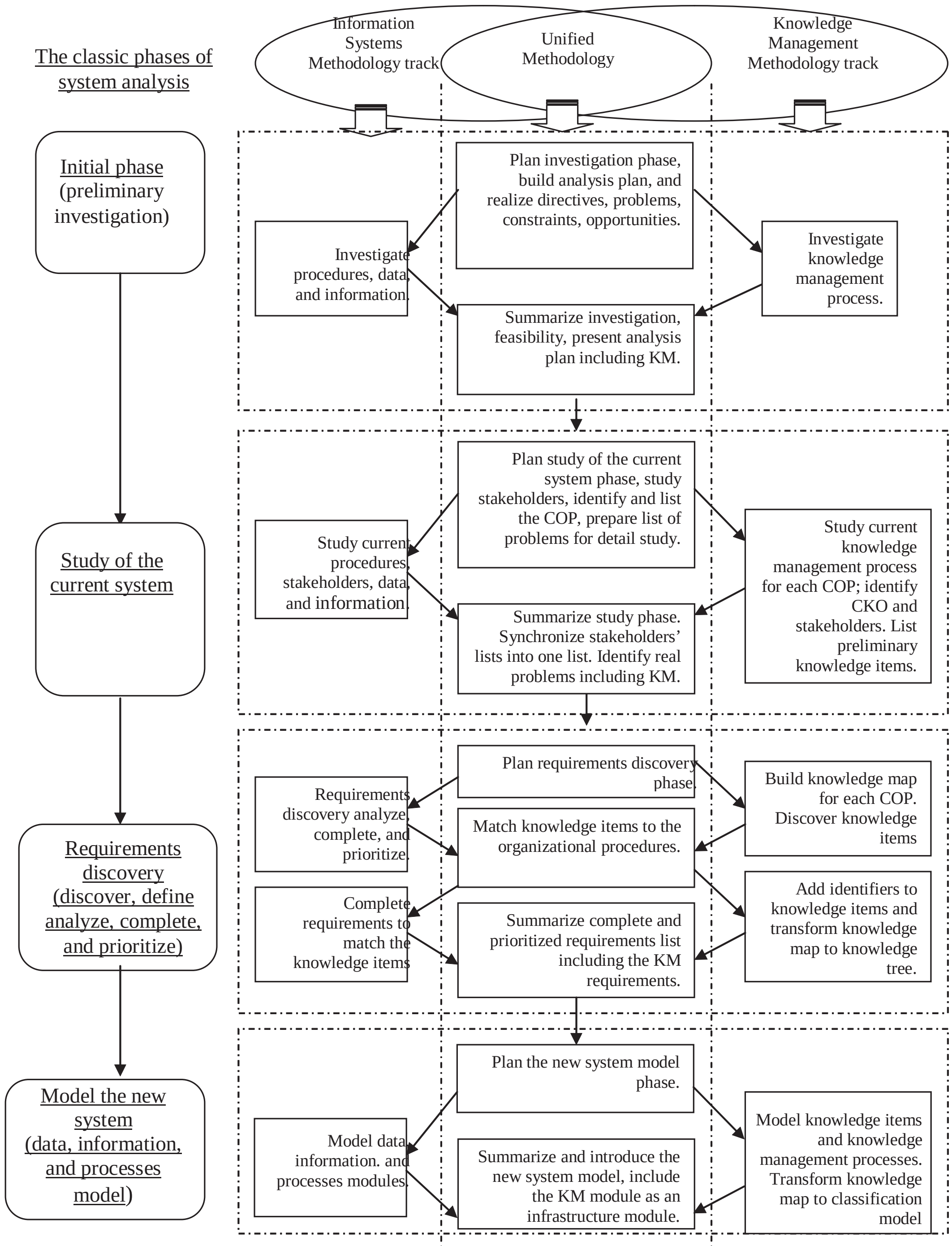
The main macro-modifications result in the bifurcation of well-known classic system analysis processes into two tracks. As shown in Figure 2, the IS track and the KMS track run in parallel with clearly defined points of intersection. The two tracks must be well planned and synchronized so the work in the two tracks will be able to be done independently (because the tools and the techniques are different) yet synchronously. Each phase begins by planning the KMS and the IS activities to be accomplished within this phase, then allowing the two tracks to diverge and be done according to their distinct methodologies (meaning IS or KMS methodology). However, as planned, the synchronization demands that the KMS will serve the IS and thus results in a situation in which knowledge serves the organizational procedures by nourishing the organizational procedures with the knowledge items at the appropriate action points.

For example, a well-known tool of KMS methodology is the knowledge map (Vail, 1999). This tool will be still used by the KMS track, but it will also be directed to serve the organizational procedural process as the IS track see and define it. Specifically, the knowledge items to be mapped will have process notification. In other words each item will be able to address the organizational procedures it serves. Another example shows that the modeling of the new organizational procedures as done in the IS track (by UML, DFD, or any other technique) will include the detailed exits points where the user should reach the knowledge items, which had been identified in the KMS track.

The summary of each phase of the KISA process is again the convergence of the two tracks. The synchronization between the two tracks is crucial for the success of the whole process. It demands a clear definition of the activities in each track so full cooperation and no unnecessary overlapping will result. This is actually the fusion that is reached by the meeting of the IS group and the KMS group. The process involves not only data and information modeling, but also the knowledge modeling. The system analyst is required to define not only the organizational work procedure, but also the knowledge artifacts that serve each event of these procedures. The new system model also handles the knowledge management process as one of the organizational procedures.

The product of the KISA process is a full systems design, which usually contains the module

Figure 2. Macro view of the moderated system analysis process



blueprints. Some of these will be infrastructure modules (which handle the users, workflow mechanism, etc.), while others are operational modules (marketing, finance, etc.). The KM component in the system is the KMS and considered as one of the infrastructure modules; this module will include the KM basic activities such as collect, formalize, store, organize, and share the knowledge that serves on demand (or request) the IS operational modules.

Micro-Level KISA

Micro-moderations are the moderations to the activities within each phase of the system analysis process. Here we describe the interface at requirements elicitation. This activity is the base for the construction of the interface between the operational IS modules that are responsible for the organizational procedures, and the KM module. The process of interface requirements elicitation can be understood as shown in Figure 3. The knowledge items were elicited prior (using the knowledge map in the KMS track), and the requirements for the organizational procedure were discovered in advance (using the UML or the DFD notation). Since not all the knowledge items and not all the organizational procedures were discovered, the meeting point of the two tracks is the place to reveal the missing parts. Now the interface modeling starts by the system analyst in each of the two groups (the IS operational modules group, and the KM module group) working synchronously in the two tracks and matching the knowledge items to their right organizational procedure.

The following example illustrates: Consider that the organizational procedure is Maintenance Planning for a ship type of A. The planner of this process needs the right lessons learned, which were recognized as knowledge items in the KMS. Receiving the right lesson learned at the time of planning is using the right knowledge at the right time for the right person in the right way. In the interface requirements elicitation and modeling stage, the lessons learned that reside in the KMS should be pointed to their right place within the Maintenance Planning procedure. The system analysts from the two groups (accompanied by the top user and the chief knowledge officer) must identify the location in the procedure and the exact identifiers which allow the IS module to request the knowledge items and the KM module to deliver. In this example, the ship type, the location of the maintenance (which shipyard), the time of year, and so forth, will serve as identifiers for these knowledge items of the type of lesson learned. The identifiers of the knowledge items can also be viewed as the knowledge items metadata.

FUTURE DIRECTIONS

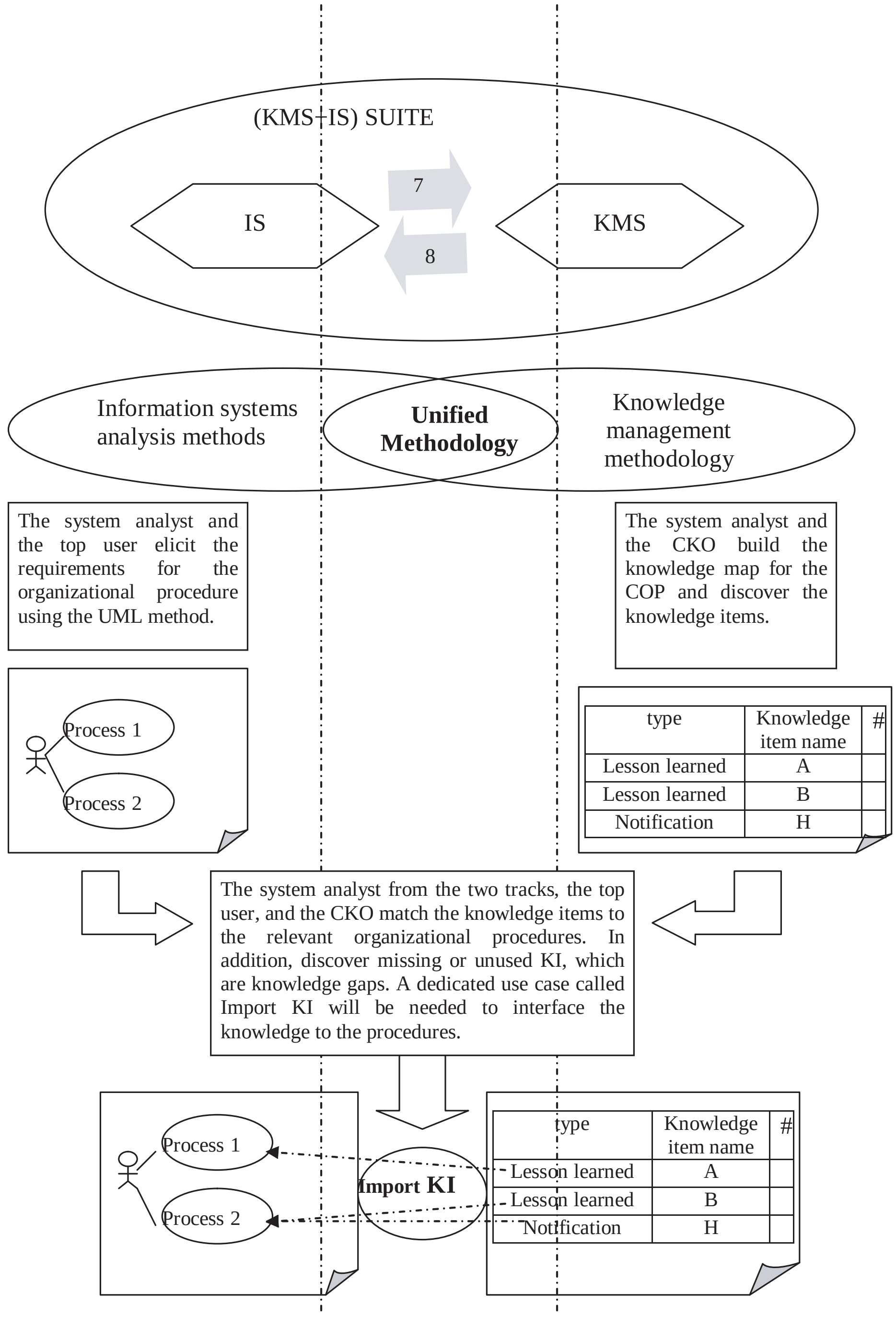
The integration of MIS and KMS analysis and design processes will surely lead to the development of new software tools to support increasingly complex interactions between analysts and users. While the development of such tools will probably grow out of the current base of modeling software, there are important techniques from the KM analysis world such as knowledge maps and social network analysis that need to be integrated.

Although the unified methodology presented in this article is robust, as we gain more experience in the analysis and design of fusion systems, we would expect the KISA process to evolve. A finer-grained bifurcation of additional steps in the analysis process will surely lead to tighter integration between KMS and MIS—both in terms of project scope and team composition.

CONCLUSION

Integrating KMS into the system analysis process requires some major modifications, and this integration affects every phase of the systems devel-

Figure 3. Micro view of the KM-IS interface requirements



opment process (as shown in Figure 2) and could well be considered a new analysis methodology in its own right. This system analysis approach combines knowledge management and traditional or classic IS system analysis. The approach requires the use of two separate but synchronously integrated tracks, the IS methodology track and the KMS methodology track. Two groups of system analysts conduct the system analysis phases: the KM group is accompanied by the CKO (chief knowledge officer), and the IS group is accompanied by the user representative who operates the organizational procedures. The two groups plan each phase activities together and meet several times along the phase. As the focus of this article was the system analysis process, it was not emphasized that the organizational knowledge management process needs to be modeled and implemented as part of any such integrated project, in order to insure that the KM modules continue to nourish the operational MIS modules.

REFERENCES

Alavi, M., & Leidner, D.E. (1999, January). Knowledge management systems: Emerging views and practices from the field. *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences (Track 7).*

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Bhatt, G.D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-75.

Booch, G. (1994). *Object-oriented analysis and design, with applications* (2nd ed.). Addison-Wesley.

Chou, S.T., & Chow, E.T. (2000). Essential factors in knowledge management with COTS product. In. D.G. Schwartz, M. Divitini, & Brasethvic (Eds.), *Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Corp, U. (2001). Managing unstructured content in enterprise information portals. *Knowledge Management Journal*, (July).

Davenport, T.H., & Glaser, J. (2002). Just-in-time delivery comes to knowledge management. *Harvard Business Review, 80*(7), 107-111.

Demarco, T. (1978). *Structured analysis and systems specification.* Englewood Cliffs, NJ: Prentice-Hall.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Fensel, D., Omelayenko, B., Ding, Y., Klein, M., Schulten, E., Botquin, G., Brown, M., Flett, A., & Dabiri, G. (2002). *Intelligent information integration in B2B electronic commerce*. Boston: Kluwer.

Ferrucci, D., & Lally, A. (2004), Building an example application with the unstructured information management architecture. *IBM Systems Journal, 43*(3). Retrieved from http://www.research.ibm.com/journal/sj/433/ferrucci.html

Fischer, G. (1999). A group has no head—conceptual frameworks and systems for supporting social interaction. *Information Processing Society of Japan (IPSJ) Magazine, 40*(6), 575-582.

Fowler, M., & Kendall, S. (2000). *UML distilled* (2nd ed.). Addison-Wesley.

Gane, C., & Sarson, T. (1979). *Structured systems analysis—tools and techniques.* Englewood Cliffs, NJ: Prentice-Hall.

Gray, P.M.D., Preece, A., Fiddian, N.J., Gray, W.A., Bench-Capon, T., Shave, M., Azarmi, N., Wiegand, M., Ashwell, M., Beer, M., Cui, Z. et al. (1997). *KRAFT: Knowledge fusion from distributed databases and knowledge bases. Proceedings of the 8th International Workshop on Database and Expert Systems Applications,* Toulouse, France.

Hahn, J., & Subramani, M.R. (2000, December 10-13). A framework of knowledge management systems: Issues and challenges for theory and practice. In W.J. Orlikowski, S. Ang, P. Weill, H.C. Krcmar, & J.I.. DeGrosss (Eds.), *Proceedings of the 21st International Conference on Information Systems (ICIS 2000),* Brisbane, Australia (pp. 302-312).

Jacobson, I., Booch, G., & Rumbaugh, J. (1999). *The unified software development process.* Addison-Wesley.

Jacobson, I., Christerson, M., Jonsson, P., & Overgaard, G. (1992). *Object-oriented software engineering.* Addison-Wesley.

Jayaratna, N. (1994). *Understanding and evaluating methodologies: NIMSAD: A systemic framework.* New York: McGraw-Hill.

Jayaratna, N., & Sommerville, I. (1998). Editorial: The role of information systems methodology in software engineering. *IEEE Proceedings-Software, 145*(4), 93-94.

King, W.R., Marks, P.V., & McCoy, S. (2002). The most important issues in knowledge management. *Communications of the ACM, 45*(9), 93-97.

Lai, Y.-C., Carlsen, M., Christiansson, P., & Svidt, K. (2003, November 15-16), Semantic Web-supported knowledge management system: An approach to enhance collaborative building design. *Proceedings of the ASCE Nashville 4th Joint Symposium on IT in Civil Engineering,* Nashville, TN.

Lindgren, R., Hardless, C., Pessi, K., & Nulden, U. (2002). The evolution of knowledge management systems needs to be managed. *Journal of Knowledge Management Practice, 3*(March). Retrieved from http://www.tlainc. com/articl34.htm

Lindvall, M., Rus, L., & Sinha, S.S. (2003). Software systems support for knowledge management. *Journal of Knowledge Management, 5*(5), 137-150.

Malhotra, Y. (2002). Why knowledge management systems fail? Enablers and constraints of knowledge management in human enterprises. In C.W. Holsapple (Ed.), *Handbook of knowledge management.* Heidelberg: Springer-Verlag.

Nissen, M.E. (2001, July). *Facilitating naval knowledge flow.* Technical Report NPS-GSBPP-01-003, Naval Post Graduate School, Monterey, CA.

Plass, J.L., & Salisbury, L.W. (2002). A living-systems design model for Web-based knowledge management systems. *Educational Technology Research and Development, 50*(1), 35-58.

Pressman, R.S. (2000). *Software engineering: A practitioner's approach* (5th ed.). New York: McGraw-Hill.

Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, F., & Lorensen, W. (1991). *Object-oriented modeling and design.* Englewood Cliffs, NJ: Prentice-Hall.

Schwartz, D.G., & Te'eni, D. (2000). Tying knowledge to action with kMail. *IEEE Intelligent Systems, 15*(3), 33-39.

Schwartz, D.G., Divitini, M., & Brasethvic, T. (2000). On knowledge management in the Internet age. In D.G. Schwartz, M. Divitini, & Brasethvic (Eds.), *Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Sircar, S., Nerur, S.P., & Mahapatra, R. (2001). Revolution or evolution? A comparison of object-oriented and structured systems development methods, *MIS Quarterly, 25*(4), 457-471.

Spiegler, I. (2000). Knowledge management: A new idea or a recycled concept? *Communications of the AIS, 3*(June).

Spiegler, I. (2003). Technology and knowledge: Bridging a "generating" gap. *Information & Management, 40,* 533-539.

Tuomi, I. (2000). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems, 16*(3), 103-117.

Ulrich, F. (2001). Knowledge management systems: Essential requirements and generic design patterns. In W.W. Smari, N. Melab, & K. Yetongnon (Eds.), *Proceedings of the International Symposium on Information Systems and Engineering (ISE'2001)* (pp. 114-121). Las Vegas: CSREA Press.

Vail, E.F. (1999). Knowledge mapping: Getting started with knowledge management. *Information Systems Management,* (Fall).

Whitten, J.L., Bentley, L.D., & Dittman, K.C. (2001). *System analysis and design methods.* New York: McGraw-Hill.

Wu, X., Ling, T.W., Lee, M.L., & Dobbie, G. (2001). Designing semistructured databases using ORA-SS model. *WISE, 1*, 171-180.

Yourdon, E. (1989). *Modern structured analysis.* Englewood Cliffs, NJ: Prentice-Hall.

Chapter 2.14
Knowledge Management Processes

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INTRODUCTION

Knowledge management (KM), as a topic for academic research and practical implementation, has had a short history dating back only to the early 1990s. Due to knowledge management's recent debut as we know it, it is not surprising that much of the writing and research on the subject is controversial. In this article we note the need of a critical awareness of desirable and undesirable shades of knowledge management processes (Land, Nolas, & Amjad, 2005).

BACKGROUND AND FOCUS

Knowledge is both disseminated and acquired. As observers we cannot know what intentions lay behind the act of dissemination, or what motivates the acquirer to acquire. We cannot blindly assume information—a major component of knowledge—as interpreted, facilitated, conceptualised, or experienced, is automatically for everyone's benefit. The process of knowledge management may have a desired or detrimental outcome for society, an organisation, a team, or the individual. Indeed, the outcome of a KM activity, say knowledge sharing, is largely unpredictable. The reality is the outcome may benefit one group at the expense of another. Benefiting one group at the expense of the other is addressed by the following conceptual fusions.

KM is a continuum of desirable and undesirable political processes. This article suggests that the combined concepts of knowledge management, organisational politics (OP), and coevolution (CE) make a contribution to the understanding of KM, whether in its benign or its darker manifestation.

Because knowledge management is a purposeful activity, it can never be neutral. Hence the article sets out to forewarn practitioners and thinkers in the area of KM that care must be taken since knowledge (K) can be manipulated for both altruistic and selfish purposes.

If the study of KM is to have an enduring future, it must take a more holistic stance. We suggest the concept of "coevolution" (McKelvey, 2002; Lewin & Volberda, 1999; Lewin et al., 1999) provides a way of understanding the implications of knowledge management on the organisation and its employees. Coevolution describes the mutual influences among actors in a collective, as well as their environment. Mutual influences can have desirable and undesirable, constructive and destructive effects. In the case of an organisation, coevolution can be envisaged as being effected in a set of multi-dimensional networks, themselves part of a larger set of networks to which they are linked.

Any event or activity will have some (possibly unknown) impact on other succeeding or collateral activities. Their responses will in turn trigger impacts and responses in further activities, including possibly in the activity that acted as the initial trigger. Each activity evolves on a trajectory which may have been planned, but the outcome and direction is often unexpected. The pattern of responses in diverse activities leads to their coevolution. The coevolution of power and knowledge contribute to the discussion of the darker sides of knowledge management by offering an understanding of shades of desirable and undesirable forms of knowledge management. The concept of coevolution permits us to replace the simple ethical/non-ethical dichotomy and attempts to explain the dynamics in a continuum of knowledge management processes, actuated by motives, mediated by sources, and realised via the dissemination and acquisition of knowledge. Nevertheless, the complex pattern woven by coevolution remains uncertain, and permits the emergence of the unexpected.

KM occurs at all levels in the organisation. It may be a planned formal process supported by KM software designed to increase the effectiveness of a team of knowledge workers. Equally it may be a hidden process of knowledge manipulation by a group attempting to direct the organisation on a path away from its formal objectives. It may be an informal process, the reaction of a group of people responding to an initiative they believe will damage them. But whatever the intention behind the process, both the study of organisational politics and coevolution suggest that the outcome will be uncertain. Outcomes, sometimes unexpected, emerge from the responses of organisational actors. In order to deal with the problem of uncertainty and emergence, at both an analytical and practical level, the article introduces the concepts of desirable and undesirable coevolution for looking at was is and not what ought to be.

CORE IDEAS OF THE ARTICLE

Knowledge, Power, and Their Dynamic Interactions

This article links together:

- Knowledge Management (KM)
- Organisational Politics (OP) and
- The concept of Coevolution (CE)

All three share a common concept: power. Knowledge management, despite much of the rhetoric surrounding the concept, is not a power-neutral process. If, as has been suggested (Land et al., 2005), knowledge is managed in order to achieve goals, be they benign or corrupt, political processes are invoked in the management process.

KM, OP, and CE all involve power, and each is profoundly affected by the way power is distributed. Knowledge management in its idealised form is independent of power. In reality the existence of an asymmetric power balance enables those with the power, often those who have formal authority, to present knowledge in directions of their choosing. Those with lesser power may respond by using knowledge to achieve their ends in more subtle and primarily informal ways, of which the spreading of rumours is one typical way. A central idea of KM is that knowledge, if considered a commodity, is manoeuvred toward shades of desirable and undesirable directions by multiple stakeholders.

OP, summarised as a wide range of descriptions of formal and informal power relationships in organisations, has been studied and documented at least since the 1970s (e.g., Pettigrew, 1973; Mintzberg, 1983; Pfeffer, 1997). OP provides a theoretical lens with which to conceptualise and observe both constructive and destructive aspects of KM.

Most academic literature agrees KM is an essential activity for a modern enterprise to flourish in a global competitive economy, and many practicing managers share this view. Despite the slippery meaning of KM, a positive relationship between knowledge and truth—and hence KM—is implicitly assumed. An interpretist view of KM is that people are capable of being aware of their own actions, further assuming knowledge and understanding are 'good' or at least neutral (Schultze, 1999). In other words, interpretivists take for granted people are self-aware, but optimistically believe knowledge management to be an inherently constructive and positive process. However, Schultze also notes that the open sharing of knowledge may not occur in competitive business environments associated with competitive advantage.

The inspiration for thinking about the interrelationship of knowledge management and power is found in the following concepts of coevolution and organisational politics.

Organisational Politics

The study of organisational politics suggests the driving force enabling organisational politics to occur is power, and in particular the asymmetrical distribution of power. Organisations are overlapping sets of political networks, rule, and role systems, engaging in coalition building as part of manipulative, selfish, under-the-table dealings, as well as for constructive purposes aimed at furthering the aims of that organisation.

The informal and formal organisation becomes part of the discussion, since it is the informal organisation where much of the political activity occurs—behind the scenes. Pfeffer (1997, p. 136), in support of this position, notes: "…these less formal methods rely more on power and influence, leverage individuals' positions in social networks, and entail ongoing negotiations among organisational participants." However, identifying political behavioural patterns for the sake of efficiency is not enough. "The skill is to try and prevent individual and organisational pathological circumstances from arising by recognising the appropriate and inappropriate behaviours that individuals and groups will and will not be able to accept" (Kakabadse & Parker, 1984, p. 101).

Three aspects of KM as a political process within an organisation are dependency, strategies for enacting power, and decision making.

Taking Pettigrew's (1973, p. 26) position that "Power is…a property of social relationships, not an attribute of the actor…Dependency is…a product of an imbalance of exchange between individuals and the ability of one actor to control others through his [/her] possession of resources," knowledge can be a critical resource. Hence the desirable or undesirable directions of K manipulation can trigger that dependency to be constructive or destructive. For example, a senior manager may become dependent on the knowledge (experience) of a junior manager, therefore strengthening the expertise and performance of the team. The senior manager is dependent on the knowledge of the junior manager. Her/his own performance is governed by the presence or absence of the subordinate.

A specific arena in an organisational politics context is a decision-making process, which determines specific actions to be taken. Influencing a decision in the making is more effective than attempting to do so after action on the decision has been taken (Mintzberg, 1983, p. 206). In practice, manipulation of information and knowledge, designed to influence the decision maker, takes place at all levels in the organisation and for many reasons.

Organisational politics provide the geo-political landscape for describing KM processes, alerting us to the manipulative nature of KM. Viewing KM as political is not an end in itself. Kakabadse and Parker (1984, pp. 104-105) summarise organisational politics and offer a remedy:

Problems arise when an individual group rejects, misunderstands, or responds with inappropriate behaviours [for example, providing false information] to the actions of other individuals or groups. In the literature, it is their negative interactions that have, to date, been labelled 'political.' We suggest that one way of reducing negative interactions is to strive for multi-rationality. Multi-rationality is a process whereby actors begin to understand their own values, beliefs, and norms; are able to assert their individuality but are equally able to accept that others hold a different rationale.

Coevolution

Tasaka (1999) describes coevolution as "a process in which each part interacts with and influences the other parts, thereby stimulating their mutual development." The coevolution of power and knowledge contribute to the discussion of knowledge management by emphasising the intricacy of the interactions, the uncertainty of what the outcomes of the interactions will be, and the opportunities the interactions provide for the manipulation of information and knowledge.

Interactions cannot be clearly classified as desirable or undesirable. Every process creates interactions. As knowledge management creates interactions, we cannot predict that the outcome of coevolution will yield what was intended. As a consequence of the multi-rationalities operating in the real world, some individuals or groups may see the outcomes as desirable, where others judge them detrimental to the organisation or to themselves. Ignoring the 'power' dimensions of the situation being studied gives the impression that organisational space is neutral, and that the action of entering the space is also neutral (Land et al., 2005). Constant change and mutual influencing among actors, processes, and scenarios add to the awareness of the non-neutrality of KM.

Coevolution explains how first-order effects trigger other second-order effects, which in turn trigger further effects. Further effects produce a cascade of non-deterministic effects where the impacts will be emergent and cannot be second-guessed. An example of this is the desire for clarity of organisational strategy, leading perhaps, in the interest of clarity, to rigidly defined organisational roles. But the imposition of stricter controls to enforce the predefined organisational architecture may have the undesired consequence of inhibiting innovation and stifling initiative.

The following two examples illustrate power dynamics and KM processes. CE is used to highlight the intricate interaction in these instances of post-merger integration (PMI) and water management. PMI is an example of what happens inside an organisation, and the case of water management here is an example of inter-organisational relationships.

Example 1: Post-Merger Integration

Organisation, a national leader in its sector, experienced a merger in 2000. The results of the merger were Organisation's unclear strategic goals, as voiced through semi-structured interviews in 2002. This lack of clarity trickled down to a particular department (henceforth Department) and other teams that interacted with the Department. Unclear strategic goals and how to operationalise them on an individual, team, and department level emerged in the following ways. Hierarchical relationships and prioritisation of work tasks are very much interrelated. The essence of this is that senior-level management commented on being out of touch with what is happening at middle-management levels. Being out of touch with middle-management levels—clearly a failure of KM—translates into prioritisation problems, where the operational levels know what the daily capabilities are and the senior management may have an overall understanding of what needs to be done to achieve organisational goals, but not the knowledge of realistic capabilities on everyday tasks. For example, a new deadline must be met sooner than previously understood by the operational and middle-management levels. Pressure is then put on the subsequent levels to produce for this deadline. The operational levels become frustrated because a particular piece of equipment is down for the moment, making the task even more difficult, and further delaying other needed, regular tasks. Being out of touch with what is happening in daily routines then becomes a vicious cycle of no space for initiative and heavy-handedness from senior management, toward operational management.

The primary problem identified here is ambiguity of roles and strategy. One common solution to alleviate such ambiguity is increasing the amount of information to the same people and to more people. In other words, change the KM processes with higher volume of information and more interaction. However, increasing the quantity of knowledge to alleviate the management levels' ambiguity of roles and strategy is not the straightforward solution. Becker (2001, pp. 1046-1048) argues for acknowledging a difference between the meanings of uncertainty and ambiguity. He states "ambiguity" is structural uncertainty, whereas "uncertainty" is stochastic, in other words random or probabilistic uncertainty. The point being that, faced with a decision problem that is due to structural rather than random uncertainty, increasing the knowledge and information at hand may further increase the structural uncertainty (ambiguity) instead of alleviating it. "What is required is to make people communicate, assimilate cognitive frameworks, and develop understanding…to support processes that lead to understanding, not just access to information"(Becker, 2001, p. 1048).

The implementation of organisational strategy is shaped by the individual priorities of the relevant organisational actors. And the implementation process is itself driven by KM processes employed by stakeholders operating in various hierarchical levels in the organisation. Ambiguity in priorities and ambiguity in roles can facilitate perverse knowledge management outcomes.

Past research identifies inherent ambiguity and issue politicisation as impediments to effective post-merger integration (Vaara, 2002, p. 887).1 Merger failure has been linked to lack of clearly defined roles, responsibilities, and incentives (Deloitte & Touche, 2002). "Increased ambiguity—due to unclear goals, roles, and procedures—allows greater opportunity for political behaviour to be employed in reaching objectives" (Parker, Dipboye, & Jackson, 1995). Political behaviour can be a problem if the power dynamics of KM processes are not realised for their constructive and destructive implications. What this means for KM processes is that multiple interpretations imply conflicting discourses which can be both constructive and destructive. People in the organisation may have a different idea of where the organisation should be headed, how it should get there, and who is responsible for getting it there. How each person at each organisational level is shaping the motivation, transfer, interpretation, and implementation of

KM processes brings into question the desirable or undesirable dimensions of KM.

Returning to the case study's ambiguity of roles and strategy during their post-merger integration, KM processes are seemingly part of the problem, and instinctively part of the solution—in terms of simply increasing information flows. Cyclical misinterpretation of expectations and responsibilities among organisational levels demonstrates miscommunicated and misunderstood knowledge management processes. However, the desired perception of clarity does not necessarily mean a desirable set of KM processes exists. Where 'better KM' may be considered part of an eventual solution, we might actually ask: How are the KM processes occurring within an arena of organisational politics or power relationships?

Example 2: Water Management

Knowledge management power relationships also exist among organisations. The following illustrates how inter-organisational relationships relate to each other in the case of water regulation in England and Wales. Every five years a review of water prices occurs. The changes in water pricing for all consumers stem from EU and UK regulatory requirements ranging from water quality, to the cost of infrastructure improvement. Maloney (2001) describes the multi-stakeholders' interactions as processes of negotiation and sanctions. The regulatory review of water price limits in England and Wales illustrate a form of knowledge management as multi-stakeholders coping with ever-changing rules (regulations) and the blurred boundaries of organisations' roles (expectations and responsibilities as public, private, and civil society).

The purpose of the periodic review, according to the Office of Water Services (OFWAT), the independent economic regulator for water for all of England and Wales, is "…to make sure that the companies are able to carry out and finance their functions under the Water Industry Act 1991" (OFWAT, 1998). OFWAT also claims they aim to set price limits that allow each company to carry out their functions while protecting the interests of customers in two ways: (1) enabling well-managed companies to finance the delivery of services in line with relevant standards and requirements, and (2) providing incentives for companies to improve efficiency and service delivery. Notice how these two main objectives already imply the non-neutrality of the ensuing knowledge management processes. First, each organisation will interpret and implement "relevant standards and requirements" to the advantage of each organisation, perhaps even unintended conflicting interpretations. Second, "providing incentives for companies to improve efficiency" is a form of KM manipulation. The water companies must provide draft business plans early in the regulatory review process to the independent economic regulatory agency (OFWAT), along with more public sector organisations such as the Environment Agency and Department for Rural Affairs and Agriculture. The negotiations that take place between the regulators and the regulated—how the business plans fit with regulatory requirements, while simultaneously sustaining the companies—illustrates how a KM process can move in many directions. The way a draft business plan is presented can persuade how the regulators decide to advise on reshaping the business plan to adjust with newer EU regulations, for example.

Governance according to the Global Water Partnership includes power and different levels of authority, and regulation is housed under the broad roof of governance—governance that in itself lends to KM manipulation.

The Global Water Partnership argues:

Governance looks at the balance of power and the balance of actions at different levels of authority. It translates into different systems, laws, regulations, institutions, financial mechanisms, and civil society development and human rights, essentially *the rules of the game. Usually improving governance means reform. (GWP, 2003)*

To organise how we approach thinking and acting on these observations may be to identify the changes of multi-level (EU-UK) organisations and types (public-private-civil society), recognising power asymmetries and their interconnections. For example if the European Union's Water Framework Directive is raising the standards in London, by driving the 2004 regulatory review process toward more stringent policies, we may want to ask how London's customers and the water company Thames Water is adjusting to these new standards, and doing to affect the new standards?

FUTURE TRENDS

As KM becomes a more comfortable topic for researchers, and numerous governments and private sector organisations buy into the language and concepts of KM, a responsibility resides with the advocates of KM of the potential abuse of KM processes. The maturing of the eventual field of KM is on the horizon. KM is slowly moving away from defining it, debating its use, gathering, storing, sharing it, toward questions of what does it essentially mean for communication and productivity. KM for better or worse—as some would say "repackaging old ideas with glossy new ones"—is here to stay. How are we going to welcome this emerging discipline that seemingly unites information systems, organisations, and politics, to name a few? One of those ways may include obvious answers such as further empirical work and sharpening of definitions. Behind any method researchers and other applied practitioners of KM choose, they should note that control is not the solution and where attempted, frequently backfires.

CONCLUSION

This article proposes the significance of conceptualising KM as a political process, with notions from OP and CE. OP provides a familiar and documented contextual boundary where power-ridden processes of KM interact. CE further energises the explanation of power-ridden KM processes by giving vocabulary and meaning to changing patterns of interaction. The PMI and water management examples illustrate KM as a political process in the real world. In this specific case of PMI, information travels among hierarchical levels of an organisation, producing conflicting expectations that worsen the politics within that organisation. As for the water management case, local, national, and international levels of organisation interact with different types of organisations—public, private, and to some extent civil society. The inter-organisational dynamics lend to multi-layer knowledge management processes among them: infrastructure improvement needs based on changing water quantity/quality, what can be reasonably charged to customers, and the question of the regulations imposing desirable behaviour.

KM processes are manipulated for constructive and destructive purposes. A context of organisational politics and a paradigm of coevolution are not the only ways of highlighting an agenda for KM. OP and CE provide ways of highlighting and connecting what we already understand as relationships of power and knowledge. KM as a growing area of research and practice has and will open new ways of thinking, while revisiting old. Wielding KM's full capabilities also includes responsibly using and interpreting the hidden and obvious agendas.

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REFERENCES

Becker, M.C. (2001). Managing dispersed knowledge: Organizational problems, managerial strategies, and their effectiveness. *Journal of Management Studies, 38*(7), 0022-2380.

Deloitte & Touche. (2001). *Solving the merger mystery, maximizing the payoffs of mergers and acquisitions.*

GWP (Global Water Partnership). (2003). *Effective water governance: Learning from the dialogues.*

Kakabadse, A., & Parker, C. (1984). *Power, politics, and organizations: A behavioural science view*. New York: John Wiley & Sons.

Land, F., Nolas, S.M., & Amjad, U. (2006). Theoretical and practical aspects of knowledge management. In D.G. Schwarz (Ed.), *Encyclopaedia of knowledge management* (pp.855-861) . Hershey, PA: Idea Group Reference.

Lewin, A., Long, C., & Carroll, T. (1999). The coevolution of new organizational forms. *Organization Science, 10*(5), 535-550.

Lewin, A., & Volberda, H. (1999). Prolegomena on coevolution: A framework for research on strategy and new organizational forms. *Organization Science, 10*(5), 519-534.

Maloney, W.A. (2001). Regulation in an episodic policy-making environment: The water industry in England and Wales. *Public Administration, 79*(3), 625-642.

McKelvey, B. (2002). Managing coevolutionary dynamics. *Proceedings of the European Group for Organizational Studies (EGOS 2002).*

Mintzberg, H. (1983). *Power in and around organizations.* Englewood Cliffs, NJ: Prentice-Hall.

OFWAT (Office of Water Services). (2004). *Introduction to the Water Framework Directive.*

Parker, C.P., Dipboye, R.L., & Jackson, S.L. (1995). Perceptions of organizational politics: An investigation of antecedents and consequences. *Journal of Management*, *21*(5), 891-912.

Pettigrew, A. (1973). *The politics of organizational decision-making.* Harper and Row, Barnes and Noble Import Division, USA.

Pfeffer, J. (1997). *New directions for organization theory: Problems and prospects*. Oxford: Oxford University Press.

Schultze, U. (1999). Investigating the contradictions in knowledge management. In T.J. Larsen, L. Levine, & J.I. De Gross (Eds.), *Information systems: Current issues and future changes* (pp. 155-174). Laxenberg, Austria: IFIP.

Tasaka, H. (1999). Twenty-first century management and the complexity paradigm. *Emergence, 1*(4), 115-123.

Vaara, E. (2002). On the discursive construction of success/failure in narratives of post-merger integration. *Organization Studies, 23*(2), 211-248.

ENDNOTE

1 Vaara (2003) identified four in total. The issues not mentioned here are cultural confusion and organizational hypocrisy, because they are not central to this article's purpose.

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Chapter 2.15
Inter-Organisational Knowledge Transfer Process Model

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INTRODUCTION

Knowledge management (KM) is an emerging discipline (Ives, Torrey & Gordon, 1997) and characterised by four processes: generation, codification, transfer, and application (Alavi & Leidner, 2001). Completing the loop, knowledge transfer is regarded as a precursor to knowledge creation (Nonaka & Takeuchi, 1995) and thus forms an essential part of the knowledge management process. The understanding of how knowledge is transferred is very important for explaining the evolution and change in institutions, organisations, technology, and economy. However, knowledge transfer is often found to be laborious, time consuming, complicated, and difficult to understand (Huber, 2001; Szulanski, 2000). It has received negligible systematic attention (Huber, 2001; Szulanski, 2000), thus we know little about it (Huber, 2001). However, some literature, such as Davenport and Prusak (1998) and Shariq (1999), has attempted to address knowledge transfer within an organisation, but studies on inter-organisational knowledge transfer are still much neglected.

An emergent view is that it may be beneficial for organisations if more research can be done to help them understand and, thus, to improve their inter-organisational knowledge transfer process. Therefore, this article aims to provide an overview of the inter-organisational knowledge transfer and its related literature and present a proposed inter-organisational knowledge transfer process model based on theoretical and empirical studies.

BACKGROUND: AN OVERVIEW OF KNOWLEDGE TRANSFER AND RELATED LITERATURE

Knowledge Transfer within an Organisation

Knowledge transfer implies that knowledge is transferred from the sender(s) (person, group, team, or organisation) to the recipient(s) (person, group, team, or organisation) (Albino, Garavelli & Schiuma, 1999; Lind & Persborn, 2000). It may happen within an organisation or between organisations. Szulanski (2000) argues that knowledge transfer is a process in which difficulty should be seen as its characteristic feature. This process view may help organisations identify difficulties in the knowledge transfer. He further proposes a process model for intra-organisational knowledge transfer as shown in Figure 1, which contains four stages: initiation, implementation, ramp-up, and integration.

In the initiation stage, the effort aims to find an opportunity to transfer and to decide whether to pursue it. An opportunity to transfer exists as soon as the seed for that transfer is formed, that is, as soon as a gap is found within the organisation, and the knowledge to address the gap is thought to be available. In the implementation stage, following the decision to transfer knowledge, attention shifts to the exchange of information and resources between the source and the recipient, that is, "learning before doing" for the recipient. In the ramp-up stage, the recipient begins using acquired knowledge, and tries to ramp-up to satisfactory performance, that is, "learning by doing" for the recipient. In the integration stage, the recipient takes subsequent follow-through and evaluation efforts to integrate the practice with its other practices (Szulanski, 2000).

The process model demonstrates that knowledge transfer within an organisation is complex and difficult. However, knowledge transfer between organisations is even harder and more complicated. When knowledge is transferred within an organisation, the organisation should try to expand the amount of shared knowledge among its employees to an appropriate level (or to the highest level possible) (Lind & Seigerroth, 2000) so as to develop (or preserve) its competitive advantage. When transferring knowledge between organisations, the organisations have to face "the boundary paradox" (Quintas, Lefrere & Jones, 1997), which involves more complicated factors impinging on the transaction. It also requires the negotiation between participating parties, strict governance mechanisms to regulate the transfer content, and higher loyalty by relevant employees.

Inter-Organisational Knowledge Transfer

Inter-organisational knowledge transfer may have different types. For instance, von Hippel (1987) classifies know-how trading between firms into two types: informal and formal. He defines informal know-how trading as the extensive exchange of proprietary know-how by informal networks in rival (and nonrival) firms. Here is an example, when a firm's engineer who is responsible for obtaining or developing the know-how his/her firm needs finds that the required know-how is not available in-house or in public sources; the engineer may, through his/her private relationships, seek the needed information from professional counterparts in rival (and nonrival) firms. Formal know-how trading is referred to as official knowledge exchange agreements between firms such as agreements to perform R&D cooperatively or agreements to license or sell proprietary technical knowledge (von Hippel, 1987). von Hippel further argues that the main differences between the informal and formal trading are (1) the decisions to trade or not trade proprietary know-how in the former are made by individual, knowledgeable engineers; no elaborate evaluations of relative rents or seeking of approvals from firm bureaucracies are involved; however, the decisions for the latter are made by firm bureaucracies; (2) the value of a particular traded module in the former is too small to justify an explicit negotiated agreement to sell, license, or exchange, but the traded module in the latter is of considerable value. In fact, the fundamental difference between the so-called informal and formal inter-organisational knowledge transfer is that the former is carried out through employees' private relationships without the direct involvement of their corporate management, but the latter has direct involvement of their corporate management.

This article is mainly concerned with the formal knowledge transfer process between organisations.

Inter-Organisational Learning

From an organisational learning perspective, inter-organisational knowledge transfer is actually the process of organisations learning from each other, that is, inter-organisational learning.

Organisational learning may occur when the organisation acquires information (knowledge, understanding, know-how, techniques, or practices) of any kind and by whatever means (Argyris & Schon, 1996). It is individuals that make up an organisation; thus each organisational learning activity actually begins from individual learning. Individual learning is a necessary condition for organisational learning which is institutionally embedded (Beeby & Booth, 2000). However, individual learning is not sufficient. It is generally accepted that the acquisition of knowledge by individuals does not represent organisational learning (Beeby & Booth, 2000; Nonaka & Takeuchi, 1995). To achieve the necessary cross-level effects, that is, successful organisational learning, individual learning should be on the organisation's behalf (Argyris & Schon, 1996) and must be shared through communication which is supported by institutional processes for transferring what is learned by individuals to the organisation as well as for storing and accessing that which is learned (Beeby & Booth, 2000).

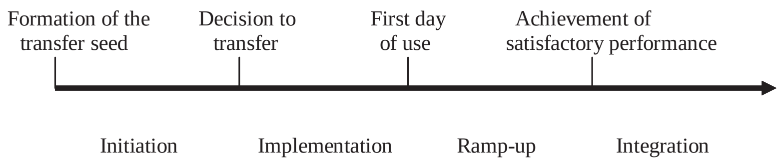
Literature review shows that study on organisational learning mainly focuses on learning within an organisation, that is, on how to convert individual learning into organisational learning once the individuals have acquired the needed knowledge. Issues related to how and from where the individuals acquire the needed knowledge are more or less ignored. When organisations learn from each other, it is normally some individuals who learn on their organisation's behalf from other individuals on another organisation's behalf. Then the learner's individual learning will be further converted into organisational learning. Therefore, inter-organisational knowledge transfer process, as a kind of inter-organisational learning, can be divided into two subprocesses: (1) inter-employee learning between employees from different organisations and (2) organisational learning within the receiving organisation by converting individual learning to organisational learning through the organisation's internal mechanisms (Chen, Duan & Edwards, 2002).

Social Networks

Social relationships play an important role in social networks. Granovetter (1985) points out that all activities are embedded in complex networks of social relations which include family, state, educational and professional background, religion, gender, and ethnicity.

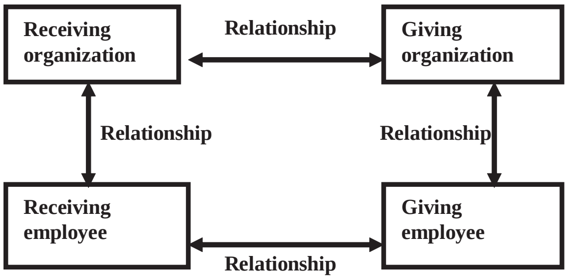
From the social network perspective, inter-organisational knowledge transfer activities can be regarded as activities within social networks. Assuming the influence from a third party is ignored, the network may have four actors: receiving organisation and receiving employee, giving organisation and giving employee. The actors' behaviours will be influenced by their relationships. In the first subprocess (i.e., inter-employee learning between employees from different or-

Figure 1. The process for knowledge transfer within an organisation (Szulanski, 2000)



ganisations), when the receiving organisation requests knowledge from the giving organisation, they will establish their own knowledge transfer strategies based on the relationship between two organisations. Then the organisations may use their relationships with their own employees to influence and guide the employees' learning behaviours to conform to their knowledge transfer strategies. The personal relationship between the receiving and giving employees will also influence their individual learning effectiveness. In the second subprocess, the relevant actors will be the receiving organisation and receiving employee. The key point for the receiving organisation is to establish its internal mechanisms to promote the conversion from the receiving employee's individual learning into organisational learning. The internal mechanisms may be considered as being embedded in the relationship between the receiving organisation and receiving employee.

Figure 2. The relationship mechanism for inter-organisational knowledge transfer



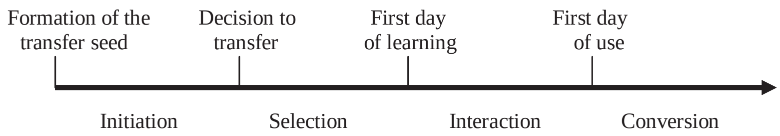
Therefore, there is a relationship mechanism, as depicted in Figure 2. This mechanism coordinates and influences the relevant actors' behaviours for inter-organisational knowledge transfer.

AN INTER-ORGANISATIONAL KNOWLEDGE TRANSFER PROCESS MODEL

Through the above review, it is known that inter-organisational knowledge transfer process can be divided into two subprocesses. Drawing on Szulanski's (2000) process model in Figure 1, the first subprocess can be further divided into three stages: initiation, selection, and interaction; the second subprocess may be called conversion. So, a similar four-stage model for inter-organisational knowledge transfer is offered in Figure 3.

In the initiation stage, two organisations try to find an opportunity to transfer and to decide whether to pursue it through negotiation. In the selection stage, the receiving and giving organisations select an employee as a receiving and giving employee respectively (more than one employee may be involved, of course, in either organisation). In the interaction stage, the giving employee transfers his/her knowledge to the receiving employee. In the conversion stage, the receiving employee transfers his/her acquired knowledge to his/her employer— the receiving organisation. The conversion stage is only related to the receiving organisation and receiving employee.

Figure 3. The inter-organisational knowledge transfer process



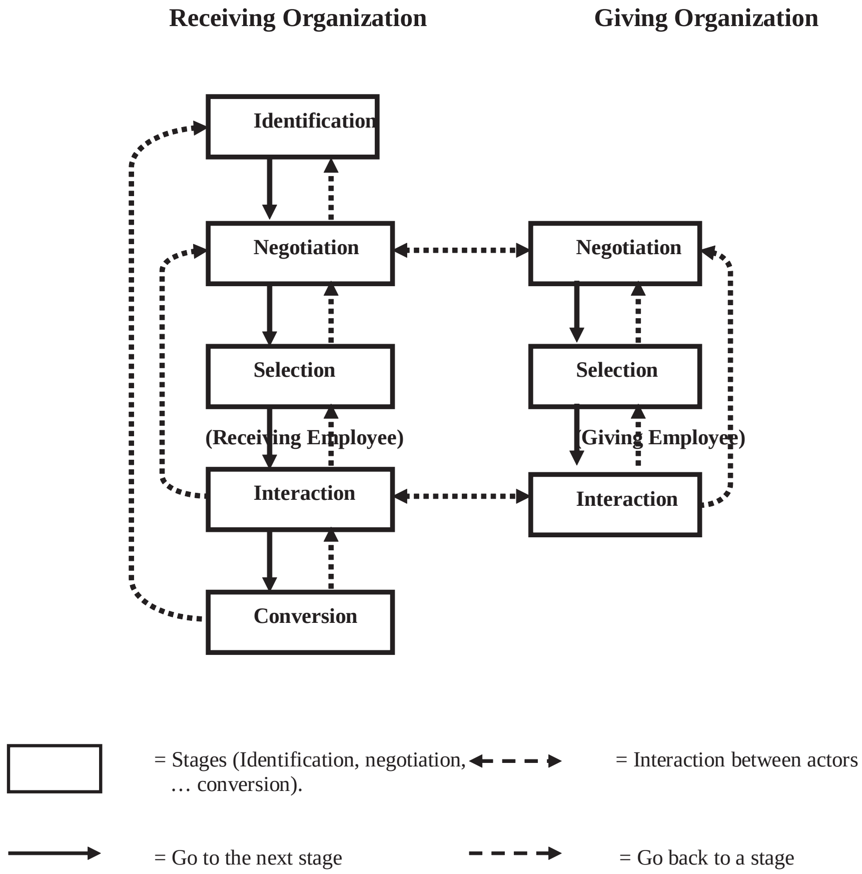
The relationship between the process model in Figure 3 and Szulanski's (2000) process model may be seen as follows: (1) The initiation and interaction stages of the former are similar to the initiation and implementation stages of the latter. (2) In the conversion stage of the former, the receiving employee plays two roles: first, he/she, as a recipient, will apply his/her acquired knowledge to his/her work and have to experience the ramp-up and integration stages; second, he/she is also a source for his organisation as his/her colleagues may learn from him/her. So, the conversion stage contains the ramp-up and integration stages, as well as the whole transfer process within an organisation.

Based on Figures 2 and 3, annd in addition to suggestions from some empirical evaluation with company managers (e.g., the initiation stage should be further divided into two stages: identification and negotiation to highlight their importance), a process model can be proposed for the inter-organisational knowledge transfer and is illustrated in Figure 4. The following explanation is provided for the five stages, although there may be no clear-cut division between them.

1. Identification: In this stage, the receiving company internally finds its knowledge gap, identifies its needs for acquiring external knowledge and the external knowledge source.
2. Negotiation: In this stage, the receiving company negotiates (or discusses) with the giving company on the knowledge transaction, or any problems happening in the transfer process, to reach an agreement or oral commitment.
3. Selection: It is a stage in which a giving (or receiving) employee is selected by the giving (or receiving) organisation to specifically carry out the agreed transfer task.
4. Interaction: It is a stage in which both the giving and receiving employees iteratively contact each other to transfer the agreed knowledge.
5. Conversion: It occurs when the receiving employee contributes his/her acquired knowledge to the employer (i.e., the receiving organisation), the individual learning will be converted into organisational learning to successfully improve the receiving organisation's business.

The proposed process model not only identifies the important stages in the inter-organisational knowledge transfer process, but also shows the dynamic interactions between the organisations involved. More importantly, the model emphasises the repetitive nature of the process among stages and demonstrates the necessity of iterative loops between some stages. The transfer process may, sometimes not simply progress in the stage sequence but in iterative loops, as it may be necessary to go back to the previous stage. For example, once the receiving organisation initially identifies its needs for acquiring external knowledge and

Figure 4. The inter-organisational knowledge transfer process model



the external knowledge source (i.e., the giving organisation), the former will negotiate or discuss with the latter to further clarify what the former exactly wants. Sometimes, the needs initially identified by the receiving organisation may be found to be inaccurate; thus it is necessary for the receiving company to go back to the identification stage to further clarify its needs. Then it will negotiate or discuss with the giving organisation again. This process may carry on until the true needs for the receiving organisation are correctly identified. Although the selection of a receiving employee is the receiving organisation's internal affair, sometimes the receiving organisation may inform or consult the giving organisation about its arrangements for the receiving employee. So, there is a feedback loop that goes from the selection stage to the negotiation stage until the receiving employee is finally selected. Further, the transfer process in the receiving organisation may also have iterative loops during its interaction with the giving organisation. Similar things may happen in the giving organisation as well.

In the conversion stage, the receiving employee will apply the acquired knowledge into the receiving organisation's business. The receiving employee may still need the giving employee's help because he/she may not fully understand the acquired knowledge or not fully absorb the knowledge needed for the application. This will initiate a feedback loop from the conversion stage to the interaction stage, then back to the conversion stage again. Furthermore, different organisations have different environments. The application of the knowledge in the new environment may trigger some new problems, which may cause the receiving organisation to identify its new needs for knowledge acquisition. Some of them may be internally met in the conversion stage. Some of them may cause the receiving organisation to seek a new external knowledge source and begin a new round of inter-organisational knowledge transfer. So, there is a backward loop from the conversion stage to the identification stage.

CONCLUSION

Through a review of the relevant literature on knowledge transfer, organisational learning and social networks, an inter-organisational knowledge transfer process model is developed. As shown in the model, inter-organisational knowledge transfer is a complex process and difficult to understand. As a result, the success of the transfer can be affected by many factors and pose serious challenges to organisations. Some empirical research has been carried out to test the model, and the preliminary findings suggest that managers feel that the process model is a sound attempt to reflect companies' knowledge transfer practices and can help the companies to better understand the nature, the mechanism, and the process of the knowledge transfer.

FUTURE TRENDS

Future research needs to be undertaken to identify the important factors in each stage. For instance, in the interaction stage, the receiving employee will learn from the giving employee, the former's absorptive capacity and prior experience, the latter's openness, prior experience and expressiveness, as well as the trust between both of them (Cohen & Levinthal, 1990; Wathne, Roos & von Krogh, 1996; Chen, Duan, & Edwards, 2002) could be identified as the important factors for the stage. Furthermore, inter-organisational knowledge transfer strategies for both receiving and giving organisations can be developed to help them to address the "boundary paradox" (Quintas, Lefrere, & Jones, 1997) more effectively and maximise the potential benefits of knowledge sharing for both organisations involved.

REFERENCES

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MISQ Quarterly, 25*(1), 107-136.

Albino, V., Garavelli, A. C., & Schiuma, G. (1999). Knowledge transfer and inter-firm relationships in industrial districts: The role of the leader firm. *Technovation, 19*, 53-63.

Argyris, C., & Schon, D. A. (1996). *Organisational learning II: Theory, method, and practice.* London: Addison-Wesley.

Beeby, M., & Booth, C. (2000). Networks and inter-organisational learning: A critical review. *The Learning Organisation, 7*(2), 75-88.

Chen, S., Duan, Y., & Edwards, J. S. (2002, September 24-25). Towards an inter-organisational knowledge transfer framework for SMEs. *Proceedings of the 3rd European Conference on Knowledge Management,* Dublin, Ireland.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*, 128-152.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organisations manage what they know.* Boston: Harvard Business School Press.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology, 91*(3), 481-510.

Huber, G. (2001). Transfer of knowledge in knowledge management systems: Unexplored issues and suggested studies. *European Journal of Information Systems, 10,* 72-79.

Ives, W., Torrey, B., & Gordon, C. (1997). Knowledge management: An emerging discipline with a long history. *Journal of Knowledge Management, 1*(4), 269-274.

Lind, M., & Persborn, M. (2000, September 12-14). Possibilities and risks with a knowledge broker in the knowledge transfer process. *Proceedings of the 42nd Annual Conference of the Operational Research Society,* University of Wales, Swansea.

Lind, M., & Seigerroth, U. (2000, September 12-14). Development of organisational ability through team-based reconstruction: Going from personal to shared contextual knowledge. *Proceedings of the 42nd Annual Conference of the Operational Research Society,* University of Wales, Swansea.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford: Oxford University Press.

Quintas, P., Lefrere, P., & Jones, G. (1997). Knowledge management: A strategic agenda. *Long Range Planning, 30*(3), 385-391.

Shariq, S. Z. (1999). How does knowledge transform as it is transferred? Speculations on the possibility of a cognitive theory of knowledgescapes. *Journal of Knowledge Management, 3*(4), 243-251.

Szulanski, G. (2000, May). The process of knowledge transfer: A diachronic analysis of stickiness. *Organisational Behaviour and Human Decision Process, 82*(1), 9-27.

von Hippel, E. (1987). Cooperation between rivals: Informal know-how trading. *Research Policy, 16,* 291-302.

Wathne, K., Roos, J., & von Krogh, G. (1996). Towards a theory of knowledge transfer in a co-operative context. In G. von Krogh & J. Roos (Eds.), *Managing knowledge: Perspectives on co-operation and competition.* London: Sage.

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Chapter 2.16
Organizational Semantic Webs

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INTRODUCTION

The main subject tackled in this article is the use of knowledge technologies to develop corporate memories or (stated more generally) "organizational memories" (OMs) (Dieng, Corby, Giboin, & Ribière, 1999).

At the end of the 1990s, AI technologies, in general, and knowledge technologies, in particular, were recognized as pertinent and promising tools (in addition to information technologies) for the design of OMs (Buckingham Shum, 1997; O'Leary, 1998; Milton, Shadbolt, Cottam, & Hammersley, 1999). These very diverse technologies (concepts, methods, and tools) have been conceived to assist knowledge acquisition, modeling, and discovery, as well as the development of knowledge-based systems (Studer, Benjamins, & Fensel, 1998). In this article, we focus on knowledge modeling and formalization techniques, since our prime interest is the preservation of knowledge within OMs and its impact on the exploitation of this knowledge.

In practice, the use of these technologies generates two complementary proposals: (1) the formalization of a part of knowledge to be preserved, which means considering hybrid memories in terms of specification modes (formal, semi-formal, and informal); and (2) the introduction of a formal ontology of the domain in question, in order to facilitate the expression, comprehension, and access to capitalized knowledge. Formalization thus relates to both (1) knowledge (as propositional knowledge) and (2) meaning (as conceptual knowledge).

Regarding the balance between formal and informal specification, a broad spectrum of OM architectures have been proposed, ranging from informal annotation of formal knowledge bases (Euzénat, 1996) to the formal annotation of informal documents (Buckingham Shum, Motta, & Domingue, 2000). It should be noted that these extremes (i.e., the development of a text-documented knowledge base and the publication of scientific articles on the Web, respectively) correspond to atypical OM applications.

The knowledge technologies used in 2004 to develop OMs are generally those of the Semantic Web, where languages like OWL (Antoniou & van Harmelen, 2004) allow us to exchange knowledge bases on the Web. One particular asset of OWL is its ability to offering several dialects with different expressive powers—the choice of the dialect depending on the specific application in question.

A review of the state of the art (cf. section 2) shows that current OM architectures rely on "lightweight" knowledge models, corresponding to formal annotations of textual resources. These approaches focus on document "enrichment" (Motta, Buckingham Shum, & Domingue, 2000), since the knowledge models and ontologies are used to facilitate access to textual resources and the dissemination of the latter to interested users.

In contrast to these initiatives (or rather by extending them), we recommend giving more importance to formalization, by going back to Buckingham Shum's original proposal (1997) of formalizing a part of the knowledge to be capitalized. Such an approach requires us to improve the knowledge technologies used, in order to make it possible to apprehend and reason on the contents of the resources independently of the specification modes (cf. sections 3, 4, and 5).

BACKGROUND

Our current work concerns the conception and development of organizational Semantic Webs (OSWs), that is, OMs whose implementation exploits Semantic Web technologies. The evolution of the Web into a Semantic Web is currently the subject of numerous research programs (Berners-Lee, Hendler, & Lasilla, 2001). The principal aim is to enable software agents to exploit the contents of textual resources present on the Web so that users can ultimately be relieved of certain information searching and combination tasks (Fensel, Wahlster, Lieberman, & Hendler, 2003). The developed technologies apply as much to the Web as a whole as to OSWs in particular.

Current OSW architectures rely on the coupling of a collection of textual resources with formal resources, the latter also being qualified as "semantic" resources. Of these, one can distinguish annotations of textual resources or "metadata" (which express knowledge about textual resources) (Handschuh & Staab, 2003) on one hand, and ontologies (which stipulate the meaning of the terms used to express the textual resources and the metadata) (Davies, Fensel, & van Harmelen, 2003; Abecker & van Elst, 2004) on the other hand. Again, one finds a distinction between knowledge and meaning. In terms of the contribution of these semantic resources, various approaches are being explored. They may thus be used for:

- navigating within a network of annotations, in order to help discover documents and apprehend their contents (Buckingham Shum et al., 2000)
- furnishing the user with the documents likely to interest him or her, by taking into account his or her centers of interest expressed in terms of ontological concepts (Davies, Duke, & Sure, 2003; Middleton, De Roure, & Shadbolt, 2004; Uschold et al., 2003)
- ranking answers to queries by taking into account the annotations' contents (Stojanovic, Studer, & Stojanovic, 2003) and/or the memory's uses such as previous consultations

The study of these architectures shows that they force formal resources into a precise role: constituting an index for textual resources. This type of coupling can be qualified as "weak," to the extent that the only aim of these formal resources is to facilitate the exploitation (access, dissemination) of the textual resources – the capitalized knowledge being only present in the latter. When a user sends a query to this type of OSW, the answer he or she receives is a list (ranked by estimated relevance) of textual resources likely to contain the desired information. This user must then still locate information within these documents.

In order to increase the assistance provided by OSWs, we recommend carrying out "strong" coupling by modeling a part of knowledge to be capitalized, which amounts to distributing the capitalized knowledge between the textual resources and the formal resources. It is necessary to choose which knowledge to model. Several dimensions must be taken into account: the value of knowledge for the organization and its degree of consensuality and stability. In this respect, our priority is to model the organization to which the OSW is dedicated, resulting to some extent in the maintenance of a modeled management report on the organization. This choice appears to us to offer a good return on investment if one compares the assistance provided with information searching on one hand, and the cost of modeling this knowledge on the other hand.

The principal utility of knowledge modeling is to enable an OSW to reason on this knowledge. For example, by reasoning on the organization model, the OSW can build views of the organization suited to the user profile—this profile itself being modeled—thus, facilitating access to the organization's documentation.

At the same time, however, knowledge modeling raises difficulties. First, the distribution of capitalized knowledge across several information sources (according to their specification modes) complicates localization of (and thus access to) this knowledge. In addition, another problem relates to the dissemination of modeled knowledge, which is specified in a formal language not easily understood by a user. One can draw a parallel with the Semantic Web's "metadata": these formal annotations are interpretable by machines but not by humans. Lastly, modeling some pieces of knowledge does not solve the problem of access to information contained within textual resources.

To overcome these difficulties, we recently proposed (1) splitting up the textual resources (in order to reveal information relating to targeted subjects) and introducing a metamodel of knowledge and information contained into the OSW, independently of the way the knowledge/information is specified and located (Fortier & Kassel, 2003a); (2) combining this metamodel with a mechanism for dynamic document generation, created on demand and meeting user expectations (Fortier & Kassel, 2003b).

"STRONG" COUPLING AT WORK

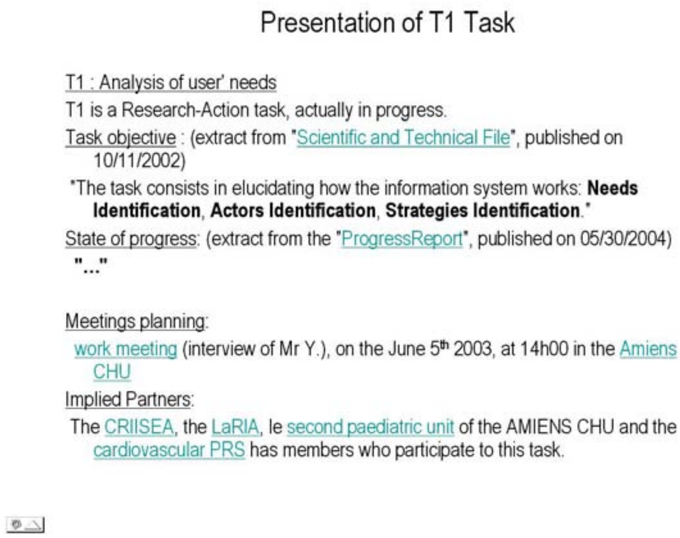
In this section, we present a general view of our proposal by illustrating it with a simple example: the memory of a R&D project. This is inspired by a real application currently conceived within the K²M3 environment (Knowledge Management through Meta-Knowledge Modeling) developed on a multi-agent platform and encapsulating DefOnto as a knowledge representation language (Cormier, Fortier, Kassel, & Barry, 2003).

Example of an OSW consultation

Consultation of an OSW consists of a series of exchanges during which (1) the user expresses a need for information on a given subject and (2) the OSW answers him or her by dynamically generating a document which gathers together relevant information.

Thus, if a participant in a R&D project requests information on a particular project task, the OSW will provide a document similar to that shown in Figure 1. This document contains information about the task, organized by the OSW into a certain order so as to constitute a coherent whole. The text begins with an acronym, followed by the task's full title and category. It continues with the presentation of the general objective as well as the

Figure 1. Information presentation generated for a participant in an R&D project



Presentation of T1 Task

T1 : Analysis of user' needs

T1 is a Research-Action task, actually in progress.

Task objective : (extract from "Scientific and Technical File", published on 10/11/2002)

"The task consists in elucidating how the information system works: **Needs Identification**, **Actors Identification**, **Strategies Identification**."

State of progress: (extract from the "ProgressReport", published on 05/30/2004)

"..."

Meetings planning:

work meeting (interview of Mr Y.), on the June 5^{th} 2003, at 14h00 in the Amiens CHU

Implied Partners:

The CRIISEA, the LaRIA, le second paediatric unit of the AMIENS CHU and the cardiovascular PRS has members who participate to this task.

task's current state of progress, before introducing the work meeting schedule and the partners involved in performance of the task.

Certain pieces of information stem from the organizational model, whereas others are extracted from documents. In our example, the acronym, the heading, the category, the meeting dates, and the involved partners are modeled information, whereas the general objective of the task, its progress report, and the agenda of the meetings of work are extracted from various documents (the project's scientific and technical file, the last progress report, e-mail messages about forthcoming meetings, and meeting reports for previous meetings, respectively).

The generated document comprises moreover two types of links added by the OSW. The first is placed whenever the OSW cites elements for which it is possible to present further information. The activation of this link leads to a new information presentation (document). In our example, these links correspond to the work meeting on June 5, 2003 and the various partners involved in performance of the task. The second type of link appears during the introduction of the document fragments whenever it is possible to consult the corresponding document. It is placed so as to allow the user to consult the entire document if he or she so desires.

The Organization Model

The organization model (with which the OSW is equipped) corresponds to the description of an organization (here a R&D project) according to different viewpoints and at different levels of abstraction. Just like an organization (i.e., a group of people carrying out a project together), a project itself comprises participants (who may be affiliated to various organizations considered as partners) and generally has a leader. As a complex process, a project can be decomposed into tasks, giving rise to the performance of a variety of activities (e.g., work meetings, document writing, software development, etc.). Finally, a project produces results, some of which are material (e.g., software, documents, and other artefacts) and others of which are immaterial (e.g., a conceptual methodology).

Hence, one finds different kinds of objects in such a model. The organization ontology makes the meaning of these different object types explicit, and contains a specification of notions such as “Partner,” “SteeringCommittee,” “FinalReport,” “Task,” and so forth. Such an ontology plays two roles: During the OSW development phase, it helps express the organizational model and thus corresponds to populating the ontology; later, at runtime, the implemented version is used to infer facts which are implicit within the organization model. In our approach, these two roles are exploited in turn.

According to the definition, the organization model includes a description of the organization’s textual resources. Therefore, we can consider that describing an organization according to different viewpoints amounts to extending the metadata approach generally used for the Semantic Web: In addition to document descriptions, we have descriptions relating to other objects. Let us note, however, that this is knowledge about objects and not knowledge about knowledge, which is the aim of the content model.

The Content Model

The content model corresponds to a description of the content of an OSW, according to different viewpoints and at different levels of abstraction. Such a model supposes the reification of the contents so as to make the latter the subject matter of descriptions. For instance, after reifying the content of the sentence “the person in charge of the project is G. Kassel” into an object (called InfoResponsible, for example), it is possible to describe this object by expressing (for example) that “InfoResponsible was made public by the project Steering Committee.” The content model thus contains meta-knowledge.

As a starting point for working out such a model, we consider that content consists of Propositions relating to Subjects and that these Subjects are conceptual in nature. Concepts playing the role of Subjects can be generic (if they classify a set of objects, e.g.: ScanningTask, TechnicalNote) or individual (when they classify only one object, e.g.: SteeringCommittee, ProjectTechnicalFile). This starting point applies indiscriminately to Assertions constituting the organizational model (in terms of Propositions considered as true by the OSW) and Information conveyed in the textual resources (in terms of Propositions stated by an author and intended for another agent). We supplement it by considering that these Propositions may or may not be confidential and that the organizational concepts playing the role of a Subject also can constitute a CentreOfInterest for OSW users.

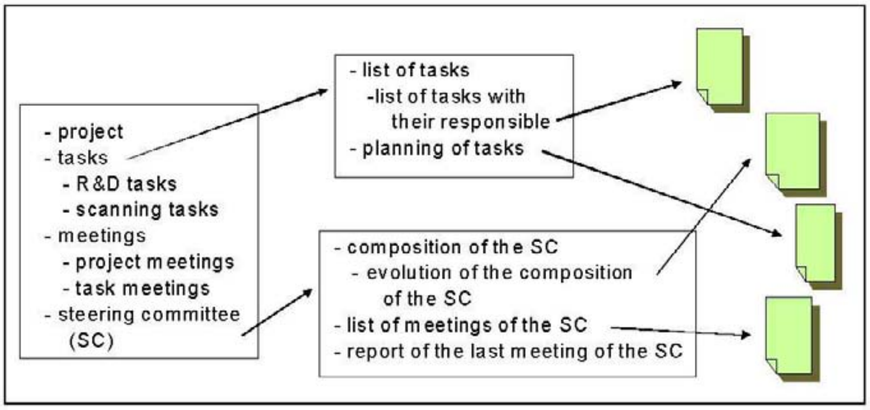
The Assertion model and the Information model rely on the same ontology, being expressed by means of the same concepts. However, the expressed Propositions are not comparable in nature: On one hand, Assertions are simple Propositions because they are formalized by means of a knowledge representation language with limited power of expression; on the other hand, pieces of Information are complex Propositions corresponding to the content of a text. To render the two models homogeneous, it is necessary to describe the text’s content on a finer level of detail. This is why we split up such texts into elementary contents relating to a MainSubject.

Expression of the Information Need

In order to help the user in his or her information search, the OSW generates an index of the different classes of information it is able to provide.

These classes of information are organized as a taxonomy of subjects. A semantic dependency between Concepts playing the role of Subject is to that end calculated. Such a classification allows us to consider, for instance, that information about

Figure 2. Excerpt of a content index



a car's engine constitutes information about the car itself. Let us note, however, that there is no subsumption link between the concepts CarEngine and Car. Following the same principle for a given project task, the OSW will suggest (see Figure 2) information about the task manager, the schedule for future work meetings, and the progress report.

Taking into account the high density of this taxonomy of information, we introduce a complementary index containing concepts of the organization model. This serves as an entrance point to the taxonomy of information by selecting a privileged view of the organization, since each index entry constitutes a partial view of the organization. In our "project memory" example, the OSW enables us to consult information about project partners, tasks, or participants. In the case of generic concepts, the index can be developed according to the subsumption hierarchy and by presenting explicitly the various semantic axis (if they exist) used to define the ontology. For example, the project tasks can be derived into tasks in progress or finished tasks on the "progress stage" axis and into survey, R&D, or management tasks on the "task category" axis. These semantic axes allow better comprehension of the distinctions made between concepts during the ontology design and also help the user refine his or her need for information.

This whole content index (i.e., made up of the two indices presented) appears to us to be more useful than the expression of requests in a dedicated language because it avoids the need to know a query language and furthermore allows the user to find unanticipated information. It is generated for each user group, taking into account its access rights and centres of interest. To that end, the OSW exploits the content model in order to be aware of the users' centres of interest as well as the information subjects.

The Generation of Personalized Virtual Documents

We introduced a mechanism for generation of information presentations by taking what has been developed in the Customized Virtual Document field as a starting point for producing the information presentations. This mechanism allows us to customize the generated presentations according to users' access rights and centres of interests. The mechanism is composed of four steps:

- Relevant information retrieval: The OSW uses an inference engine to deduce all the propositions which deal with the required subject, being formalized or expressed in natural language in textual resources.
- Selection: The OSW carries out an initial sorting by only retaining those propositions which are transmissible to the user. For example, a person outside the project will only obtain general information about the project, whereas a project participant has access to more precise information, such as a task's progress report.
- Scheduling: The OSW must present the propositions in a logical order to the user. This is achieved by using presentation methods which specify order of ranking for different concept categories. Thus, for information in documents, the OSW will add a link to this document and will notably specify the author, the publication date, and the reason for drafting the document: This allows the user to contextualize a document, more easily evaluate its relevance, and only activate the link to consult the full document if it proves to be of interest.
- Composition: Once the presentation's logical structure has been defined, the OSW must generate the physical document. When the presentation mentions other elements on which the OSW is able to give further information, the OSW adds a link which leads to an index of available information on the subject.

FUTURE TRENDS

The approach presented concerning—the implementation of "strong" coupling between textual and formal resources—builds on the modeling of meta-knowledge. The taking into account of such meta-knowledge—on both the conceptual level (via ontologies) and the formal level (via knowledge representation languages)—is now recognized as an important issue for the future of the Semantic Web, and is subject of much research from which OSWs will benefit.

On the conceptual level, there is a need to introduce (meta-)concepts such as Subject, Centre of interest (denoting concepts), or Assertion, Definition, Confidential Information, Hypothesis (denoting propositions) into ontologies. Fox and Huang (2003) thus proposed an ontology of propositions to deal with the origin and validity of information contained in Web pages. Gangemi and Mika (2003) have, for their part, defined an ontology of Description and Situation to allow software agents to exchange information on the Web. Recently, we proposed a synthesis of these efforts with the Information and Discourse Acts (I&DA) ontology, which proposes a set of generic concepts allowing simultaneous definition of contents, the expression of contents, and the discourse acts which create and/or interpret these contents (Fortier & Kassel, 2004).

On the formal level, the issue is one of being able to simultaneously represent the content of propositions (e.g.: "current architectures of OSWs are based on weak coupling between textual and formal resources") and meta-knowledge relating to propositions (e.g.: "this information is a thesis defended by J.-Y. Fortier and G. Kassel") or concepts (e.g.: "the OSW concept is the subject of recent articles by J.-Y. Fortier and G. Kassel"). The OWL-Full language reuses the RDFS primitive "meta-class" and enables representation of certain pieces of meta-knowledge but does not enable one to perform inferences on the latter (Antoniou & van Harmelen, 2004). One of the objectives of our ongoing work on the definition of the DefOnto language is to equip Semantic Web languages with a semantic which enable representation and reasoning on meta-knowledge (Cormier et al., 2003).

CONCLUSION

In this article, we have situated our work within the context of the Semantic Web (a subject that it is impossible to ignore these days), considered the design of "Organizational Semantic Webs" and proposed an approach for the development of a new generation of OSWs—strong coupling between textual and formal resources.

The objective underlying this approach amounts to putting on an equal footing texts and knowledge models for capitalizing knowledge and thus exceeding the simple formal annotation of textual resources. We emphasized the fact that if the scientific community is to reach this objective, it must make progress with Semantic Web technologies, in particular in terms of representing meta-knowledge related to formal or informal contents.

The key issue of this proposal is to confer OSWs with better capacities to exploit their contents. It is a matter of transforming these knowledge and information "repertories"—currently OSWs—into agents which assist users with their work in general and with knowledge management tasks in particular (Baek, Liebowitz, Prasad, & Grangier, 1999).

REFERENCES

Abecker, A., & van Elst, L. (2004). Ontologies for knowledge management. In S. Staab & R. Studer (Eds.), *Handbook on ontologies* (pp. 435-454) Springer-Verlag.

Antoniou, G., & van Harmelen, F. (2004). Web ontology language: OWL. In S. Staab & R. Studer (Eds.), *Handbook on ontologies* (pp. 67-92) Springer-Verlag.

Baek, S., Liebowitz, J., Prasad, S.Y., & Grangier, M. (1999). Intelligent agents for knowledge management: Towards intelligent Web-based collaboration within virtual teams. In J. Liebowitz (Ed.), *Knowledge management handbook* (pp. 11-1, 11-23). CRC Press.

Berners-Lee, T., Hendler, J., & Lasilla, O. (2001). The semantic Web. *Scientific American, 279*(5), 34-43.

Buckingham Shum, S. (1997). Balancing formality with informality: User-centred requirements for knowledge management technologies. In B.R. Gaines & R. Uthurusamy (Eds.), *Proceedings of the AAAI'97 Spring Symposium on Artificial Intelligence in Knowledge Management,* Stanford University, Palo Alto, AAAI Press. Retrieved June 20, 2005, from http://ksi.cpsc.ucalgary.ca/AIKM97/sbs/sbs-paper1.html

Buckingham Shum, S., Motta, E., & Domingue, J. (2000). ScholOnto: An ontology-based digital library server for research documents and discourse. *International Journal on Digital Libraries, 3*(3), 237-248.

Cormier, C., Fortier, J.-Y., Kassel, G., & Barry, C. (2003). Representation of metaknowledge for the development of organizational Semantic Webs. In *Proceedings of the K-CAP'2003 Workshop on Knowledge Management and the Semantic Web,* Sanibel Island, FL.

Davies, J., Duke, A., & Sure, Y. (2003). OntoShare: A knowledge management environment for virtual communities of practice. In *Proceedings of the 2nd International Conference on Knowledge Capture (K-CAP 2003),* Sanibel Island, FL, 20-27.

Davies, J., Fensel, D., & van Harmelen, F. (Eds.) (2003). *Towards the semantic Web: Ontology-driven knowledge management.* John Wiley & Sons.

Dieng, R., Corby, O., Giboin, A., & Ribière, M. (1999). Methods and tools for corporate knowledge management. *International Journal of Human-Computer Studies, 51*(3), 567-598.

Euzénat, J. (1996). Corporate memory through cooperative creation of knowledge bases and hyperdocuments. In *Proceedings of the 10th Knowledge Acquisition for Knowledge-Based Systems Workshop,* Banff, Canada. Retrieved June 20, 2005, from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/euzenat/euzenat96b.html

Fensel, D., Wahlster, W., Lieberman, H., & Hendler, J., (Eds.) (2003). *Spinning the semantic Web.* Cambridge, MA: MIT Press.

Fortier, J.-Y., & Kassel, G. (2003a). Modeling the information contained in an organizational memory to facilitate its access. In *Proceedings of the 10th International Conference on Human-Computer Interaction (HCI-2003),* Crete, Greece (vol. 4, pp. 715-719).

Fortier, J.-Y., & Kassel, G. (2003b). Building adaptive information retrieval systems for organizational memories: A case study. In *Proceedings of the 12th International Conference on Intelligent and Adaptive Systems and Software Engineering (IASSE-2003),* San Francisco, (pp. 50-53).

Fortier, J.-Y., & Kassel, G. (2004). Managing knowledge at the information level: An ontological approach. In *Proceedings of the ECAI'2004 Workshop on Knowledge Management and Organizational Memories,* Valencia, Spain, (pp. 39-45).

Fox, M.S., & Huang, J. (2003). *Knowledge provenance: An approach to modeling and maintaining the evolution and validity of knowledge.* EIL Technical Report, Univ. of Toronto. Retrieved June 20, 2005, from www.eil.utoronto.ca/km/papers/fox-kp1.pdf

Gangemi, A., & Mika, P. (2003). Understanding the semantic Web through descriptions and situations. In R. Meersman et al. (Eds.), *Proceedings of the International Conference ODBASE03*, Berlin, Germany.

Handschuh, S., & Staab, S. (Eds.) (2003). *Annotation for the semantic Web.* IOS Press.

Middleton, S., De Roure, D., & Shadbolt, N. (2004). Ontology-based recommender systems. In S. Staab & R. Studer (Eds.), *Handbook on ontologies* (pp. 477-498), Springer-Verlag.

Milton N., Shadbolt N., Cottam, H., & Hammersley, M. (1999). Towards a knowledge technology for knowledge management. *International Journal of Human-Computer Studies, 51*, 615-641.

Motta, E., Buckingham Shum, S., & Domingue, J. (2000). Ontology-driven document enrichment: Principles, tools and applications. *International Journal of Human Computer Studies, 52*(5), 1071-1109.

O'Leary, D.E. (1998). Using AI in knowledge management: Knowledge bases and ontologies. *IEEE Intelligent Systems*, May-June, 34-39.

Stojanovic, N., Studer, R., & Stojanovic, L. (2003). An approach for the ranking of query results in the Semantic Web. In *Proceedings of the 2nd International Semantic Web Conference (ISWC 2003),* Sanibel Island, FL, (pp. 500-516).

Studer, R., Benjamins, V.R., & Fensel, D. (1998). Knowledge engineering: Principles and methods. *Data & Knowledge Engineering, 25,* 161-197.

Uschold, M., Clark, P., Dickey, F., Fung, C., Smith, S., Uczekaj, S., Wilke, M., Bechhofer, S., & Horrocks, I. (2003). A semantic infosphere. In *Proceedings of the 2nd International Semantic Web Conference (ISWC 2003),* Sanibel Island, FL 882-898.

Chapter 2.17
A Mobile Portal Solution for Knowledge Management

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ABSTRACT

This chapter discusses the use of mobile applications in knowledge management (mobile KM). Today more and more people leave (or have to leave) their fixed working environment in order to conduct their work at changing locations or while they are on the move. At the same time, mobile work is getting more and more knowledge intensive. However, the issue of mobile work and KM is an aspect that has largely been overlooked so far. Based on requirements for mobile applications in KM an example for the implementation of a mobile KM portal at a German university is described. The presented solution offers various services for university staff (information access, colleague finder, campus navigator, collaboration support). The chapter is concluded by outlining an important future issue in mobile KM: the consideration of location-based information in mobile KM portals.

INTRODUCTION

Today many working environments and industries are considered as knowledge intensive, that is, consulting, software, pharmaceutical, financial services, and so forth. Knowledge management (KM) has been introduced to overcome some of the problems knowledge workers are faced by handling knowledge, that is, the problems of storing, organizing, and distributing large amounts of knowledge and its corresponding problem of information overload, and so forth. Hence, KM and its strategies aim at improving an organization's way of handling internal and external knowledge in order to improve organizational performance (Maier, 2004).

At the same time more and more people leave (or have to leave) their fixed working environment in order to conduct their work at changing locations or while they are on the move. Mobile business tries to address these issues by providing (mobile) information and communication technologies (ICT) to support mobile business processes. However, compared to desktop PCs, typical mobile ICT, like mobile devices such as PDAs and mobile phones, have some disadvantages (Hansmann, Merk, Niklous, & Stober, 2001):

- Limited memory and CPU – Mobile devices are usually not equipped with the amount of memory and computational power in the CPU found in desktop computers.
- Small displays and limited input capabilities – for example, entering a URL on a Web-enabled mobile phone is cumbersome and slower than typing with a keyboard.
- Low bandwidth – in comparison to wired networks, wireless networks have a lower bandwidth. This restricts the transfer of large data volumes.
- Connection stability – due to fading, lost radio coverage, or deficient capacity, wireless networks are often inaccessible for periods of time.

Taking into account the aforementioned situation one must question whether current IT support is already sufficient in order to meet the requirement of current knowledge-intensive mobile work environments. So far, most of the off-the-box knowledge management systems are intended for use on stationary desktop PCs and provide just simple access from mobile devices. As KMS are generally handling a huge amount of information (e.g., documents in various formats, multimedia content, etc.) the management of the restrictions described above become even more crucial. In addition, neither an adaptation of existing knowledge services of stationary KMS nor the development of new knowledge services according to the needs of mobile knowledge workers is taking place.

The goals of this chapter are to identify the main issues when mobile work is meeting knowledge management. In particular the focus lies on mobile knowledge portals, which are considered to be the main ICT to support mobile KM. Further on the applicability of these suggestions is shown with the help of a mobile knowledge portal that was implemented at a German university.

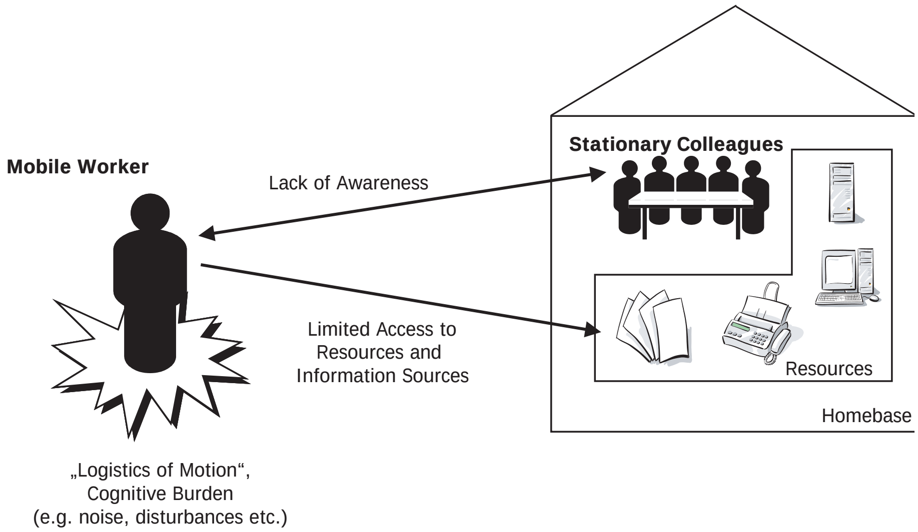
The chapter is structured as follows: Section two will detail the understanding about mobile KM and derive important requirements to be fulfilled. In section three mobile knowledge portals are then described as main ICT to support tasks in mobile KM. As an example the mobile KM portal of the University of Regensburg is presented (section four) whereas section five shows location orientation as the next step in mobile KM. Finally, section six concludes this chapter and gives an outlook on future research issues within the field of mobile KM.

KNOWLEDGE MANAGEMENT MEETS MOBILE WORK

A mobile working environment differs in many ways from desk work and presents the business traveler with a unique set of difficulties (Perry, O'Hara, Sellen, Brown, & Harper, 2001). In the last years several studies have shown that mobile knowledge workers are confronted with problems that complicate the fulfillment of their job (Figure 1).

Mobile workers working separated from their colleagues often have no access to the resources they would have in their offices. Instead, business travelers, for example, have to rely on faxes and messenger services to receive materials from their offices (Schulte, 1999). In case of time-critical data, this way of communication with the home base is insufficient. Bellotti and Bly (1996) show in their survey about knowledge exchange in a design consulting team that it is difficult for a mobile team to generally stay in touch. This is described as "Lack of Awareness." It means that a common background of common knowledge and shared understanding of current and past

Figure 1. Problems related to mobile work



activities is missing. This constrains the exchange of knowledge in teams with mobile workers. In addition, mobile workers have to deal with different work settings, noise levels, and they have to coordinate their traveling. This “Logistics of Motion” lowers their ability to deal with knowledge-intensive tasks (Sherry & Salvador, 2001) while on the move. The danger of an information overflow increases.

Mobile KM is an approach to overcome these problems. Rather than adding to the discussion of what actually is managed by KM—knowledge workers, knowledge, or just information embedded into context—in this chapter, mobile KM is seen as KM focusing on the usage of mobile ICT in order to:

- provide mobile access to KMS and other information resources;
- generate awareness between mobile and stationary workers by linking them to each other; and
- realize mobile KM services that support knowledge workers in dealing with their tasks (Berger, 2004, p. 64).

The next section reviews the state of the art of KMS and reviews if it meets these requirements.

MOBILE KM PORTALS

Currently, many KMS are implemented as centralistic client/server solutions (Maier, 2004) using the portal metaphor. Such knowledge portals provide a single point of access to many different information and knowledge sources on the desktop together with a bundle of KM services. Typically, the architecture of knowledge portals can be described with the help of layers (Maier, 2004). The first layer includes data and knowledge sources of organizational internal and external sources. Examples are database systems, data warehouses, enterprise resource planning systems, and content and document management systems. The next layer provides intranet infrastructure and groupware services together with services to extract, transform, and load content from different sources. On the next layer, integration services are necessary to organize and structure knowledge elements according to a taxonomy or ontology.

The core of the KMS architecture consists of a set of knowledge services in order to support discovery, publication, collaboration, and learning. Personalization services are important to provide a more effective access to the large amounts of content, that is, to filter knowledge according to the knowledge needs in a specific situation and offer this content by a single point of entry (portal). In particular, personalization services together with mobile access services become crucial for the use of KMS in mobile environments.

Portals can be either developed individually or by using off-the-shelf portal packages, for example, Bea WebLogic, IBM Portal Server, Plumtree Corporate Portal, Hyperwave Information Portal, or SAP Enterprise Portal. These commercial packages can be flexibly customized in order to build up more domain-specific portals by integrating specific portal components (so called portlets) into a portal platform. Portlets are more or less standardized software components that provide

Figure 2. Tasklist, calendar, and discussion board of Open Text's Livelink Wireless (Open Text, 2003, p. 12)

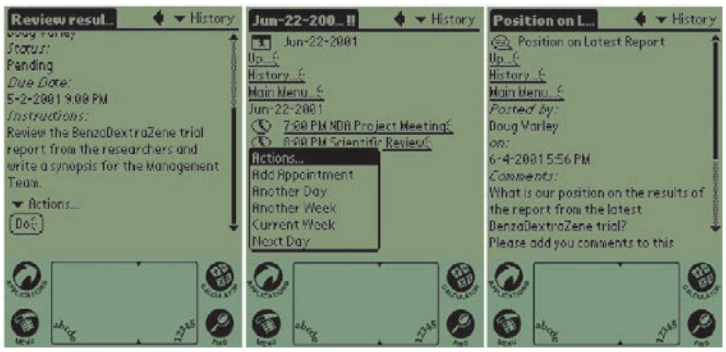


Figure 3. Automatic text summarization (Open Text, 2003, p. 11)

access to a various amount of applications and (KM) services, for example, portlets to access ERP-systems, document management systems, personal information management.

In order to realize mobile access to knowledge portals, portlets have to be implemented as mobile portlets. That means that they have to be adapted according to technical restrictions of mobile devices and the user's context. At the moment, commercial portal packages cannot fulfill sufficiently the needs of mobile KM. Most of the systems are enhanced by mobile components, which are rather providing mobile access to stationary KM services instead of implementing specific mobile KM services.

Hyperwave's WAP (Wireless Application Protocol) Framework, for example, enables mobile users to browse the Hyperwave Information Portal with WAP-enabled devices. The Wireless Suite of Autonomy is a WAP-based solution with the focus on awareness-generating features such as peoplefinder and community support.

At present, the most comprehensive support for mobile KM is provided by the Livelink portal from Opentext Corporation. With the help of the Wireless Server users can access discussion boards, task lists, user directories (MS Exchange, LDAP, Livelink User Directory), e-mail, calendar, and documents (Figure 2). In addition, it provides some KM services specially developed for mobile devices, for example, automatic summarization of text. Hence even longer texts can be displayed on smaller screens (Figure 3).

EXAMPLE: A MOBILE KM PORTAL FOR A GERMAN UNIVERSITY

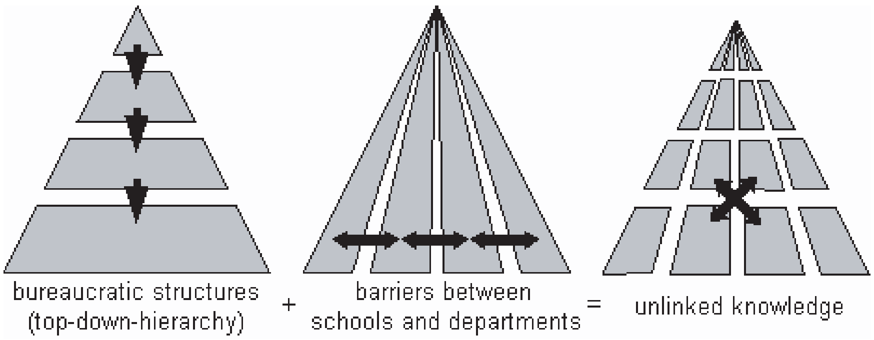
In recent years German universities, which are financed to a large extent by public authorities (federal states and federal government), have been severely affected by public saving measures. As a result lean, efficient administrative procedures are more important than ever. KM can help to achieve these objectives. One example is to provide easy accessible expert directories, where staff members with certain skills, expertise, and responsibilities can be located ("Person XY is responsible for third-party funding") in order to support communication and collaboration.

However, there are several reasons why the access to information of this type is limited at the University of Regensburg. First, there is the decentralized organizational structure. All together about 1,000 staff members are working in 12 different schools and about 15 research institutes at the university, serving about 16,000 students. Because most of the organization units are highly independent, they have their own administrations and the exchange of knowledge with the central administration is reduced to a minimum. Likewise there is hardly an exchange of knowledge between different schools and departments. As a result, knowledge that would be useful throughout the whole university is limited to some staff members ("unlinked knowledge," Figure 4).

A second problem is that many scientific staff members work on the basis of (short-term) time contracts. This leads to an increasing annual labor turnover, comparable to the situation that consulting companies are facing. Important knowledge about past projects, courses, and scientific results is lost very easily. Due to this fact, a high proportion of (new) staff members are relatively inexperienced to cope with administration processes, which can be described as highly bureaucratic and cumbersome.

To overcome these problems—the lack of communication between departments and the need to provide specific knowledge (i.e., administrative knowledge) for staff members—the University of Regensburg decided to build up a knowledge portal called U-Know (Ubiquitous Knowledge). U-Know is meant to be a single point of access for all relevant information according to the knowledge needs described above. When conducting a knowledge audit it became obvious that a large amount of knowledge is needed

Figure 4. Unlinked knowledge because of independent organization structures



when knowledge workers are on the move, that is, working in a mobile work environment. Staff is frequently commuting between offices, meeting rooms, laboratories, home offices; they attend conferences; and sometimes they are doing field studies (e.g., biologists or geographers).

Hence the picture of one single resource-rich office has to be extended towards different working locations, where a large number of knowledge-intensive tasks are carried out as well (Figure 5). Consequently the considered solution should meet these "ubiquitous" knowledge needs of current work practices at a university.

The portal should support staff members by managing the following:

1. Documented knowledge: A knowledge audit was conducted in order to obtain a better picture of knowledge demand and supply. This was mainly done with the help of questionnaires and workshops where staff members were asked to assess what kind of (out-of-office) information is considered as useful.
2. Tacit knowledge: In order to support the exchange of tacit knowledge (which is difficult to codify due to the fact that this knowledge lies solely in the employees' heads, often embedded in work practices and processes), the considered KM solution should enable communication and cooperation between staff members.

In order to meet these requirements U-Know should offer the KM services in Figure 6.

The services can be categorized into information, communication, collaboration, and search. The first category comprises all services that are responsible to manage simple information in the knowledge base. By invoking these services staff members obtain the information they need to perform their daily tasks, for example, news, notifications about changes in rooms, or phone numbers. A very important part of this section is the yellow pages (Figure 7) where all staff members are listed. This list can be browsed by names, departments, fields of research, and responsibilities.

Frequently asked questions (FAQ) answer questions that are typically asked by new staff members. The Campus Navigator helps locate places and finding one's way around the campus. Each room at the university carries a doorplate with a unique identifier. After entering a starting point in form of the identifier and a destination in form of the name of a person, of an office (e.g., "Office for Third-Party Fundings," "Academic Exchange Service"), or just another room number,

Figure 5. Knowledge demand in "mobile" situations

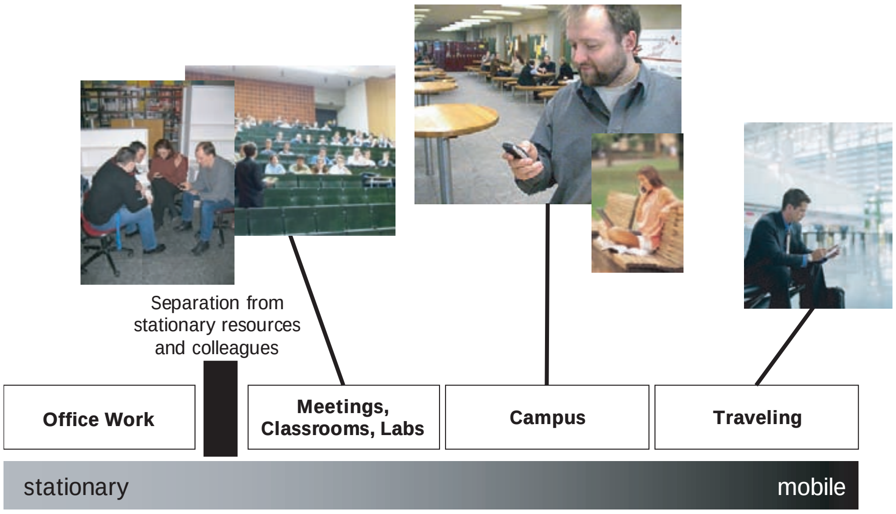
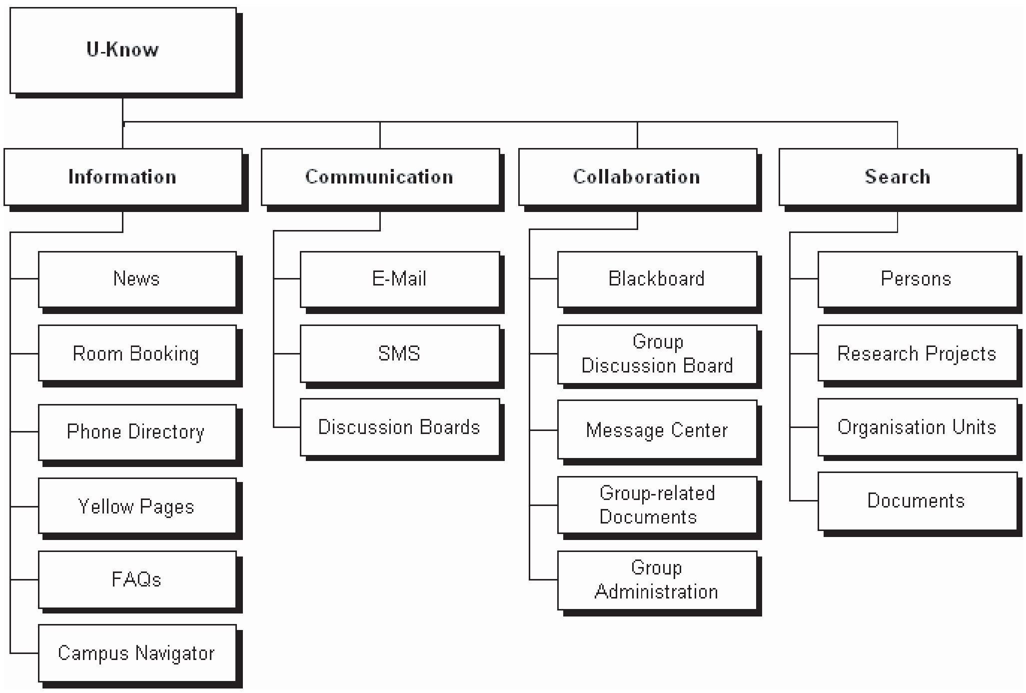


Figure 6. Features of U-Know



the shortest way to the destination is calculated and shown on maps of different sizes (Figure 8).

Communication-oriented features like e-mail, short message service (SMS), and discussion

Figure 7. U-Know yellow pages

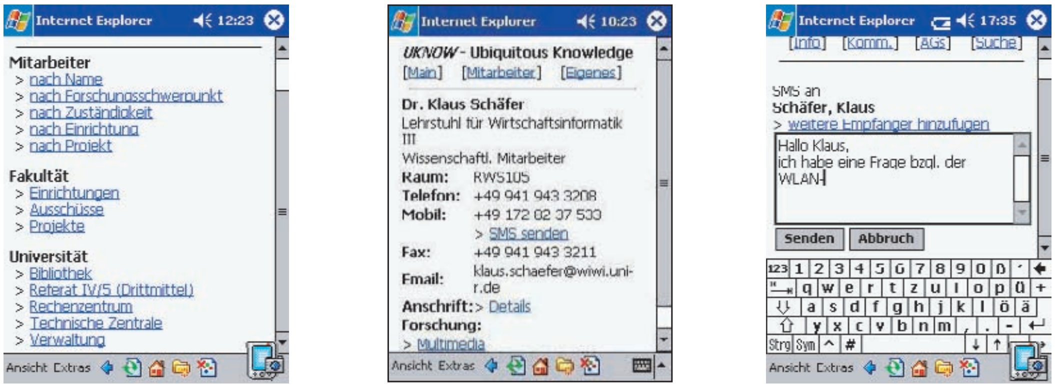


Figure 8. U-Know Campus Navigator

boards are intended to support the exchange of tacit knowledge between staff members.

To foster collaboration, for example, in temporary project groups, staff members can initiate workgroups by inviting colleagues via SMS or e-mail to join a virtual teamspace. After forming a workgroup the participants can use their teamspace for (electronic) group discussions and sharing documents. The blackboard displays all recent events, including new group members, new files, discussion entries, and administrative actions that are taken. In the search section queries can be limited to persons, research projects, organization units, or documents.

To support different networks there are several ways to access the portal. University staff can use the campuswide Wi-Fi network with Wi-Fi–capable devices. Users can also deploy a mobile phone and access the portal via a GSM-network and the Wireless Application Protocol (WAP). Hence it is possible to use the portal even when users are outside the university, for instance, at a conference. The phone directory or the yellow pages can be accessed via voice as the entry of longer words may be cumbersome in many situations. An integrated speech-recognition system "translates" the user's spoken words into database requests and the results back into speech.

LOCATION ORIENTATION AS NEXT STEP IN MOBILE KM

Generally, there is agreement about the distinction between human- and technology-oriented KM approaches which basically reflects the origin of the approaches. KM research should try to bridge the gap between human- and technology-oriented KM. Many authors have propagated a so-called "holistic" approach to KM. However, so far these authors leave it to the interpretation of the reader what such an approach might look like. The examples in the last column of Table 1 should be seen as a step towards detailing this approach which is called "bridging the gap" KM. In Table 1 this classification (Maier, 2004; Maier & Remus, 2003) is enhanced towards the consideration of mobile KM. As mobile KM is mainly focusing on instruments and systems, other dimensions like strategy, organization, and economics are not considered in this table.

In order to structure mobile KM, one can distinguish two dimensions: mobile access and location orientation. Mobile access is about accessing stationary KMS whereas location orientation explicitly considers the location of the mobile worker. The field of location-oriented KM draws attention from research in mobile KM, ubiquitous computing, location-based computing, and context-aware computing (Lueg & Lichtenstein, 2003).

So far, the implemented solution provides mobile access to a broad range of different knowledge sources in a mobile work environment. Univer-

Table 1. Mobile KM approaches (gray highlighted cell is covered by U-Know)

	Technology-oriented instruments and systems	**Human-oriented instruments and systems**	**Bridging the Gap instruments and systems**
Mobile Access	Mobile access to content, e.g. knowledge about organization (e. g. Campus Navigator), processes, products, internal studies, patents, online journals by using mobile devices focusing on services for presentation (e.g. summarization functions, navigation models) and visualization	Mobile access to employee yellow pages, skill directories, directories of communities, knowledge about business partners using mobile devices focusing on asynchronous E-Mail, Short Message Service (SMS) and synchronous communication (Chat), collaboration and cooperation, community support	Mobile access to ideas, proposals, lessons learned, best practices, community home spaces (mobile virtual team spaces), evaluations, comments, feedback to knowledge elements using mobile devices focusing on profiling, personalization, contextualization, recommendation, navigation from knowledge elements to people
Location-orientation	Adaptation of documented knowledge according to the user's current location	Locating people according to the user's location, e.g. locating colleagues, knowledge experts	Personalization, profiling according to the user's location and situation, providing proactive mobile KM services

sity staff can use the KM services provided by U-Know in order to access information, to find colleagues, to navigate the campus, to collaborate, and so forth. These KM services mainly support the human-oriented KM approach. In fact, typical knowledge services were adapted with regard to the characteristics of mobile devices, that is, small display, bandwidth, and so forth.

However, an adaptation of these services according to the user's location has not taken place yet, whereas a customization of services according to the location of the user would enable a mobile knowledge portal to supply mobile knowledge workers with appropriate knowledge in a much more targeted way. At the same time, information overload can be avoided, since only information relevant to the actual context and location is filtered and made available. Think of a researcher who is guided to books in a library according to his/her own references but also according to his/her actual location.

Currently, common "stationary" knowledge portals are ill-suited to support these new aspects of KM derived from a location-oriented perspective (Berger, 2004). One reason is that the context, which is defined by the corresponding situation (tasks, goals, time, identity of the user) is still not extended by location-oriented context information (Abecker, van Elst, & Maus, 2001).

Location-oriented knowledge services could contribute to

- More efficient business processes: Shortcomings arising from mobility can be compensated by considering location-oriented information. Times for searching can be reduced due to the fact that information about the location might restrict the space of searching (e.g., an engineer might get information about a system that he/she is currently operating). Possibly, redundant ways between mobile and stationary work place are omitted when the information is already provided on the move.
- Personalization: When considering the user's location information can be delivered to the user in a much more customized and targeted way (Rao & Minakakis, 2003). For example, an engineer in a production hall is seeking information about outstanding orders, whereas close to machines he might need information about technical issues or repair services. In addition, location-oriented information might be helpful to locate other "mobile" colleagues who are nearby.
- New application areas: The integration of common knowledge services together with location-oriented mobile services may also extend the scope for new applications in KM, for example, the use of contextual information for the continuous evolution of mobile services for mobile service providers (Amberg, Reus, & Wehrmann, 2003). One can also think of providing a more "intelligent" environment where information about the user's location combined with sophisticated knowledge services adds value to general information services (e.g., in museums, where customized information to exhibits can be provided according to the user's location).

To build up mobile knowledge portals that can support the scenario described above, mobile portlets are needed that can realize location-oriented KM services. In case of being implemented as proactive services (in the way that a system is going to be active by itself), these portlets might be implemented as push services. In addition, portlets have to be responsible for the import of location-oriented information, the integration with other contextual information (contextualization), and the management and exploitation of the location-oriented information. Of course, the underlying knowledge base should be refined in order to manage location-oriented information.

With respect to mobile devices, one has to deal with the problem of locating the user and sending this information back to the knowledge portal. Mobile devices might be enhanced with systems that can automatically identify the user's location. Depending on the current net infrastructure (personal, local, or wide area networks), there are many possibilities to locate the user, for example, Wi-Fi, GPS, or radio frequency tags (Rao & Minakakis, 2003).

CONCLUSIONS AND OUTLOOK

The example of U-Know shows some important steps towards a comprehensive mobile KM solution. With the help of this system it is possible to provide users with KM services while being on the move. With its services like yellow pages, messaging features, and so forth, it creates awareness among remote working colleagues and thus improves knowledge sharing within an organization.

With respect to the acceptance of U-Know, two user groups can be distinguished. The first group is characterized by users who already own a mobile device, especially a PDA, in order to organize their appointments and contacts (personal information management). They are the main users of the system because they perceive the additional KM-related services as an extension of the capabilities of their devices. In contrast, staff members who did not use mobile devices for their personal information management are more reluctant to adopt the new system.

The Wi-Fi access soon became the most popular way of accessing the system. This is because of several reasons. Most of the staff members are actually working on the campus and the Wi-Fi access is free of charge for university members. Another reason is probably the higher bandwidth (and therefore faster connections) of Wi-Fi in comparison to a GSM-based access via WAP. Nevertheless, it can be assumed that decreasing connection fees and higher bandwidths of 3G-Networks (UMTS) would encourage staff to use the system from outside the university.

However, in order to fully meet the requirements of mobile KM in the near future, mobile KM portals have to be enhanced with mobile knowledge services that consider location-oriented information. Current work needs once more to address the adaptation of mobile services, the consideration of the user and work context for KM, and the design of highly context-aware knowledge portals.

REFERENCES

Abecker, A., van Elst, L., & Maus, H. (2001, July 13–16). Exploiting user and process context for knowledge management systems. *Workshop on User Modeling for Context-Aware Applications at the 8th International Conference on User Modeling,* Sonthofen, Germany.

Amberg, M., Remus, U., & Wehrmann, J. (2003, September 29–October 2). Nutzung von Kontextinformationen zur evolutionären Weiterentwicklung mobiler Dienste. *Proceedings of the 33rd Annual Conference "Informatics 2003," Workshop "Mobile User - Mobile Knowledge - Mobile Internet,"* Frankfurt, Germany.

Belotti, V., & Bly, S. (1996). Walking away from the desktop computer: Distributed collaboration and mobility in a product design team. *Proceedings of CSCW '96* (pp. 209-218). Boston: ACM Press.

Berger, S. (2004). *Mobiles Wissensmanagement. Wissensmanagement unter Berücksichtigung des Aspekts Mobilität.* Berlin: dissertation.de.

Grimm, M., Tazari, M.-R., & Balfanz, D. (2002). Towards a framework for mobile knowledge management. *Proceedings of the Fourth International Conference on Practical Aspects of Knowledge Management 2002 (PAKM 2002),* Vienna, Austria.

Hansmann, U., Merk, L., Niklous, M.S., & Stober, T. (2001). *Pervasive computing handbook*. Berlin: Springer.

Lueg, C., & Lichtenstein, S. (2003, November 26-28). *Location-oriented knowledge management: A workshop at the Fourteenth Australasian Conference on Information Systems (ACIS 2003)*, Perth, Australia.

Maier, R. (2004). *Knowledge management systems, information and communication technologies for knowledge management.* Berlin: Springer.

Maier, R., & Remus, U. (2003). Implementing process-oriented knowledge management strategies. *Journal of Knowledge Management, 7*(4), 62-74.

Open Text Corporation. (2003). *Livelink Wireless: Ubiquitous access to Livelink Information and Services* (White paper). Waterloo, Canada: Author.

Perry, M., O'Hara, K., Sellen, A., Brown, B., & Harper, R. (2001). Dealing with mobility: understanding access anytime, anywhere. *ACM Transactions on Human-Computer Interaction, 8*(4), 323-347.

Rao, B., & Minakakis, L. (2003). Evolution of mobile location-based services. *Communications of the ACM, 46*(12), 61-65.

Schulte, B.A. (1999). *Organisation mobiler Arbeit. Der Einfluss von IuK-Technologien.* Wiesbaden, Germany: DUV.

Sherry, J., & Salvador, T. (2001). *Running and grimacing: The struggle for balance in mobile work. Wireless world: Social and interactional aspects of the mobile age* (pp. 108-120). New York: Springer.

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Chapter 2.18
Organizational Structure

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INTRODUCTION

For many decades, organization scientists have paid considerable attention to the link between knowledge and organization structure. An early contributor to these discussions was Max Weber (1922), who elaborated his concepts of professional bureaucracy. History shows a multitude of other descriptions and propositions which depict knowledge-friendly organization structures such as the 'organic form' for knowledge-intensive innovation promoted by Burns and Stalker (1961), professional bureaucracies and adhocracies described by Mintzberg (1983), and the brain metaphor for organization structure (Morgan, 1986). Discussions on such knowledgefriendly organization structures led to many neologisms including the flexible, intelligent, smart, hypertext, N-form, inverted, network, cellular, or modular organization.

This article discusses the fundamental importance of organization structure for a knowledge perspective on organizations. This discussion involves two classes of questions. Organization structure can be studied as the backdrop against which the knowledge aspects of organizations take shape. Key questions then are how different structural configurations involve stimuli and barriers to the generation and embedding of organizational knowledge through such processes as knowledge exploration and knowledge sharing. Organization structure can also be studied from the perspective of organization design, which is the premeditated construction or change of organization structure (see Bowditch & Buono, 1985). Questions that appear then include: what are possible design interventions and how does one assess their knowledge-friendliness? The article addresses both classes of questions. Its objective therefore is: (1) to look at what defines a knowledge-friendly organization structure, and (2) to explore which interventions organizations have at their disposal when trying to achieve such a structure.

BACKGROUND

The importance of organization structure is well established in the discussions that address matters of organizational knowledge and associated concepts such as creativity, learning, or R&D activities in organization design (e.g., Myers, 1996). Yet, in the stricter circle of studies that explicitly present themselves as knowledge management (KM) studies, organization structure plays second fiddle to issues of ICT and HRM. Organization structure concerns patterns of work relationships (a more elaborate definition of organization structure is given below). Such work relationships can be predefined (formal organization structure) or organically evolving (informal organization structure). There is a general recognition that relationships among individuals in collectives are centrally important in the organizational production of knowledge and its organizational embedding (e.g., Blackler, 1995). Several trends lend support to the idea that the perspective of knowledge workers and their work relationships should guide discussions of organization design. These trends include the increased complexity in the competitive environment, the greater pressure on innovation and proactive manipulation of markets, and the emergence of provisional structural arrangements such as in network organizations and organizational networks.

A common undertow in these discussions is that knowledge workers need the freedom or autonomy to decide for themselves when to establish work relationships. Such accounts stress that the formal organization structure can be a burden to knowledge aspects of work. They argue that organizational knowledge shows up much better in the informal organization structure (such as communities of practice, e.g., Brown & Duguid, 2001). As Teece (2000, pp. 39-40) puts it: "The migration of competitive advantage away from tangible assets towards intangible ones [forces organizations to] focus on generating, acquiring, transferring and combining such assets to meet customer needs. In order to be successful in these activities, firms and their managements must be entrepreneurial." This implies, according to Teece, that knowledge-intensive, entrepreneurial firms must have:

- flexible boundaries,
- high-powered incentives,
- non-bureaucratic structures,
- shallow hierarchies, and
- an innovative and entrepreneurial culture.

In short, the following suggestions are made for the design of knowledge-intensive forms: reduce hierarchy, only provide the basic outline of production structure, and transfer decisions to connect knowledge worker tasks from the formal to the informal organization structure. Note, however, that loosening control for knowledge work is a disputed issue (e.g., Butler, Price, Coates, & Pike, 1998).

Many of the proposed prescriptions for building knowledge-friendly organization structures (e.g., Quinn, 1992; Sanchez & Mahoney, 1996; Miles, Snow, Mathews, Miles, & Coleman, 1997) share with Teece's prescription a 'one-size-fits-all' character. The assertion that no single organization structure can be a panacea for all management ills, which underlies several organization theories (e.g., the contingency and configurational approaches; see Donaldson, 2001), seems to be fairly broadly accepted. Nevertheless, it appears to be weakly developed where organization structures for knowledge work are concerned. When authors do introduce contingencies (e.g., Nonaka & Takeuchi, 1997; Hobday, 2000), these are usually of a general nature (e.g., complexity or turbulence of the environment, analyzability of the task, size of the firm, type of technology), and not specifically knowledge related. The characteristics of an organization's knowledge base can also serve as contingency variables, as Birkinshaw, Nobel, and Ridderstrale (2002) show in a study of international R&D. Particularly the importance of system embeddedness, which is the extent to which knowledge is a function of the social and physical system in which it exists (Winter, 1987; Zander & Kogut, 1995), emerges from their study as an important contextual variable.

ORGANIZATIONAL STRUCTURE AND ORGANIZATIONAL KNOWLEDGE

Defining Organization Structure

In order to be able to assess the suitability of specific design advice for organizations from a knowledge perspective, we need to understand the denotation of the twin concepts of organization structure and organization design. The division of labor is the key concept underlying organization structure and design. When labor is divided among people and machines, the need also arises to integrate the tasks involved. These two elements, which Lawrence and Lorsch (Lawrence, Lorsch, & Garrison, 1967; Lawrence & Lorsch, 1969) identify as differentiation and integration, are generally recognized as the building blocks of organization structure. For instance, the definition of organization structure that Bowditch and Buono (1985, p. 258) give, which combines Mintzberg's (1979, 1983) well-known definition with the approach taken by Lawrence and Lorsch, states:

Organization structure can be broadly defined as the sum total of ways in which an organization divides its tasks and then coordinates them, in essence balancing job-related specialization (differentiation) with group-, intergroup, and organization-based coordination (integration) as appropriate.

Implied in any system of job definition are the relationships among the totality of tasks. Work relationships therefore define organization structure. A work relationship exists if and when the output of one task is used as part of the input of another task. Work relationships may be distinguished by their content or form. Regarding their content, two types of relationships are commonly discerned. Firstly, relationships exist within the production process (e.g., knowledge workers using the ideas or products of others as inspiration, or input, for their work). The pattern of these relationships defines what is commonly called 'the production structure'. Secondly, relationships can be discerned which affect the definition and realization of work relationships (e.g., knowledge workers deciding for themselves or being directed by a manager to use specific outputs as inputs). The pattern of these relationships is usually referred to as the control structure. As to their form, Thompson (1967) distinguishes three types of input-output connections or—as he calls them—three types of interdependencies: pooled (one actor receives input from multiple others), sequential (one actor transforms the output of an actor before passing it on as input for a third actor), and reciprocal interdependencies (two actors use each other's outputs as input).

The organization structure seen as patterns of work relationships concerns the content side of these relationships. Addressing issues of organization structure implies an abstraction from the personal elements in these relationships, such as individual preferences for work contacts, motivation, trust, and so forth. Obviously, such factors are important in the sense that they are affected by existing organization structures. They are also critical in the sense that they codetermine the success of organizational design choices. Therefore, fully understanding issues of organization structure is not possible when these are addressed in isolation.

From this account it follows that decisions of organization design fall into two basic categories. They concern: (1) either splitting or integrating tasks within production, and (2) either separating production from control or integrating production and control. Four archetypes of organization structures then appear situated on a continuum (see Table 1). The archetype of maximal splitting within production, combined with maximal separation of production from control, defines one end of the continuum (this describes the classical Tayloristic bureaucracy with its focus on specialization within production and elaborate control hierarchies). Full integration on both aspects defines the other end of the continuum (here one finds the team-based or project-based organization in which autonomous, multi-skilled work teams are responsible for their own work; e.g., Sitter, Hertog, & Dankbaar, 1997; Hobday, 2000). Intermediate positions are taken by the two remaining archetypes that combine splitting in production with integration in control and vice versa. A team-based organization becomes a network organization when decisions as to integration within production and control are not specified beforehand, but are left to individual team or network members.

An important question for KM is how different organization structures affect knowledge aspects of work. A basic way of addressing this question is to inspect how splitting or integrating in production and separating or integrating in control affect the knowledge processes within an organization (see Table 1). Splitting production into sub-functions, leading to specialization in the production of knowledge, has both positive and negative impacts on all knowledge processes (knowledge exploration, knowledge exploitation, knowledge sharing, and knowledge retention; see Hendriks & Vriens, 1999). What the effects will be depends on the criteria used for splitting. For instance, splitting according to knowledge domains or areas of expertise will stimulate knowledge exploration within these domains, but it will hinder knowledge sharing across domains. Splitting according to market knowledge, on the other hand, puts more emphasis on individual, tacit elements in knowledge. It comes with the boons of improved customer presence in knowledge exploitation and knowledge exploration. However, it also brings the risks of impaired knowledge sharing and knowledge retention within domains.

The Tayloristic machine bureaucracy is the archetype of an organization that combines maximal splitting in production with maximal separation of production from control. This organizational

Table 1. Effects of separation, splitting, and integration of tasks on knowledge processes

	Separation of production from control	Integration of production and control
Splitting of tasks within production	Tayloristic bureaucracy: knowledge application and retention via formal routines, knowledge transfer via the hierarchy, improved retention and exploitation of explicit knowledge, possible specialization in knowledge development, problems of tacit knowledge sharing.	Professional bureaucracy designed around small cells with specialized task elements within a larger task that manage their own work and connections to other cells within their production chain (e.g., in health services): possible specialization in knowledge development, advantages of tacit knowledge sharing within the cells, but across-cell transfer limited to explicit knowledge.
Integration within production	E.g., the hypertext organization with integral tasks but separate control structures: flexible knowledge exploration within teams and exploitation within the hierarchically organized layer, but possible conflicts of transferring and connecting ideas and plans developed in the project team layer and the application of these in new business (possible clashes between innovatism and conservatism).	The integrated team-based organization: more flexible knowledge development in connected knowledge domains, advantages of within team transfer of tacit knowledge, possible problems of reinventing the wheel by teams, barriers to inter-team cooperation and knowledge sharing.

form is characterized by advantages of possible specialization in knowledge exploration, by the fact that knowledge sharing takes the form of formalized knowledge transfer, and by the fact that procedures mainly address explicit knowledge, which is an important vehicle in knowledge retention.

Combining sub-functions in production, which leads to integrated knowledge in production, may in turn involve problems of knowledge retention associated with the risk of reinventing the wheel by different integrated units. Conversely, it implies combination benefits of knowledge from different knowledge domains in knowledge exploration and knowledge exploitation. An example of the archetype that combines maximal integration in production with maximal integration of production and control is that of the team-based project organization. This organizational form does not stimulate specialization in knowledge exploration, as it aims at broad employability. It focuses on mostly informal knowledge sharing via communication in teams and retains knowledge mainly through the team members. This organization type also aims to facilitate the exchange of tacit, implicit knowledge.

Blackler (1995; Blackler, Crump, & McDonald, 2000) and Lam (2000) provide examples of an alternative way to link organization structure to knowledge. They identify contingencies for organizational effectiveness as dimensions of a matrix, and enter a combined description of design choices and knowledge types of individual organizations or classes of organizations in the

Table 2. Structural configurations and knowledge types (Blackler, 1995; Lam, 2000)

	Focus on problems with low complexity and variability, and high analyzability	Focus on problems with high complexity and variability, and low analyzability
Focus on individual knowledge agents	- *typical organization structure*: professional bureaucracy, which is individualistic, functionally segmented, hierarchical; experts have a high degree of autonomy - *key knowledge type*: embrained knowledge, or knowledge of generalizations and abstract concepts - *learning*: organizations have a narrow learning focus facing problems of innovation; power and status of experts inhibit knowledge sharing	- *typical organization structure*: adhocracy with its diverse, varied, and organic knowledge base, or other knowledge-intensive form - *key knowledge type*: embodied knowledge, or the tacit skills of key members - *learning*: fast and fluid learning and unlearning, but has problems of widely diffusing knowledge
Focus on collective knowledge agents	- *typical organization structure*: machine bureaucracy, which is characterized by specialization, standardization, control, functionally segmentation, hierarchy, seeking to minimize role of tacit knowledge - *key knowledge type*: encoded knowledge, or knowledge in documents and other registrations; a clear dichotomy exists between application and generation of knowledge - *learning*: learns by correction, through performance monitoring; unable to cope with novelty or change	- *typical organization structure*: communication-intensive organization organized as an adhocracy or other knowledge-intensive form; communication and collaboration are key processes; empowerment through integration; expertise is pervasive - *key knowledge type*: encultured knowledge, shared sense-making - *learning*: the organization is adaptive and innovative, but may find it difficult to innovate radically (learning is potentially conservative)

cells of the resulting matrix. Table 2 presents the approaches of these authors condensed into a two-by-two matrix. The arguments presented above calling for openness in the production structure and flat hierarchies imply calls to elaborate the right-hand column of the table.

Designing Knowledge-Friendly Organizational Structures

We now turn to the second theme of this article, which is designing knowledge-friendly organization structures. This theme involves looking at the interventions available for defining or changing organization structures. Two different types of such interventions, or KM practices, exist with respect to the organization structure: (1) practices that involve (re)designing the basic production structure from a knowledge standpoint, adjusting the control structure to the resulting production layout; and (2) practices that involve adapting existing production and control structures to knowledge-related demands with additional interventions of organization design. The following two sections will address both types of KM practices in more detail, under the labels of 'basic structures' and 'support structures', respectively.

Knowledge-Friendly Basic Structures

The literature describes several knowledge-friendly organization structures. Among these, the three that appear to have received the most attention are: the team-based organization, the network structure, and the hypertext organization.

Team-Based Structure

A team is generally defined as a group of people working together towards a common goal. The team concept and the associated project structure (Hobday, 2000) have a rich history in organization studies, which also includes references to knowledge work (e.g., Mohrman, Mohrman, & Cohen, 1995). Two traditions provide the most extensive exploration of team concepts (Benders & Van Hootegem, 1999). The first of these is the sociotechnical system design approach, which focuses on self-managing teams (e.g., Sitter et al., 1997). Team concepts also play a central role in Japanese management studies, which focus on such concepts as 'lean teams' and 'just-in-time' teams. From a knowledge perspective, the team structure involves both pros and cons. The main advantage of a team structure is that teams can be designed to integrate the knowledge needed for a particular task (e.g., a team of experts from various specialties that share the goal of serving a particular regional market). This may lead to improvements in all of the knowledge processes within the team. The main disadvantage of teams is that the cohesion they need for success erects barriers for establishing lateral linkages with other teams. This will impair cross-team cooperation in knowledge exploration and knowledge exploitation. Several authors describe structural configurations that show resemblance to the team concept, but are at best less-developed accounts of elements of team concepts. These include the cellular structure (e.g., Miles & Creed, 1995; Miles et al., 1997) and the inverted organization (Quinn, 1992; Quinn, Anderson, & Finkelstein, 1996).

Network Structure

The network structure involves the largest degree of freedom for knowledge workers to establish work relationships. The term 'network structure' is not a neatly delineated concept in organization studies, but it serves as an umbrella for several organizational forms that show similarities with or are elaborations of the adhocracy structure described above (see Thompson, 2003). The network organization comes under several names: Hedlund (1994) labels it the N-form organization ('N' for 'new'), and Quinn (1992, 1996) uses the term 'spider-web organization'. At least three elements connect the various network concepts of organizations (Hedlund, 1994, p. 83ff.). First, they promote temporary constellations that use the pool of people and their competencies as a touchstone for design. Second, they stress the importance of lateral communication networks within and among production units. Third, they see top management as catalysts, architects, and protectors. Several different variants of the network structure exist. These range from an organization which adopts a web structure to connect its own semi-permanent parts via a network organization that consists as a network of semi-autonomous organizations, to an organizational network that is built around the semi-permanent relationships between autonomous organizations.

Hypertext Organization

Nonaka (1994; Nonaka & Takeuchi, 1995, 1997; Nonaka, Takeuchi, & Umemoto, 1996) describes a structural form that combines the traditional functional structure that is associated with efficiency gains with a project-based organization, that comes with the benefits of flexibility needed for a knowledge-creating company. It is grounded in a business system layer, which is the central layer for normal, routine operations organized as a hierarchical pyramid. On top of that layer, Nonaka identifies a project team layer for knowledge-creation activities. This layer involves the exclusive assignment of team members from different units across the business system to a project team until the project has been completed. These two layers are complementary rather than mutually exclusive. A strong corporate culture is therefore needed to combine the team-based project part of the organization with the hierarchical, bureaucratic part. This connecting culture Nonaka calls the organization's knowledge base. It involves the recategorization and recontextualization of knowledge newly generated in the other two layers. Nonaka uses the term 'hypertext' to indicate that combining knowledge contents more flexibly across layers and over time calls for the existence of dormant links between various parts and layers of the organization that can be activated when needed. This resembles the hypertext links connecting Web sites.

Knowledge-Focused Support Structures

Several mechanisms are described in the literature for improving existing organization structures from the perspective of knowledge processes. These include:

1. Knowledge centers: An organization may decide to assign tasks aimed at furthering the flow of knowledge processes to dedicated departments (e.g., Moore & Birkinshaw, 1998; Hertog & Huizenga, 2000). As an example, consider a library that adopts an active role of offering knowledge mapping services to further possibly fruitful cooperation based on the documents it stores. Thus, it facilitates the processes of knowledge transfer.
2. Knowledge-centered roles and functions, such as chief knowledge officer (CKO), knowledge manager, and knowledge broker (see Davenport & Prusak, 1998; Earl & Scott, 1999; Snyman, 2001; McKeen & Staples, 2003). The tasks involved are typically control tasks at strategic or operational levels that aim at providing knowledge workers with the appropriate infrastructure required for task completion.
3. Den Hertog and Huizenga (2000) describe several forms of lateral knowledge linkages between organizational units that aim to transcend the boundaries involved in the basic structure. These include the establishment of 'expertise circles' that bring together the domain specialists of several teams or other organizational units to discuss developments in that domain and exchange

best practices. Programs of job rotation may also be appropriate tools to install lateral linkages.

4. Communities of practice (CoPs) and communities of interest (CoIs) are elements of the informal organization structure that, because of their organic nature, are generally recognized as important to knowledge flows. Within the domain of formal organizational design, an organization may want to use instruments that aim at facilitating existing communities and stimulating the emergence of new ones. As an example, consider an organization that uses project evaluation procedures as a vehicle to stimulate individuals to explore possibilities for community formation.

FUTURE TRENDS

In the discussions of organization structure, the links to knowledge have played an important role for many decades. Some of these discussions have presented themselves as KM studies, but most of them do not adopt that label. The contribution of KM studies in organization structure usually comes from two areas. The first area concerns the recognition of organization structure as a contextual factor influencing the choice and success rates of KM programs (Bennett & Gabriel, 1999; Gold, Malhotra, & Segars, 2001). The second area involves the design and implementation of concrete measures, management practices, and the like, which all involve an adaptation of the existing organization structure. KM may serve as an integrating umbrella to connect disparate thinking around knowledge aspects of organization structure. One form this integration is likely to take is through a further development of the knowledge element in the contingency theory of organizations. Many discussions of knowledge-friendly organization structures are contemplative in nature, and lack a firm basis in empirical research. Therefore, one would anticipate an increase of empirical studies which address how organizations choose among the alternatives available for making their organization structures knowledge friendly. A final trend that has become more apparent is the trend in which KM research on organization structure has increasingly turned to existing analysis models that allow focusing on relationships, such as social network theory or actor network theory (e.g., Benassi, Greve, & Harkola, 1999; Nelson, 2001; Chang & Harrington, 2003; Sorenson, 2003).

CONCLUSION

Organization structure is an important aspect of knowledge work as it concerns the establishment of work relationships. Any organization structure will stimulate the establishment of certain relationships at the expense of others. It is important to note that flatter, fuzzier, or less structure is by no means inherently superior to crisper or more structure. Too much openness in organization structures not identifying possible work relationships may well result in limited identification and exploitation of such relationships. Too much closure introduces the risk of virtually making it impossible for specific classes of possibly productive relationships to come about. The challenge for knowledge management is to come up with the appropriate mix of design interventions which will guide individuals when they try to establish work contacts, without depriving them of the freedom they need to be knowledgeable and to continue learning. This involves a threefold challenge: (1) choosing a basic structure that honors the key elements of knowledge exploration and knowledge exploitation; (2) identifying the drawbacks of the basic structure for the flow of knowledge processes, and correcting these with the appropriate support structures; and (3) addressing the limitations of organization design with interventions from other management realms, such as human resource management.

REFERENCES

Benassi, M., Greve, A., & Harkola, J. (1999). Looking for a network organization: The case of GESTO. *Journal of Market-Focused Management, 4*(3), 205-229.

Benders, J., & Van Hootegem, G. (1999). Teams and their context: Moving the team discussion beyond existing dichotomies. *Journal of Management Studies, 36*(5), 609-628.

Bennett, R., & Gabriel, H. (1999). Organizational factors and knowledge management within large marketing departments: An empirical study. *Journal of Knowledge Management, 3*(3), 212-225.

Birkinshaw, J., Nobel, R., & Ridderstrale, J. (2002). Knowledge as a contingency variable: Do the characteristics of knowledge predict organization structure? *Organization Science, 13*(3), 274-289.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Blackler, F., Crump, N., & McDonald, S. (2000). Organizing processes in complex activity networks. *Organization, 7*(2), 277-300.

Bowditch, J.L., & Buono, A.F. (1985). *A primer on organizational behavior.* New York: John Wiley & Sons.

Brown, J.S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Burns, T.R., & Stalker, G.M. (1961). *The management of innovation*. London: Tavistock.

Butler, R.J., Price, D.H.R., Coates, P.D., & Pike, R.H. (1998). Organizing for innovation: Loose or tight control? *Long Range Planning, 31*(5), 775-782.

Chang, M.H., & Harrington, J.E. (2003). Multimarket competition, consumer search, and the organizational structure of multiunit firms. *Management Science, 49*(4), 541-552.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge. How organizations manage what they know.* Boston: Harvard Business School Press.

Donaldson, L. (2001). *The contingency theory of organizations.* Thousand Oaks, CA: Sage Publications.

Earl, M.J., & Scott, I.A. (1999). Opinion—what is a chief knowledge officer? *Sloan Management Review, 40*(2), 29-38.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hedlund, G. (1994). A model of knowledge management and the N-Form Corporation. *Strategic Management Journal, 15*(Special Issue, Summer), 73-90.

Hendriks, P.H.J., & Vriens, D.J. (1999). Knowledge-based systems and knowledge management: Friends or foes? *Information and Management, 35*(2), 113-125.

Hertog, J.F.D., & Huizenga, E.I. (2000). *The knowledge enterprise: Implementation of intelligent business strategies.* London: Imperial College Press.

Hobday, M. (2000). The project-based organization: An ideal form for managing complex products and systems? *Research Policy, 29*(7-8), 871-893.

Lam, A. (2000). Tacit knowledge, organizational learning and societal institutions: An integrated framework. *Organization Studies, 21*(3), 487-513.

Lawrence, P.R., & Lorsch, J.W. (1969). *Developing organizations: Diagnosis and action.* Reading, MA: Addison-Wesley.

Lawrence, P.R., Lorsch, J.W., & Garrison, J.S. (1967). *Organization and environment: Managing differentiation and integration.* Boston: Division of Research, Graduate School of Business Administration, Harvard University.

McKeen, J., & Staples, S. (2003). Knowledge managers: Who are they and what do they do? In C.W. Holsapple (Ed.), *Handbook on knowledge management* (Vol. 1, pp. 21-42). Berlin: Springer-Verlag.

Miles, R.E., & Creed, W.E.D. (1995). Organizational forms and managerial philosophies—a descriptive and analytical review. *Research in Organizational Behavior: An Annual Series of Analytical Essays and Critical Reviews, 17*, 333-372. Greenwich, CT: JAI Press.

Miles, R.E., Snow, C.C., Mathews, J.A., Miles, G., & Coleman, H.J. (1997). Organizing in the knowledge age: Anticipating the cellular form. *Academy of Management Executive, 11*(4), 7-24.

Mintzberg, H. (1979). *The structuring of organizations: A synthesis of the research.* Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H. (1983). *Structure in fives: Designing effective organizations.* Englewood Cliffs, NJ: Prentice-Hall.

Mohrman, S.A., Mohrman, A.M., & Cohen, S.G. (1995). Organizing knowledge work systems. In M.M. Beyerlein, D.A. Johnson, & S.T. Beyerlein (Eds.), *Knowledge work in teams* (vol. 2, pp. 61-91). Greenwich, CT: JAI Press.

Moore, K., & Birkinshaw, J. (1998). Managing knowledge in global service firms: Centers of excellence. *Academy of Management Executive, 12*(4), 81-92.

Morgan, G. (1986). *Images of organization*. Beverly Hills, CA: Sage Publications.

Myers, P.S. (1996). *Knowledge management and organizational design.* Boston: Butterworth-Heinemann.

Nelson, R.E. (2001). On the shape of verbal networks in organizations. *Organization Studies, 22*(5), 797.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* New York: Oxford University Press.

Nonaka, I., & Takeuchi, H. (1997). A new organizational structure. In L. Prusak (Ed.), *Knowledge in organizations; resources for the knowledge-based economy* (pp. 99-103). Boston: Butterworth-Heinemann.

Nonaka, I., Takeuchi, H., & Umemoto, K. (1996). A theory of organizational knowledge creation. *International Journal of Technology Management, 11*(7-8), 833-845.

Quinn, J.B. (1992). *Intelligent enterprise: A knowledge and service based paradigm for industry.* New York: The Free Press.

Quinn, J.B., Anderson, P., & Finkelstein, S. (1996). Managing professional intellect: Making the most of the best. *Harvard Business Review, 74*(2), 71-80.

Sanchez, R., & Mahoney, J.T. (1996). Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal, 17,* 63-76.

Sitter, L.U.D., Hertog, J.F.D., & Dankbaar, B. (1997). From complex organizations with simple jobs to simple organizations with complex jobs. *Human Relations, 50*(5), 497-534.

Snyman, R.M.M. (2001). Do employers really know what they want? An analysis of job advertisements for information and knowledge managers. *ASLIB Proceedings, 53*(7), 273-281.

Sorenson, O. (2003). Interdependence and adaptability: Organizational learning and the long-term effect of integration. *Management Science, 49*(4), 446-463.

Teece, D.J. (2000). Strategies for managing knowledge assets: The role of firm structure and industrial context. *Long Range Planning, 33*(1), 35-54.

Thompson, G.F. (2003). *Between hierarchies and markets: The logic and limits of network forms of organization.* Oxford: Oxford University Press.

Thompson, J.D. (1967). *Organizations in action: Social science bases of administrative theory.* New York: McGraw-Hill.

Weber, M. (1922). *Wirtschaft und Gesellschaft.* Tübingen: Mohr.

Winter, S.G. (1987). Knowledge and competence as strategic assets. In D. Teece (Ed.), *The competitive challenge* (pp. 159-184). New York: Harper Collins.

Zander, U., & Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities—an empirical test. *Organization Science, 6*(1), 76-92.

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Chapter 2.19
Logic and Knowledge Bases

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INTRODUCTION

Knowledge bases (KBs) must be able to capture a wide range of situations. One must be able to represent and answer questions regarding indefinite information where it is not clear that there is a unique answer to a question. One must also represent and answer questions about negative information. We discuss a powerful way to represent such information, namely through reasoning about knowledge bases using logic.

In the real world, information known at one time may change. However, in first-order logic, information once known cannot change. This phenomenon is known as monotonicity. Since KBs deal with incomplete information, they are not monotonic. We shall discuss a form of logic programming, below, which is able to handle nonmonotonic information and situations required by KBs such as definite and indefinite data, and logical and default negation.

The question of how to adapt first-order logic to handle complex situations started in the 1950s. Early systems handled problems in an ad hoc way. Several primitive deductive databases (DDBs), function-free logic programs, were developed in the 1960s. Robinson (1965) developed a general method for automated theorem proving to perform deduction. This method is known as the Robinson Resolution Principle; it is a generalization of modus ponens to first-order predicate logic. Green and Raphael (1968) were the first to recognize the importance and applicability of the work performed by Robinson and developed a system using this principle.

November 1977 is generally considered to be the start of the modern era of DDBs. A workshop, "Logic and Data Bases," was organized in Toulouse, France, by Gallaire and Nicolas in collaboration with Minker. The workshop included researchers who had performed work in deduction from 1969 to 1977 using the Robinson Resolution Principle. The book Logic and Data Bases, edited by Gallaire and Minker (1978), contained these papers. Many significant contributions were described in the book. Nicolas and

Gallaire discussed the difference between model theory and proof theory. They demonstrated that the approach taken by the database community was model theoretic—that is, the database represents the truths of the theory, and queries are answered by a bottom-up search. However, in logic programming, answers to a query use a proof theoretic approach, starting from the query, in a top-down search. Reiter discussed the closed world assumption (CWA), whereby in a theory, if one cannot prove that an atomic formula is true, then the negation of the atomic formula is assumed to be true. The CWA is a default rule that permits one to make a decision on negation even if the decision may not be correct.

Reiter's paper elucidated three major issues: the definition of a query, an answer to a query, and how one deals with negation. Clark presented an alternative theory of negation, the concept of if-and-only-if conditions that underlie the meaning of negation, called negation-as-finite-failure. The Reiter and Clark papers are the first to formally define default negation in logic programs and deductive databases. Several implementations of deductive databases were reported. Nicolas and Yazdanian described the importance of integrity constraints in deductive databases. The book provided, for the first time, a comprehensive description of the interaction between logic and databases, and knowledge bases.

References to work on the history of the development of the field of deductive databases and to a description of early systems may be found in Minker (1996).

BACKGROUND

Much of the world's data is stored in relational databases. A relational database consists of tables, each with a fixed number of rows. Each row of a table contains information about a single object. For example, an employee table may contain columns for an employee number, name, address, age, salary, and department name. Each row contains data about one employee. In the same database a department table may contain department name, department number, phone number, and manager's employee number. The connection between the two tables is provided by the common column on department name. Relational databases also allow for integrity constraints that prevent some types of incorrect updates. For example, the specification of employee number as the key of the employee table means that only one row is allowed for any employee number.

Writing a relational database in logic formalism, we associate a predicate with each table, using the same name for convenience. Then an atomic formula (atom), such as,

Department(sales, 5, 1234567, 11223),

means that there is a row in the Department table with the values listed there. In general, an atom consists of a predicate and a set of arguments which may be constants, variables, or function symbols with arguments. We shall deal only with function-free atoms. Deductive databases extend the concept of relational databases by allowing tables to be defined implicitly by using a formula. In this example, we may define an intensional predicate,

Supervisor(emp1, emp2) ← Employee(emp1, _, _, _,_,, dept1),
Department(dept1,_, _, emp2)

to stand for the fact that emp2 is the manager of emp1's department. We use underscores to indicate irrelevant attributes.

This type of definition is allowed for relational databases, where it is called a view.

However, the following definition:

Superior(emp1, emp2) ← Supervisor(emp1, emp2)

Superior(emp1, emp2) ← Supervisor(emp1, emp3),
Superior(emp3, emp2)

where superior stands for the supervisor, the supervisor's supervisor, and so on, uses recursion and was not allowed in the original relational database framework.

More formally, a deductive database, DDB, is a triple, <EDB, IDB, IC>. EDB, the extensional database, is a set of facts, namely the rows in tables. IDB, the intensional database, is a set of rules that implicitly define new tables. IC is a set of integrity constraints. All three parts of a DDB are written as logic formulas. Queries are also written as logic formulas. For example, the query:

← Employee(_, name, address, _, _, deptname),
Department(deptname, 5, _,_)

asks for the names and addresses of employees in department 5, including the name of the department, while the query:

← Supervisor(11223, emp)

asks for the supervisors of employee 11223.

The IDB, in the general case, contains a set of rules of the form:

A1, . . ., An ← B1, . . . , Bm, not Bm+1, . . . , not Bm+k (1)

where all the Ai, $1 \leq i \leq n$, and Bj , $1 \leq j \leq m + k$, are literals (atoms or logically negated atoms, e.g., ¬p, where p is an atom), and not stands for default negation. Whereas logical negation specifies that an atom is definitely not true, default negation not is an implicit form of negation that permits one to conclude that a defaulted atom is not true, even if it is not explicitly known to be not true. The left-hand side of the reverse implication is called the head and the right hand side is the body. The meaning of such a rule is:

A1 or . . . , or An is true if B1 and . . . , and Bm and not Bm+1 and , . . . , not Bm+k are true.

A logic program is a collection of rules of the form (1). Since we deal only with function-free rules, we call such a set of rules a deductive database. There are different kinds of deductive databases depending upon the rules used.

The first generalization of relational databases permitted function-free recursive Horn rules in a database—that is, rules in which n = 1 and k = 0. These deductive databases are called Datalog databases. Formulas where the head is empty are also allowed: they stand for queries and some types of integrity constraints. When the formula is considered to be a query, Q(X1, . . . , Xn), and hence the head is empty and the free variables are X1, . . . , Xn, an answer to the query has the form < a1, . . . , an > so that Q(a1, . . . , an) follows from the database.

MAIN FOCUS OF THE ARTICLE

Datalog Semantics

Van Emden and Kowalski (1976) formalized the semantics of logic programs that consist of Horn rules, where the rules are not necessarily function-free. They recognized that these programs can be characterized in three distinct ways: by model, fixpoint, or proof theory, leading to the same semantics. When the logic program is function-free, their work provides the semantics for Datalog databases. Horn rules may be recursive, that is, a predicate on the left-hand side of a rule may have the same predicate on the right-hand side of the rule. Hence, Datalog allows for more general knowledge bases than the relational model.

Model theory deals with the collection of models (a set of atoms that are true in the theory) that captures the intended meaning of the database. Fixpoint theory deals with a fixpoint operator that constructs the collection of all atoms that can be inferred to be true from the database. Proof theory provides a procedure that finds answers to queries with respect to the database. Van Emden and Kowalski (1976) showed that there is a unique minimal model, which is the same as all of the atoms in the fixpoint, and are exactly the atoms provable from the theory.

To deal with negation, one can subtract from the set of all atoms formed from the predicates and constants in the database, the minimal set of answers to the DDB. If an atom is contained in this set, then it is assumed false.

Initial approaches to answering queries in DDBs did not handle recursion and were primarily top-down (or backward reasoning). However, answering queries in relational database systems was bottom-up (or forward reasoning) to find all answers. Several approaches were developed to handle recursion to improve search time. Two of them are called the Alexander and magic set methods. They take advantage of constants in the query, and effectively compute answers using a combined top-down and bottom-up approach.

Integrity constraints are important to KBs. They are used primarily to assure that a KB update is consistent. Reiter (1978) showed that Datalog databases can be queried with or without ICs and the answer to the query is identical. However, ICs provide semantic information about the data in the KB and can be used to optimize search for answers to queries. The use of ICs to constrain search is called semantic query optimization (SQO). Semantic query optimization has been incorporated into some relational databases. A topic related to SQO is that of cooperative answering systems. The objective is to give a user the reason why a particular query succeeded or failed (see Minker, 1996, for references).

The first article on magic sets may be found in Bancilhon, Mayer, Sagiv, and Ullman (1986). A description of the magic set method to handle recursion in DDBs may be found in Ullman (1988a, 1988b). For work on the fixpoint theory of Datalog, and the work of Van Emden and Kowalski, see Lloyd (1987). A comprehensive survey and references to work in cooperative answering systems is in Gaasterland, Godfrey, and Minker (1992). References to alternative definitions of ICs, semantic query optimization, and cooperative answering may be found in Minker (1996).

Stratified Deductive Databases

Datalog databases provide additional capabilities for KBs. However, they are still not able to handle more complex situations. There may be a need to handle both logical and default negation in some applications. The logic programming formalism handles these situations by permitting more complex rules which have a literal (i.e., an atomic formula or the negation of an atomic formula) in the head and literals with possibly negated-by-default literals in the body of a rule. Such rules are called extended, where in Formula (1) $n = 1$, $m \geq 0$, $k \geq 0$, and the As and Bs are literals. Such databases combine classical negation (¬) and default negation (not), and are called extended DDBs.

Logic programs that use default negation in the body of a clause were first defined in 1986 by Apt, Blair, and Walker (1988) and Van Gelder (1988) as stratified logic programs in which A1 and the Bj , $1 \leq j \leq m+k$, in Formula (1) are atomic formulas, and there is no recursion through negation. They show that there is a unique preferred minimal model, computed from strata to strata, termed the perfect model by Przymusinski (1988). In a stratified theory, rules are placed in different strata, where the definition of a predicate in the head of a rule is in a higher stratum than the definitions of predicates negated in the body of the rule. The definition of a predicate is the collection of rules containing the predicate in their head. One computes positive predicates in a lower stratum, and a negated predicate's complement is true in the body of the clause if the positive atom has not been computed in the lower stratum. The identical semantics is obtained, independent of how the database KB is stratified. This DDB is termed Datalog¬. If a KB can be stratified, then there is no recursion through negation, and the database is called Datalog¬strat.

If the rule:

Happyemp(emp1) ← Employee(emp1), not
Supervisor(emp1, 11223)

is added to the predicates given earlier, a stratified program is obtained with two strata. The lowest stratum contains Employee, Department, and Supervisor, since Happyemp depends negatively on Supervisor, it must be in a higher stratum.

Non-Stratified Deductive Databases

In some KBs it is useful to allow recursion through negation. Once this happens, the KB is no longer stratified. Consider the following simple example:

r1: rich(X) ← not poor(X)
r2: poor(X) ← not rich(X)
r3: satisfied(joe) ← poor(joe)
r4: satisfied(joe) ← rich(joe).

Non-stratified KBs may not have unique answers to queries. Additionally, there may be more than one semantics that define answers to queries in such KBs, and hence alternative ways to answer queries. One such semantics is the answer set semantics (ANS) developed by Gelfond and Lifschitz (1988), and another semantics is the well-founded semantics (WFS) developed by Van Gelder, Ross, and Schlipf (1991). The different semantics for ANS and WFS are illustrated on the above example.

The first two rules, namely that an individual is rich if not poor and poor if not rich, are recursive through negation. Thus this KB is not stratified. But note that by the last two rules, joe is satisfied if he is poor and also if he is rich. By using the answer-set semantics (ANS), there are two answer sets, namely S1 = {poor(joe), satisfied(joe)} and S2 = {rich(joe), satisfied(joe)}. A query is answered "yes" if it is true in all answer sets and "false" if it is false in all answer sets. In this case we can conclude {rich(joe) or poor(joe), satisfied(joe)},that is, joe is rich or poor, and joe is satisfied.

The semantics for ANS is defined first for programs without default negation as the smallest set of literals S, with the property that if all the literals of a rule in the program are in S, then the head is also in S. Consider now a program P with default negation and candidate answer set C. Obtain a new program P1 without default negation as follows: for any rule that has a default negation not L in the body with L ∈ C, the rule is eliminated (the rule cannot apply); for the remaining rules all the default negations are eliminated (the default negation must be true). Since P1 does not have negation, its semantics may be computed by the first method. If the semantics to P1 is the set C, then C is accepted as the semantics for the original program P. If C is the answer set of P1, it is called an answer set of P.

The well-founded semantics (WFS) coincides with the ANS on stratified programs. In the case of non-stratified programs, WFS uses three truth values: true, false, and unknown. In the example above, all three atoms: satisfied(joe), poor(joe), and rich(joe), would be considered as unknown.

Disjunctive Databases

So far we have considered only definite databases (i.e., where in Formula (1) n = 1). Disjunctive databases are useful for KBs when information, either in the EDB or IDB, is indefinite (i.e., in some formulas n > 1). Hence, disjunctive databases permit the representation of indefinite knowledge such as p∨q, where it is not known if p is true, or q is true, but it is known that p∨q is true. Such KBs are called extended disjunctive deductive databases (EDDDBs) or Datalog¬disj,ext. An important special case, disjunctive deductive databases (DDDBs), or Datalog¬disj, allows only atoms in Formula (1). Minker (1982) started the study of DDDBs and showed how to answer both positive and negated queries.

For positive queries over DDDBs, it suffices to show that the query is satisfied in every minimal model. For negated queries, Minker developed the Generalized Closed World Assumption (GCWA), which assigns the value true to a negated atom if the atom does not appear in any minimal model. Minker and others then developed various techniques for answering queries in DDDBs.

Various semantics have been given for EDDDBs. The most prominent of these is the Answer Set Semantics (ANS) modified appropriately from the definite case.

TOOLS FOR IMPLEMENTING KBS

The development of KB systems using logic has been facilitated by enhancements made to relational databases through techniques within DDBs added to the language SQL, through deductive database implementations, and through implementations of the well-founded and answer set semantics for non-stratified and disjunctive databases. In addition, we discuss the use of logic in a large knowledge base system, Cyc.

SQL

The SQL:1999 standard includes queries involving recursion and hence recursive views. The recursion must be linear with at most one invocation of the same recursive item. Default negation is stratified and applies only to predicates defined without recursion. SQL:1999 allows a general class of ICs, called Asserts, that allow for arbitrary relationships between tables and views that express types of ICs generally associated with DDBs.

Linear recursion is implemented as a part of the client server of IBM's DB2 system using magic sets. Techniques from semantic query optimization also have been incorporated into DB2.

Datalog

Several prototype implementations of Datalog¬ have been developed; however, only two systems are active: Aditi, developed at the University of Melbourne under the direction of Dr. K. Ramamohanarao (1993), and LDL++, developed at UCLA under the direction of Dr. Carlo Zaniolo (see Arni, Ong, Tsur, Wang, & Zaniolo, 2003).

Well-Founded Semantics and Answer Set Semantics

The most important implementations for extended DDBs are the Well-Founded Semantics and the Answer Set Semantics. See Minker (1996) for a discussion of alternate proposals and alternative systems. Rao, Sagonas, Swift, Warren, and Friere (1997) developed a system, XSB, that computes the well-founded semantics. The system extends the full functionality of Prolog, an important logic programming language, to the WFS. The use of XSB for medical diagnosis is described in Swift (1999). XSB also permits the user to employ Smodels, discussed below, and is available on the Internet as open source.

Niemelä and Simons (1996) developed Smodels to compute the answer sets of programs in Datalog with negation. Smodels is presently considered the most efficient implementation of Answer Set Semantics. The system can be licensed from a company in Finland called Neotide.

Implementation of Disjunctive Deductive Databases

Eiter, Leone, Mateis, Pfeifer, and Scarcello (1997) developed DLV (DataLog with Or) to compute answer sets for disjunctive deductive databases. The work is a joint effort between the Technical University of Austria and the University of Calabria, Italy.

Cyc

Cyc, developed by Lenat (1995), is both a knowledge base and a system that contains a set of tools to manipulate the database. The Cyc KB consists of a large quantity of basic human knowledge: facts, rules of thumb, and heuristics for reasoning about objects and events that arise in normal life situations. There are approximately 200,000 terms and several dozen assertions about and involving each term. The database is being continually updated by human knowledge experts.

The Cyc system contains an inference engine that performs logical deduction (including modus ponens, and universal and existential quantification). It also contains special inferencing mechanisms, such as inheritance and automatic classification, as special cases. It also includes special purpose inferencing modules for handling a few specific classes of inference such as handling equality, temporal reasoning, and mathematical reasoning. It contains a variety of interface tools that permit the user to browse, edit, and extend the Cyc KB, to pose queries to the inference engine, and to interact with the database integration module and other features in the system.

Knowledge Base Management

A knowledge base consists of a large set of data, the description of the data (metadata), and a potentially large set of rules. A Knowledge Base Management System (KBMS) provides the capabilities to manage, manipulate, and handle the KB. Many capabilities may be required of a KBMS. We discuss some of the more important ones.

The KBMS must provide a language to represent the facts, the description of the facts, the integrity constraints associated with the database, and the rules in the KB. Facts may be temporal in nature. Users may specify preferences in what they would like for answers to queries, and may also specify priorities. The language must provide a capability to enter, delete, or modify data and rules in the KB. It must provide an ability to query all parts of the KB: the data, the description of the data (metadata), and the rules.

In addition to the language, the underlying system should permit many of the following capabilities:

1. An inference capability to use the rules, the data description, and the facts to derive new information: The inference capability must have a nonmonotonic reasoning capability. This is needed since it is not possible to include all the negative data that might be known in any realistic problem, and one must make conclusions in the absence of information. The inference mechanism should also permit the mixing of the metadata (that is, the description of the data), together with the rules and facts.
2. A mechanism to update (i.e., enter, delete, or modify) the KB: Depending upon the inference mechanism used, this might require careful attention (e.g., Fernandez, Grant, & Minker, 1996).
3. A capability to optimize a query: Unless there is a query optimizer, queries may take excessive amounts of time. This is true even in relational database systems that do not have an inference capability.
4. The ability to integrate multiple KBs: This is required in many KBSs such as in organizations that are distributed. Inconsistencies may arise when integrating such systems, and there is the need for handling the integration to provide correct answers to users (see Grant & Minker, 2002; Levy, 2000).
5. The ability to provide cooperative answers to users: For example, there is a need to know when a query can never be answered because

of the nature of the database, or because there may be no data about the query currently in the database (see Gaasterland et al., 1992). The user might require that a route for a trip not go through a particular city, or a plane have at most one intermediate stop.

6. The ability to provide data mining, or the discovery of knowledge in a database: There are several distinguished forms of human reasoning identified by the philosopher Pierce (1883). Deduction is an analytic process based on the application of general rules to particular cases, with the inference as a result. The focus of this article is on providing explicit knowledge that exists in a database through deduction. Data mining or discovery are forms of analytic reasoning called induction, which infer the rule from the case and the result. That is, it discovers a general rule (see Plotkin, 1969; Shapiro, 1981; Hand, Manilla, & Smythe, 2001). Another form of reasoning, abduction, uses synthetic inference, which generates hypotheses H such that (KB U H), where KB is the knowledge base, implying a consequence, C' (see Kakas, Kowalski, & Toni, 1993).

Logic-based languages provide a powerful method for constructing KBMSs. All work developed for DDBs and extended DDBs concerning semantics and complexity apply directly to KBMS. Baral and Gelfond (1994) describe how extended DDBs may be used to represent KBs. The features of KBMSs as described in this section can be used to implement all of the capabilities discussed above. Many of the systems already have these capabilities. Hence, they can allow the KB experts to focus on the database, the description of the data, the specification of the rules, and integrity constraints of the KB. They can then employ an appropriate DDB system that has the required semantics.

Applications

Many applications of KBs exist in a wide variety of fields. We mention only a few here. Abduction is a method of reasoning used to find explanations of observations. This concept has been used in areas such as medical diagnosis and legal reasoning. Information agents, able to handle data on the World Wide Web, have been proposed for solving information retrieval problems. Data integration deals with the integration of data in different databases. The planning problem in artificial intelligence is closely related to the ANS. The handling of preferences and inconsistencies are other areas where KBs are useful.

We illustrate the use of a DDB formalism for KBs with two examples. Consider a family KBs with the following rules and data:

parent(pat, mike) ←
father(X, Y), mother(X, Y) ← parent(X, Y).

The first statement is a fact, the second is a disjunctive rule. From this KB we conclude that pat is mike's father or mike's mother.

A second example deals with eligibility for a scholarship in a university KB. Basically, students with a high grade point average (GPA) or who are athletes and have a good GPA are eligible. Some students are not eligible. Students who are neither eligible nor not eligible are interviewed.

eligible(X) ← gpa(X, high)
eligible(X) ← athlete(X), gpa(X, good)
¬eligible(X) ← ¬gpa(X, good), ¬gpa(X, high)
interview(X) ← eligible(X), not ¬eligible(X)
gpa(sam, good) ←
athlete(sam) ←
gpa(mary, good) ←
¬athlete(mary) ←.

From this KB, eligible(sam) and interview(mary) can be deduced using the answer set semantics.

FUTURE TRENDS AND CONCLUSION

The field of KBs has been enhanced by developments in DDBs. Future developments, discussed briefly below, will make it easier for users to develop KBs.

Relational databases have already incorporated techniques from DDBs. Other tools such as the incorporation of join elimination, and SQO techniques such as equalities and arithmetic constraints can be added to the SQL language. Additional tools that provide cooperative responses to users can also be incorporated in future versions of SQL. It is unclear if additional features of DDBs can be added without major revisions to the relational systems.

DDBs have not yet been made available as commercial systems. The future of commercial systems in this area is not promising except for the XSB system that provides the well-founded semantics; Smodels that provides the answer set semantics; and DVL that provides a disjunctive semantics. These systems already are in use, primarily in university communities. KB systems have been implemented using these systems. Should such systems become commercial, they will make it easier to develop KBs.

REFERENCES

Apt, K.R., Blair, H.A., & Walker, A. (1988). Towards a theory of declarative knowledge. In J. Minker (Ed.), *Foundations of deductive databases and logic programming* (pp. 89-148). San Francisco: Morgan-Kaufmann.

Arni, F., Ong, K., Tsur, S., Wang, H., & Zaniolo, C. (2003). The deductive database system ldl++. *Theory and Practice of Logic Programming, 3,* 61-94.

Bancilhon, F., Maier, D., Sagiv, Y., & Ullman, J. (1986) Magic sets and other strange ways to implement logic programs. *Proceedings of the ACM Symposium on Principles of Database Systems.*

Baral, C., & Gelfond, M. (1994). Logic programming and knowledge representation. *Journal of Logic Programming, 19/20*, 73-148.

Eiter, T., Leone, N., Mateis, C., Pfeifer, G., & Scarcello, F. (1997). In J. Dix, U. Furbach, & A. Nerode (Eds.), *Proceedings of the 4th International Conference on Logic Programming and Nonmonotonic Reasoning (LPNMR'97)* (pp. 363-374), Berlin: Springer-Verlag (LNAI 1265).

Fernandez, J.A., Grant, J., & Minker, J. (1996). Model theoretic approach to view updates in deductive databases. *Journal of Automated Reasoning, 17*(2), 171-197.

Gaasterland, T., Godfrey, P., & Minker, J. (1992). An overview of cooperative answering. *Journal of Intelligent Information Systems, 1*(2), 162-207.

Gallaire, H., & Minker, J. (1978). *Logic and data bases.* New York: Plenum Press.

Gelfond, M., & Lifschitz, V. (1988). The stable model semantics for logic programming. In R.A. Kowalski & K.A. Bowen (Eds.), *Proceedings of the 5th International Conference and Symposium on Logic Programming* (pp. 1070-1080).

Grant, J., & Minker, J. (2002). A logic-based approach to data integration. *Theory and Practice of Logic Programming, 2*(3), 293-321.

Green, C.C., & Raphael, B. (1968). The use of theorem-proving techniques in question-answering systems. *Proceedings of the 23rd National ACM Conference*.

Hand, D., Mannila, H., & Smyth, P. (2001). *Principles of data mining.* Boston: The MIT Press.

Kakas, A.C., Kowalski, R.A., & Toni, F. (1993). Abductive logic programming. *Journal of Logic and Computation, 6*(2), 719-770.

Lenat, D.B. (1995). Cyc: A large-scale investment in knowledge infrastructure. *Communications of the ACM, 38*(11), 32-38.

Levy, A.Y. (2000). Logic-based techniques in data integration. In J. Minker (Ed.), *Logic-based artificial intelligence* (pp. 575-595). Norwell, MA: Kluwer.

Lloyd, J.W. (1987). *Foundations of logic programming* (2nd Ed.). Berlin: Springer-Verlag.

Minker, J. (1982). On indefinite databases and the closed world assumption. *Lecture Notes in Computer Science, 138,* 292-308.

Minker, J. (1996). Logic and databases: A 20-year retrospective. In D. Pedreschi & C. Zaniolo (Eds.), Logic in databases. *Proceedings of the International Workshop (LID'96)* (pp. 3-57), San Miniato, Italy. Berlin: Springer-Verlag.

Niemela, I., & Simons, P. (1996). Efficient implementation of the well-founded and stable model semantics. In I. Niemela & T. Schaub (Eds.), *Proceedings of JICSLP-96.* Boston: The MIT Press.

Pierce, C.S. (1883). *A theory of probable inference. Note B. The logic of relatives. Studies of logic by members of the Johns Hopkins University* (pp. 187-203). Baltimore: Johns Hopkins University.

Plotkin, G.D. (1969). A note on inductive generalisation. In B. Meltzer & D. Michie (Eds.), *Machine Intelligence 5* (pp. 153-163). Edinburgh: Edinburgh University Press.

Przymusinski, T.C. (1988). On the declarative semantics of deductive databases and logic programming. In J. Minker (Ed.), *Foundations of deductive databases and logic programming* (pp. 193-216). San Francisco: Morgan-Kaufmann.

Ramamohanarao, K. (1993). An implementation overview of the Aditi deductive database system. *Proceedings of the 3rd International DOOD Conference (DOOD'93)* (pp. 184-203), Phoenix, AZ. Berlin: Springer-Verlag (LNCS 760).

Rao, P., Sagonas, K., Swift, T., Warren, D.S., & Friere, J. (1997). XSB: A system for efficiently computing well-founded semantics. In J. Dix, U. Ferbach, & A. Nerode (Eds.), *Proceedings of Logic and Nonmonotonic Reasoning: 4th International Conference (LPNMR'97)* (pp. 430-440).

Reiter, R. (1978). Deductive question-answering on relational data bases. In H. Gallaire & J. Minker (Eds.), *Logic and data bases* (pp. 149-177). New York: Plenum Press.

Robinson, J.A. (1965). A machine-oriented logic based on the resolution principle. *Journal of the ACM, 12*(1), 23-41.

Shapiro, E.Y. (1981). An algorithm that infers theories from facts. *Proceedings of the 7th International Joint Conference on Artificial Intelligence (IJCAI'81).* San Francisco: Morgan-Kaufmann.

Swift, T. (1999). *Tabling for non-monotonic programming.* Technical report, SUNY Stony Brook, USA.

Ullman, J.D. (1988a). *Principles of database and knowledge-base systems I.* Rockville, MD: Computer Science Press.

Ullman, J.D. (1988b). *Principles of database and knowledge-base systems II.* Rockville, MD: Computer Science Press.

Van Emden, M.H., & Kowalski, R.A. (1976). The semantics of predicate logic as a programming language. *Journal of the ACM, 23*(4), 733-742.

Van Gelder, A. (1988). Negation as failure using tight derivations for general logic programs. In J. Minker (Ed.), *Foundations of deductive databases and logic programming* (pp. 149-176). San Francisco: Morgan-Kaufmann.

Van Gelder, A., Ross, K.A., & Schlipf, J. (1991). Unfounded sets and well-founded semantics for general logic programs. *Journal of the ACM, 38*(3).

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Chapter 2.20
A Knowledge Management Portal System for Construction Projects Using Knowledge Map

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ABSTRACT

Knowledge management (KM) has become an important term in the construction industry. Knowledge management involves creating, securing, capturing, coordinating, combining, retrieving, and distributing knowledge. Most know-what, know-how, and experience exists only in the minds of individual participants during the construction phase of construction projects. The knowledge can be reused and shared among the involved engineers and experts to improve the construction process and reduce the time and cost of solving problems. Sharing and reusing knowledge depends on acquiring and preserving of both tacit knowledge and explicit knowledge as the property of a corporation. This study addresses application of knowledge management in the construction phase of construction projects and proposes a construction activity-based knowledge management (ABKM) concept and system for general contractors. This chapter proposes a practical methodology to capture and represent construction project knowledge by using knowledge maps. Using knowledge maps, users can get an overview of available and missing knowledge in core project areas and take appropriate management in tacit and explicit knowledge. Also, a Web-based system is developed to assist and present project-related knowledge by providing keyword and map search on the Internet environment. The ABKM system is then applied in a case study of a construction precast building project in Taiwan to verify our proposed methodology and demonstrate the effectiveness of sharing knowledge special in the construction phase. By effectively using information and Web technologies during the construction phase of a project, knowledge can be captured and managed to benefit future projects. The combined results demonstrate that an ABKM-like

system can be an effective tool for all experts and engineers participating in construction projects by utilising the knowledge management concept and Web technology.

INTRODUCTION

Knowledge is the true asset of a marketing-oriented organisation, and its integration across departments and disciplines should be emphasised (Carneiro, 2001). Many organisations are now engaged in knowledge management (KM) efforts in order to leverage knowledge both within their organisations, and externally to their stakeholders and customers (Malhotra, 2000, 2001). These assets, or knowledge, can be classified as either tacit or explicit. Explicit knowledge is that which has been codified and expressed in formal language; it can be represented, stored, shared, and effectively applied (Nonaka & Takeuchi, 1995). Tacit knowledge is knowledge that is difficult to express, represent, and communicate (Nonaka & Takeuchi, 1995). The distinction between these two types of knowledge is relevant because each must be managed differently. Knowledge management in the construction phase mainly deals with the process of creating value from construction operation, organisation, to company knowledge. Valuable knowledge can be available in different forms and media, such as in the minds of experts, in operation procedures, and in documents, databases, intranets, and so forth; however, knowledge management in the construction phase of projects aims at effectively and systematically collecting and sharing the experience and knowledge of the project by Web-based and intranet technologies.

The reuse of information and knowledge minimises the need to refer explicitly to past projects, reduces the time and cost of solving problems, and improves the quality of solutions during the construction phase of a construction project. If experience and knowledge are shared, then the same problems in construction projects do not need to be repeatedly solved. Reduced problem solving has the following advantages: (1) the cost of problem solving is reduced; and (2) the probability of repeated problems is decreased. Several enabling activities should be considered to help to achieve the ultimate goal of efficient experience and knowledge reuse; experience and knowledge should be preserved and managed—that is, they should be captured, modelled, stored, retrieved, adapted, evaluated, and maintained (Bergmann, 2002).

Knowledge reuse and update improves the performance of future activities and projects. Most of the data and information for construction projects are stored in paper-based documents; these consist of contracts, specifications, notes, discussion, and field reports. In order to facilitate the information management and enable knowledge reuse, it is important to convert the paper document into electronic versions to be shared and applied in other and future projects. Information and knowledge of a project can then be identified as project components in the project management and preserved in a Web-based system that provides the platform for the exchange and storage of information and knowledge.

LEARNING OBJECTIVES

1. Understand the application of knowledge management for construction projects.
2. Understand each phase of knowledge management specific for construction projects.
3. Form a case study for knowledge management using knowledge map in the construction phase.
4. Study procedures of implementing knowledge management for construction projects.
5. Study procedures of applying knowledge mapping in knowledge management.

PROBLEM STATEMENT

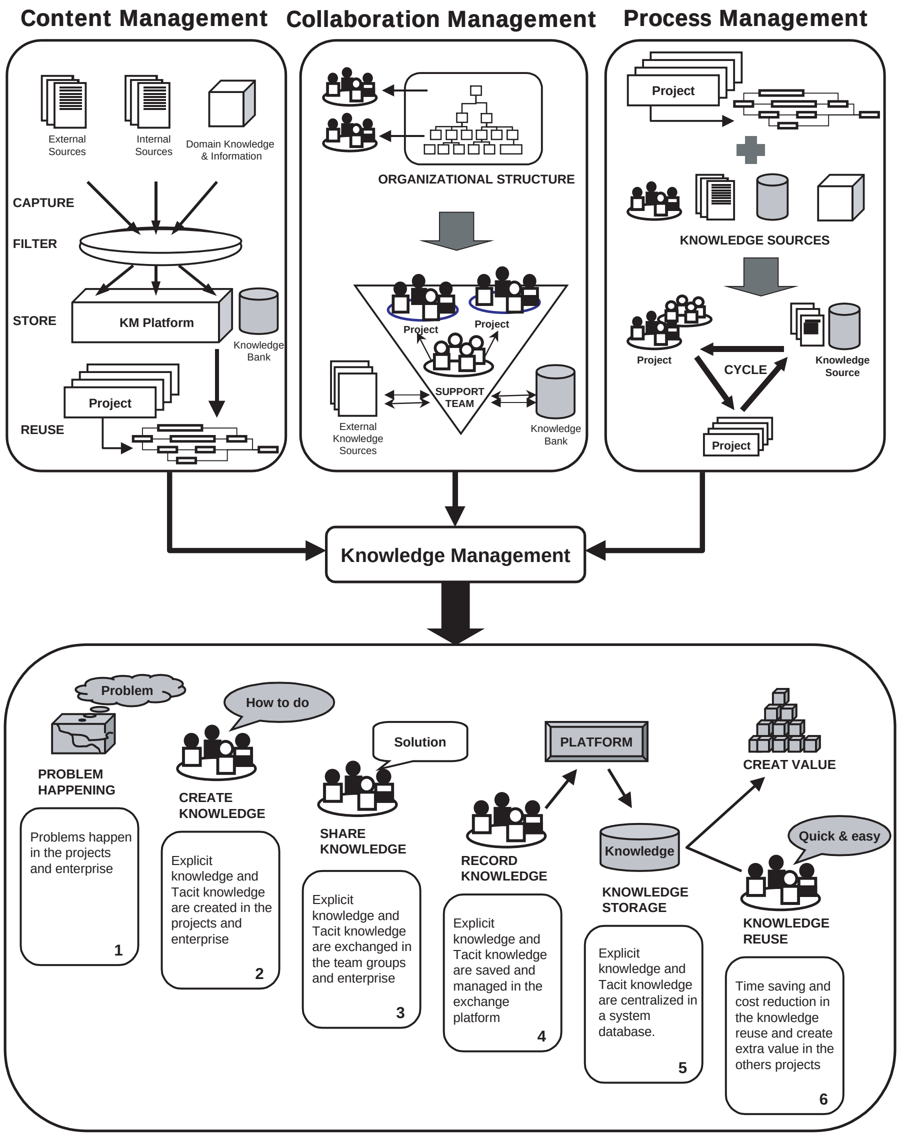
Construction projects are complex and time consuming. Construction projects are characterised by their complexity, diversity, and the non-standard nature of the production (Clough, Sears, & Sears, 2000). Professional competency in project management is attained by combining knowledge acquired during training and skills developed through experience, as well as the application of the acquired knowledge (Edum-Fotwe & McCaffer, 2000). Whatever successful and unsuccessful projects have been executed by general contractors, a valuable record of each one should be kept to identify best and worst company practices. During the construction phase of projects, an effective means of improving construction management is to share experiences among engineers, which helps to prevent mistakes that have already been encountered in past projects. Drawing on experience avoids the need to solve problems from scratch: Problems that have already been solved do not need to be solved again. According to a survey conducted for this study, most engineers and experts agree that KM is necessary and expect that knowledge management may benefit a construction project. However, no suitable platforms exist to assist senior engineers or experts in sharing and collecting their know-how and experiences when general contractors execute a project.

This situation represents a major loss for general contractors who do not preserve the know-how and experiences of senior engineers and experts. When these engineers and experts complete projects or leave the company, they normally take domain knowledge with them and leave little or nothing that will benefit subsequent projects or the company. From the perspective of knowledge management, this know-how and these experiences of construction engineers and experts are the most valuable, because their accumulation depends not only on manpower, but also on the spending of much money and time.

RESEARCH OBJECTIVES

The main purpose for conducting this research is to develop an activity-based knowledge management (ABKM) system for construction projects, to provide knowledge exchange and management service in the construction phase of a project for the reuse of domain knowledge and experience in future and other related projects. Usually, the management of knowledge in a general contractor revolves around projects. Thus the capture, transfer, reuse, and maintenance of the construction project knowledge are critical (Kamara, Augenbroe, Anumba, & Carrillo, 2002). Knowledge management in the construction phase of a project is a knowledge-intensive organisational environment where knowledge creation has critical importance for general contractors. To be competitive, a general contractor has to make innovative use of knowledge created and accumulated through project activities, and share it across other relative projects. Engineers and experts participating in projects act as knowledge workers, facilitating the collection and management of knowledge between current and past projects. In order to apply knowledge management to construction projects, the process and content of working construction knowledge need to be modified because of construction project characteristics. In order to improve the knowledge capture function, a knowledge map as a tool allows the user to quickly note key concepts, identify important processes and tools, and gain insights into associated behaviours. Figure 1 illustrates the main concepts of knowledge management applied in construction projects. With appropriate modification, the ABKM system can be utilised in construction companies to support knowledge management functionality for any construction project.

Figure 1. Knowledge management applied in construction projects



KNOWLEDGE MANAGEMENT IN CONSTRUCTION PHASE

In construction projects, knowledge management is a discipline that promotes an integrated approach to the creation, capture, access, and use of a profession's domain knowledge on products, services, and processes. During the construction phase of a project, most project-related problems, solutions, experiences, and know-how are in the heads of individual engineers and experts. Implicit knowledge usually is not documented or stored in a system database. To reuse the knowledge in other projects and also preserve it as corporation property, how to capture the implicit knowledge and make it become available as explicit knowledge is important in the execution of knowledge management in the construction phase. Experience, problem solving, know-how, know-what, and innovation are created in the construction phase of any project. By practicing knowledge management, tacit knowledge can be reused for other projects and speed the improvement of operations in the construction phase.

LIFE CYCLE OF CONSTRUCTION KNOWLEDGE MANAGEMENT

There are five phases in the construction knowledge management life cycle as shown in Figure 2. They are knowledge acquisition, knowledge extraction, knowledge storage, knowledge sharing, and knowledge update. Each phase is briefly outlined in the following descriptions.

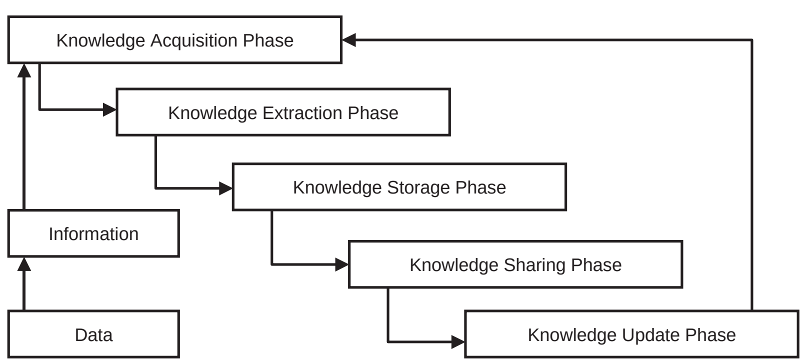
Knowledge Acquisition Phase

The knowledge to be shared must be acquired. In the construction phase, most information and knowledge is acquired on the job site. Hence, the collection of knowledge on a job site plays an important role in the knowledge acquisition phase. Most work of knowledge acquisition is done in the office, because all information and tacit knowledge sent back from the job site can be transferred to explicit knowledge.

Knowledge Extraction Phase

In this study, we define knowledge extraction as a process by which the expert's thoughts and experience are captured. Some knowledge that must be extracted for reuse and storage may only be available from the memories of experts and engineers. In a broader view, knowledge extraction may also include capturing knowledge from other sources such as problem-solution descriptions, construction operation process digital record, virtual communication, and collaboration. However, knowledge is usually captured when the knowledge worker interviews the experts or engineers who answer the questions. In the system, all the descriptions of experience and know-how knowledge are necessary to be edited directly by experts or engineers using unstructured text ways because the knowledge is not necessary to convert into rules or a decision tree. Furthermore, knowledge work will assist with experts and engineers, and deal with the digital process recording work

Figure 2. Five phases of construction knowledge management



if they are important or valuable enough to be kept as the company asset.

Knowledge Storage Phase

The collected knowledge can be stored for future use. During knowledge storage, all information and knowledge are centralised and stored in the knowledge bank (central database) to prevent the collection of redundant information and knowledge. All information and knowledge can be stored in the system by ensuring that data are all electronic and in standard format for each type of file, such as a specific document format or a drawing format.

Knowledge Sharing Phase

Knowledge sharing is the ultimate goal of knowledge management. After the development of knowledge management, people who need to apply knowledge on a particular project can access relevant knowledge for reuse. If necessary, they can adapt it to a new project and solve the new problem.

Knowledge Update Phase

Available knowledge and experience should be continually updated. Reused experience can be evaluated in the context of a new problem to be solved. It can be evaluated in terms of the appropriateness of the selected experience, or in terms of the accuracy of the retrieved experience. Such evaluation is important to ensure the continued improvement of the process by which experience is reused. Invalid knowledge must be identified and be removed or updated. The updating of knowledge can be triggered by a negative experience evaluation or can be conducted as a precaution.

KNOWLEDGE CONTENT IN CONSTRUCTION PROJECTS

Most knowledge content in the construction phase of a project can be classified into two broad categories—tacit knowledge and explicit knowledge. Tacit knowledge is personal, context-specific knowledge that is difficult to formalise, record, or articulate; it is stored in the heads of people (Hart, 1992). The tacit component is primarily developed through a process of trial and error in practice. Tacit knowledge is personal knowledge embedded in individual experience, and shared and exchanged through direct, face-to-face contact (Tiwana, 2000). Tacit knowledge can be communicated directly and effectively. In contrast, the acquisition of explicit knowledge is indirect: It must be decoded and re-coded into one's mental models, and is then internalised as tacit knowledge. Explicit knowledge can be codified and transmitted in a systematic and formal language. Explicit knowledge is formal knowledge that can be packaged as information. It can be found in the documents of organisations, including reports, articles, manuals, patents, pictures, images, video, audio, software, and other forms. It can also be found in organisational documents, such as organisational charts, process maps, mission statements, domains of experience, and others.

Explicit knowledge is easier to collect and manage during the construction phase of a project because the information and knowledge are available in document form. Document management can preserve and manage information and knowledge without extracting explicit knowledge. Therefore, explicit knowledge is easier than tacit knowledge to manage. However, the main problem with tacit knowledge concerns its effective extraction into structured information and unstructured information. After tacit knowledge is extracted, the structured information and unstructured information can be maintained and managed with the assistance of document management tools.

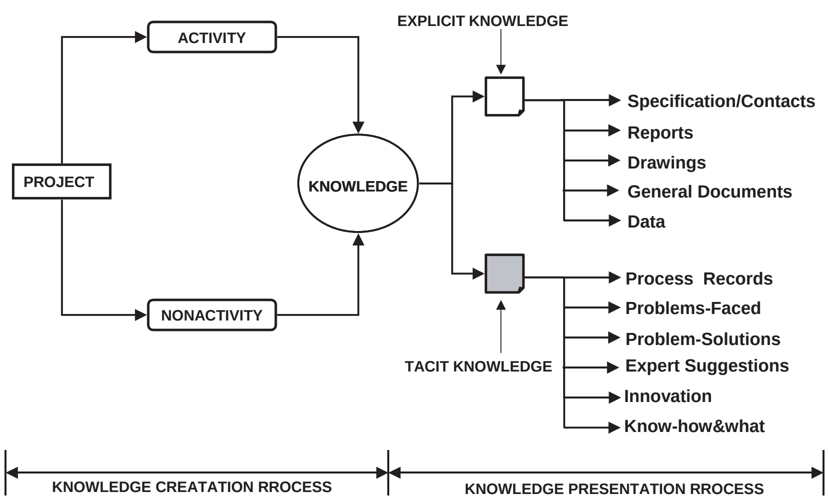
CONCEPTS OF ACTIVITY-BASED KNOWLEDGE MANAGEMENT

Similar to project scheduling management, knowledge management is based on the concept of undertaking activities of project planning and control. Figure 7 presents an overview and conceptual framework of activity-based knowledge management used in construction projects. Knowledge and information associated with activities in previous projects may be reused and applied in future projects. Information and domain knowledge from all projects are divided and saved as "activity" units in categories related to the projects for collection and management. The main advantage of activity-based knowledge management is the ease with which the information and knowledge can be understood and reapplied.

When knowledge is saved in project units, the knowledge includes both tacit and explicit knowledge. In terms of explicit knowledge, project-related information or knowledge usually include specification/contract, reports, drawing, change order, and data. Actually, each project does not contain one-to-one information or knowledge because some of them belong to activity-based information. In contrast, tacit knowledge may include process records, problems faced, problems solved, expert suggestions, know-how, innovation, and experience notes. The information and knowledge is better saved as activity-based units because the result makes it easier to be classified and searched by users. In addition, users may search and refer to related information and knowledge from related activities in past projects. The tacit and explicit knowledge of activity-based knowledge management is the same as the duration and relationship of activity-based project management.

The relationship of current and past activities is important for users to link related information and knowledge together. According to Figure 3, not only the information and knowledge of the current project can be applied, but also same or similar activities of past projects can be referred to as experiences are recorded. When experts or engineers enter related information and knowledge into the system, they need to add the relationships for the activities in the project. Of course, the system is designed to link same or similar activities together based on high similarity automatically or manually.

Figure 3. Activity-based knowledge management



Some of the information and knowledge belongs to the whole project without clear classification of project units. To let users access the information by the Web-based portal, the basic electronic information concerning the project (i.e., specifications, contracts, reports, and drawings) may be saved as explicit knowledge. In terms of tacit knowledge, advanced electronic information and knowledge for the project (i.e., meeting records and e-courses) are saved in the system. The information and knowledge will be saved under the catalogue of current projects. The benefit of non-active classification is the collection of related electronic information in the centralised system.

KNOWLEDGE BANK

To enrich the knowledge bank in the system, the system is designed to encourage all engineers and experts to submit their domain knowledge and valuable experience to the knowledge bank. Traditionally, companies included mostly numeric, structured data in their data warehouse. From this point of view, decision support systems are divided into two components: data warehouses deal with structured data; knowledge management involves unstructured data (Ponniah, 2002). It is a need to integrate both structured (such as data and text) and unstructured information (such as image, video, audio, image, and drawing) in the knowledge bank for further reference and decision making. The main purpose of a knowledge bank is to provide the rich source of content concerning all projects and gather project-related explicit information and tacit knowledge together for involved engineers and experts.

KNOWLEDGE MAP

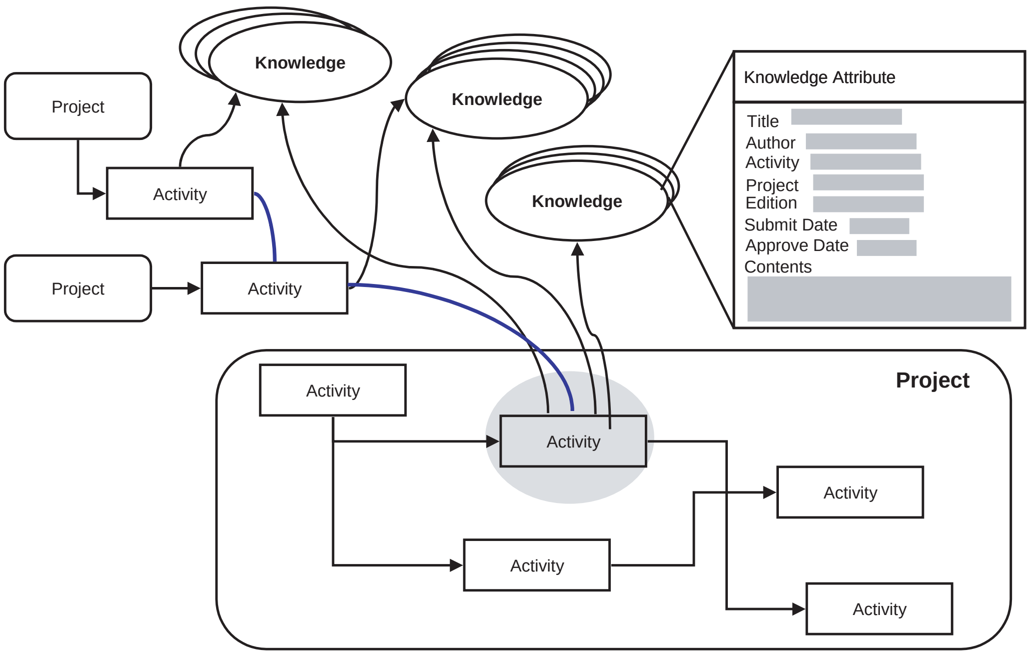
A knowledge map is used to categorise the content within a particular discipline area. A knowledge map (Wexler, 2001) is a consciously designed communication medium using graphical presentation of text, models, numbers, or symbols between makers and users. Knowledge mapping helps one understand the relationships between knowledge stores and dynamics. Davenport and Prusak (1998) note that developing a knowledge map involves locating important knowledge in the organisation and then publishing some sort of list or picture that shows where to find it. The knowledge map plays important roles in implementing knowledge management. All captured knowledge can be summarised and abstracted through the knowledge map. The knowledge map also gives a useful blueprint for implementing a knowledge management system.

The knowledge map in the system mainly deals with the assistance to find the needed knowledge easily and effectively. Furthermore, applying a knowledge mapping technique has the following two advantages. First, the knowledge map is represented in a simple, clear, visual presentation in the knowledge management system. Second, the mapping methodology helps users to identify key critical and available knowledge areas to the project.

A knowledge map can be defined as a diagrammatic and graphic presentation of knowledge linking the relationships between knowledge and knowledge attribute. As shown in Figure 4, a knowledge map consists of two components:

1. Knowledge diagram: Graphical representation of knowledge, having node, sub-node, and linkage:
   - Node: Rectangular object (denoting project or activity representation)
   - Sub-node: Ellipse object (denoting captured knowledge)
   - Linkage: Arrow between nodes implying relationships among knowledge
2. Knowledge attribute: Descriptive representation of knowledge feature

Figure 4. A concept map of the activity-based knowledge management



A knowledge map approach is employed in this chapter to represent explicit and tacit knowledge location within a construction project. A knowledge map in the system provides users with a robust foundation to capture, share, and use project-related or activity-related knowledge. Advantages gained from building the knowledge map in the system can be summarised as follows:

- efficient capture of knowledge;
- understanding of relationships between knowledge; and
- formalisation of all knowledge inventories within a construction project.

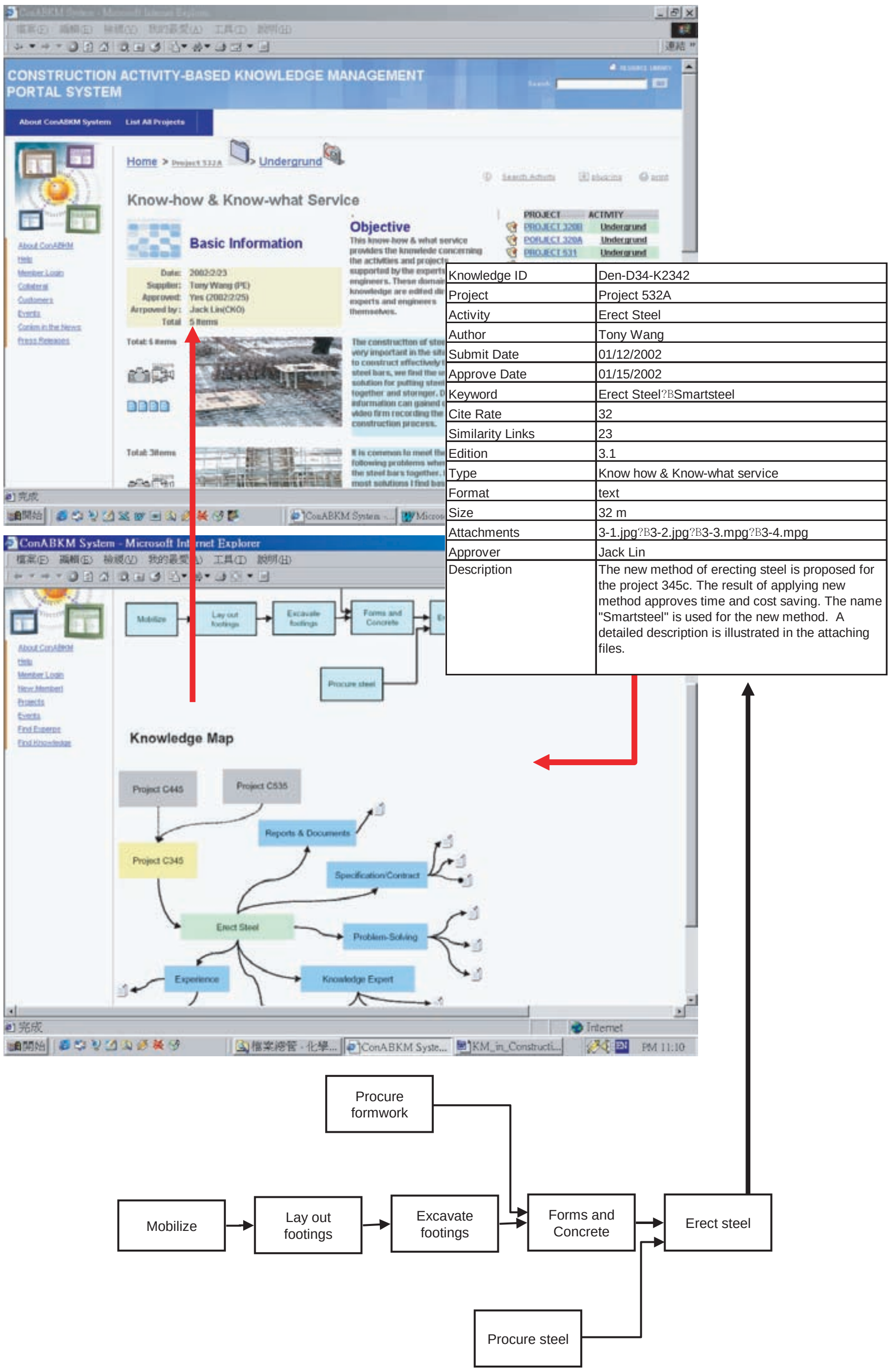
PROCEDURES FOR BUILDING THE KNOWLEDGE MAP

According to the knowledge management framework, procedures are proposed for building the knowledge map using the ABKM system. The procedure consists of the following five phases: knowledge determination phase, knowledge extraction phase, knowledge attribute phase, knowledge linking phase, and knowledge validation phase.

Knowledge Determination Phase

The purpose of this phase is to provide a uniform, text-based intermediate representation of the knowledge types specific to construction projects. This phase covers defining knowledge and baseline taxonomy within a project. The scope of the knowledge map decides whether the knowledge map is constructed throughout a specific project. After deciding the scope, we determine the detail level of knowledge analysis. It is necessary and important to determine the proper level of detail to meet project-based knowledge demand effectively. When analysing the source of knowledge within a project, activity is suggested as a unit to analyse the construction project knowledge. We analyse related knowledge based on an activity-unit of the construction project. In other words, we consider which experience and know-how should and can be captured according to the activity of the selected

Figure 5. An example of a knowledge attribute of a activity unit with the help of a knowledge map



Knowledge ID	Den-D34-K2342
Project	Project 532A
Activity	Erect Steel
Author	Tony Wang
Submit Date	01/12/2002
Approve Date	01/15/2002
Keyword	Erect Steel?BSmartsteel
Cite Rate	32
Similarity Links	23
Edition	3.1
Type	Know how & Know-what service
Format	text
Size	32 m
Attachments	3-1.jpg?B3-2.jpg?B3-3.mpg?B3-4.mpg
Approver	Jack Lin
Description	The new method of erecting steel is proposed for the project 345c. The result of applying new method approves time and cost saving. The name "Smartsteel" is used for the new method. A detailed description is illustrated in the attaching files.

project. After the analysis process of this phase, the types of tacit and explicit knowledge specific to the activity will be considered. Furthermore, all capturing and documenting knowledge with regards to the activity are saved in this activity category.

Knowledge Extraction Phase

Knowledge is extracted through the project execution. There are two types of knowledge extracted from the projects. They are tacit knowledge and explicit knowledge. Tacit knowledge and explicit knowledge may exist in any project. After identifying knowledge through those activities of the project, we decide which knowledge needs to be extracted from the activities of the projects. Suggested knowledge extraction techniques include interviewing with experts, making system analysis, and digital process record.

Knowledge Attribute Phase

Knowledge attributes illustrate the basic description of extracted knowledge and derive relationships with project and similarity activity (see Figure 4). The main purpose of knowledge attribute is to provide the relationship and available knowledge information for knowledge workers and general users. Knowledge attributes include the keywords, description, project name, activity name, contributor, and attached files. Figure 5 illustrates an example using the knowledge attribute with the help of a knowledge map.

Knowledge Linking Phase

The knowledge link is identified after completing the knowledge attribute. The knowledge link is first indicated when the tacit or explicit knowledge is available and documented, and is later confirmed. Three types of knowledge linking are proposed in the chapter. One is activity link activity based on high similarity. Second is activity link knowledge based on the relationship between activity and knowledge. The third is knowledge link knowledge based on high knowledge similarity. When the contributor creates a new link, the link needs to be examined and confirmed before the knowledge map is published.

Knowledge Validation Phase

All knowledge maps need to be validated before a map is published. All the validation processes must be communicated with domain experts, knowledge workers, and knowledge map producers in the enterprise knowledge management division.

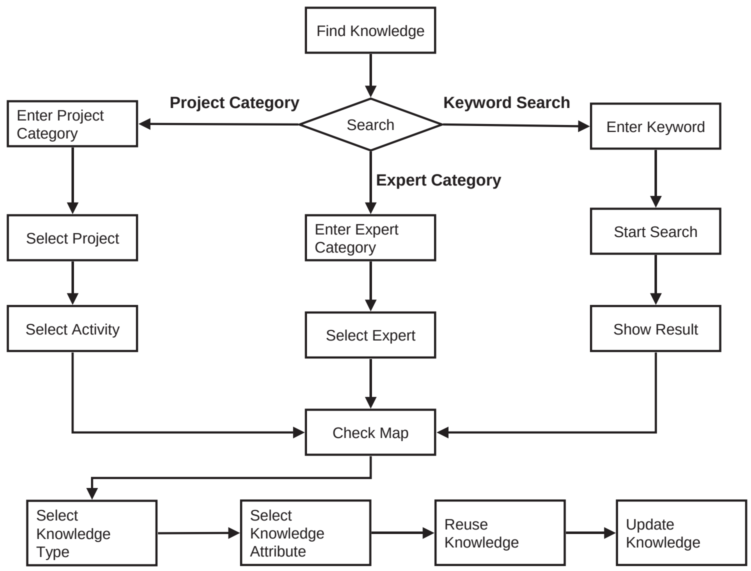
THE SYSTEM

This section describes in detail the ABKM system. There are three search functions supported in the system. They are project category search, keyword search, and expert category search. With the function of keyword search and project category, users can find the knowledge they need directly form the activities of selected projects. Also, the system provides another service for users to find the related knowledge of the domain experts. The information of each domain expert is provided to the people who want to find the domain knowledge-related experts (Figure 6).

Figure 7 illustrates the system architecture. The server of the ABKM system supports four distinct layers— interface, access, application, and database layers; each has its own responsibilities.

The interface layer defines administrative and end-user interfaces. Users can access information through Web browsers such as Microsoft Internet Explorer or Netscape Navigator. Administrators can control and manage information via the Web browser or using a separate server interface. The access layer provides system security and restricted access, firewall services, and system administration functions. The application layer

Figure 6. Knowledge searching process



defines various applications for collecting and managing information. These applications offer indexing, full text search, collaborative work, and document management functions. The database layer consists of a primary SQL Server 2000 database and a backup database (also based on SQL Server 2000).

All project information and knowledge in the ABKM system is centralised in a system database. Project participants may have access to all or some of these documents through the Internet, as determined by their levels of access authorisation. Any information/knowledge about the project can be obtained from and deposited into the system database only through a secure interface. The Web and database servers are distributed on different computers, between which a firewall can be built to protect the system database against intrusion.

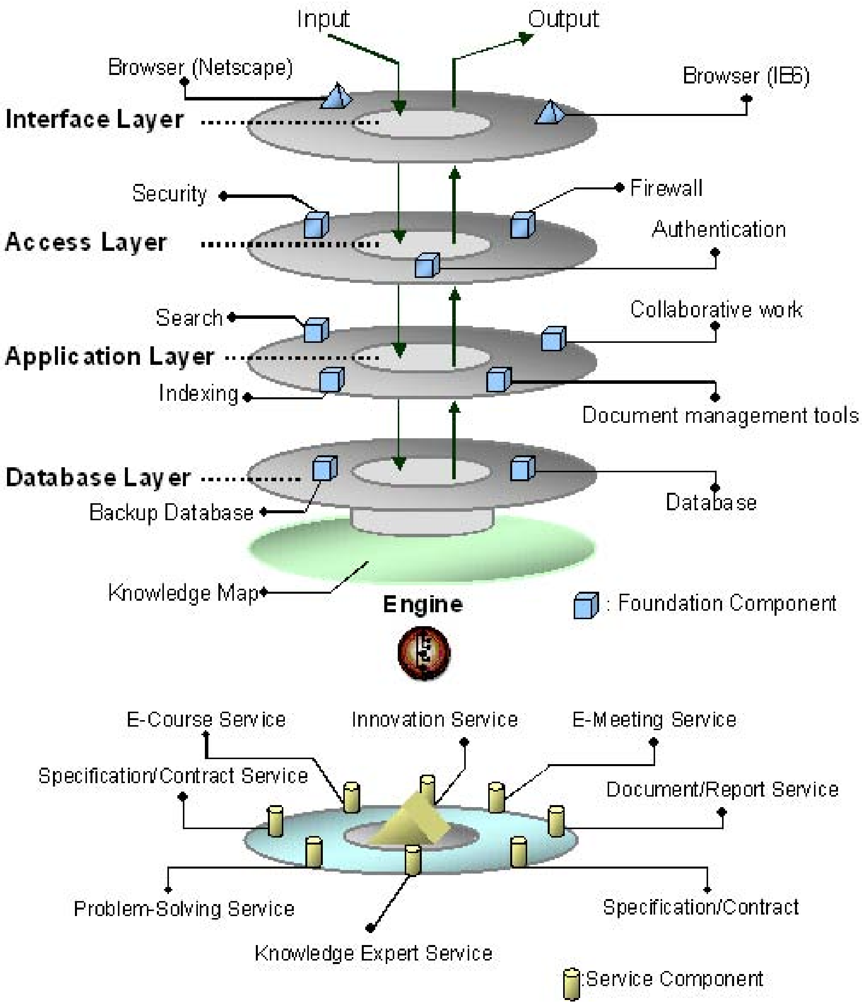
The ABKM portal services described in this study are made available to all participants of the corporation through a specially designed portal, which also serves as a messaging (mail) server for the company (organisation). The portal is a key element of the proposed system and consists of three content areas - public, member, and knowledge manager areas. The public area is open to anyone who is interested in the project. The project member and knowledge manager are accessible only by members with passwords.

Anyone can access information in the public area, so project managers can reasonably use this space for public relations, for example, by posting project descriptions, news, and announcements.

In the project member area, project members can use ABKM services, such as messaging, accessing data, and accessing files. Only project members can access information and knowledge concerning the projects.

Only knowledge managers can log into the manager area, where they can access all information in the project server. Knowledge managers have the right to use the administration service to: (1) post and edit news and announcements, and (2) add new user accounts.

Figure 7. System architecture



All project-related information and knowledge in the ABKM system are classified and stored in the system database. Different kinds of project information/knowledge are stored in different tables in the system database. The ABKM system backs up all databases in the system to ensure the reliability of data storage. The backup database is in another building to protect it against disasters such as earthquakes or fire. All functions are briefly outlined in Table 1, and Figure 8 illustrates some applications of knowledge sharing in the ABKM system.

CASE STUDY

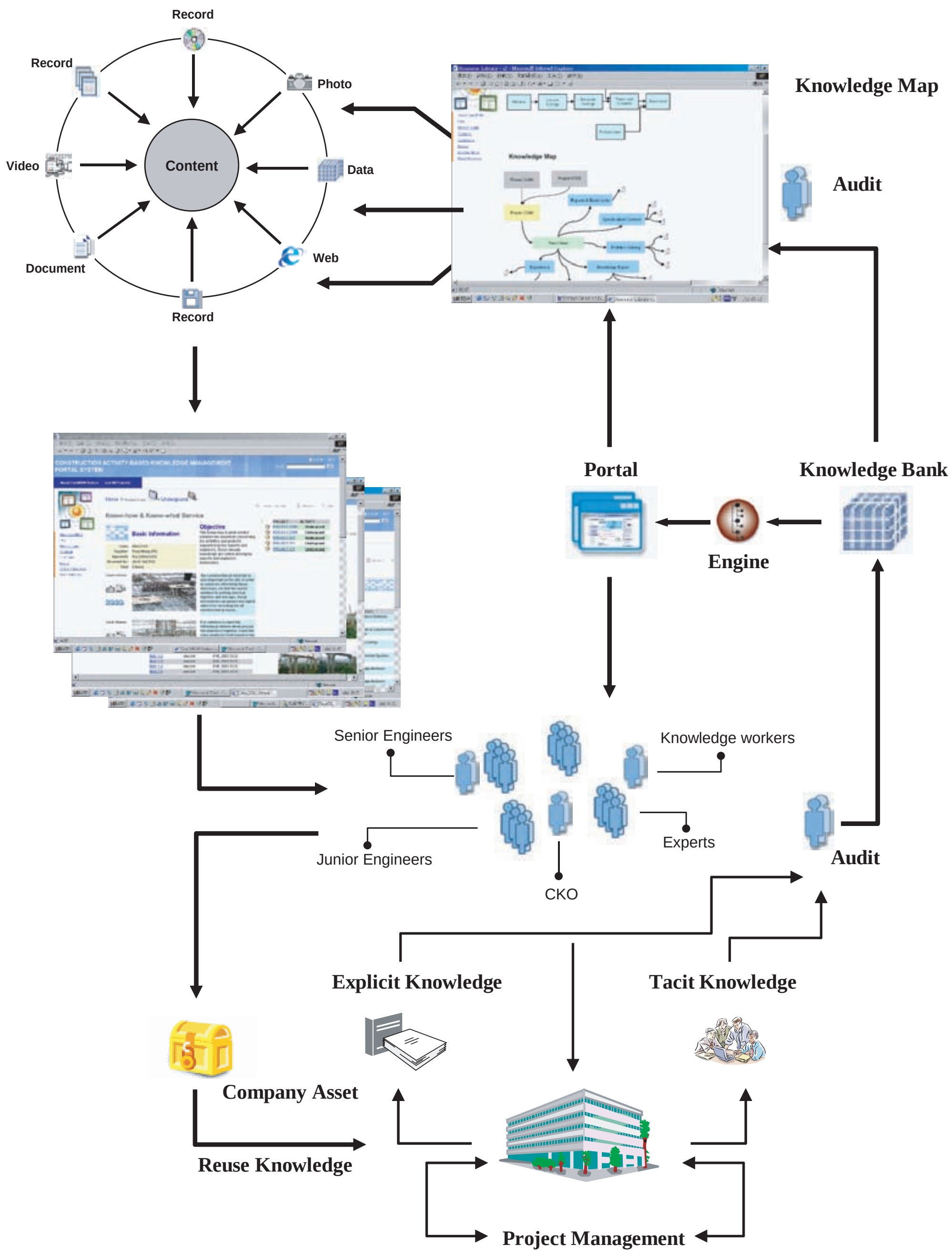
In the following case, the general contractor won the bid of a precast project, to construct a high-tech office building within seven months in Taipei. However, the contractor has no experience of precast construction, and the contractor estimates that the construction period might need to extend to nine months at least to complete the project. Therefore, the contractor decided to hire two construction specialists, particularly in precast

Table 1. The descriptions of function provided by ABKM services

Category	*Function description*
Specification\Contract Managers	Each project's specifications and contracts are stored in the active and non-active categories of a project category. One of the best benefits of this is it is easy to find all specifications and contracts for all projects without wasting time and mass storage space. Paper-based specifications and contracts from past projects need to be scanned by knowledge workers into electronic format (PDF files) then subsequently saved into the system database. All specifications and contracts of past and current projects can be found and downloaded in PDF format from the ABKM system.
Document/Report Managers	All project-related documents and reports are centralized in the server of the ABKM system. The main purpose of these services is to be the e-information center for the company. All users who need to find project-related information or documents can just access the system and get what they need. Therefore, project-related documents must be transferred to electronic format so they can be preserved in the system and be accessible. These documents and reports will be saved under the categories of active and non-active for related-project categories. In the ABKM system, documents and reports files must be uploaded in PDF format, the standard file format. It is convenient for users to reuse these documents and reports without the problems of different software versions or file format.
Video/Photo Managers	In order to reduce the cost of training for problem-solving, it is necessary to record videos and photos by the on-site engineers during the construction phase of a project. With the use of digital cameras and camcorders, all operational processes and problem-solving of a project can be recorded and preserved as company knowledge asset. For future related-projects, digital records can be reused and shared for experts and managers to reduce the time to solve problems.
E-Courses Services	The purpose of e-course services is to provide e-learning to all participants in the construction phase of a project. Without time and location limitations, it is helpful to provide e-courses for needed people via the internet or intranet. Especially for junior engineers, it is convenient for them to learn and understand how a project operates in the construction phase.
E-Meeting Services	The purpose of e-meeting services is to record all project-related meetings and discussions. All meetings or discussions are recorded and saved as digital files in the ABKM server. Also, video conferencing is one of the e-meeting services. The contents of meetings or discussions can be recorded and preserved in the ABKM system.
Expert Yellow Page Services	Experts Yellow Page is a service that assists with finding related experts in the enterprise. It is just like a yellow page. All related-area experts will be mapped in the system based on their specific and professional trade. Users can access this service to find and contact the experts they need in a project.
Problem-solving Services	During the construction phase of a project, lots of problems may occur in the construction phase. Some problems may be solved or improved by engineers or experts, and some are unsolved. To avoid making similar mistakes in other projects, the valued experience and know-how can be saved using problem-solving services. During or before the same problems happen, engineers may find existing solutions concerning the problem.
Collaboration Services	During the construction phase of a project, collaboration services allow experts and engineers to perform tasks and work on projects together by the collaborative communication platform. The communications support video conferencing, voice, multimedia, and conversations.
Knowledge Communities	Knowledge communities provides the platform to let experts and engineers to discuss the project-related topic and share their idea and concept with others or participants. The benefit of knowledge communities in the system is to store the all unstructured project-related information.
Message Services	The message manager is a web-based project-oriented mail system that allows project participants to receive notice mail when the knowledge bank is updated.

construction, to assist the senior engineers in order to finish the project on time as required. For the future, precast projects could process more easily; the company decided to take a good advantage of knowledge management to pass on the valuable know-how to the engineers and manage it well to keep the knowledge inside the company. In the following case study, the contractor applied

Figure 8. The application of knowledge sharing in the ABKM system



and practiced knowledge management by using the knowledge management concept and map. In addition, Table 2 presents the details of various stages for construction knowledge management implementations.

Table 2. Scenario description for using ABKM system

Step		Phase	Scenario
Knowledge Acquisition	1	Collect Information	Senior engineer collects all activities-related documents/information/data
	2	Digital Information	Senior engineer transfers paper-based information/documents into the digital information/data set
	3	Edit Information	Senior engineer edits the description and comment/note for digital document/information
	4	Package Information	Senior engineer packages the description and comment/note with attaching related files that can illustrate the explanation or example
	5	Submit Information	Senior engineer submmits package that includes the description and comment/note with attaching related files for approving
Knowledge Extraction	6	Record Operation & Event	Senior engineer or a knowledge worker records digital related process information for the operation of successful and failure events
	7	Edit Knowledge	Senior engineer or a knowledge worker edits the description and note/comment for the records of video and photo
	8	Manage Knowledge	Knowledge workers collect and manage the coordinated information (includes grouping the meeting records and knowledge communities)
	9	Package Knowledge	Senior engineer or a knowledge worker packages the description and comment/note with attaching related files
	10	Submit Knowledge	Senior engineer or a knowledge worker submmits the package that includes the description and comment/note with attaching related files
Knowledge Storage	11	Approve Knowledge	knowledge worker audits; knowledge worker/expert checks and approves the submission of knowledge package before the classification and storage
	12	Classify Knowledge	Knowledge worker attributes knowledge and classifies this knowledge by placing it in an appropriate position (the activities of project map) in the system.
	13	Store Knowledge	Knowledge worker stores knowledge package into knowledge bank based on the classification.
	14	Backup Knowledge	Knowledge Package is automatically backuped from the knowledge bank to another database for the safety purposes.
	15	Publish Knowledge	Knowledge package is published after knowledge map is validated and announced for the re-use and application
Knowledge Sharing	16	Search Knowledge	Junior engineer found past related knowledge/experience by using knowledge map and keywords or domain expert search
	17	Refer Knowledge	Junior engineer refers and studies past existing knowledge/experience that is stored in the activities of knowledge map
	18	Modify Knowledge	Junior engineer modifies the original knowledge package based on new projects or others existing projects
	19	Apply Knowledge	Junior engineer applies the modified existing knowledge package in other existing projects or future projects
	20	Collect Feedback	Junior engineer collects feedback from the applied-original or modified knowledge package
Knowledge Update	21	Collect Information	Junior engineer collects all paper-based and electronic format of document/information/data
	22	Renote Knowledge	Junior engineer edits the digital document/information by adding detail description and comment/note
	23	Repackage Knowledge	Junior engineer packages the description and comment/note with attaching related files that can illustrate the explanation or example
	24	Approve Knowledge	Knowledge package would be approved to be processed under an accurate procedure before saving in the knowledge bank
	25	Republish Knowledge	Knowledge package is republished in the knowledge map and announced for the reuse or application, based on the original knowledge

Knowledge Acquisition Phase (Step 1-Step 5)

A senior engineer collects related information/ documentation and coverts it into digital format. After the related information and documentation have been digitised, the senior engineer writes descriptions/notes concerning that digital information and packages them as a knowledge set for submission.

Knowledge Extraction Phase (Step 6-Step 10)

A senior engineer and a knowledge worker record all the operating procedures by taking digital video and photographs. The senior engineer discussed progress with two experts every two days to accelerate the solving of the problem in question. All discussions were recorded and summarised as suggested by experts. Discussions with experts continued for five months, until the problem was solved. The senior engineer recorded and summarised his experience and domain knowledge in the system to enable the problem's solution to be reused in other and future projects. The domain knowledge included the problem description (including documents, photographs, drawings, and specifications), the problem's solution (including related documents, photographs, and video of processes), and expert suggestions (such as notes, discussions, and meeting records). Knowledge was extracted according to each process defined as related to the activity of a project. Domain knowledge and experience was organised according to the attribute of the activity concerned. Most senior engineers are required to provide their own knowledge concerning the tasks for which they are responsible.

Knowledge Storage Phase (Step 11-Step 15)

When the submitted knowledge set is approved, a knowledge worker attributes knowledge and classifies this knowledge by placing it in an appropriate position (the activities of project map) in the system. In other words, users can find and read related domain knowledge directly, just by clicking these activities of the project (see Figure 5). All knowledge maps need to be validated to perform well before the map is published. All the validations must be conducted with domain experts, knowledge workers, and knowledge map producers in the enterprise knowledge implantation term. Finally, the knowledge set is automatically backed up from the knowledge bank to another database. After approving and storing knowledge, the system sends a message regarding the updating of the knowledge to the appropriate users automatically.

Knowledge Sharing Phase (Step 16-Step 20)

In a new project that began just after the precast building was constructed three month ago, a junior engineer with no prior experience meets a similar problem and tries to locate past knowledge/information to help him solve the problem. The junior engineer uses the keyword search to find the expert who has domain knowledge concerning the precast building. The junior engineer finds the experts and retrieves, refers to, and studies the knowledge set (including digital video and documentation) supported by these senior engineers. He starts to apply and reuse the knowledge in his own project. Also, the junior engineer gives some feedback and offers knowledge that can be reused when others face new problems. Additionally, some senior engineers in other projects reuse the same knowledge to solve the same problem at reduced cost.

Knowledge Update Phase (Step 21-Step 25)

After applying knowledge and information to the other similar projects, the junior engineer solves his problem and finds a new solution in collaboration with some senior engineers. Finally, the junior engineer notes and submits the new suggestion and experience to the project map, associated with the original knowledge. Furthermore, the knowledge is updated later because of further feedback, and another solution is provided regarding the same problem. After the approval process has been completed, the updated knowledge set is republished in the activities of the project map, and a notice message will be sent to the authorised members.

CONCLUSION

Web technologies and knowledge management concepts can be effectively used during the construction phase of a project, to enable knowledge to be captured and reused in similar projects in the future. This study presents the application of knowledge management in the construction phase of construction projects by using a Web-based portal. The concept of activity-based knowledge management (ABKM) is presented, and a system for use as a knowledge-sharing platform in construction projects is presented. The construction activity-based knowledge management system maps valuable information and knowledge into activity units during the construction phase of a project. The ABKM system is advanced, at least in the following respect: The ABKM system provides insight into the factors that have an impact on construction management activities, and so helps engineers to share knowledge and improve the results of the entire construction project. Junior engineers can interact with the computer to gain domain knowledge, and thus prepare for and participate in a construction project. Briefly, the ABKM system can assist engineers by providing structured and unstructured information to support reference to, and the reuse of, explicit and tacit knowledge. The integration of knowledge management and Web-based technologies appears to be a promising means of improving construction operation and management, especially in the construction phases of projects.

The content of the knowledge bank in the system not only provides specific problem-solutions, but also includes all domain knowledge and experiences gained on projects. Although effort is required to update the explicit/tacit knowledge, the developed system will support construction management by: (1) providing an effective and efficient computerised environment to support knowledge management tasks, and (2) facilitating the implementation of a Web-based knowledge management system pertinent to these activities in the projects.

The demonstration of the system in a case study of the new precast office building located in Taipei indicates that the ABKM system effectively promotes the sharing and reuse of knowledge for new construction projects. The case study also highlighted the need for improving knowledge management and exchange platforms. However, the received feedbacks based on the use of the system are as follows: (1) the content of knowledge bank in the system is not enough to support and provide the junior engineers to get past experience and knowledge in the beginning; (2) most of senior engineers and experts have a low willingness to share their knowledge and experience without the proper reword policy and strategy; (3) it takes time and is very inconvenient for senior engineers to edit and record the knowledge without any assistance form knowledge workers, and (4) most senior engineers agree the ABKM system is a useful platform for them to edit and manage their knowledge and experience.

The knowledge map in the system mainly deals with the assistance to find the needed knowledge easily and effectively. The primary purposes of using a knowledge map in the system are as follows: The knowledge map (1) is represented in a clear and visual way to identify key knowledge areas that are most strategic and critical to the project, and (2) deals with the assistance for users to find the needed knowledge easily and effectively.

The major contributions of the study are as follows: (1) elucidating the content and procedure of knowledge management in construction projects; (2) proposing procedures for building knowledge maps for construction projects, and (3) developing a construction knowledge management system specific for managing construction projects with reference to activities by using a knowledge map.

PRACTICAL TIPS AND LESSONS LEARNED

- Knowledge management is necessary in any life cycle phase of construction projects.
- The content and method of knowledge management in a construction project will be different in each life cycle phase.
- Without the Internet, it is impossible to run knowledge management successfully for construction projects.
- A knowledge map is one of best ways to illustrate whether the knowledge is available and where the knowledge is located in construction projects.
- The way and method of application in construction knowledge management will differ from the size and culture of various construction corporations.

REFERENCES

Bergmann, R. (2002). *Experience management: Foundations, development methodology, and Internet-based applications.* Germany: Springer-Verlag.

Carneiro, A. (2001). The role of intelligent resources in knowledge management. *Journal of Knowledge Management, 5*(4), 358-367.

Clough, R.H., Sears, C.A., & Sears, S.K. (2000). *Construction project management* (4th edition). New York: John Wiley & Sons.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge.* Boston, MA: Harvard Business School Press.

Edum-Fotwe, F.T., & McCaffer, R. (2000). Developing project management competency: Perspectives from the construction industry. *International Journal of Project Management, 18,* 111-124.

Hart, A. (1992). *Knowledge acquisition for expert systems* (2nd ed.). New York: McGraw-Hill.

Kamara, J.M., Augenbroe, G., Anumba, C.J., & Carrillo, P.M. (2002). Knowledge management in the architecture, engineering and construction industry. *Construction Innovation, 2,* 53-67.

Malhotra, Y. (2000). *Knowledge management and virtual organizations.* Hershey, PA: Idea Group Publishing.

Malhotra, Y. (2001). *Knowledge management and business model innovation.* Hershey, PA: Idea Group Publishing.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford: Oxford University Press.

Ponniah, P. (2002). *Data warehousing fundamentals: A comprehensive guide for IT professionals.* New York: John Wiley & Sons.

Tiwana, A. (2000). *The knowledge management toolkit—Practical techniques for building a knowledge management system.* Englewood Cliffs, NJ: Prentice-Hall.

Wexler, M.N. (2001). The who, what, and why of knowledge mapping. *Journal of Knowledge Management, 5*(3), 249-263.

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Chapter 2.21
A Model of Knowledge Management Success

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ABSTRACT

This article describes a knowledge management (KM) success model that is derived from observations generated through a longitudinal study of KM in an engineering organization and KM success factors found in the literature, which were modified by the application of these observations and success factors in various projects. The DeLone and McLean (1992, 2003) IS Success Model was used as a framework for the model, since it was found to fit the observed success criteria and provided an accepted theoretical basis for the proposed model.

INTRODUCTION

Knowledge management (KM) and knowledge management system (KMS) success is an issue that needs to be explored. The Knowledge Management Foundations workshop held at the Hawaii International Conference on System Sciences in January 2006 discussed this issue and reached agreement that it is important for the credibility of the KM discipline that we be able to define KM success. Also, Turban and Aronson (2001) list three reasons for measuring the success of KM and KMS:

- To provide a basis for company valuation
- To stimulate management to focus on what is important
- To justify investments in KM activities.

All are good reasons from an organizational perspective. Additionally, from the perspective of KM academics and practitioners, identifying the factors, constructs, and variables that define KM success is crucial to understanding how these initiatives and systems should be designed and implemented. It is the purpose of this article to present a model that specifies and describes the antecedents of KM and KMS success so that researchers and practitioners can predict if a specific KM and KMS initiative will be successful. The article assumes that KM and KMS success cannot be separated, which is based on a broad, Churchman view of what constitutes KMS and a definition of success that is not reliant solely on technical effectiveness. The other basic assumption for this article is that success and effectiveness, as used in the KM literature, are synonymous terms. The remainder of the article uses the term KM to refer to KM and KMS and the term success to refer to success and effectiveness. The reasoning for these assumptions is discussed later in the article.

The proposed KM Success Model is an explication of the widely accepted DeLone and McLean (1992, 2003) IS Success Model, which was used since it was able to be modified to fit the observations and data collected in a longitudinal study of Organizational Memory, OM, and KM. It fit success factors found in the KM literature, and the resulting KM Success Model was useful in predicting success when applied to the design and implementation of a KM initiative and/or a KMS. Additionally, the stated purpose of the DeLone and McLean (1992, 2003) IS Success Model is to be a generalized framework that describes success dimensions for which researchers can adapt and define specific contexts of success (DeLone & McLean, 2003). Before presenting the KM Success Model, we will discuss the concepts of knowledge, KM, KMS, and KM/KMS success. We then will discuss briefly the DeLone and McLean (1992, 2003) IS Success Model, present the KM Success Model, and discuss the differences. We will conclude by summarizing studies that support the KM Success Model and will present operationalizations that can be used to evaluate the constructs used to define the KM Success Model dimensions.

KNOWLEDGE, OM, AND KM

Alavi and Leidner (2001) summarize and extend the significant literature relating to knowledge, knowledge management, and knowledge management systems. They view organizational knowledge and OM as synonymous labels, as do Jennex and Olfman (2002). This is useful, as it allows for the combination of research results from OM and KM. It is also born out in the literature. Huber, Davenport, and King (1998) summarize OM as the set of repositories of information and knowledge that the organization has acquired and retains. Stein and Zwass (1995) define OM as the means by which knowledge from the past is brought to bear on present activities, resulting in higher or lower levels of organizational effectiveness, and Walsh and Ungson (1991) define OM as stored information from an organization's history that can be brought to bear on present decisions.

Davenport and Prusak (1998) define knowledge as an evolving mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. Knowledge often becomes embedded in documents or repositories and in organizational routines, processes, practices, and norms. Knowledge is also about meaning in the sense that it is context-specific (Huber et al., 1998). Jennex (2006) extends the concepts of context also to include associated culture that provides frameworks for understanding and using knowledge. Ultimately, we conclude that knowledge contains information, but information is not necessarily knowledge. Also, we conclude that OM contains knowledge. However, for the sake of simplicity, we will use the term knowledge to refer to OM and knowledge throughout this article.

Various knowledge taxonomies exist. Alavi and Leidner (2001) and Jennex and Croasdell (2005) found that the most commonly used taxonomy is Polanyi's (1962, 1967) and Nonaka's (1994) dimensions of tacit and explicit knowledge. This article uses this taxonomy for knowledge. Tacit knowledge is that which is understood within a knower's mind. It consists of cognitive and technical components. Cognitive components are the mental models used by the knower, which cannot be expressed directly by data or knowledge representations. Technical components are concrete concepts that can be expressed readily. Explicit knowledge also consists of these technical components that can be directly expressed by knowledge representations. KM in an organization occurs when members of an organization pass tacit and explicit knowledge to each other. Information Technology (IT) assists KM by providing knowledge repositories and methods for capturing and retrieving knowledge. The extent of the dimension of the knowledge being captured limits the effectiveness of IT in assisting KM. IT works best with knowledge that is primarily in the explicit dimension. Knowledge that is primarily in the tacit dimension requires that more context be captured with the knowledge where context is the information used to explain what the knowledge means and how it is used. Managing tacit knowledge is more difficult to support using IT solutions.

Jennex (2005) looked at what KM is and found no consensus definition. However, using the review board of the International Journal of Knowledge Management as an expert panel and soliciting definitions of KM that were used by the board members, the following working definition is used to define KM for this article:

KM is the practice of selectively applying knowledge from previous experiences of decision making to current and future decision making activities with the express purpose of improving the organization's effectiveness. (Jennex, 2005, p. iv)

KM is an action discipline; knowledge needs to be used and applied in order for KM to have an impact. We also need measurable impacts from knowledge reuse in order for KM to be successful. Decision making is something that can be measured and judged. Organizations can tell if they are making the same decisions over and over and if they are using past knowledge to make these decisions better and more quickly. Also, decision making is the ultimate application of knowledge. This working definition provides this direction for KM and leads to a description of success for KM as being able to provide the appropriate knowledge for decision making when it is needed to those who need it.

KNOWLEDGE MANAGEMENT SYSTEMS

Alavi and Leidner (2001) defined KMS as "IT (Information Technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application" (p. 114). They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for the KMS by calling it an ICT (Information and Communication Technology) system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application. Stein and Zwass (1995) define an Organizational Memory Information System (OMS) as the processes and IT components as necessary to capture, store, and apply knowledge created in the past on decisions currently being made. Jennex and Olfman (2002) expanded this definition by incorporating the OMS into the KMS and by adding strategy and service components to the KMS. We expand the boundaries of a KMS by taking a Churchman view of a system. Churchman (1979) defines a system as “a set of parts coordinated to accomplish a set of goals” (p. 29) and that there are five basic considerations for determining the meaning of a system:

- System objectives, including performance measures
- System environment
- System resources
- System components, their activities, goals, and measures of performance
- System management

Churchman (1979) also noted that systems are always part of a larger system and that the environment surrounding the system is outside the system’s control but influences how the system performs. The final view of a KMS is as a system that includes IT/ICT components, repositories, users, processes that use and/or generate knowledge, knowledge, knowledge use culture, and the KM initiative with its associated goals and measures. This final definition is important, as it makes the KMS an embodiment of the KM initiative and makes it possible to associate KM success with KMS success.

KM SUCCESS

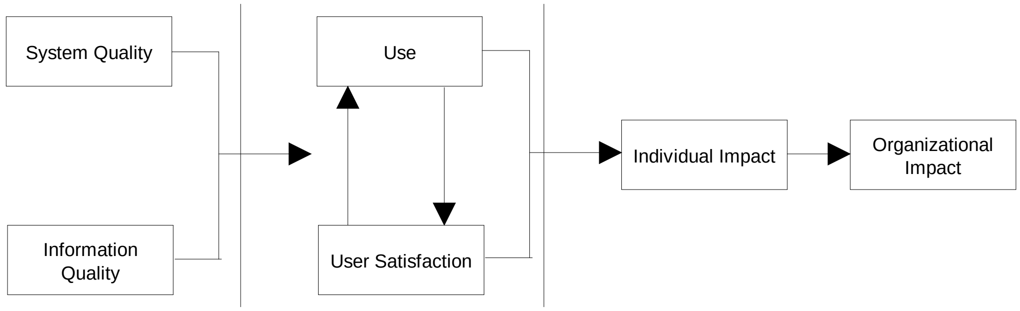
The previous paragraphs define KM success as reusing knowledge to improve organizational effectiveness by providing the appropriate knowledge to those that need it when it is needed. KM is expected to have a positive impact on the organization that improves organizational effectiveness. DeLone and McLean (1992, 2003) use the terms success and effectiveness interchangeably. This article uses KM success and KM effectiveness interchangeably by implying that increasing decision-making effectiveness has a positive impact on the organization, resulting in successful KM. KM and KMS success also is used interchangeably. KMS success can be defined as making KMS components more effective by improving search speed, accuracy, and so forth. For example, a KMS that enhances search and retrieval functions enhances decision-making effectiveness by improving the ability of the decision maker to find and retrieve appropriate knowledge in a more timely manner. The implication is that by increasing KMS effectiveness, KMS success is enhanced, and decision-making capability is enhanced, which leads to positive impacts on the organization. This is how KM success is defined, and it is concluded that enhancing KMS effectiveness makes the KMS more successful as well as being a reflection of KM success.

DELONE AND MCLEAN IS SUCCESS MODEL

In 1992 DeLone and McLean published their seminal work that proposed a taxonomy and an interactive model for conceptualizing and operationalizing IS success (DeLone & McLean, 1992). The DeLone and McLean (D&M) (1992) IS Success Model is based on a review and integration of 180 research studies that used some form of system success as a dependent variable. The model identifies six interrelated dimensions of success, as shown in Figure 1. Each dimension can have measures for determining their impact on success and on each other. Jennex, Olfman, Pituma, and Yong-Tae (1998) adopted the generic framework of the D&M IS Success Model and customized the dimensions to reflect the System Quality and Use constructs needed for an organizational memory information system (OMS). Jennex and Olfman (2002) expanded this OMS Success Model to include constructs for Information Quality.

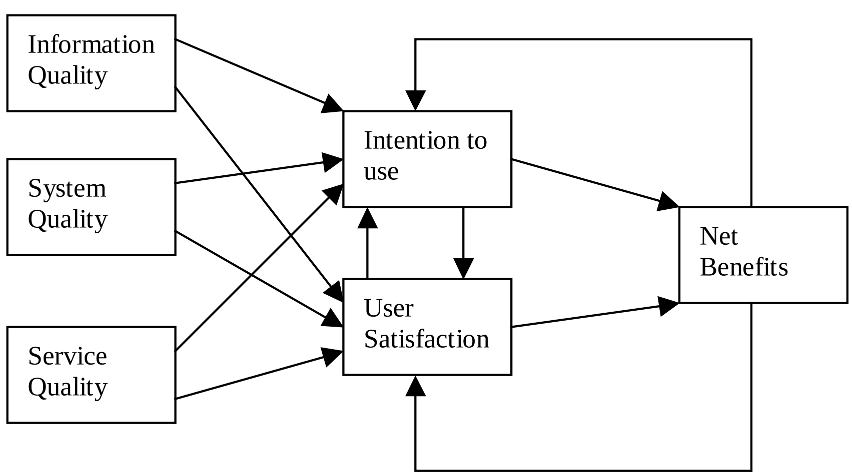
DeLone and McLean (2003) revisited the D&M IS Success Model by incorporating subsequent IS success research and by addressing criticisms of the original model. One hundred forty-four articles from refereed journals and 15 papers from the International Conference on Information

Figure 1. DeLone and McLean's (1992) IS success model



Systems (ICIS) that cited the D&M IS Success Model were reviewed, with 14 of these articles reporting on studies that attempted to empirically investigate the model. The result of the article is the modified D&M IS Success Model shown in Figure 2. Major changes include the additions of a Service Quality dimension for the service provided by the IS group, the modification of the Use dimension into a Intent to Use dimension, the combination of the Individual and Organizational Impact dimensions into an overall Net Benefits dimension, and the addition of a feedback loop from Net Benefits to Intent to Use and User Satisfaction. This article modifies the Jennex and Olfman (2002) OMS Success Model into a KM Success Model by applying KM research and the modified D&M IS Success Model.

Figure 2. DeLone and McLean's (2003) revisited IS success model



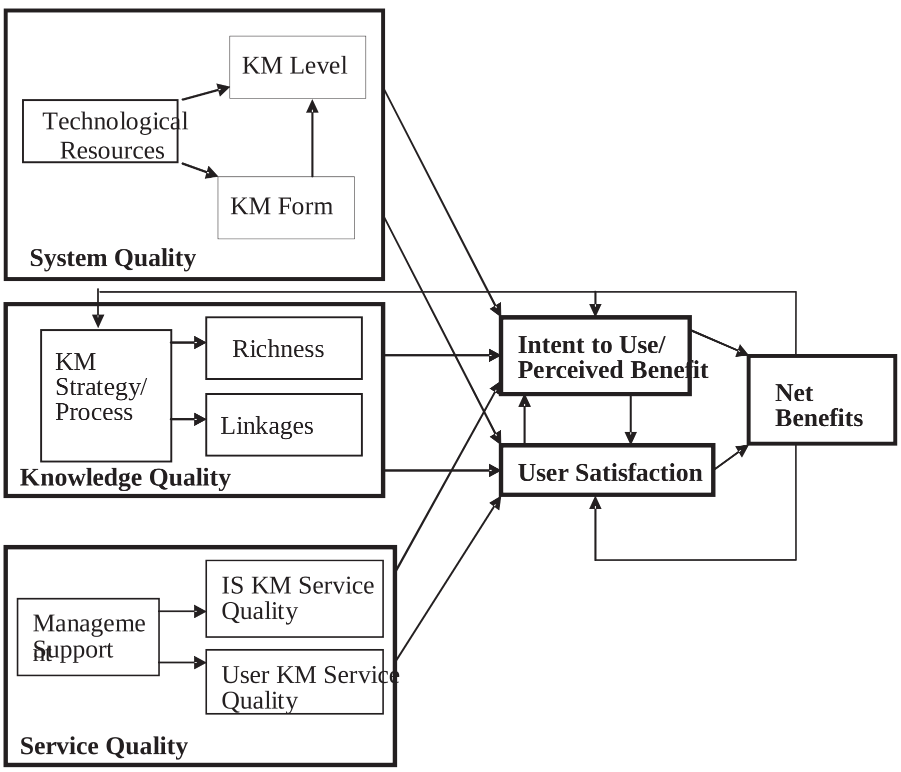
KM SUCCESS MODEL

The model developed in this article was initially proposed by Jennex, et al. (1998) after an ethnographic case study of KM in an engineering organization. The model was modified by Jennex and Olfman (2002) following a five-year longitudinal study of knowledge management in an engineering organization and is based on the DeLone and McLean (2003) revised IS Success Model. This final model was developed to incorporate experience in using the model to design KMS and for incorporating other KM/KMS success factor research from the literature. Figure 3 shows the KM Success Model. The KM Success Model is based on DeLone and McLean (2003). Since the KM Success Model is assessing the use of organizational knowledge, the Information Quality dimension is renamed the Knowledge Quality dimension. Also, because use of a KMS is usually voluntary, the KM Success Model expanded the Intention to Use dimension to include a Perceived Benefit dimension based on Thompson, Higgins, and Howell's (1991) Perceived Benefit model used to predict system usage when usage is voluntary. Finally, since KM strategy/process is key to having the right knowledge, the feedback loop is extended back to this dimension. Dimension descriptions of the model follow.

System Quality

Jennex and Olfman (2000, 2002) found infrastructure issues such as using a common network structure; adding KM skills to the technology support skill set; and using high-end personal computers,

Figure 3. KM success model



integrated databases; and standardizing hardware and software across the organization to be keys to building KM. The System Quality dimension incorporates these findings and defines system quality by how well KM performs the functions of knowledge creation, storage/retrieval, transfer, and application; how much of the knowledge is represented in the computerized portion of the OM; and the KM infrastructure. Three constructs—the technological resources of the organization, KM form, and KM level—are identified. Technological resources define the capability of an organization to develop, operate, and maintain KM. These include aspects such as amount of experience available for developing and maintaining KM; the type of hardware, networks, interfaces, and databases used to hold and manipulate knowledge, capacities, and speeds associated with KM infrastructure; and the competence of the users to use KM tools. Technical resources enable the KM form and KM level constructs.

KM form refers to the extent to which the knowledge and KM processes are computerized and integrated. This includes how much of the accessible knowledge is online and available through a single interface and how integrated the processes of knowledge creation, storage/retrieval, transfer, and application are automated and integrated into the routine organizational processes. This construct incorporates concerns from the integrative and adaptive effectiveness clusters proposed for KMS effectiveness used by Stein and Zwass (1995). This construct, along with the technological resources construct, influences the KM level construct.

KM level refers to the ability to bring knowledge to bear upon current activities. This refers explicitly to the KM mnemonic functions such as search, retrieval, manipulation, and abstraction, and how well they are implemented. The technological resources and form of the KMS influence this construct in that the stronger the technical resources and the more integrated and computerized knowledge is, the more important this construct is and the more effective it can be.

Additional support for these constructs comes from Alavi and Leidner (1999), who found it important to have an integrated and integrative technology architecture that supports database, communication, and search and retrieval functions. Davenport, DeLong, and Beers (1998) found technical infrastructure to be crucial to effective KM. Ginsberg and Kambil (1999) found knowledge representation, storage, search, retrieval, visualization, and quality control to be key technical issues. Mandviwalla, Eulgem, Mould, and Rao (1998) described technical issues affecting KMS design to include knowledge storage/repository considerations; how information and knowledge is organized so that it can be searched and linked to appropriate events and use; and processes for integrating the various repositories and for reintegrating information and knowledge extracted from specific events and access locations, as users rarely access the KMS from a single location (leads to network needs and security concerns). Sage and Rouse (1999) identified infrastructure for capturing, searching, retrieving, and displaying knowledge and an understood enterprise knowledge structure as important. Finally, several of the KMS classifications focus on KM support tools, architecture, or life cycle, which all require strong system quality.

Ultimately, given the effectiveness of information technology to rapidly provide search, storage, retrieval, and visualization capabilities, it is expected that a more fully computerized system that utilizes network, semantic Web, and data warehouse technologies will result in the highest levels of system quality.

Knowledge Quality

Jennex and Olfman (2000, 2002) identified that having a KM process and an enterprise-wide knowledge infrastructure, incorporating KM processes into regular work practices, and that knowledge needs were different for users of different levels, were key issues in order to determine and implement what is the right knowledge for KM to capture. Additionally, it was found that KM users have formal and/or informal drivers that guide them in selecting information and knowledge to be retained by KM and formal and informal processes for reviewing and modifying stored information and knowledge. The Knowledge Quality dimension incorporates this and ensures that the right knowledge with sufficient context is captured and available for the right users at the right time. Three constructs: the KM strategy/process, knowledge richness, and linkages among knowledge components are identified. The KM strategy/process construct looks at the organizational processes for identifying knowledge users and knowledge for capture and reuse, the formality of these processes including process planning, and the format and context of the knowledge to be stored. This construct determines the contents and effectiveness of the other two constructs. Richness reflects the accuracy and timeliness of the stored knowledge as well as having sufficient knowledge context and cultural context to make the knowledge useful. Linkages reflect the knowledge and topic maps and/or listings of expertise available to identify sources of knowledge to users in the organization.

Hansen, Nohria, and Tierney (1999) describe two types of knowledge strategy: personification and codification. They warn of trying to follow both strategies equally at the same time. These strategies refer to how knowledge is captured, represented, retrieved, and used. However, KM strategy/process also needs to reflect that the knowledge needs of the users change over time, as found by the longitudinal study (Jennex & Olfman, 2002) and that new users have a hard time understanding codified tacit knowledge (Koskinen, 2001). For example, new users will follow personification until they understand the context in which knowledge is captured and used, and then they are willing to switch to a codification strategy. Personification corresponds to linkages in the model shown in Figure 3 and refers to the situation in which new users initially feel more comfortable seeking knowledge contexts from recognized human experts on a particular subject. Following this phase, these users tend to switch to codified knowledge; thus, codification corresponds to richness in the model. Additionally, Brown, Dennis, and Gant (2006) found that as the procedural complexity and teachability of knowledge increased, the tendency of users to rely on linkages (person-to-person knowledge transfer) also increased. Jennex (2006) discuses the impact of context and culture on knowledge reuse, and the conclusion is that as knowledge complexity grows, the ability to capture the context and culture information needed to ensure the knowledge is usable and, used correctly, becomes more difficult, and the richness of the stored knowledge is less able to meet this need, which results in users shifting to using linkages and personification. This model disagrees with Hansen, et al.'s (1999) finding that organizations need to select a single strategy on which to concentrate, while using the other strategy in a support role by recognizing that both strategies will exist and that they may be equal in importance.

Additional support for these constructs comes from Barna (2003), who identified creating a standard knowledge submission process, methodologies, and processes for the codification, documentation, and storage of knowledge, processes for capturing and converting individual tacit knowledge into organizational knowledge as important. Cross and Baird (2000) found that in order for KM to improve business performance, it had to increase organizational learning by supporting personal relationships between experts and knowledge users, providing distributed databases to store knowledge and pointers to knowledge, providing work processes for users to convert personal experience into organizational learning, and providing direction to what knowledge the organization needs to capture and from which to learn. Davenport, et al. (1998) identified three key success factors for KM strategy/process: clearly communicated purpose/goals, multiple channels for knowledge transfer, and a standard, flexible knowledge structure. Mandviwalla, et al. (1998) described several strategy issues affecting KM design, which include the KM focus (who are the users); the quantity of knowledge to be captured and in what formats (who filters what is captured); what reliance and/or limitations are placed on the use of individual memories; how long the knowledge is useful; and the work activities and processes that utilize KM. Sage and Rouse (1999) identified modeling processes to identify knowledge needs and sources, KM strategy for the identification of knowledge to capture and use and who will use it, an understood enterprise knowledge structure, and clear KM goals as important.

Service Quality

The Service Quality dimension ensures that KM has adequate support in order for users to utilize KM effectively. Three constructs—management support, user KM service quality, and IS KM service quality—are identified. Management support refers to the direction and support an organization needs to provide in order to ensure that adequate resources are allocated to the creation and maintenance of KM; a knowledge sharing and using organizational culture is developed; encouragement, incentives, and direction are provided to the work force to encourage KM use; knowledge reuse; and knowledge sharing; and that sufficient control structures are created in the organization in order to monitor knowledge and KM use. This construct enables the other two constructs. User KM service quality refers to the support provided by user organizations to help their personnel to utilize KM. This support consists of providing training to their users on how to use KM, how to query KM, and guidance and support for making knowledge capture, knowledge reuse, and KM use a part of routine business processes. IS KM service quality refers to the support provided by the IS organization to KM users and to maintaining KM. This support consists of building and maintaining KM tools and infrastructure; maintaining the knowledge base; building and providing knowledge maps of the databases; and ensuring the reliability, security, and availability of KM.

Our previous KM success model versions included the previous constructs as part of the system quality and knowledge quality dimensions. These constructs were extracted from these dimensions in order to generate the constructs for the service quality dimension and to ensure that the final KM success model was consistent with DeLone and McLean (2003).

Additional support for these constructs comes from Alavi and Leidner (1999), who found organizational and cultural issues associated with user motivation to share and use knowledge to be the most significant. Barna (2003) identified the main managerial success factor as creating and promoting a culture of knowledge sharing within the organization by articulating a corporate KM vision, rewarding employees for knowledge sharing and creating communities of practice. Other managerial success factors include obtaining senior management support, creating a learning organization, providing KM training, precisely defining KM project objectives, and creating relevant and easily accessible knowledge-sharing databases and knowledge maps. Cross and Baird (2000) found that in order for KM to improve business performance, it had to increase organizational learning by supporting personal relationships between experts and knowledge users and by providing incentives to motivate users to learn from experience and to use KM. Davenport, et al. (1998) found senior management support, motivational incentives for KM users, and a knowledge-friendly culture to be critical issues. Ginsberg and Kambil (1999) found incentives to share and use knowledge to be the key organizational issues. Holsapple and Joshi (2000) found leadership and top management commitment/support to be crucial. Resource influences such as having sufficient financial support and skill level of employees were also important. Malhotra and Galletta (2003) identified the critical importance of user commitment and motivation but found that using incentives did not guarantee a successful KMS. Sage and Rouse (1999) identified incentives and motivation to use KM, clear KM goals, and measuring and evaluating the effectiveness of KM as important. Yu, Kim, and Kim (2004) determined that KM drivers such as a learning culture, knowledge-sharing intention, rewards, and KM team activity significantly affected KM performance

User Satisfaction

The User Satisfaction dimension is a construct that measures satisfaction with KM by users. It is considered a good complementary measure of KM use, as desire to use KM depends on users being satisfied with KM. User satisfaction is considered a better measure for this dimension than actual KM use, as KM may not be used constantly yet still may be considered effective. Jennex (2005) found that some KM repositories or knowledge processes such as e-mail may be used daily, while others may be used once a year or less. However, it also was found that the importance of the once-a-year use might be greater than that of daily use. This makes actual use a weak measure for this dimension, given that the amount of actual use may have little impact on KM success, as long as KM is used when appropriate and supports DeLone and McLean (2003) in dropping amount of use as a measurement of success.

Intent to Use/Perceived Benefit

The Intent to Use/Perceived Benefit dimension is a construct that measures perceptions of the benefits of KM by users. It is good for predicting continued KM use when KM use is voluntary, and amount and/or effectiveness of KM use depend on meeting current and future user needs. Jennex and Olfman (2002) used a perceived benefit instrument adapted from Thompson, et al. (1991) to measure user satisfaction and to predict continued intent to use KM when KM use was voluntary. Thompson, et al.'s (1991) perceived benefit model utilizes Triandis' (1980) theory that perceptions on future consequences predict future actions. This construct adapts the model to measure the relationships among social factors concerning knowledge use, perceived KM complexity, perceived near-term job fit and benefits of knowledge use, perceived long-term benefits of knowledge use, and fear of job loss with respect to willingness to contribute knowledge. Malhotra and Galletta (2003) created an instrument for measuring user commitment and motivation that is similar to Thompson, et al.'s (1991) perceived benefit model but is based on self-determination theory that uses the Perceived Locus of Causality that also may be useful for predicting intent to use. Additionally, Yu, et al. (2004) found that KM drivers such as knowledge-sharing intention significantly affected KM performance.

Net Impact

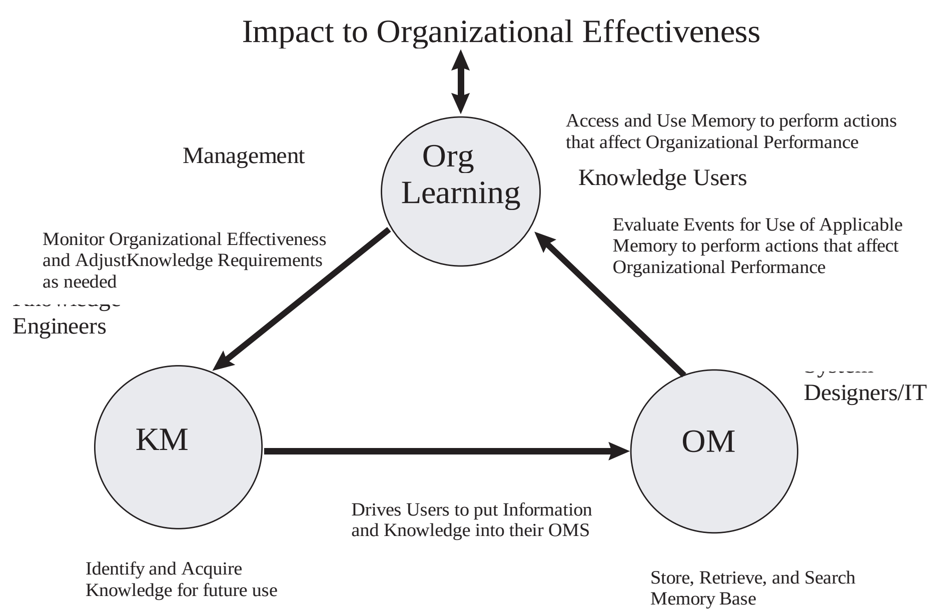
An individual's use of KM will produce an impact on that person's performance in the workplace. In addition, DeLone and McLean (1992) note that an individual impact also could be an indication that an information system has given the user a better understanding of the decision context, has improved his or her decision-making productivity, has produced a change in user activity, or has changed the decision maker's perception of the importance or usefulness of the information system. Each individual impact should have an effect on the performance of the whole organization. Organizational impacts usually are not the summation of individual impacts, so the association between individual and organizational impacts is often difficult to draw. DeLone and McLean (2003) recognized this difficulty and combined all impacts into a single dimension. Davenport, et al. (1998) overcame this by looking for the establishment of linkages to economic performance. Alavi and Leidner (1999) also found it important to measure the benefits of KM, as did Jennex and Olfman (2000).

We agree with combining all impacts into one dimension and the addition of the feedback loop to the User Satisfaction and Intent to Use/Perceived Benefit dimensions but take it a step further and extend the feedback loop to include the KM Strategy/Process construct. Jennex and Olfman (2002) showed this feedback in their model relating KM, OM, organizational learning, and effectiveness, as shown in Figure 4. This model recognizes that the use of knowledge may have good or bad benefits. It is feedback from these benefits that drives the organization either to use more of the same type of knowledge or to forget the knowledge, which also provides users with feedback on the benefit of the KMS. Alavi and Leidner (2001) also agree that KM should allow for forgetting some knowledge when it has detrimental or no benefits. To ensure that this is done, feedback on the value of stored knowledge needs to be fed into the KM Strategy/Process construct.

OPERATIONALIZATION OF THE SUCCESS MODEL

Jennex and Olfman (2002) performed a longitudinal study of KM in an engineering organization that identified a link between knowledge use and improved organizational effectiveness. Although a great deal of quantitative data were taken, it was not possible to quantify productivity gains as a function of knowledge use. KM was found to be effective and to have improved in effectiveness over a five-year period. Additionally, the engineers were found to be more productive.

Figure 4. The OM/KM model



Jennex (2000) applied an early version of this model to the construction and implementation of a knowledge management Web site for assisting a virtual project team. It was found that applying the model to the design of the site resulted in the project going from lagging to a leading project in just a few months.

Hatami, Galliers, and Huang (2003) used the KM Success Model to analyze knowledge reuse and the effectiveness of decision making. They found the model useful in explaining the effects of culture and knowledge needs on the overall KM success.

Jennex, Olfman, and Addo (2003) investigated the need for having an organizational KM strategy to ensure that knowledge benefits gained from projects are captured for use in the organization. They found that benefits from Y2K projects were not being captured, because the parent organizations did not have a KM strategy/process. Their conclusion was that KM in projects can exist and can assist projects in utilizing knowledge during the project. However, it also led to the conclusion that the parent organization will not benefit from project-based KM unless the organization has an overall KM strategy/process.

The following discussion combines these studies to provide methods of operationalizing the constructs proposed previously. Table 1 summarizes the various measures applied in these studies.

System Quality

Three constructs were proposed for the system quality dimension: technical resources, KM form, and KM level. Jennex and Olfman (2002) found that the capabilities of the IS organization

Table 1. KMS success model data collection methods

Construct	Data Collection Method
Technical Resources	User competency survey, observation and document research of IS capabilities, interview with IS Manager on infrastructure
Form of KMS	Interviews and survey of knowledge sources and form
Level of KMS	Survey of satisfaction with retrieval times, usability testing on KMS functions
KM Strategy/ Process	Survey on drivers for putting knowledge into the KMS and for satisfaction with the knowledge in the KMS, check on if a formal strategy/process exists
Richness	Usability test on adequacy of stored knowledge and associated context, interviews and satisfaction survey on adequacy of knowledge in KMS
Linkages	Usability test on adequacy of stored linkages, interviews and satisfaction surveys on satisfaction with linkages stored in KMS
Management Support	Interviews and Social Factors construct of Thompson, Higgins, and Howell’s survey on perceived benefit
IS KM Service Quality	Interview with IS Manager on IS capabilities. Interviews with users on needs and capabilities. Suggest adding user satisfaction survey on service issues
User Organization KM Service Quality	Interview with user organization KM team on capabilities and responsibilities, and needs from IS. Interview with users on needs and capabilities. Suggest adding user satisfaction survey on service issues
User Satisfaction	Doll and. Torkzadeh (1988) End User Satisfaction Measure, any other user satisfaction measure
Intent to Use/ Perceived Benefit	Thompson, Higgins, and Howell’s (1991) survey on perceived benefit
Net Impacts	Determine Individual and Organizational productivity models through interviews, observation, tend to be specific to organizations

and the users can impact the success of KM. IS infrastructure and organizational capabilities that enhanced KM effectiveness included a fast, high-capacity infrastructure, strong application development skills, network skills, and awareness of the user organization's knowledge requirements. Users' capabilities that enhanced KM effectiveness included a high degree of computer literacy and high-end personal computers. Given the importance of these technical resources, operationalization of the technical resources construct can be accomplished by focusing on the overall experience of the development group in building and maintaining networked systems that support KM; the computer capabilities of KM end users; and the quality of hardware, network, application, and operating system capabilities of workstations supporting KM.

KM level was defined as the ability to bring past information to bear upon current activities. This can be measured in terms of Stein and Zwass' (1995) mnemonic functions, including knowledge acquisition, retention, maintenance, search, and retrieval. It is expected that more effective KM will include more sophisticated levels of these functions. For example, more sophisticated KM should contain the ability to do filtering, guided exploration, and to grow memory. Usability testing of these functions can serve as measures of how effective they are implemented.

KM form refers to the extent to which knowledge is computerized and integrated. In essence, the more computerized the memory (personification and codification approaches), the more integrated it can be. That is, if all knowledge sources are available in computer-based form, then it will be possible to search and retrieved knowledge more effectively. Integration also speaks to the external consistency of the various KM tools. Jennex and Olfman (2002) found that although much of the KM used by the engineering organization was computerized, there were many different KMS components, each with varying kinds of storage mechanisms and interfaces. These components were poorly integrated, relying mainly on the copy-and-paste features of the Windows interface and, therefore, limited the ability of workers to utilize KM effectively. It was evident that more sophisticated technical resources could produce a more integrated set of components. Surveys of actual knowledge repositories that are used for KM can determine how much knowledge is stored in computerized forms. It is desired but not practical to have all knowledge in a computer. Assessment of this construct should focus on how much of the knowledge that is practical for computer storage is computerized.

Knowledge Quality

Knowledge quality has three constructs: KM strategy/process, richness, and linkages. Jennex and Olfman (2002) used surveys of users to determine drivers for putting knowledge into KM repositories and user satisfaction with the knowledge that was in these repositories. Jennex, et al. (2003) surveyed organizations to determine if they had a KM strategy and how formal it was. Jennex and Olfman (2002) used interviews of KM users to determine their satisfaction with the accuracy, timeliness, and adequacy of available knowledge. The need for linkages and personification of knowledge was found through interviews with users on where they went to retrieve knowledge. Additionally, it was found that users' KM needs vary, depending on their experience levels in the organization. Context of the knowledge is critical. New members did not have this context, and the knowledge repositories did not store sufficient context in order for a new member to understand and use the stored knowledge. It was found that new members need linkages to the human sources of knowledge. It is not expected that KM will ever be able to do an adequate job of storing context, so it is recommended that KM store linkages to knowledge.

Service Quality

Service quality was defined previously as how well the organization supports KM. Three constructs are proposed: management support, IS KM service quality, and user KM service quality. Jennex and Olfman (2002) identified these constructs through interviews that found evidence to show that the service quality of the IS and user organizations can impact KM success and that service quality was determined by the organizations that possess certain capabilities. IS KM service consisted of IS being able to build and maintain KM components and to map the knowledge base. IS organizational capabilities that enhanced this service effectiveness included data integration skills, knowledge representation skills, and awareness of the user organization's knowledge requirements. User organization KM service consisted of incorporating knowledge capture into work processes and being able to identify key knowledge requirements. User organization KM capabilities that enhanced this service effectiveness included understanding and being able to implement KM techniques, such as knowledge taxonomies, ontologies, and knowledge maps, and to process analysis capabilities. Additionally, service was enhanced either by the IS or the user organization providing training on how to construct knowledge searches, where the knowledge was located, and how to use KM.

The key construct—management support—was measured by using interviews and the social factors measure of Thompson, Higgins, and Howell's (1991) survey on perceived benefit. The social factors measure uses a Likert scale survey to determine perceptions of support from peers, supervisors, and managers, and gives a good view of the ability of the organizational culture to support KM and management support for doing KM. Additionally, individual and organizational productivity models were generated by using interviews with managers that provide an assessment of the impact of knowledge use on individuals and organizations and what incentives are being used to encourage KM participation.

IS organization KM support was measured by determining the overall experience of the development group in building and maintaining networked systems that support KM and the satisfaction of the KM end users with this support. User organization KM support was measured by determining what support was provided and how satisfied the users were with it. Measures assessing specific areas of capability can be used, should less-than-acceptable service satisfaction be found.

User Satisfaction

User satisfaction is a construct that measures perceptions of KM by users. This is one of the most frequently measured aspects of IS success, and it is also a construct with a multitude of measurement instruments. User satisfaction can relate to both product and service. As noted, product satisfaction often is used to measure knowledge quality. Product satisfaction can be measured by using the 12-item instrument developed by Doll and Tordzadeh (1988). This measure addresses satisfaction with content, accuracy, format, ease of use, and timeliness. Additionally, measures addressing satisfaction with interfaces should be used. Other user satisfaction measures can be used to assess the specific quality constructs, as discussed in previous paragraphs.

Intent to Use/Perceived Benefit

Jennex, et al. (1998) used Thompson, Higgins, and Howell's (1991) Perceived Benefit Model to predict continued voluntary usage of KM by the engineering organization. The following four factors from the model plus one added by Jennex and Olfman were in the survey:

- Job fit of KM, near-term consequences of using KM

- Job fit of KM, long-term consequences of using KM
- Social factors in support of using KM
- Complexity of KM tools and processes
- Fear of job loss for contributing knowledge to KM

All five factors were found to support continued KM use during the initial measurements. Jennex and Olfman (2002) found continued KM use throughout the five years of observing KM usage and concluded that the Perceived Benefit model was useful for predicting continued use. Jennex (2000) used these factors to design the site, work processes, and management processes for a virtual project team, using Web-based KM to perform a utility Year 2000 project. Promoting the social factors and providing near-term job fit were critical in ensuring that the virtual project team utilized KM. KM use was considered highly successful, as the project went from performing in the bottom third of utility projects to performing in the top third of all utility projects.

Net Benefits

The net benefits dimension looks for any benefits attributed to use of the KMS. We attempted to measure benefits associated with individual and organizational use of KM through the generation of productivity models that identified where knowledge use impacted productivity. KM benefits for an individual are found in their work processes. Jennex and Olfman (2002) queried supervisors and managers in order to determine what they believed was the nature of individual productivity in the context of the station-engineering work process. The interviews revealed a complex set of factors. Those benefiting from KM include the following:

- Timeliness in completing assignments and doing them right the first time
- Number of assignments completed
- Identification and completion of high-priority assignments
- Completeness of solutions
- Quality of solutions (thoroughness and accuracy)
- Complexity of the work that can be assigned to an engineer
- Client satisfaction

While many of these factors are measured quantitatively, it was not possible to directly attribute changes in performance solely to KM use, although improvements in performance were qualitatively attributed to KM use. Additionally, Jennex and Olfman (2002) asked 20 engineers to indicate whether they were more productive now than they were five or 10 years ago, and all but one thought that they were. This improvement was attributed primarily to KM use but also was a qualitative assessment.

Organizational impacts relate to the effectiveness of the organization as a whole. For a nuclear power plant, specific measures of effectiveness were available. These measures relate to assessments performed by external organizations as well as those performed internally. External assessments were found to be the most influenced by KM use. Jennex and Olfman (2002) found measures such as the SALP (Systematic Assessment of Licensee Performance) Reports issued by the Nuclear Regulatory Commission and site evaluations performed by the Institute of Nuclear Power Operations (INPO). Review of SALP scores issued since 1988 showed an increase from a rating of 2 to a rating of 1 in 1996. This rating was maintained through the five years of the study. An INPO evaluation was conducted during the spring of 1996 and resulted in a 1 rating. This rating also was maintained throughout the five years of the study. These assessments identified several strengths directly related to engineer productivity using KM, including decision making, root cause analysis, problem resolution, timeliness, and Operability Assessment documentation.

This demonstrates a direct link between engineer productivity and organization productivity. Also, since organization productivity is rated highly, it can be inferred that engineer productivity is high.

Two internal indicators were linked to KM use: unit capacity and unplanned automatic scrams. Unit capacity and unplanned scrams are influenced by how well the engineers evaluate and correct problems. Both indicators improved over time. These two indicators plus unplanned outages and duration of outages became the standard measure during the Jennex and Olfman (2002) study, and reporting and monitoring of these factors significantly improved during the study.

The conclusion is that net benefits should be measured by using measures that are specific to the organization and that are influenced by the use of KM. Suitable measures were found in all the studies used for this article, and it is believed that they can be found for any organization.

CONCLUSION

The DeLone and McLean IS Success Model is a generally accepted model for assessing success of IS. Adapting the model to KM is a viable approach to assessing KM success. The model presented in this article meets the spirit and intent of DeLone and McLean (1992, 2003). Additionally, Jennex (2000) used an earlier version of the KM Success Model to design, build, and implement intranet-based KM that was found to be very effective and successful. The conclusion of this article is that the KM Success Model is a useful model for predicting KM success. It is also useful for designing effective KM.

AREAS FOR FUTURE RESEARCH

DeLone and McLean (1992) stated, "Researchers should systematically combine individual measures from the IS success categories to create a comprehensive measurement instrument" (pp. 87–88). This is the major area for future KM success research. Jennex and Olfman (2002) provided a basis for exploring a quantitative analysis and test of the KM Success Model. To extend this work, it is suggested that a survey instrument to assess the effectiveness of KM within other nuclear power plant engineering organizations in the United States should be developed and administered. Since these organizations have similar characteristics and goals, they provide an opportunity to gain a homogeneous set of data to use for testing the model and, ultimately, to generate a generic set of KM success measures.

Additionally, other measures need to be assessed for applicability to the model. In particular, the Technology Acceptance Model, Perceived Usefulness (Davis, 1989) should be investigated as a possible measure for Intent to Use/Perceived Benefit.

REFERENCES

Alavi, M., & Leidner, D.E. (1999). Knowledge management systems: Emerging views and practices from the field. *Proceedings of the 32nd Hawaii International Conference on System Sciences.* IEEE Computer Society.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Barna, Z. (2003). *Knowledge management: A critical e-business strategic factor.* Master's thesis, San Diego State University, CA.

Brown, S.A., Dennis, A.R., & Gant, D.B. (2006). Understanding the factors influencing the value of person-to-person knowledge sharing. *Proceedings of the 39th Hawaii International Conference on System Sciences.*

Churchman, C.W. (1979). *The systems approach.* New York: Dell Publishing.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 41-54.

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13,* 319-340.

DeLone, W.H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. Information *Systems Research, 3*, 60-95.

DeLone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems*, *19*(4), 9-30.

Doll, W.J., & Torkzadeh, G. (1988). The measurement of end-user computing satisfaction. *MIS Quarterly, 12,* 259-275.

Ginsberg, M., & Kambil, A. (1999). Annotate: A Web-based knowledge management support system for document collections. *Proceedings of the 32nd Hawaii International Conference on System Sciences.*

Hansen, M.T., Nohria, N., & Tierney, T. (1999, March-April). *What's your strategy for managing knowledge?* Harvard Business Review, 106-116.

Hatami, A., Galliers, R.D., & Huang, J. (2003). Exploring the impacts of knowledge (re)use and organizational memory on the effectiveness of strategic decisions: A longitudinal case study. *Proceedings of the 36th Hawaii International Conference on System Sciences.*

Holsapple, C.W., & Joshi, K.D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information Systems, 9,* 235-261.

Huber, G.P., Davenport, T.H., & King, D. (1998). Some perspectives on organizational memory (Working Paper for the Task Force on Organizational Memory). *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.*

Jennex, M.E. (2000). Using an intranet to manage knowledge for a virtual project team. In D.G. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management* (pp. 241-259). Hershey, PA: Idea Group Publishing.

Jennex, M.E. (2005). What is knowledge management? *International Journal of Knowledge Management, 1*(4), i-iv.

Jennex, M.E. (2006). Culture, context, and knowledge management. *International Journal of Knowledge Management, 2*(2), i-iv.

Jennex, M.E., & Croasdell, D. (2005). Knowledge management: Are we a discipline? *International Journal of Knowledge Management, 1*(1), i-v.

Jennex, M.E., & Olfman, L. (2000). Development recommendations for knowledge management/organizational memory systems. *Proceedings of the Information Systems Development Conference.*

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.*

Jennex, M.E., Olfman, L., & Addo, T.B.A. (2003). The need for an organizational knowledge management strategy. *Proceedings of the 36th Hawaii International Conference on System Sciences.*

Jennex, M.E., Olfman, L., Pituma, P., & Yong-Tae, P. (1998). An organizational memory information systems success model: An extension of DeLone and McLean's I/S success model. *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.*

Koskinen, K.U. (2001). Tacit knowledge as a promoter of success in technology firms. *Proceedings of the 34th Hawaii International Conference on System Sciences.*

Maier, R. (2002). *Knowledge management systems: Information and communication technologies for knowledge management.* Berlin: Springer-Verlag.

Malhotra, Y., & Galletta, D. (2003). Role of commitment and motivation as antecedents of knowledge management systems implementation. *Proceedings of the 36th Hawaii International Conference on System Sciences.*

Mandviwalla, M., Eulgem, S., Mould, C., & Rao, S.V. (1998). Organizational memory systems design [working paper for the Task Force on Organizational Memory]. *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.*

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Polanyi, M. (1962). *Personal knowledge: Toward a post-critical philosophy.* New York: Harper Torchbooks.

Polanyi, M. (1967). *The tacit dimension*. London: Routledge and Keoan Paul.

Sage, A.P., & Rouse, W.B. (1999). Information systems frontiers in knowledge management. *Information Systems Frontiers, 1*(3), 205-219.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Thompson, R.L., Higgins, C.A., & Howell, J.M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Triandis, H.C. (1980). *Beliefs, attitudes, and values.* Lincoln: University of Nebraska Press.

Turban, E., & Aronson, J.E. (2001). *Decision support systems and intelligent systems* (6th ed.). Upper Saddle River, NJ: Pearson/Prentice Hall.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Yu, S.-H., Kim, Y.-G., & Kim, M.-Y. (2004). Linking organizational knowledge management drivers to knowledge management performance: An exploratory study. *Proceedings of the 37th Hawaii International Conference on System Sciences.*

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Chapter 2.22
Knowledge Management System Success:
Empirical Assessment of a Theoretical Model

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ABSTRACT

This article presents the empirical testing of a theoretical model of knowledge management system success. The Jennex and Olfman model of knowledge management system success was developed to reflect the DeLone and McLean model of information systems success in the knowledge management context. A structural equation model representing the Jennex and Olfman theoretical model is developed. Using data from a prior study aimed at knowledge management system use and individual learning, this model is tested. The overall fit of the model to the data is fair, although some interpretation of the estimated model parameters is problematic. The results of the model test provide limited support for the Jennex and Olfman theoretical model, but indicate the value of continued investigation and refinement of it. Suggestions for future research are provided.

INTRODUCTION

Involvement with a knowledge management system (KMS) generally leads to the desire to determine how successful it is. Practically, the measurement of KMS success (or effectiveness) can be valuable in a number of ways, including the justification of knowledge management (KM) investments (Turban & Aronson, 2001). Academically, the conceptualization of information system (IS) effectiveness is one of the most important research domains in the IS discipline (ISWorld, 2004a). A valid specific model of KMS success would have value for KM researchers in much the same way that a valid general model of IS success would have for the IS field.

The DeLone and McLean (D&M) model of IS success (1992, 2002, 2003) is currently the most widely accepted conceptualization of IS effectiveness among researchers (ISWorld, 2004b). The D&M model comprises six theoretical dimensions: Information Quality, System Quality, Service Quality, Intention to Use/Use, User Satisfaction, and Net Benefits (DeLone & McLean, 2003). Each of these dimensions constitutes a well-trodden research path in its own right, as indicated by the separate pages devoted to each on the ISWorld Web site (ISWorld, 2004a). Figure 1 illustrates the model.

The DeLone and McLean model is a general framework for understanding IS effectiveness and must be adapted to specific contexts. For example, DeLone and McLean (2003) provide an adaptation of the most recent iteration of their model to e-commerce. Jennex, Olfman, and their colleagues have adapted the D&M model to the KM context (Jennex, Olfman, Pituma, & Park, 1998; Jennex, Olfman, & Addo, 2003; Jennex & Olfman, 2002, 2004). This adaptation—which can be labeled as the Jennex and Olfman (J&O) model—can claim both empirical and theoretical justification. The earliest version of the model (Jennex et al., 1998) was informed empirically by an ethnography concerning KMS use in an engineering setting and theoretically by the 1992 D&M model, along with thinking at that time about KM and organization memory (such as Stein & Zwass, 1995). A revision of the model was informed empirically by a longitudinal study of engineering use of a KMS over a five-year period and theoretically by the 2002 revised D&M model, along with thinking at that time about KM (such as Alavi & Leidner, 2001). The latest version of the J&O model reflects the reasoning given for the latest version of the D&M model (DeLone & McLean,

Figure 1. DeLone and McLean (2003) IS success model

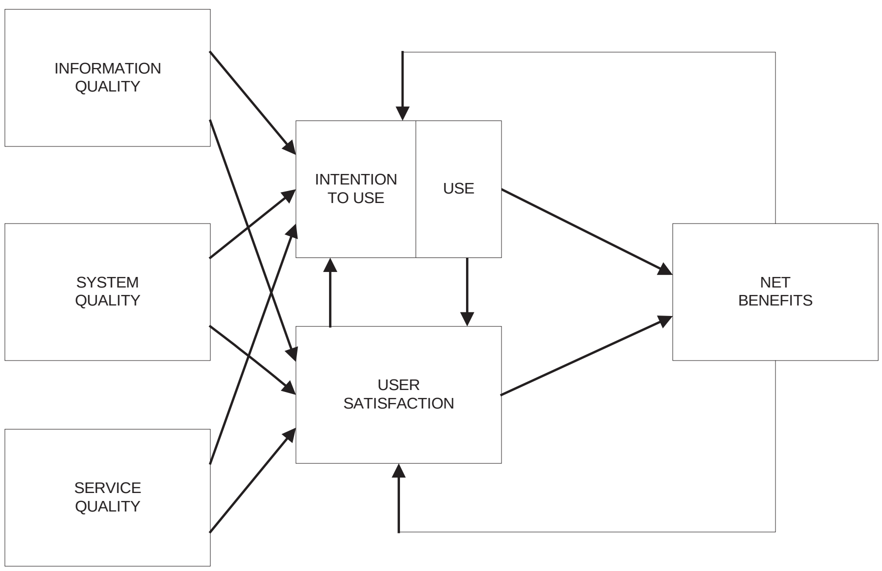
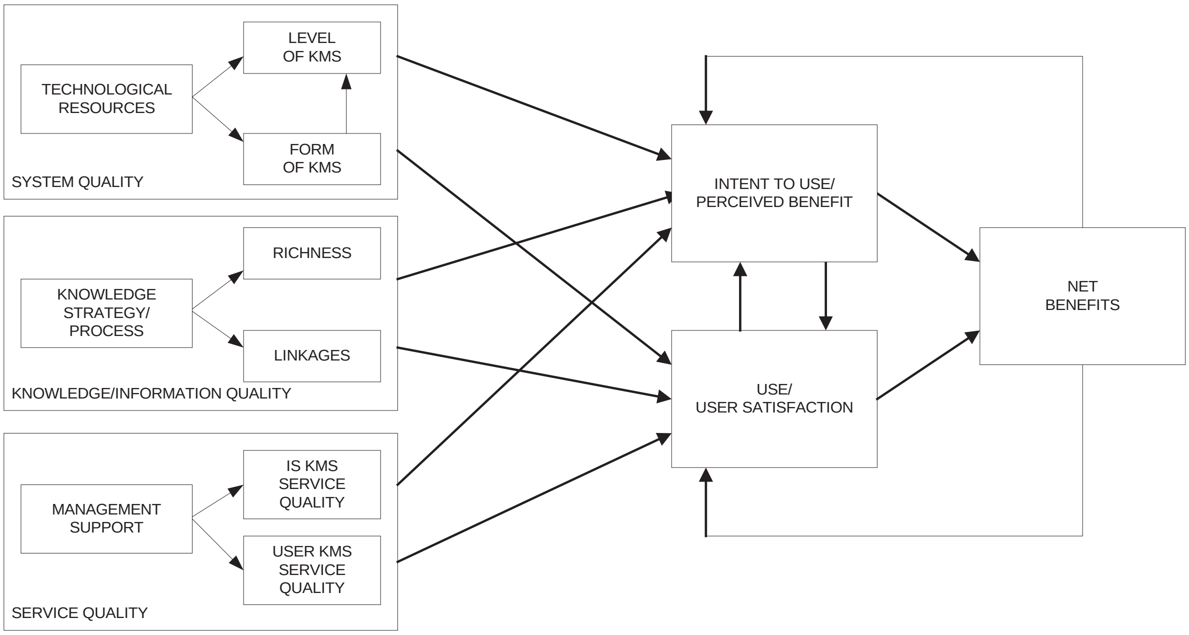


Figure 2. Jennex and Olfman (2004) IS success model



2003), along with the maturation of thinking of researchers in the KM field. Figure 2 depicts the J&O model in its current incarnation (Jennex & Olfman, 2004).

Although the J&O model was developed to reflect system success in a KM context, as is true for any theoretical model, its value as an explanation is open to empirical test. This research constitutes such a test; that is, it aims to assess how well the J&O model describes KMS success in the world. More specifically, the article reports the testing of a structural equation modeling (SEM) model conforming to the J&O theoretical model, with survey data collected from KMS users. This test provides an evaluation of the adequacy of the J&O model in its present form, along with suggestions of improvements that might be made to it.

BACKGROUND

Relationship Between the D&M Model and the J&O Model

The J&O model is an adaptation to the KM context of the well-accepted D&M model of IS success. The J&O model conceptualizes the basic dimensions of success in much the same ways that the D&M model does, but the ideas involved in the J&O model are more targeted to the KM setting than are the concepts constituting the D&M model. The J&O model consists of the same number of dimensions, with the same fundamental relationships among them, as the D&M model; the differences between the two models lie in the sub-dimensions proposed by Jennex, Olfman, and their colleagues to map the D&M dimensions to the KM setting. In the following paragraphs, the mapping is explained between each D&M dimension and its corresponding J&O dimension.

The D&M System Quality dimension is conceptualized in the J&O model as involving three sub-dimensions. The first of these sub-dimensions is Technological Resources, which involves "the capability of an organization to develop, operate, and maintain a KMS" (Jennex & Olfman, 2004). This construct captures ideas about the networks, databases, and other hardware involved in the KMS, as well as the experience and expertise behind the KMS initiative and the usage competence of typical KMS users. The second System Quality sub-dimension is Form of KMS, which has to do with "the extent to which the knowledge and knowledge management processes are computerized and integrated" (Jennex & Olfman, 2004). This concept reflects the amount of knowledge that is accessible through the KMS interface, as well as the extent of automation and integration of the interface and the activities of knowledge creation, storage, retrieval, transfer, and application. The third System Quality sub-dimension is Level of KMS. This is defined as the ability of the KMS "to bring knowledge to bear upon current activities" (Jennex & Olfman, 2004); it is centered on the nature and implementation of the KMS's search and retrieval functions. These sub-dimensions jointly cover the aspects of a KMS that theory and empirical observation point to as most critical in understanding what system quality is in KM settings.

The D&M dimension Information Quality is relabeled in the J&O model as Knowledge/Information Quality. A high value for this dimension occurs whenever "the right knowledge with sufficient context is captured and available for the right users at the right time" (Jennex & Olfman, 2004). The dimension involves three sub-dimensions. The first of these, Knowledge Strategy/Process, captures three ideas: the processes used for identifying the knowledge that can be captured and reused (and the users who can capture and reuse it); the formality of the processes, including how much planning occurs; and the format and content of the knowledge to be captured. This sub-dimension has evolved to reflect ideas of personalization and codification (Hansen, Nohria, & Tierney, 1999); it recognizes that evolution occurs in how knowledge is captured and reused. The second sub-dimension involved in Knowledge/Information Quality is Richness. This notion "reflects the accuracy and timeliness of the stored knowledge as well as having sufficient knowledge context to make the knowledge useful" (Jennex & Olfman, 2004). The third sub-dimension for this dimension, Linkages, is intended to "reflect the knowledge and topic maps and/or listings of expertise available to the organization" (Jennex & Olfman, 2004).

The D&M dimension Service Quality is defined in the J&O model as being those aspects of a KMS that ensure "the KMS has adequate support for users to use the KMS effectively" (Jennex & Olfman, 2004). The dimension comprises three sub-dimensions. The first of these, Management Support, has to do with the allocation of adequate resources, encouragement and direction, and adequacy of control. The second Service Quality sub-dimension, User KM Service Quality, involves support from the user organization in how to use the KMS, how to capture knowledge as part of the work, and how to use the KMS in the normal course of business processes. The third of these sub-dimensions, IS KM Service Quality, centers on support from the IS organization in KMS tools, maintenance of the knowledge base, maps of databases, and reliability and availability of the KMS.

The D&M dimension Intention to Use/Use in the J&O model becomes Intent to Use/Perceived Benefit. This dimension "measures perceptions of the benefits of the KMS by the users" (Jennex & Olfman, 2004). It reflects intention to use, in that it concerns prediction of future usage behavior; it does not reflect use, which Jennex, Olfman, and their colleagues view as a different matter—in the

J&O model use is aligned with user satisfaction (see below). The reflection of intention to use in the J&O model is extended in theoretical terms by incorporating perceived benefit, a concept originally advanced by Triandis (1980) and adapted to the IS context by Thompson, Higgins, and Howell (1991). This extension of the dimension allows it to reflect social and job-related characteristics of KMS user expectations that would not otherwise be captured (Jennex & Olfman, 2004).

The D&M dimension User Satisfaction maps to Use/User Satisfaction in the J&O model. The J&O dimension combines use and user satisfaction because Jennex, Olfman, and their colleagues see the two concepts as complementary notions in the KM setting. In their view, when system use is optional, how much the system is used serves as a good indicator of success, and user satisfaction can be considered a complementary indicator. User satisfaction becomes a more useful indicator of success when system use is not optional. Beyond this, in situations where a KMS is only needed occasionally—in situations where the absolute amount of usage is unimportant—employing use as a measure would underestimate KMS success; satisfaction provides a better indicator in that case.

The final D&M dimension, Net Benefits, corresponds to a J&O model dimension of the same name. The conceptualizations of this dimension are essentially the same in the two models.

Relationship Between the J&O Model and the SEM Model

The SEM model tested in this study corresponds to the J&O model in most respects. Figure 3 depicts the dimensions in the SEM model and the scales—corresponding to sub-dimensions—used in this study. Figure 4 depicts the structural aspects of the SEM model.

The J&O model and the SEM model differ in two important ways. The first involves the elimination of feedback paths in the SEM model to allow its estimation as a recursive model. The second involves the limitation of certain theoretical content in the SEM model's dimensions to map them to the data available in this study.

Figure 3. Indicators of SEM model dimensions

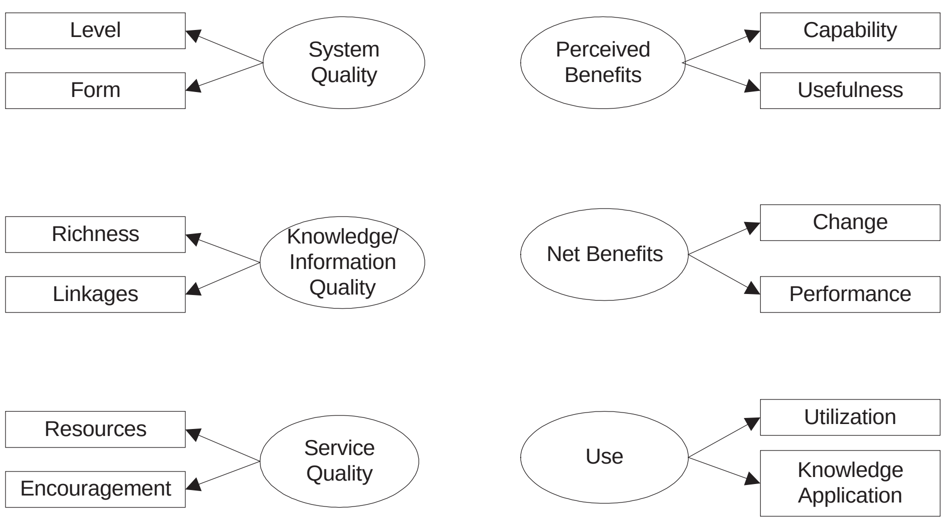
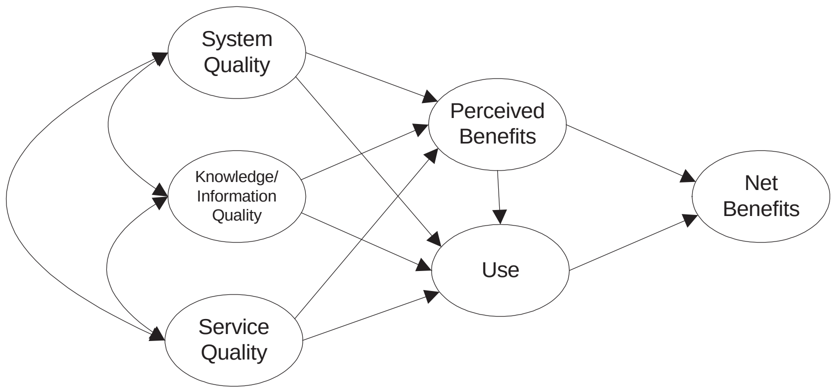


Figure 4. SEM structural model



According to Kline (1998), the statistical demands for SEM analysis are greatly simplified for recursive models—those in which all causal effects are unidirectional and all disturbances are mutually independent. "The likelihood of a problem in the analysis of a nonrecursive model is much greater than for a recursive model" (p. 107). Formulating the SEM model as a recursive one (with one-way causal effects among endogenous variables, but without disturbance correlations) guaranteed it would be identified (Kline, 1998).[1]

To convert the J&O model to a recursive form, three feedback paths were dropped: 1) from Net Benefits to Intent to Use/Perceived Benefit, 2) from Net Benefits to Use/User Satisfaction, and 3) from Use/User Satisfaction to Intent to Use/Perceived Benefit. The first two of these paths were viewed as being more appropriate for inclusion in a longitudinal study, which this study was not intended to be. The third path was viewed as less important theoretically than the path from Intent to Use/Perceived Benefit to Use/User Satisfaction. It was felt that perceptions of possible benefit influence system use more strongly than the other way around. As compromises to allow the testing of a recursive form of the SEM model, it was felt that these path deletions were reasonable.

The dimensions of the SEM model are limited in terms of how much of the conceptual content of the J&O model's dimensions they carry. The primary reason for this limitation is that the data used to test the SEM model were collected in an earlier study aimed at assessing individual learning in KMS situations (Liu, 2003). The data from Liu's study reflect most of the theoretical content of the J&O model's dimensions, but not all of it.[2] Where some theoretical content was not reflected in the indicators Liu selected or created for her study, at least two reasons were active. First, Liu did not feel such content to be relevant in understanding individual learning. Second, Liu had reference to an earlier version of the J&O model (Jennex & Olfman, 2002). Nonetheless, the indicators Liu used show enough correspondence to the theoretical content of the current (2004) J&O model to allow a SEM model reflecting it to be tested here. Table 1 summarizes the theoretical dimensions of the J&O model reflected in the SEM model. Note that 12 of the 15 sub-dimensions included in the J&O model are mapped to the SEM model.

It is prudent to be concerned that three of the 15 sub-dimensions of the J&O model (Technical Resources, Knowledge Strategy/Process, IS KM Service Quality) are not represented in the SEM

Table 1. Correspondence of dimensional theoretical content between J&O and SEM models

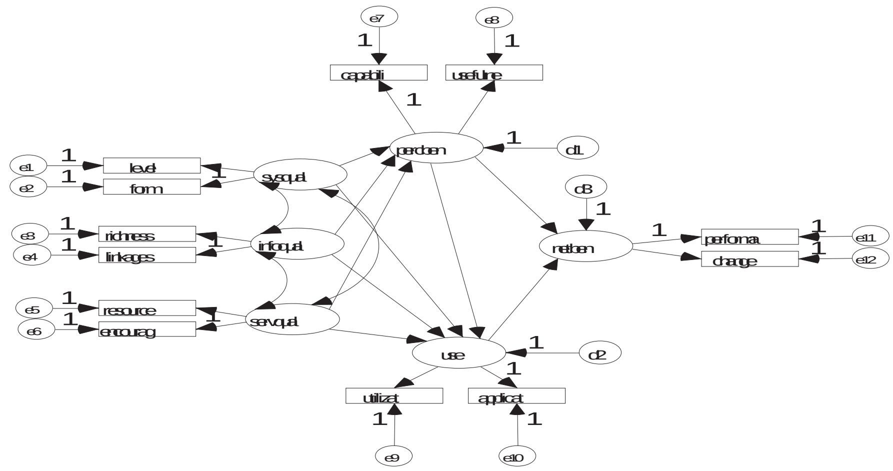
J&O Model Dimension	J&O Model Sub-Dimensions	SEM Model Dimension	SEM Model Sub-Dimensions
System Quality	Form	System Quality	Form
	Level		Level
	Technological Resources		<Missing> [1]
Knowledge/ Information Quality	Linkages	Knowledge/ Information Quality	Linkages
	Richness		Richness
	Knowledge Strategy/ Process		<Missing> [5]
Service Quality	Management Support	Service Quality	Encouragement
	User KM Service Quality		Resources
	IS KM Service Quality		<Missing> [5]
Intent to Use/ Perceived Benefit	Capability	Intent to Use/ Perceived Benefit	Capability
	Usefulness		Usefulness
Use/ User Satisfaction	Utilization	Use/ User Satisfaction	Utilization
	Knowledge Application		Knowledge Application
Net Benefits	Change	Net Benefits	Change
	Performance		Performance

model. On the other hand, the SEM model only employs the J&O model's sub-dimensions as indicators of its dimensions. Keeping in mind that any indicator reflects only imperfectly the theoretical ideas it represents, it was decided that the SEM model that could be specified with the available indicators was acceptable as a representation of the J&O model. Figure 5 depicts the modified SEM model in its full form.

Connecting the SEM Model with Type of System and Stakeholder

Seddon Staples, Patnayakuni, and Bowtell (1999) assert that how one assesses information systems success should reflect the type of system and the system's stakeholders. They present a taxonomy of IS effectiveness measures, organized by six types of system and five types of stakeholder. For this study, a type of IT application (KMS) is considered, as it is used to benefit individual stakeholders (distinct KMS users).[4] These two focuses lead to a concentration on a benefit that any KMS might provide to any individual user. For purposes of this study, this benefit is individual learning, an outcome of KMS use that leads to "individual better-offness" (Seddon et al., 1999, p. 7). Individual learning is unquestionably important as a KMS outcome. Argyris and Schön (1996) argue that "individuals are the only subjects of learning" (p. 188), asserting that organizations learn only through the experiences and actions of individuals. While outcomes of KMS use other than individual learning might be considered, it appears to be one acceptable point for anchoring the Net Benefits dimension in terms of outcomes

Figure 5. Proposed SEM model (full)



that would matter to individual stakeholders. The focus on individual learning, along with the emphasis on use by individual users, allows reconciliation of this study's investigation of the J&O model with Seddon et al.'s advice about assessing IS effectiveness.

METHOD

Liu (2003) gathered the data used to assess the SEM model tested in this study through a study of individual learning in a KM setting. Liu designed an online survey, using an early version of the J&O model (Jennex & Olfman, 2002) as a general guide. The survey included 54 items and was developed using, with some modification, the three-stage instrument development process proposed by Moore and Benbasat (1991). First, an initial version of the survey instrument was developed based on theory grounded in operationalization of the constructs. Additionally, demographic items were included in the survey to capture information about gender, age, length of time with the organization and in current position, years using KMS, industry employed, job title and function, and the highest education attained. Published forms of items were used whenever possible, relying on work by Jennex and Olfman (2002), Dewitz (1996), Doll and Torkzadeh (1988), Bahra (2001), Gold, Malhotra, and Segars (2001), Thompson et al. (1991), King and Ko (2001), and Davis (1989), and constructing new items only when necessary. Second, based on solicited input from people with expertise in KMS and instrument development, the instrument was restructured and reworded to make it focused, brief, and clear (Alreck & Settle, 1995). Third, the instrument underwent a pilot study utilizing 56 KMS users from different firms to pretest the revised questionnaire, resulting in the final revision of the instrument.

This study uses data items from Liu's (2003) survey assembled into sub-dimension scales to serve as indicators for the SEM model depicted in Figure 3. Appendix 1 details the items as they were worded in the survey and assembled into sub-dimension scales for this study. Respondents rated each item on a rating scale from 'strongly agree' (5) to 'strongly disagree' (1), although they had the option of rating any item as 'not applicable'. Analysis of items and sub-dimension scales was done with SPSS; estimation of the SEM model was done with Amos, a package for SEM analysis.[5]

Individuals were invited to participate who, through a business firm or other organization, used a KMS for acquisition, organization, storage, or dissemination of knowledge. This sampling procedure was purposive in nature: it was oriented towards obtaining as many survey responses as possible, rather than sampling from a particular sampling frame.

RESULTS

Three hundred sixty-nine (369) people provided responses to Liu's (2003) survey. Nine cases were dropped due to non-completion of the survey or non-use of a KMS, leaving a total of 360 respondents. The majority of these (52.8%) were from engineering or manufacturing organizations, 61.9% were male, and 71.2% were between 30 and 49 years of age. This analysis dropped an additional six cases due to one or more missing scale values, leaving a sample size of 354.

Scale scores were calculated as the averages of relevant item scores to serve as measured variables in the SEM model. Table 2 provides descriptive statistics for the scale scores, as well as reliability coefficients for each scale and R2 estimates for the regression of each scale score on the set of all the others (as a basis for judging multivariate multicollinearity). Tables 3a and 3b provide a correlation matrix for the scale scores.

To avoid problems in SEM analysis, one must check the data for normality, outliers, and multicollinearity (Kline, 1998). The distributions of scale scores are roughly symmetrical, and estimates of skewness and kurtosis are not too large. There are no outliers, with no scale score as much as three standard deviations from its mean. There are no extremely large bivariate correlations, and none of the R2 values for regressions of scale scores on the sets of all other scale scores exceed 0.90, indicating no multivariate multicollinearity problems. The data, at least in these terms, seem to be adequate to conduct SEM analysis.

Table 2. Scale descriptive statistics, reliability, and MV multicollinearity estimates (N=354)

Name	Mean	Std. Dev.	Skewness	Kurtosis	Alpha	R^2 to Test MV Multicollinearity
Level	2.14	0.58	1.06	1.67	0.76	0.31
Form	2.38	0.77	0.95	0.94	0.84	0.47
Richness	2.00	0.70	1.13	1.51	0.89	0.67
Linkages	2.33	0.79	1.16	1.79	0.79	0.56
Resources	2.30	0.78	0.97	1.77	0.52	0.71
Encouragement	2.33	0.84	1.00	1.38	0.82	0.63
Capability	1.67	0.60	0.87	0.83	0.79	0.47
Usefulness	1.63	0.61	1.34	2.11	0.73	0.45
Change	2.25	0.73	0.82	2.33	0.83	0.48
Performance	2.19	0.69	0.38	1.07	0.87	0.57
Utilization	1.87	0.89	1.63	3.07	0.85	0.77
Knowledge Application	2.21	0.70	0.137	0.50	0.75	0.73

Table 3a. Scale correlations (2-tailed significance, N=354)

	Level	Form	Richness	Linkages	Resources	Encouragement
Level	1 .000	.681 .000	.699 .000	.680 .000	.513 .000	.418 .000
Form	.681 .000	1 .	.625 .000	.643 .000	.402 .000	.265 .000
Richness	.699 .000	.625 .000	1 .	.695 .000	.495 .000	.424 .000
Linkages	.680 .000	.643 .000	.695 .000	1 .	.520 .000	.426 .000
Resources	.513 .000	.402 .000	.495 .000	.520 .000	1 .	.576 .000
Encouragement	.418 .000	.265 .000	.424 .000	.426 .000	.576 .000	1 .
Capability	.491 .000	.361 .000	.617 .000	.448 .000	.385 .000	.282 .000
Usefulness	.543 .000	.397 .000	.556 .000	.506 .000	.374 .000	.474 .000
Change	.541 .000	.335 .000	.428 .000	.419 .000	.369 .000	.416 .000
Performance	.480 .000	.300 .000	.313 .000	.415 .000	.360 .000	.388 .000
Utilization	.296 .000	.138 .009	.359 .000	.180 .001	.272 .000	.360 .000
Knowledge App.	.292 .000	.151 .004	.170 .001	.204 .000	.220 .000	.275 .000

Byrne (2001) describes the core parameters of the SEM model (those that must be estimated typically) as including the regression coefficients for measurements and structure, the variances for errors and disturbances, and the factor variances and covariances. Based on these rules for counting parameters, the proposed model requires that 36 parameters be estimated. With 12 observed variables, there are 78 available data points. This implies that the SEM model is over-identified, having 43 degrees of freedom above what would have been a just identified model.[6]

As indicated by Nidumolu and Knotts (1998), sample size significantly influences statistical conclusion validity. Sample size requirements for SEM models are related to model complexity, but no definitive relationship exists between sample size and model complexity (Kline, 1998). One standard dictates that the sample size must be 50 observations more than eight times the number of variables (Garson, 2004); by this rule, the minimum sample size for this study would be 194 respondents. Another standard says that there should be 15 cases for every indicator (Stevens, 1996, reported by Garson, 2004); given this model has 12 indicators, the implication is that at least 180 respondents would be needed. Yet another standard advises that there should be 10 cases per parameter estimate (Kline, 1998), which means a sample size of 360 would be required. Irrespective of the guideline followed, the achieved sample size, 354, can be considered adequate.

Table 3b. Scale correlations (2-tailed significance, N=354)

	Capability	Usefulness	Change	Performance	Utilization	Knowledge App.
Level	.491 .000	.543 .000	.541 .000	.480 .000	.296 .000	.292 .000
Form	.361 .000	.397 .000	.335 .000	.300 .000	.138 .009	.151 .004
Richness	.617 .000	.556 .000	.428 .000	.313 .000	.359 .000	.170 .001
Linkages	.448 .000	.506 .000	.419 .000	.415 .000	.180 .001	.204 .000
Resources	.385 .000	.374 .000	.369 .000	.360 .000	.272 .000	.220 .000
Encouragement	.282 .000	.474 .000	.416 .000	.388 .000	.360 .000	.275 .000
Capability	1 .	.522 .000	.351 .000	.356 .000	.378 .000	.136 .010
Usefulness	.522 .000	1 .	.575 .000	.614 .000	.388 .000	.356 .000
Change	.356 .000	.614 .000	1 .	.823 .000	.344 .000	.600 .000
Performance	.351 .000	.575 .000	.823 .000	1 .	.297 .000	.642 .000
Utilization	.378 000	.388 .000	.344 .000	.297 .000	1 .	.326 .000
Knowledge App.	.136 .010	.356 .000	.600 .000	.642 .000	.326 .000	1 .

Evaluating the Proposed Model

Evaluation of a SEM model considers both the estimates of individual parameters and the overall fit of the model to the data (Byrne, 2001). According to Byrne, there are three aspects of individual parameters to consider:

1. all should be reasonable (no correlations larger than 1, no negative variances, and positive definite matrices of correlations and covariances);
2. estimates should be significant, having critical ratios greater than or equal to 1.96; and
3. standard errors should not be too large or too small (although no clear standards available for what too large or too small would be).

Table 4 presents values for individual parameter estimates and related statistics. In these terms, the proposed model can be considered to produce fairly reasonable individual parameters. The greatest problem noted with individual parameters is the occurrence of some low values for critical ratios, particularly for two of the structural regression coefficients. The estimates for the paths from Service Quality to Perceived Benefits and from System Quality to Perceived Benefits have critical ratios of 0.601 and –0.875, respectively. This indicates that the values for

Table 4. Individual parameter estimates and related statistics for proposed SEM model

			Estimate	S.E.	C.R.	P
percben	<---	servqual	.050	.083	.601	.548
percben	<---	infoqual	.698	.304	2.294	.022
percben	<---	sysqual	-.250	.286	-.875	.382
use	<---	servqual	.400	.226	1.770	.077
use	<---	infoqual	-2.296	1.353	-1.697	.090
use	<---	sysqual	1.631	1.037	1.573	.116
use	<---	percben	1.720	.735	2.340	.019
netben	<---	percben	.482	.130	3.696	***
netben	<---	use	.893	.138	6.459	***
form	<---	sysqual	1.000			
level	<---	sysqual	.872	.052	16.759	***
linkages	<---	infoqual	1.000			
richness	<---	infoqual	.926	.050	18.447	***
encourag	<---	servqual	1.000			
resource	<---	servqual	1.017	.091	11.172	***
applicat	<---	use	1.000			
utilizat	<---	use	.662	.100	6.632	***
capabili	<---	percben	1.000			
usefulne	<---	percben	1.256	.104	12.039	***
performa	<---	netben	1.000			
change	<---	netben	1.030	.044	23.433	***

these parameters cannot be distinguished with confidence from 0.

Three other regression parameter estimates have low critical ratios as well, but not so low as the ones just mentioned, and probably within the range of acceptability.

Besides individual parameters, the overall fit of the model must be examined. It is common in reports of SEM analysis to present a variety of statistics that reflect different aspects of overall model fit.

Kline (1998) describes a variety of indicators of overall model fit. He asserts that a minimum set of these indicators should be reported, including:

"…the X2 statistic and its degrees of freedom and significance level; an index that describes the overall proportion of explained variance; an index that adjusts the proportion of explained variance for model complexity; and an index based on the standardized residuals…." (p. 130)

Kline (1998) cautions that researchers should bear in mind the limitations of fit indexes: 1) they are indicative of average fit; 2) they are not indicative of theoretical meaning; and 3) they are not indicative of a model's predictive power (p. 130). Table 5 presents overall model fit indexes for the proposed SEM model.

For a model to have a fair level of fit to data, according to Kline (1998), "low and non-significant values of the X2 index are desired" (p. 128). Because the X2 index is sensitive to sample size, researchers sometimes employ X2/df. A significant X2 value means: "an unconstrained model fits the covariance/correlation matrix as

Table 5. Overall model fit indexes for the proposed SEM model

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	36	253.327	42	.000	6.032
Saturated model	78	.000	0		
Independence model	12	2508.159	66	.000	38.002

GFI	CFI	IFI	NFI	NNFI (TLI)	RMR	RMSEA
.894	.913	.914	.899	.864	.041	.119

well as the given model" (Garson, 2004); a non-significant value suggests the fit of the data to the model is adequate. The X2 statistic calculated for the proposed model is significant (CMIN=253.3, df=42, p=.000), which suggests that the fit of the model is not entirely adequate. On the other hand, according to Garson (2004):

"Many researchers who use SEM believe that with a reasonable sample size (ex., > 200) and good approximate fit as indicated by other fit tests (ex., NNFI, CFI, RMSEA, ...), the significance of the chi-square test may be discounted…." (p.11)

The GFI (Goodness of Fit Index) reflects the degree to which the observed covariances are explained by the covariances implied by the proposed model. The standard for GFI values to indicate a good fit is values greater than or equal to .90 (Garson, 2004). The GFI value achieved for the proposed model is .894. Although this is below the conventional cutoff value, GFI values are biased downward at times, such as when the number of degrees of freedom is large relative to the sample size and when the number of parameters is not large. Garson reports Steiger's suggestion to use an adjusted GFI to account for GFI's downward bias. The adjusted GFI for this study, calculated with the formula Garson provides, is .980.

The CFI (Comparative Fit Index) contrasts the fit of the proposed model with that of a model that assumes no correlation among the latent variables (Garson, 2004). Values above .90 indicate a good fit of the model to the data. The value of CFI for this study is .913.

The IFI (Incremental Fit Index) "should be equal to or greater than .90 to accept the model" (Garson, 2004). The IFI value obtained in this research is .914.

The NNFI (Non-Normed Fit Index) is also known as the TLI (Tucker-Lewis Index). It expresses, in a manner adjusted for model complexity, how much the proposed model improves fit, compared with a null model—one having random variables. Garson (2004) reports several guidelines for judging goodness of fit using the NNFI, with the most lenient being values greater than or equal to .80, and the most strict being values greater than or equal to .95. The value of NNFI achieved for the proposed model is .864.

The RMR (Root Mean Square Residual) is an index that indicates good fits with small values—the closer to 0, the better. According to Kline (1998), "in a well-fitting model this value will be small, say, .05 or less" (p. 82). This index represents the average of residual differences between the variances and covariances observed and those hypothesized. In this study, RMR had a value of .041.

The RMSEA (Root Mean Square Error of Approximation) "takes into account the error of approximation in the population." RMSEA values over .10 indicate poor fit (Byrne, 2001). The value achieved for the proposed model is .119.

Across the set of indicators, the proposed model shows some evidence of having an acceptable fit to the data (in terms of the Adjusted GFI, CFI, IFI, NFI, NNFI/TLI, and RMR), and it shows some evidence of unacceptable fit (in terms of the X2 and RMSEA).

DISCUSSION

The J&O model of KM success received fair support from the results presented above. Although the data used were collected in an earlier study with different research aims, being concerned with the intersection of KMS use and individual learning (Liu, 2003), and hence were not explicitly intended to serve for testing the J&O model, the fit of the proposed SEM model to the data can be characterized as adequate, if not particularly good.

To the extent that the J&O model is more credible as a whole in light of these findings, some implications of the research merit additional attention. First, the relationships involving Perceived Benefit, Use, and Net Benefits in the J&O model can be treated as more plausible. The regression coefficients corresponding to these relationships were significant and substantial. These findings support the theoretical relationships, flowing through the J&O model from the D&M model, that higher levels of Perceived Benefit associated with a KMS leads to higher levels of Use—users make use of the system when they perceive benefits from doing so.

Second, the covariance relationships involving System Quality, Knowledge/Information Quality, and Service Quality were confirmed as well. The coefficients calculated for these relationships in the model were all sizeable, but not too large. This finding supports the ideas from the J&O (and D&M) model that the three KMS (IS) quality factors are inter-related, but distinct, qualities.

Third, the relationships involving the effects of System Quality, Knowledge/Information Quality, and Service Quality on Perceived Benefits and Use were not consistently confirmed. The calculated coefficients—six in all—showed a decidedly mixed pattern of significance: two of the calculated coefficients should not be viewed as significant, three should be taken as marginally significant, and one should be considered significant. The significant coefficient for the influence of Knowledge/Information Quality on Perceived Benefit had a value of .698 (p=.02). This estimate confirms the notion that an increase in the amount of knowledge a KMS provides leads to an increase in the amount by which individuals view the KMS as providing benefit. As such, this is good news for the J&O model. The marginally significant estimates provide news of a more mixed nature. Two of these—from System Quality to Use (1.631, p=.12) and from Service Quality to Use (.400, p=.08)—provide the suggestion of support to the J&O model, but the other—from Knowledge/Information Quality to Use (-2.296, p=.09)—is in the opposite direction suggested by the J&O model. The non-significant estimates—from System Quality to Perceived Benefits (-.250, p=.382) and from Service Quality to Perceived Benefits (.050, p=.548)—are not supportive of the J&O model.

What to make of these estimates as a group is somewhat puzzling. While together they do not overwhelmingly support the J&O model, neither do they disconfirm it. Rather, one should conclude from these findings that there is now enough empirical support for the J&O model to justify additional efforts to confirm and refine it. The following section contains suggestions for how such research might be done effectively.

To provide a convincing test of the J&O model, better data will be needed. For the data employed in this study to have been completely acceptable, several changes would have been needed. Most important of these changes would have been the inclusion of omitted scales. The data Liu (2003) collected did not include items that could serve to represent several sub-dimensions of the J&O

model, including Technological Resources, Knowledge Strategy/Process, IS KM Service Quality, and User KM Service Quality. While other data from the Liu study allowed a partial coverage of the conceptual content of the System Quality, Knowledge/ Information Quality, and Service Quality dimensions, it is likely that the theoretical under-representation of the J&O model in the data used made the test conducted here less precise than it might have been. Future research attempting to assess the J&O model should be sure to represent all sub-dimensions.

A second change in the data that would have likely improved the fit to the proposed model would have involved additional refinement of the scales employed. Since the Liu data was not collected explicitly to represent the sub-dimensions of the J&O model, they do not provide as many items for each sub-dimension as would be desirable, nor do they obviously represent the constructs related to these sub-dimensions in any certain fashion. Future research would benefit from instrument development and validation efforts targeted explicitly to the testing of the J&O model's conceptualizations of dimensions and sub-dimensions of KMS success.

A third change in the data that would have improved the fit to the proposed model would have involved a different sampling strategy. The Liu (2003) sampling strategy, which amounted to "snowball sampling" (Atkinson & Flint, 2001), did not assure that all respondents had interacted with similar KMSs. Neither did it employ random selection of participants from a well-defined sampling frame. If future research can identify a group of potential respondents who all employ information systems that are similar in their adherence to some definition of a KMS, then random selection of individuals from this group would probably improve the research's chances of reducing the level of extraneous variance. This should allow better estimates to be derived. Future research should strive to attain a random sample of users of a known type of KMS.

A fourth change in the data that would have improved fit would have been to recruit a larger sample size for the study. The sample Liu collected (N=354), although not small, was certainly no larger than what the analysis minimally required. If a future study could attract a much larger group of respondents, the chances of calculating better estimates would improve. It would also make it possible to retest the model in the form it was tested here and then test re-specifications of it that might be suggested by such retests. One of the virtues of a SEM approach to research is that, given sufficient sample size, researchers can identify opportunities for model improvement with one sub-sample and then attempt to confirm such improvements with another sub-sample. The current study had insufficient data to take on this task, but replications might have adequate numbers of respondents to do so. Future research should strive to attract enough respondents to allow the testing of multiple versions of the model.

Despite the need for future research to be conducted somewhat differently in order to foster progress in confirming and modifying the J&O model of knowledge management success, the current research provides some support for the model, certainly enough to prompt continued investigation. Additional work to develop this model will result, it is to be hoped, in an improved version that will provide researchers and practitioners with a sound explanation of success in knowledge management.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alreck, P.L., & Settle, R.B. (1995). *The survey research handbook: Guidelines and strategies for conducting a survey* (2nd ed.). New York: McGraw-Hill.

Argyris, C., & Schön, D.A. (1996). *Organizational learning II: Theory, method, and practice.* Reading, MA: Addison-Wesley.

Atkinson, R., & Flint, J. (2001). Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social Research Update, 33*. Retrieved September 30, 2004, from http://www.soc.surrey.ac.uk/sru/SRU33.html

Bahra, N. (2001). *Competitive knowledge management.* New York: Palgrave.

Byrne, B.M. (2001). *Structural equation modeling with AMOS: Basic concepts, applications, and programming.* Mahwah, NJ: Lawrence Erlbaum.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-339.

DeLone, W.H., & McLean, E.R. (1992). Information system success: The quest for the dependent variable. *Information Systems Research, 3*(1).

DeLone, W.H., & McLean, E.R. (2002). Information systems success revisited. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

DeLone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4).

Dewitz, S.D. (1996). *Systems analysis and design and the transition to objects.* New York: McGraw-Hill.

Doll, W.J., & Torkzadeh, G. (1988). The measurement of end-user computing satisfaction. *MIS Quarterly, 12*(2), 259-274.

Garson, G.D. (2004). *Quantitative research in public administration.* Retrieved October 1, 2004, from http://www2.chass.ncsu.edu/garson/pa765/

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

ISWorld. (2004a). *Information system effectiveness: IS effectiveness.* Retrieved September 29, 2004, from http://business.clemson.edu/ISE/html/is_effectiveness.html.

ISWorld. (2004b). *Information system effectiveness: Home*. Retrieved September 29, 2004, from http://business.clemson.edu/ISE/

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity, a longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Jennex, M.E., & Olfman, L. (2004, July). Modeling knowledge management success. *Proceedings of the Conference on Information Science and Technology Management (CISTM).*

Jennex, M.E., Olfman, L., & Addo, T.B.A. (2003). The need for an organizational knowledge management strategy. *Proceedings of the 36th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

Jennex, M.E., Olfman, L., Pituma, P., & Park, Y.T. (1998). An organizational memory information systems success model: An extension of DeLone and McLean's IS success model. *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.* IEEE Computer Society.

King, W.R., & Ko, D.G. (2001). Evaluating knowledge management and the learning organization. *Communications of the AIS, 5*(14), 1-26.

Kline, R.B. (1998). *Principles and practice of structural equation modeling.* New York: Guilford.

Liu, S.-C. (2003). *A study of the factors the facilitate use of knowledge management systems and the impact of use on individual learning*. Doctoral Dissertation, Claremont Graduate University, USA.

Moore, G.C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an IT innovation. *Information Systems Research, 2*(3), 192-222.

Nidumolu, S.R., & Knotts, G.W. (1998). The effects of customizability and reusability on perceived process and competitive performance of software firms. *MIS Quarterly, 22*(2).

Seddon, P.B., Staples, S., Patnayakuni, R., & Bowtell, M. (1999). Dimensions of information systems success. *Communications of the AIS, 2*(20).

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Thompson, R.L., Higgins, C.A., & Howell, J.M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Triandis, H.C. (1980). *Beliefs, attitudes, and values*. University of Nebraska Press.

Turban, E., & Aronson, J.E. (2001). *Decision support systems and intelligent systems* (6th ed.). Englewood Cliffs, NJ: Prentice-Hall.

ENDNOTES

[1] If a model is not identified, it is not theoretically possible to calculate unique estimates of its parameters references.

[2] The data collected in the Liu (2003) model are discussed when the survey that collected them is described.

[3] No data included in Liu (2003).

[4] Seddon et al. (1999) found that the combination of type of IT application and individual stakeholder was the second most common of the 30 possible combinations in their taxonomy, in terms of its appearance in an analysis they performed of 186 studies in three journals over a nine-year period.

[5] Information about Amos can be found at Assessment Systems Corporation (http://www.assess.com/frmSoftCat.htm).

[6] To be able to test a SEM model, it must be over-identified.

APPENDIX 1

Model Dimensions, Scales, and Items Used in Study

System Quality

Level

1. Completeness of search: Your KS allows you to do both information and people searches.
2. Effectiveness—knowledge base: Whenever you search the KS knowledge base and/or yellow pages, the retrieved knowledge is always what you need.
3. Effectiveness—linkage: Whenever you search the KS knowledge base and/or yellow pages, the returned linkage always directs you to the right person.
4. Speed of retrieval: Whenever you search the KS knowledge base and/or yellow pages, the retrieved results normally display quickly.
5. Ease of search: Your KS search function is easy to use.
6. Reliability: Your KS is not subject to frequent problems and crashes.

Form

1. Computerization: Your KS allows you to find most of the organizational information/knowledge online.
2. Integration: Whenever you search the KS, you don't need to try different ways to locate the needed information.
3. Integration: Whenever you search the KS, you don't need to try different ways to locate the right person.
4. Integration: Whenever you search the KS, you don't need to access more than one system to locate the needed information.
5. Integration: Whenever you search the KS, you don't need to access more than one system to locate the right person.

Information Quality

Richness

1. Relevance: Your KS provides information/knowledge that is exactly what you need.
2. Understandability: Your KS provides information/knowledge that uses recognized vocabulary rather than highly specialized terminology.
3. Adequacy: Your KS provides information/knowledge that is adequate for you to complete tasks.
4. Contextuality: Your KS provides contextual information/knowledge so that you can truly understand what is being accessed.
5. Contextuality: Your KS provides contextual information/knowledge so that you can easily apply it to your work.
6. Currency: Your KS provides up-to-date information/knowledge.

Linkages

1. Completeness of linkage: The knowledge portal of your KS links you to a complete collection of documents and data.
2. Accuracy of linkage: The yellow pages of your KS guides you to connect to the people with the know-how for which you are seeking.
3. Currency of linkage: Your organization keeps updating its knowledge portal so that you have access to current documents and data.
4. Currency of linkage: Your organization keeps updating its yellow pages so that you can locate newly hired or acquired expertise without a problem.

Service Quality

Resources

1. Technical support: Whenever you have difficulties with your KS, there is a specific person (or group) exist to help you.
2. Allow sufficient time for dialogue: You have sufficient time to engage in dialogue online with your coworkers about important problems and solutions.

Encouragement

1. Encouragement from peers: You are encouraged to engage in online exploration and experimentation by your peers.
2. Encouragement from supervisor: You are encouraged to engage in online exploration and experimentation by your supervisor.
3. Endorse knowledge sharing: Your organization actively endorses knowledge sharing.
4. Encourage online discussion: Your organization encourages online discussion of new ideas and working methods.

Perceived Benefits

Capability

1. Self-efficacy: You can use your KS without needing someone's help.
2. Cognitive capability: You find it easy to understand the information/knowledge you found in the knowledge base.

3. Cognitive capability: You find it easy to use the information/knowledge you found in the knowledge base.

Usefulness

1. Willingness to search: When job-related problems occur, you are willing to do an online search of your KS for solutions.
2. Tendency to analyze: You analyze and interpret what is brought to your attention in your KS.
3. Perceived usefulness: You find your KS useful in your job.

Use

Utilization

1. Distribution: Your KS helps your daily work by distributing customized knowledge to you.
2. Distribution: Your KS helps your daily work by distributing customized knowledge to others.

Knowledge Application

1. Decision making and problem solving: You use knowledge from the KS to perform decision-making and problem-solving tasks.
2. Questioning rules and routines: You use knowledge from the KS to question existing rules and routines.
3. Exploring alternatives: You use knowledge from the KS to search for and explore alternatives.

Net Benefits

Change

1. Cognitive change: Your KS helps you to detect work-related problems.
2. Cognitive change: Your KS enlightens you to new ways of thinking.
3. Behavioral change: Your KS changes the way you do things in a way beneficial to the organization's overall interest.

Performance

1. Better decisions: Your KS improves the decisions you make.
2. Fewer mistakes: Your KS helps you to make fewer mistakes.
3. Better experience transfer/knowledge reuse: Your KS allows better experience transfer and knowledge reuse.
4. Reduce duplicate work: Your KS reduces duplicate work.
5. Better cycle time: Your KS allows you faster cycle time to problem resolution.

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Chapter 2.23
Extracting Knowledge from Neural Networks

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INTRODUCTION

Neural networks (NN) as classifier systems have shown great promise in many problem domains in empirical studies over the past two decades. Using case classification accuracy as the criteria, neural networks have typically outperformed traditional parametric techniques (e.g., discriminant analysis, logistic regression) as well as other non-parametric approaches (e.g., various inductive learning systems such as ID3, C4.5, CART, etc.).

In spite of this strong evidence of superior performance, the use of neural networks in organizations has been hampered by the lack of an "easy" way of explaining what the neural network has learned about the domain being studied. It is well known that knowledge in a neural network is "mysteriously" encapsulated in its connection weights. It is well accepted that decision-makers prefer techniques that can provide good explanations about the knowledge found in a domain even if they are less effective in terms of classification accuracy.

Over the past decade, neural network researchers have thus begun an active research stream that focuses on developing techniques for extracting usable knowledge from a trained neural network. The literature has become quite vast and, unfortunately, still lacks any form of consensus on the best way to help neural networks be more useful to knowledge discovery practitioners.

This article will then provide a brief review of recent work in one specific area of the neural network/knowledge discovery research stream. This review considers knowledge extraction techniques that create IF-THEN rules from trained feed-forward neural networks used as classifiers.

We chose this narrow view for a couple of important reasons. First, as mentioned, the research in this area is extraordinarily broad and a critical review cannot be done without focusing on a smaller subset within the literature. Second, classification problems are a familiar problem in business. Third, creating basic IF-THEN rules from a trained neural network is viewed as the most useful area in the entire research stream for the knowledge management and data mining practitioner.

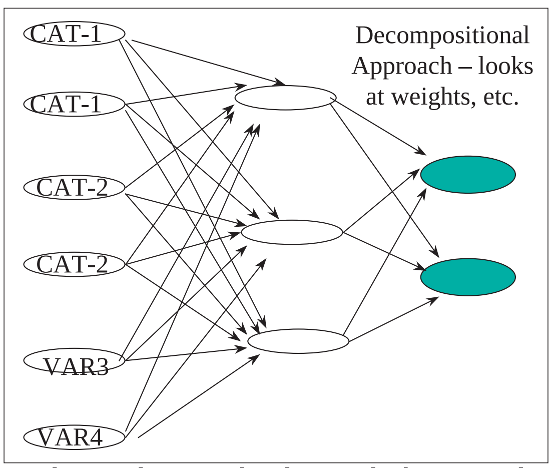
With this narrow focus, some aspects of knowledge extraction from neural networks are obviously not mentioned here. With the focus on deterministic IF-THEN rules, outputs that include "fuzziness" (fuzzy logic) are omitted. In addition, research that involves different neural network architectures (e.g., recurrent networks) and/or different knowledge discovery problem areas (e.g., regression/prediction rather than classification) are also excluded from the review.

BACKGROUND

The discussion of the different neural network knowledge extraction techniques are organized around the fundamental premise or process used for rule extraction. Previous researchers (including Tickle, Maire, Bologna, Andrews, & Diederich, 2000) have used the following terms to help segment the different approaches: decompositional, pedagogical, and eclectic.

Decompositional techniques for rule extraction are approaches that perform rule extraction at the individual neuron (or neural component) level. Pedagogical approaches, on the other hand, extract knowledge by treating the entire NN as a "black box," creating rules by correlating inputs to the neural network to the resultant outputs (without considering anything about the structure or weights of the NN). It is reasonable to think of these two terms as extreme points in a continuous spectrum of approaches. Eclectic approaches are techniques that borrow some aspects from each of the two extremes.

Figure 1.



Pedagogical Approach – does not look at internal weights – just inputs and outputs

Figure 1 helps visualize how these algorithms work. Figure 1 shows a 6-input, 3 hidden neuron, 2 output neural network. Assuming no bias inputs and a fully connected neural network, there would be 24 connection weights (not shown) which represent the knowledge stored in the neural network (after, of course, the NN has been trained on a set of data). The decompositional approaches will examine (at least) the connection weights that lead to each hidden neuron and will "discover rules" such as IF X2 < 7, THEN CONCLUDE Class A. Pedagogical approaches would present systematic random inputs to the neural network, observe the output of the neural networks, and "learn" rules like above through studying the relationship between input and output variations.

The review of pertinent neural network rule extraction algorithms also will include three different measures of technique usefulness (accuracy, fidelity, and comprehensibility) when such measures have been studied. These three different measures of technique usefulness are important in assessing the quality of the different methodologies. Accuracy measures the ability of the derived rule set to classify cases from the problem domain. This is typically reported as percentage correctly classified. Fidelity measures how well classification of cases using rules extracted from the trained NN mimic the classification of just the original NN. Comprehensibility measures the size of the rule set extracted from the neural network, looking at both number of rules and the number of antecedents in the rule. This is a measure of rule complexity.

Additionally, any empirical comparisons to other "competing" rule extraction techniques will also be shared, as well as any empirical comparisons to other comparable well-known knowledge discovery techniques such as inductive learning systems (which might include such well-studied techniques as ID3, C4.5, CART, and See5, among others).

The comparisons to other knowledge discovery techniques that result in decision trees, rules, and so forth are particularly relevant to practice. The techniques discussed in this article use a two-step approach to knowledge elicitation: first, one trains a neural network on a set of cases, and then rules are found through the specific technique. Inductive learning approaches accomplished this in one step directly from the cases. The ongoing research into the two-step neural network process seeks to explore the contention by Tickle et al. (2000) and others who claim that rule extraction from trained neural networks will (someday) be a better approach than inductive learning systems. This claim stems from the potential for realizing additional correct classifications (which is well documented) possible with neural networks. The quest for this still continues, and results (as shown) show promise. The next section outlines recent progress in this area.

NN RULE EXTRACTION REVIEW

Decompositional Approaches

Su, Hsu, and Tsai (2002) present a decompositional methodology that is similar to many in this category. After a feed-forward NN is trained, important inputs are identified and unnecessary connections are pruned from the network in an iterative fashion. Input data is then transformed into binary form, and then the knowledge (in rules) is extracted by building truth tables for each hidden neuron. The rules are simplified using Karnaugh maps and removing repetitive statements. The classification accuracy of this algorithm showed mixed results when compared to the original neural network model and the inductive learning approach See5. However, their algorithm had increased comprehensibility compared to See5, requiring far fewer attributes to classify the data.

The GLARE approach (GeneraLized Analytic Rule Extraction) is similar, extracting rules from standard feed-forward backpropagation networks requiring binary inputs (Gupta, Park, & Lam, 1999). First, weights between input nodes and hidden nodes are ranked, determining the largest connection weights. Next, another index calculates the importance of the connections between the hidden and output layers using the ranking. This step leads to the extraction of symbolic rules. Using classification accuracy as a benchmark with strictly categorical datasets, GLARE performs as well or better as the inductive learning system C4.5 and the original backpropagation NN. When used with datasets possessing continuous inputs that were converted to Boolean inputs, GLARE's performance suffered significantly.

Vaughn, Cavill, Taylor, Foy, and Fogg (2000) report on a rule extraction method developed for mutli-layer feed-forward neural networks with binary inputs. Their method ranks the activation contributions to each of the hidden neurons, and then repeats the process to determine the significant input neurons. Rules are extracted by combining the significant inputs related to a particular class, in ranked order.

The FERNN (Fast method for Extracting Rules from NN) approach applies a different strategy to the problem. It uses two primary components to generate rules from a neural network (Setiono & Leow, 2000). First, the neural network is trained using an algorithm that seeks to minimize the connection weights of irrelevant inputs. Then, a decision tree is generated from the network's single hidden layer. The algorithm identifies and removes irrelevant inputs while maintaining the network's accuracy. Unlike other algorithms that may apply pruning, FERNN does not require the network to be retrained after connections are removed, which makes rule extraction faster. Rules can be generated from datasets with both continuous and discrete attributes. Empirically, this algorithm was shown to be more accurate than C4.5 for most datasets, while also creating smaller trees. The authors report that FERNN has a high degree of fidelity with the original neural networks.

Fan and Li (2002) present a method for rule extraction in which the hidden neurons are used to partition the input space into subspaces. There are as many partitions as hidden neurons in the network. To extract rules, the data that "fall" in the subspaces are analyzed based on their "classes." The derived rules from this step are then reduced and simplified. The methods were compared to the original NN, genetic algorithms, C4.5, and rough set approaches using the linearly separable IRIS dataset. In this domain, the proposed rule extraction method showed better accuracy and greater comprehensibility than the other methods.

Tsukimoto (2000) presents a decompositional method for extracting rules using Boolean functions. The algorithm is not dependent on any particular network structure or training algorithm and can be applied to NN's with both discrete and continuous values. The only specific requirement is that the NN must have a monotone output function. Experimental results of this algorithm show its accuracy to be slightly better than C4.5 for a binary dataset and slightly worse for discrete and continuous datasets. The comprehensibility of the rules extracted using this method was about the same as C4.5.

Continuous/discrete Rule Extractor via Decision tree Induction (CRED) is another decompositional algorithm that can be used with both discrete and continuous input variables (Sato & Tsukimoto, 2001). In contrast to previous "old" approaches TREPAN (Craven & Shavlik, 1996) and the method of Krishnan et al. (1999) mentioned later in this article, CRED extracts separate trees at the hidden-to-output and input-to-hidden layers instead of a single tree. Rules are formed from these trees, which are then merged and simplified. CRED was tested on several datasets and demonstrated acceptable accuracy levels, but was not compared to other rule extraction or data mining methods.

Schmidt and Chen (2002) use an Aggregate Feed-Forward Neural Network (AFFNN) as a foundation for their rule extraction/neural network approach. The AFFNN is a fully connected network with a single hidden layer, using a combination of pre-and post-processing operations with a modified training routine. The proposed algorithm begins at the output layer, working backward to discover the supporting or related hidden nodes to the specific output neuron, then likewise finds the corresponding supporting input nodes. Fifteen rules were created from the AFFNN in analyzing the well-known MONK-2 dataset with 100% accuracy, compared to inductive learning system ID3 which created a tree with 66 nodes and 110 leaves and had 67.9% accuracy.

Finally, a greedy clustering algorithm (GCA) which fits the decompositional approach was proposed by Setiono and Liu (1998). The GCA creates clusters based on the activation values of the hidden neurons of the neural network. After clusters are formed, they are used to associate output neurons to relevant inputs. For the classic Pima Indian Diabetes dataset, GCA created a more accurate network than C4.5 on testing data and required only one rule to classify the data, compared to 12 rules (with up to ten antecedents) for C4.5. Also, for the aforementioned MONK-2 problem, the GCA created a 100% accurate network requiring one rule to classify the data.

In summary, many different decompositional approaches have been proposed, but few of these studies have directly compared the different approaches. There remain numerous choices for the data mining practitioner, but no clear cut "best" approach. It is interesting to note that much of the early work in this area focused on converting continuous data to binary or discrete data values prior to knowledge extraction. This may be a big drawback of such techniques in real-world settings unless little is lost in accuracy when discretizing the variables.

Pedagogical Approaches

Taha and Ghosh (1999) present a family of approaches for the neural network rule extraction problem starting with BIO-RE, a pedagogical approach. BIO-RE requires a trained network with binary inputs. The authors claim their method is suitable only for a small number of inputs but does not require a particular network structure or training algorithm.

If binary inputs are not suitable or the number of inputs is large, Partial-RE is their alternative approach. Partial-RE identifies dominant node combinations in the network, and extracts rules according to user-specified parameters on completeness. However, performances were problematic if data was not in binary or discretized form.

Finally, the authors also propose Full-RE, a decompositional variant of this rule extraction family that can extract rules from networks with continuous, normal, or binary inputs and is claimed effective for networks of any size. For the IRIS and Wisconsin Breast Cancer data, Full-RE performed favorably to older rule extraction techniques such as NeuroRule (see Setiono & Liu, 1995) and inductive learning approaches such as C4.5, extracting fewer rules with the same or less number of antecedents and had comparable accuracy.

Krishnan, Sivakumar, and Bhattacharya (1999) present a pedagogical method based on genetic algorithms for extracting decision trees from trained neural networks. The method first determines which inputs are relevant to build the decision tree. The tree is then modified systematically to increase comprehensibility or accuracy. This algorithm was less accurate than the original neural network and ID3, but did produce a much smaller tree than ID3. The decision trees resulting from this algorithm were shown to have fidelity over 90%.

Palade, Neagu, and Puscasu (2000) propose a method of rule extraction by interval propagation of an inverted neural network. Their extraction algorithm calculates the required input of the NN for a specified output. The method does not require a particular neural network structure and can utilize continuous inputs and outputs. Unfortunately, this method was not compared to other approaches.

Shigaki and Narazaki (1999) employed a similar approach in the domain of modeling the sintering process used in iron and steel making industry. Their algorithm estimates monotonic regions in the neural network by sampling input vectors. These regions are composed of points with the same class membership and consider various sensitivity patterns. Their approach was not compared to other methods.

Artificial neural-network decision tree algorithm (ANN-DT) is a pedagogical rule extraction technique similar to the inductive learning approach CART (Schmitz, Aldrich, & Gouws, 1999). ANN-DT does not require a particular network structure and input can be discrete or continuous. The algorithm samples the input space of the network, resulting in reduction of the number of rules needed to accurately describe the data. ANN-DT uses a statistical pruning technique similar to that employed by CART. Experimental results showed the ANN-DT algorithm is at least as accurate as CART and has increased fidelity. However, the decision trees created by ANN-DT were more complex for most of the datasets tested.

STAtistics-based Rule Extraction (STARE) is another pedagogical approach. This algorithm limits extracted rules to three antecedents, which increases comprehensibility (Zhou, Chen, & Chen, 2000). The STARE approach also does not require a specific type of network or training method. The rule discretizes continuous attributes while rules are generated. Fidelity also is evaluated as part of the algorithm. Rules not meeting user-specified criteria are not be added to the rule set. Due in part to the limit on the number of antecedents per rule, STARE created more rules than Craven and Shavlik's (1994) approach to rule extraction, but with greater fidelity. Also, STARE had greater classification accuracy when compared to C4.5 for most datasets utilized.

Interestingly, the basic principles of STARE also have been applied to trained neural network ensembles using the Rule Extraction From Neural Network Ensemble (REFNE) approach (Zhou, Jiang, & Chen, 2003). REFNE prioritizes rules and discretizes attributes in a similar manner. Experimental comparisons have been made between REFNE, a trained ensemble, a single neural network, and C4.5. REFNE showed better accuracy than the other three methods. REFNE created more rules per dataset than C4.5, but the rules created by C4.5 had more antecedents per rule.

Again, as with the decompositional approaches, very little comparison has been done between the pedagogical approaches. Many techniques still require discretization of continuous inputs. Systematic analysis of these similar techniques remains lacking in the research literature.

Hybrid/Eclectic Approaches

We end our article by discussing techniques that fit somewhere between the two extreme approaches. Bologna (2000a, 2000b) proposed the Discretized Interpretable Multi Layer Perceptron Model (DIMLP) where neurons of the first hidden layer are connected to only one input neuron. The rest of the network is fully connected. A staircase activation function is used in the first hidden layer (instead of the usual sigmoid function) to transform continuous inputs into discrete values. The extraction technique determines discriminant hyper-plane frontiers, builds a decision tree from this result, and then further prunes and modified the resultant rules. Thus, it uses components of decompositional approaches (pruning, hidden layer analysis) and pedagogical (use of hyper-plane frontiers).

In analyzing the results of DIMLP, it had nearly the same classification accuracy as the original NN on test data and had 100% fidelity on training data. DIMLP also was more accurate than C4.5 on several datasets, but demonstrated less comprehensibility (i.e., more rules and more antecedents per rule).

Interestingly, much like the aforementioned REFNE, DIMLP has recently been extended to generate rules from ensembles of DIMLP networks (Bologna, 2001; Bologna, 2003). Rule extraction from the ensembles showed improved accuracy over rule extraction from single DIMLP networks. Therefore, as more and more practitioners use an ensemble approach in their data mining applications, DIMLP offers additional promise.

Finally, Garcez, Broda, and Gabbay (2001) present a method for extracting rules that they claim has high accuracy and fidelity. Their algorithm performs a partial ordering on the set of input vectors of a neural network and then uses a related set of pruning and simplification rules. The method is unique in its use of default negation to capture nonmonotonic rules from the network. This algorithm is slightly less accurate than the classic M of N approach and Setiono's method (Setiono, 1997; Towell & Shavlik, 1993), but the method shows increased fidelity. To achieve this fidelity, the algorithm produces a larger set of rules. The algorithm requires a network with only one hidden layer, but has no specific training requirements.

FUTURE TRENDS

It is clear that no technique or tool has emerged as useful in all (or most) knowledge discovery/data mining circumstances for extracting rules from classification neural networks. Many techniques show promise, but there is a clear lack of systematic study and analysis in the literature. Few comparative studies of rule extraction techniques have been done, and even when such studies have been undertaken, small datasets have been employed. Table 1 provides a comprehensive summary of the techniques previously discussed.

Decision-makers in the knowledge-enabled organizations of today need more than just the high "classification" accuracy that sophisticated techniques like neural networks deliver to their desktop. They also want to gain insight into the problem domain; thus, the explanatory or "lessons learned" knowledge from their analyses is

Table 1.

	Category	Data sets used for experiments	Other techniques compared to:	Form of input data:	Specialized Network or Network requirement(s)
Bologna, 2000 a, b	Eclectic	Ionosphere, Monk-1, Monk-2, Monk-3, Pen Based Handwritten digits, Sonar	MLP, C4.5	Neurons of first hidden layer transform continous inputs into discrete values	Each neuron in first hidden layer connected to only one input neuron. Other layers fully connected. Staircase activation function for first hidden layer.
Bologna, 2001, 2003	Eclectic	Arrythmia, Breast-cancer, Wisconsin Breast Cancer(Original and Diagnostic), Dermatology, Echocardiogram, Heart Disease-Cleveland, Heart Disease-Hungarian, Heart Disease-statlog, Hepatitis, Hypothyroid, Iris, Liver-disorders, Lymphography, Pima Indians Di	MLP, CN2, C4.5		Network ensembles. Staircase activation function for neurons in first hidden layer.
Fan & Li, 2002	Decompositional	Iris, *High-pressure air compressor*	NN, Genetic Algorithm, C4.5, Rough Set	Not specified	Hidden-to-output function is linear
Garcez, Broda, & Gabbay, 2001	Eclectic	DNA Sequence Analysis, Monk's, Power Systems Fault Diagnosis	MofN, Subset, Setiono, 1997	Binary	single hidden layer
Gupta, Park, & Lam, 1999	Decompositional	Balloon, BUPA, Glass, Hepatitis, Iris, Postoperative Patient (Post)	NN, C4.5	Inputs converted to boolean	Single hidden layer
Krishnan, Sivakumar, & Bhattacharya, 1999	Pedagogical	Iris, Wine Recognition, Wisconsin Breast Cancer	NN, ID3	No requirement	No special requirements.
Palade, Neagu, & Puscasu, 2000	Pedagogical	*Liquid Tank*	None	Continuous	Nonlinear activation function
Sato & Tsukimoto, 2001	Decompositional	Auto-mpg, Wisconsin University Breast-cancer, BUPA, Credit, IRIS, Machine, Monk 1, Monk 3, University	None	Continuous and Discrete	No special requirements.
Schmidt & Chen, 2002	Decompositional	Iris, Monk-2,	mFOIL, ID3, NN	Binary	Requires pre- and post-processing operations and specialized performance wedge

extremely important. Conventional wisdom also would indicate that the simpler the explanation or knowledge extraction results, the higher desirability, larger user acceptance, and bigger payoff to the organization. Thus, the attraction of using NN's (shown to be, for the most part, empirically superior knowledge discovery tools) to provide IF-THEN level explanations (simple yet effective explanations of organizational phenomenon) normally provided by inductive learning systems or by expert knowledge seems worthy of more in-depth study.

We expect future data mining researchers to begin to focus more in this area of knowledge extraction and elicitation, rather than seeking new classification algorithms. Clearly, the potential exists for the organizational usefulness of neural networks to be enhanced by continued progress in this area.

Table 1 (cont.)

	Category	Data sets used for experiments	Other techniques compared to:	Form of input data:	Specialized Network or Network requirement(s)
Schmitz, Aldrich, and Gouws, 1999	Pedagogical	Abalone, *Sap Flow in Pine Trees, Sine and Cosine Curves*	CART	Discrete or Continuous	No special requirements.
Setiono & Leow, 2000	Decompostional	Monk 1, Monk2, Monk 3, *CNF12a, CNF 12b, DNF 12a, DNF 12b, MAJ12a, MAJ12b, MUX 12* , Australian Credit Approval, Wisconsin Breast Cancer, Heart Disease, Pima Indians, Sonar	N2P2F+C4.5, C4.5	Discrete or Continuous	Minimize augmented cross-entropy error.
Setiono & Liu, 1998	Decompositional	*Contiguity, 5-Bit Parity* , Monks, Pima Indian	ARTMAP, C4.5	Binary, Discrete or Continuous (normalized to [-1,1])	Sigmoid or hyperbolic tangent activation function. Minimize cross entropy error, BFGS training algorithm.
Shigaki & Narazaki, 1999	Pedagogical	*Sintering*	None	Continuous	No special requirements.
Su, Hsu & Tsai, 2002	Decompositional	Pima Indian Liver	NN, See5	Not limited	Output function must be monotone.
Taha & Ghosh, 1999	BIO-RE-Pedagogical; Partial-RE, Full-REDecomposition al	*Artificial Binary Problem* , Iris, Wisconsin Breast Cancer	NeuroRule, C4.5, KT	BIO-Re: Binary, Partial-RE Normalized (0,1), Full-RE: No restriction	Monotonically increasing activation function.
Tsukimoto, 2000	Decompositional	Congressional Voting Records, Iris, Mushroom	C4.5,	Discrete or Continuous	Output function must be monotone increasing.Sigmoidal activation function.
Vaughn, Cavill, Taylor, Foy, & Fogg, 2000	Decompositional	*Lower Back Pain*	None	Binary	No special requirements.
Zhou, Chen, & Chen, 2000	Pedagogical	Auto imports, Credit screening, *Fault Diagnosis* , Hepatitis, Iris plant, Lung cancer	Craven & Shavlik,1994, C4.5	Discrete or Continuous	No special requirements.
Zhou, Jiang, & Chen, 2003	Pedagogical	Balance Scale, Congressional Voting Records, Hepatitis, Iris, Statlog Australian Credit approval, Stalog German credit	C4.5	Discrete or Continuous	Network ensemble generated via plurality voting.
Note: For italicized data sets, see cited article for description of data. For all other data sets, source of data is University of California-Irvine Machine Learning Repository (http://www.ics.uci.edu/~mlearn/MLRepository.html).					

CONCLUSION

The potential of neural network use as data mining tools has not been fully exploited due to the inability to explain the knowledge they learn. In reviewing the literature in this article, it is apparent that there are techniques that may offer this ability, but systematic study of such approaches has been minimal. Our hope is that once this "gap" is filled in the literature, and assuming positive results are found, neural network use by practitioners will be greatly enhanced, which will serve to increase the usefulness and profitability of knowledge management initiatives in many organizations.

REFERENCES

Bologna, G. (2000a). *Rule extraction from a multilayer perceptron with staircase activation functions.* Paper presented at the International Joint Conference on Neural Networks.

Bologna, G. (2000b). Symbolic rule extraction from the DIMLP neural network. In *Hybrid neural systems* (Vol. 1778, pp. 240-254). Berlin: Springer-Verlag Berlin.

Bologna, G. (2001). A study on rule extraction from several combined neural networks. *International Journal of Neural Systems, 11*(3), 247-255.

Bologna, G. (2003). A model for single and multiple knowledge-based networks. *Artificial Intelligence in Medicine, 28*(2), 141-163.

Craven, M.W., & Shavlik, J.W. (1996). Extracting tree-structured representations of trained networks. Advances In *Neural Information Processing Systems*, (8), 24-30.

Craven, M.W., & Shavlik, J.W. (1994). Using sampling and queries to extract rules from trained neural networks. *Proceedings of the 11th International Conference of Machine Learning,* San Francisco.

Fan, Y., & Li, C.J. (2002). Diagnostic rule extraction from trained feed forward neural networks. *Mechanical Systems and Signal Processing, 16*(6), 1073-1081.

Garcez, A.S.D., Broda, K., & Gabbay, D.M. (2001). Symbolic knowledge extraction from trained neural networks: A sound approach. *Artificial Intelligence, 125*(1-2), 155-207.

Gupta, A., Park, S., & Lam, S.M. (1999). Generalized analytic rule extraction for feed forward neural networks. *IEEE Transactions on Knowledge and Data Engineering, 11*(6), 985-991.

Krishnan, R., Sivakumar, G., et al. (1999). Extracting decision trees from trained neural networks. *Pattern Recognition, 32*(12), 1999-2009.

Palade, V., Neagu, D.-C., & Puscasu, G. (2000). Rule extraction from neural networks by interval propagation. *Proceedings of the 4th International Conference on the Knowledge-Based Intelligent Engineering Systems and Allied Technologies.*

Sato, M., & Tsukimoto, H. (2001). *Rule extraction from neural networks via decision tree induction*. Paper presented at the International Joint Conference on Neural Networks.

Schmidt, V.A., and Chen, C.L.P. (2002). Using the aggregate feedforward neural network for rule extraction. *International Journal of Fuzzy Systems, 4*(3), 795-806.

Schmitz, G.P.J., Aldrich, C., & Gouws, F.S. (1999). ANN-DT: An algorithm for extraction of decision trees from artificial neural networks. *IEEE Transactions on Neural Networks, 10*(6), 1392-1401.

Setiono, R. (1997). Extracting rules from neural networks by pruning and hidden-unit splitting. *Neural Computation, 9*(1), 205-225.

Setiono, R., & Leow, W.K. (2000). FERNN: An algorithm for fast extraction of rules from neural networks. *Applied Intelligence, 12*(1-2), 15-25.

Setiono, R., & Liu, H. (1995). Understanding neural networks via rule extraction. Paper presented at the *Proceedings of International Joint Conference on Artificial Intelligence,* Montreal, Quebec, Canada.

Setiono, R., & Liu, H. (1998). Analysis of hidden representations by greedy clustering. *Connection Science, 10*(1), 21-42.

Shigaki, I., & Narazaki, H. (1999). A machine-learning approach for a sintering process using a neural network. *Production Planning & Control, 10*(8), 727-734.

Su, C.T., Hsu, H.H., & Tsai, C.H. (2002). Knowledge mining from trained neural networks. *Journal of Computer Information Systems, 42*(4), 61-70.

Taha, I.A., & Ghosh, J. (1999). Symbolic interpretation of artificial neural networks. *IEEE Transactions on Knowledge and Data Engineering, 11*(3), 448-463.

Tickle, A.B., Maire, F., Bologna, G., Andrews, R., & Diederich, J. (2000). Lessons from past, current issues, and future research directions in extracting the knowledge embedded in artificial neural networks. In *Hybrid neural systems* (Vol. 1778, pp. 226-239). Berlin: Springer-Verlag Berlin.

Towell, G.G., & Shavlik, J.W. (1993). Extracting refined rules from knowledge-based neural networks. *Machine Learning, 13*(1), 71-101.

Tsukimoto, H. (2000). Extracting rules from trained neural networks. *IEEE Transactions on Neural Networks, 11*(2), 377-389.

Vaughn, M.L., Cavill, S.J., Taylor, S.J., Foy, M.A., & Fogg, A.J.B. (2000). Direct explanations and knowledge extraction from a Multilayer Perceptron network that performs low back pain classification. In *Hybrid neural systems* (Vol. 1778, pp. 270-285). Berlin: Springer-Verlag Berlin.

Zhou, Z.-H., Jiang, Y., & Chen, S.-F. (2003). Extracting symbolic rules from trained neural network ensembles. *AI Communications* (Vol. 16, p. 3). IOS Press.

Zhou, Z.-H., Chen, S.-F., & Chen, Z.-Q. (2000). A statistics based approach for extracting priority rules from trained neural networks. Paper presented at the *Proceedings of IEEE-INNS-ENNS International Joint Conference on Neural Networks,* Como, Italy.

Chapter 2.24
Critical Success Factors of ERP Implementation

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INTRODUCTION

An enterprise resource planning (ERP) system is an integrated set of programs that provides support for core organizational activities, such as manufacturing and logistics, finance and accounting, sales and marketing, and human resources. An ERP system helps the different parts of an organization share data and knowledge, reduce costs, and improve management of business processes. In spite of their benefits, many ERP systems fail (Stratman & Roth, 1999). Implementing an ERP system is a major undertaking. About 90% of ERP implementations are late or over budget (Martin, 1998), and the success rate of ERP systems implementation is only about 33% (Zhang et al., 2003).

Over the past few years, limited research has been conducted about ERP implementation issues: mainly, case studies in individual organizations have been reported. A major problem with such ERP case studies is that very few implementation failures have been recorded in the literature, and thus, the reasons why implementations fail are not known to practitioners and researchers. That is a motivation toward conducting empirical studies to explore critical factors that affect ERP systems implementation. A recent summary of ERP literature stated that research of critical success factors (CSFs) in ERP implementation is rare and fragmented (Nah, Lau, & Kuang, 2001). The idea of identifying CSFs as a basis for determining the information needs of managers was popularized by Rockart (1979). CSFs are those factors that are critical to the success of any organization, in the sense that, if objectives associated with the factors are not achieved, the organization will fail—perhaps catastrophically (Rockart, 1979). In the context of ERP project implementation, CSFs represent the essential ingredients, without which a project stands little chance of success. This study examines the CSFs for implementing ERP systems in Venezuela. Managers from seven corporations, who were identified as having key roles in ERP systems implementation, were surveyed in order to assess empirically which CSFs are critical in leading a successful implementation of ERP systems in Venezuela. This article is organized into four sections. First, ERP-related literature is reviewed. The next section introduces the research methodology, followed by presentation of the results. The article ends with the conclusions and implications for future research and practice.

BACKGROUND

Implementing an ERP system is not an easy task. It can cause dramatic changes that need to be carefully administered if the potential advantages of an ERP solution (Al-Mudimigh, Zairi, & Al-Mashari, 2001) are to be gained. In some well-documented cases, spectacular results have been achieved (Johnston, 2002). There is, on the other hand, a relatively high failure rate: it was reported that three-quarters of ERP projects were judged to be unsuccessful by the ERP implementing firms (Kyung & Young, 2002). Also, failures are much less extensively documented. As a result, pitfalls to be avoided tend to be less well known. Venezuelan companies are just starting to use ERP systems. They started applying ERP concepts late in the 1990s. Because of the complex and integrated nature of ERP, and the large investment involved, it is imperative for organizations to study the experiences of others and to learn from their practices and success factors (Zairi et al., 2000). Identifying CSFs relevant to local companies is one way to increase the chances of a successful local implementation (Sum, Ang, & Yeo, 1997).

A literature review was conducted to understand the CSFs in successful ERP implementations. The review covered numerous articles (Bingi, Sharma, & Godla, 1999; Esteves & Pastor, 2001; Falkowski et al., 1998; Holland & Light, 1999; Nah, Lau, & Kuang, 2001; Rosario, 2000; Stefanou, 1999; Sumner, 1999; Wee, 2000). The literature varies according to the variables required for implementation success, so there is no general consensus as to the factors that are key to success in ERP implementation. It is probably a combination of factors that is important in explaining ERP implementation success (Zhang et al., 2003). From the review, 20 factors emerged as critical to the successful implementation of ERP systems. They were obtained after careful analysis and grouping of related subfactors:

1. Top management support
2. User training
3. Use of consultants
4. User participation
5. Vendor package selection
6. Use of steering committee
7. Discipline and standardization
8. Minimal customization
9. Use of vendor's development tools
10. Best people full time
11. Technical and business knowledge
12. Implementation approach
13. Clear goals, focus, and scope
14. Business process reengineering
15. Project management
16. Effective communications
17. Presence of a champion
18. Interdepartmental cooperation and communication
19. Management of expectations
20. Vendor/customer partnership

RESEARCH METHODOLOGY

The choice of an appropriate research methodology is critical in guiding researchers on how best to meet research objectives. In this study, the purpose was to discover the perceptions and experiences of companies using ERP systems in Venezuela, and to use that information as the basis of data collection. The analysis has enabled the identification CSFs of ERP systems implementation in Venezuelan companies.

The targets of the study were the organizations that implemented ERP systems successfully. The key informant method was used for collecting information in a social setting by surveying (or interviewing) a selected number of participants. Seven firms were identified from the list provided by ERP vendors. We contacted the ERP project managers in charge of ERP implementation of each company. About 100 questionnaires were sent to the ERP project managers of each firm, who forwarded the questionnaires to the project team members in charge of individual processes. A total of 72 questionnaires were returned, of which 69 were valid.

The questionnaire consisted of two main parts: the company background and the CSFs. The first part was designed to determine characteristics such as size of the company, type of industry, location of company, etc. The second part consisted of 20 statements about the success factors of ERP systems implementation derived from the literature review. The language used in the survey was Spanish. Translation was easy, because Venezuelans used original English terms for many technical and management concepts and especially for information systems and computing concepts.

Participants were requested to rate the importance of each CSF using a five-point Likert scale, where a score of 5 indicated “extremely critical,” and a score of 1 indicated “not critical.” This method was employed on the grounds that a rating method avoids the problem of having to consider 20 CSFs simultaneously in order to rank them. The data collected were then analyzed by using SPSS. Based on the responses, descriptive statistics, factor analysis (FA), and reliability tests were carried out to identify the CSFs for the successful implementation of ERP systems and data validity, respectively.

RESULTS

Ranking

The importance rating of the 20 CSFs is listed in Table I.

The individual mean value of the Likert rating scale is the popular usage indicator for measuring an item’s importance, without regard to the other items; therefore, the higher the value, the more important the factor. Most items are rated above the 3.0 scale (midpoint). The three most important factors, in order of declining importance, are top management support, presence of a champion, and project management, with a mean value ranging from 4.80–4.64. Just as the literature argues, these are key items for ERP implementation management (Johnston, 2002). Conversely, use of steering committee, business process reengineering, and use of vendor’s development tools, are the three items lowest in the list, with a mean value ranging from 2.95–2.06.

Factor Analysis

In an attempt to reduce the number of items (CSFs), and to understand their underlying structure, a factor analysis (FA) was performed. FA is a data reduction technique that uses correlations between data variables. The underlying assumption of FA is that a number of factors exist to explain the correlations or interrelationships among observed variables (Chatfield & Collins, 1992). For the present study, FA was performed on all 20 variables using principal components extraction (Tabachnick & Fidell, 1989). The goal of this method is to extract maximum variance from the data set within each factor. It is basically used to reduce a large number of variables to a smaller number of components. The measure of sampling adequacy for the 20 items was 0.87, indicating that the items were suitable for factoring (Kaiser, 1974).

Table 1.Ranking of CSFs

Rank	CSF	Mean	Standard Deviation
1	Top management support	4.80	0.62
2	Presence of a champion	4.75	0.85
3	Project management	4.64	0.92
4	Best people full time	4.58	0.60
5	Effective communications	4.51	0.85
6	Interdepartmental cooperation and communication	4.40	0.91
7	Management of expectations	4.36	1.02
8	Technical and business knowledge	4.33	1.21
9	User participation	4.22	0.82
10	Discipline and standardization	4.09	0.85
11	Vendor package selection	4.02	0.61
12	User training	4.01	1.12
13	Implementation approach	4.00	1.20
14	Clear goals, focus, and scope	3.89	1.14
15	Use of consultants	3.75	0.85
16	Minimal customization	3.68	1.52
17	Vendor/customer partnership	3.15	0.52
18	Use of steering committee	2.95	0.63
19	Business process reengineering	2.84	0.55
20	Use of vendor's development tools	2.06	0.42

Notes: N: 69; Scale: 1–5 (5: "extremely critical," 1: "not critical").

A three-stage factor analysis was conducted with an orthogonal (varimax) rotation to obtain a stable factor structure (Rai et al., 1996), resulting in easily interpretable factors. Under this three-round factor analysis, items were omitted according to the following two criteria: (1) no loading greater than 0.35, or (2) loading greater than 0.35 on two or more factors (Kim & Mueller, 1978).

Table 2 shows the results of this analysis. A first-factor analysis was conducted and produced five factors. According to the two criteria, three items were dropped. A second factor analysis on the remaining 17 items resulted in four factors and the dropping of three items. Finally, a three-factor structure was derived that kept a total of 14 items after three iterations. The minimum eigenvalue from a varimax rotation for which a factor was to be retained was set at 1.0 in order to satisfy the minimum eigenvalue criterion (Nunnally, 1978). The three factors are as follows:

1. Factor 1, named "ERP implementation management," comprises six items relating to implementation management: top management support, presence of a champion, project management, management of expectations, implementation approach, and clear goals, focus, and scope.
2. Factor 2, named "user aptitudes and communication," comprises four items relating to user participation: effective communication, interdepartmental cooperation and communication, user participation, and user training.
3. Factor 3, named "technical knowledge," comprises four items relating to knowledge

Table 2. Results of factor analysis

CSF	Mean	Factor Loading (Final Factor Structure 3rd FA) F1	F2	F3
Top management support	4.80	0.608		
Presence of a champion	4.75	0.541		
Project management	4.64	0.586		
Best people full time	4.58			0.741
Effective communications	4.51		0.565	
Management of expectations	4.40	0.420		
Interdepartmental cooperation and communication	4.36		0.452	
Technical and business knowledge	4.33			0.584
User participation	4.22		0.562	
Discipline and standardization	4.09			0.387
Vendor package selection	4.02			
User training	4.01		0.510	
Implementation approach	4.00	0.478		
Clear goals, focus, and scope	3.89	0.411		
Use of consultants	3.75			0.573
Minimal customization	3.68			
Vendor/customer partnership	3.15			
Use of steering committee	2.95			
Business process reengineering	2.84			
Use of vendor's development tools	2.06			
Eigenvalue		7.56	2.54	1.20
Percentage of variance		58.50	14.36	8.65
Cumulative percentage of variance		58.50	72.86	81.51
Cronbach alpha coefficient		0.88	0.74	0.56

N: 69.

Scale: 1–5 (5: "extremely critical," 1:"not critical").

F1: ERP implementation management.

F2: Users' aptitudes and communication.

F3: Technical knowledge.

of business and ERP: best people full time, technical and business knowledge, use of consultants, and discipline and standardization.

Cronbach alpha coefficients were calculated to test the reliability of these CSFs, as shown in the last row of Table 2. The reliability of coefficients obtained ranges from 0.56 (Factor 3) to 0.88 (Factor 1). Srinivasan (1985) proposed that a coefficient of 0.7 or higher is acceptable, while a coefficient of 0.5 or higher is considered sufficient when dealing with exploratory research combined with unvalidated data. Thus, the reliability coefficients in this study are deemed acceptable. The strength of factor analysis is that it provides a basis for data reduction. Rather than look at all 20 items, only three factors need be examined. That simplifies the rankings and clarifies the most important items. Rather than focus on individual items, practitioners and researchers can focus on the broad set of items represented by the essential factors.

FUTURE TRENDS

Many companies around the world are following the trend toward making large investments in implementing ERP systems. Several approaches and methodologies of ERP project implementation recognise a series of critical factors that must be carefully considered to ensure successful implementation of an ERP system project. In essence, there are dominant critical factors hypothesised to play an overriding role in the implementation of an ERP project, and they should be ongoing throughout all implementation levels. Clearly, the dominant factors are those that will shape the overall project culture and, subsequently, the organisational cultura, as ERP is far reaching in nature.

Post-ERP activity seems to follow a clear path. A Deloitte Consulting study of 62 companies segments post-ERP activity into three stages. The first stage entails a three- to nine-month productivity decline that is overcome by redefining jobs, establishing new procedures, fine-tuning ERP software, and taking charge of the new streams of information created by the platform. The second stage, which lasts from six to 18 months, involves skills development, structural changes, process integration, and add-on technologies that expand ERP functionality. The third stage, of one to two years in duration, is one of transformation, where the synergies of people, processes, and technology reach a peak. Perhaps most important, ERP forces discipline and organization around processes, making the alignment of IT and business goals more likely in the post-ERP era.

CONCLUSION

Despite the benefits that can be achieved, there is already evidence of failure in projects related to ERP systems implementation (Davenport, 1998). It is, therefore, important to find out what the CSFs are that drive ERP project success.

According to the respondents in this study, the six top CSFs for ERP systems implementation in Venezuelans firms are top management support, presence of a champion, project management, best people full time, effective communications, and management of expectations.

This research has derived three composite CSFs in ERP systems implementation in Venezuela:

1. ERP implementation management
2. User's aptitudes and communication
3. Technical knowledge

Four of the six top individual items contribute to the composite factor of ERP implementation management, which is, by far, the most important. It is made up of items that are concerned with the management of ERP systems implementation projects.

The results of ranking ERP CSFs in this study are largely consistent with the literature review, though the relative ranking of some factors varied. In the literature, top management support, change management, presence of a champion, and management of expectations are the four most often cited critical factors.

A majority of factors, 12, were rated as critical (rating >4). Only one factor, business process reengineering, which is rated as critical in most articles reviewed, was not rated as critical in this study (rating <3). Hence, the perceptions on CSFs of Venezuelan managers involved in ERP systems implementation projects are largely consistent with the findings reported in the literature.

There are a number of questions still to be determined. For example, although this article establishes the relative importance of CSFs in seven firms, it has not established the reasons. Future studies could look at differences by size of firms, by industry type, by number of locations, by number of customers, etc.

Finally, it should be noted that all CSFs are based on previous research; the success items can be modified when further research is conducted. For instance, discovery-oriented research through comprehensive interviews with several top-level managers in an attempt to identify new CSFs is an option.

REFERENCES

Al-Mudimigh, A., Zairi, M., & Al-Mashari, M. (2001). ERP software implementation: An integrative framework. *European Journal of Information Systems, 10,* 216–226.

Bingi, P., Sharma, M. K., & Godla, J. (1999). Critical issues affecting an ERP implementation. *Information Systems Management, 16*(2), 7–14.

Chatfield, C., & Collins, A. J. (1992). *Introduction to multi-variate analysis* (3rd ed.). London: Chapman & Hall.

Davenport, T. H. (1998). Putting the enterprise into the enterprise system. *Harvard Business Review*, July–August, 121–131.

Esteves, J., & Pastor, J. (2001). Analysis of critical success factors relevance along SAP implementation phases. In *Proceedings of the Seventh Americas Conference on Information Systems* (pp. 1019–1025), Boston, MA.

Falkowski, G., Pedigo, P., Smith, B., & Swanson, D. (1998). A recipe for ERP success. *Beyond Computing,* September, 44–45.

Holland, C. P., & Light, B. (1999). A critical success factors model for ERP implementation. *IEEE Software, 16,* 30–36.

Johnston, S. (2002). ERP: Payoffs and pitfalls. *HBS Working Knowledge,* October, 14–21.

Kaiser, H. F. (1974). An index of factorial simplicity. *Psychometrika,* (39) 31–62.

Kim, J., & Mueller, C. W. (1978). *Factor analysis: Statistical methods and practical issues.* Thousand Oaks, CA: Sage Publications.

Kyung-Kwon, H., & Young-Gul, K. (2002). The critical success factors for ERP implementation: An organizational fit perspective. *Information and Management, 40,* 25–40.

Martin, M. H. (1998). An ERP strategy. Fortune, February, 95–97.

Nah, F. F. -H., Lau, J. L. -S., & Kuang, J. (2001). Critical factors for successful implementation of enterprise systems. *Business Process Management, 7*(3), 285–296.

Nunnally, J. C. (1987). *Psychometric theory*. Englewood Cliffs, NJ: Prentice Hall.

Rai, A., Borah, S., & Ramaprasad, A. (1996). Critical success factors for strategic alliances in the information technology industry: An empirical study. *Decision Sciences, 27*(1), 141–155.

Rockart, J. (1979). Chief executives define their own data needs. *Harvard Business Review, 57*(2), 238–241.

Rosario, J. G. (2000). On the leading edge: Critical success factors in ERP implementation projects. *Business World,* May, 27–32.

Srinivason, A. (1985). Alternative measures of system effectiveness: Associations and implications. *MIS Quarterly, 9*(3), 243–253.

Stefanou, C. J. (1999). Supply chain management (SCM) and organizational key factors for successful implementation of Enterprise Resource Planning (ERP) systems. In *Proceedings of Fifth Americas Conference on Information Systems* (pp. 800–802).

Stratman, J., & Roth, A. (1999). Enterprise resource planning competence: A model, propositions and pre-test, design-stage scale development. In *Proceedings of 30th Decision Science Institute* (pp. 1199–1201).

Sum, C. C., Ang, J. S. K., & Yeo, L. N. (1997). Contextual elements of critical success factors in MRP implementation. *Production and Inventory Management Journal, 3,* 77–83.

Sumner, M. (1999). Critical success factors in enterprise wide information management systems projects. In *Proceedings of Fifth Americas Conference on Information Systems* (pp. 232–234).

Tabachnick, B. G., & Fidell, L. S. (1989). *Using multivariate statistics.* New York: Harper Collins.

Wee, S. (No date.) *Juggling toward ERP success: Keep key success factors high.* ERP News. Retrieved January 22, 2002, from http://www.erpnews.com/erpnews/ erp904/ 02get.html

Zairi, M., Al-Mudimigh, A., & Jarrar, Y. (2000). ERP implementation critical success factors—The role and impact of business process management. In *Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology* (pp. 122–127).

Zhan, L., Lee, M., Zhang, Z., & Banerjee, P. (2003). Critical success factors of enterprise resource planning systems implementation success in China. In *Proceedings of the 36th Hawaii International Conference on System Sciences* (pp. 562–567).

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Chapter 2.25
Communication Security Technologies in Smart Organizations

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ABSTRACT

In this chapter, we discuss the security technologies that are important in guaranteeing the good quality of communication within smart organizations. We first briefly review the various forms of communication that can be used in the current information age, before outlining the possible threats that can be faced in each communication medium. We then describe the relevant security technologies that help to protect communication media from common threats, as well as the security tools available in the market that implement these technologies. The topics discussed in this chapter would serve to educate the smart organizations towards securing their various means of communication, which is vital for a business establishment to exist and coexist with peers and partners.

INTRODUCTION

Smart organizations are knowledge-driven, internetworked, dynamically adaptive to new organizational forms, agile in ability to create and exploit opportunities offered by the new economy (Filos & Banahan, 2000). Being internetworked, therefore, some form of communication has to exist between two or more parties. This communication has to be effective and dependable, and furthermore the parties would have to know what is basically happening behind the scenes, and be ever ready to upgrade their knowledge with the latest in technology. Otherwise, this may result in communication breakdowns and hence prevent transactions from being accomplished or contracts from being sealed properly with peers and business partners. What this means is dependability of the communication process, and is the focus of this chapter.

Dependability means that our system can be trusted to perform the service for which it has been designed, and can be decomposed into specific aspects as follows. Reliability characterizes the ability of a system to perform its service correctly when asked to do so. Availability means that the system is available to perform this service when it is asked to do so. Safety is a characteristic that quantifies the ability to avoid catastrophic failures that might involve risk to human life or excessive costs. Finally, security is the ability of a system to provide the following services (Stallings, 1999; Menezes, van Oorschot, & Vanstone, 1996) to communicating parties:

- Confidentiality: Ensures that the communicated information is accessible only by authorized parties.
- Authentication: Ensures that the origin of the message is correctly identified.
- Integrity: Ensures that only authorized parties can modify the communicated information, or enables parties to detect any unauthorized modifications to the information.
- Non-Repudiation: Ensures that neither party can deny having made any previous communications.

This chapter presents a discussion of security technologies available today to ensure the dependability of the communication process, which is vital within smart organizations since its parties are internetworked with each other, and therefore prone to network attacks and exploits by malicious crackers. One of the most important ways that smart organizations use to communicate is via the Internet. Performing transactions online via the Internet is an effective means (VeriSign, 2002) by which organizations can advertise and perform transactions with customers and other parties. However, online transactions will only be popular if the public trusts in their security (Amazon, 2003; Bolivia, 2003; Harris, 1998; Rawal, 2003; Tedeschi, 2000). Therefore, for an organization to be able to compete and advance, it needs knowledge, and hence careful management, of the various security technologies (Anderson, 2001; Garfinkel & Spafford, 1997) that help protect and safeguard public trust in its online transactions. The interested reader is also referred to the chapter on “New Challenges in Smart Organizations: Demands of Mobility” that also appears in this book for a discussion of other relevant future trends.

At the end of this chapter, we hope that the reader would have obtained a general perspective of communications security technologies that can be used in smart organizations. In particular, the objectives of this chapter include:

- Understanding of the various types of communication techniques
- Understanding of the possible threats faced by the communication process
- Familiarity with communication security technologies such as encryption, digital signatures, and message authentication codes (MACs)
- Familiarity with common software and hardware tools used to provide security technologies

BACKGROUND

Security is an important criteria these days, especially with in current information age in which information is available and accessible everywhere, in any form and with any means. The largest depository of information is the Internet, where infinite information is speedily available at one’s fingertips.

With this vastness and freedom of information also comes the threats of abuse and misuse by malicious parties whose intent could be to deceive, steal, impersonate, cheat, or merely intrude into others’ privacy.

Smart organizations are equally affected by this, since the communication process within such establishments requires speed, ease of access, and wide coverage, and further they have to readily adapt to using the latest communication techniques such as the Internet, high-speed networks, and wireless communications. Nevertheless, one has to do so with caution since new technologies are at times not fully tested, and may further have bugs exploitable by attackers to gain entry into the organization's network. Also, smart organization personnel should each be fully aware of how to use such technologies, the possible weaknesses inherent in them, plus how to prevent attacks of any kind.

Protecting the security of the communication process is indeed very important. Based on the recent 2004 Computer Crime and Security Survey (CSI, 2004) by the U.S. Computer Security Institute (CSI) and FBI, it was shown that the Internet connection is increasingly becoming the most frequent point of attack, mostly due to viruses, abuse of net access, unauthorized access, system penetration, and denial of service. Other popular attacks include sabotage, financial fraud, and telecom fraud, which also target the communication process.

WAYS OF COMMUNICATION IN SMART ORGANIZATIONS

In this section, we will look at the ways in which two or more parties can communicate within smart organizations. The main characteristic of communication these days is that it is mainly done via the internet or wireless networks. In other words, communication is online.

World Wide Web (WWW)

One of the earliest ways of communicating online at high speed was via the World Wide Web (WWW), which incorporates all Internet services and allows various parties to access documents, images, music, videos. These are all hosted on computers that run special software called server software and are online all the time. One simply uses a Web browser software such as Netscape's Navigator or Microsoft's Internet Explorer in order to view these online information. Websites in the WWW start with the header "http://www"—for example, http://www.google.com.

File Transfer Protocol (FTP)

Another popular way of communication that has been popular since some time ago is via the file transfer protocol (FTP). This is a specially dedicated specification of how one could transfer files from one computer to another. This is similar to sharing folders or directories in your computer with everyone in the world, and they can log in and access them as if they were physically sitting in their own computers. FTP sites can also be accessed via web browsers or special FTP client software. FTP addresses start with the header "ftp://"—for example, ftp://ftp.example.com.

Electronic Mail (E-Mail)

By far the most popular and commonly-used communication technique is the electronic mail (e-mail). These are messages sent through the Internet from one party to another. Not only that, but other files such as images, music, and video can be included as attachments to these e-mails. Every party communicating via e-mail has an e-mail address, with the format username@emailserver.domain—for example rphan@swinburne.edu.my.

Telnet

Telnet is a terminal emulation program for the Internet. This means that when you run a telnet program on your computer, you can connect your computer to another telnet server on the Internet so you can interact with it by typing in commands, as if you were physically sitting at that server machine and typing at its keyboard. This allows you to remotely control computers and servers.

Chat

Internet chat is popular especially among the young and young at heart. You could chat either using special chat software such as ICQ or Internet relay chat (IRC), or on specific chat Web sites. A chat window is open throughout the chat period and you can type your message and the person at the other end would almost immediately see it. Advanced chat features also include chats among more than two parties (called meetings or conferences), voice chats, and streaming video of the chatting parties.

Short Message Service (SMS) and Multimedia Message Service (MMS)

Meanwhile, the mobile phone revolution started several years ago and never looked back. These days, almost everyone has a mobile phone; for instance, the 2004 mobile penetration rate (Netsize, 2005) in European countries including the UK, Italy, and Sweden has crossed 100%. Although mobile phones were initially used mostly for voice conversations, another revolution ensued, namely the Short Message Service (SMS). This allows parties to send short text messages (up to 160 characters) to one another by using their mobile phones. Following this is an advanced version known as the Multimedia Message Service (MMS), which also allows short videos—including sound—to be sent as messages to other mobile phones. This is just starting to become popular, and is also envisioned to revolutionize the way people communicate in future.

THREAT MODELS FOR THE COMMUNICATION PROCESS

Threats faced by communicating parties are generally grouped into threats from two types of attackers: namely, passive attackers and active attackers (Stallings, 1999).

Passive attackers are those who eavesdrop on or monitor the communications channel, but do not affect or interfere with the communication in any way. Therefore, such attackers are very hard to detect since there is no straightforward way of knowing when communication is being monitored.

Considering the previously discussed ways of communication, passive attacks on the WWW, FTP, and e-mail services, for example, could involve simply monitoring which addresses (WWW, FTP or e-mail) that a certain party is accessing or communicating with. This is possible because these communication services by default simply involve the communication of messages that are in the clear, meaning in readable form. So an attacker could obtain information related to the personal life of a party—for example, which types of Web sites he has visited,what type of files he has accessed, what e-mail addresses he sends to, and so forth. This of course intrudes on the privacy of communicating parties. Individual communicating parties are often not aware of such threats, and do not bother to customize default security and privacy settings within the communication software they use.

Mobile communications via mobile phone conversations, SMS, and MMS are also potentially susceptible to passive attacks. Messages are communicated via microwave signals, which can be easily intercepted by specially built receivers that tune in to the same frequency. Further, since these signals are free to propagate through the air, they are out in the open and so it is almost impossible for one to detect if they are being read by passive attackers. This is in contrast to a telephone line, where a passive attacker would have to make a physical tap somewhere along the line in order to do any eavesdropping. Therefore, there is a need in mobile communications to cover up the meaning of the message. This is usually achieved via the technology called encryption, which will be discussed in the next major section. Doing so ensures that even if a message were intercepted, a passive attacker would not be able to understand what it is.

Active attackers, on the other hand, are those who directly interfere with the communication, either by interrupting, modifying, or fabricating messages. Interruptions of messages are direct attacks on the availability of the communication service, while modifications are attacks on the integrity of the service. Finally, fabrications are attacks on the authenticity of the communication service. All these are serious attacks and should be guarded against.

An active attacker would be able to mount more devastating attacks on the above communication services. For example, he or she could modify the e-mail messages being sent from one party to another and hence cause reputation-damaging consequences. Since e-mails are by default sent in the clear, spoofing such as this can be done easily. Similarly, he or she could masquerade as a certain Web site and dupe WWW browsers into providing information that he is not supposed to have; for example, passwords and credit card information. This is known as "phishing," and is a huge threat because there is a serious lack of public awareness on this. The reason is partly also due to most parties being unfamiliar with the latest technologies, such as the WWW. Therefore, they do not know what is really happening and simply trust such Web sites for what they claim to be. For this reason, commercial banks are starting to give warnings to their customers not to trust any Web site claiming to be them (Personal Computer World, 2004) because Web sites are so easily set up. Another common type of active attack is the Denial of Service (DoS) attack on e-mail servers and WWW servers that intentionally makes limitless accesses to a communication service and heavily overloads the service provider until it disrupts the provision of service to authorized and legal customers. What aids this is the fact that unsuspecting computer users could be forwarding interesting e-mail attachments to friends and colleagues that contain Trojans—malicious software that appear innocent but are doing malicious activities in the background. Such Trojans can be used to collectively mount DoS attacks on Web sites.

Another example of active attack is hacking into a network via a computer within the network, such as through the telnet service provided by the computer to outsiders. Aiding the increase of such hacks is the fact that the learning curve for hackers is decreasing with the vast availability of easy-to-use hacking tools freely downloadable from the Internet (Yunos, 2004).

Finally, viruses and worms are active attacks and really devastate an organization's networks and operations. The damages done could cause losses in millions of dollars (Yunos, 2004) to both the government and the affected organizations themselves. Viruses and worms spread easily due to individual computer users' unawareness of how to safeguard their own computers against these threats. Often, these threats enter an organization's network via an innocent and ignorant employee's computer. The easy availability of virus authoring tools also means new variants can be speedily created by amateurs, and may escape detection by antivirus software.

ESSENTIAL SECURITY TECHNOLOGIES IN SMART ORGANIZATIONS

The most fundamental (primitive) security technologies (Stallings, 1999) that allow one to ensure the security of communication are known as encryption, digital signatures, and message authentication codes (MACs). These fundamental security technologies provide the basic security services of confidentiality, authentication, integrity, and non-repudiation described in the preceding introduction section. We also include in this section a discussion of security protocols and standards that make use of these security primitives.

Encryption

Encryption is basically the process of transforming an original confidential message (plaintext) into unreadable form (ciphertext), and is done by using a key, often generated from a password that is specified. Only the persons who know the key can reverse the process (decrypt) to get back the original message. This clearly ensures that only those who are supposed to read the message can do so. Encryption provides the confidentiality service.

The method to do encryption is called an algorithm. There are generally two types of encryption algorithms, namely symmetric and asymmetric algorithms. Symmetric algorithms use the same key for doing encryption and decryption. This is shown in Figure 1.

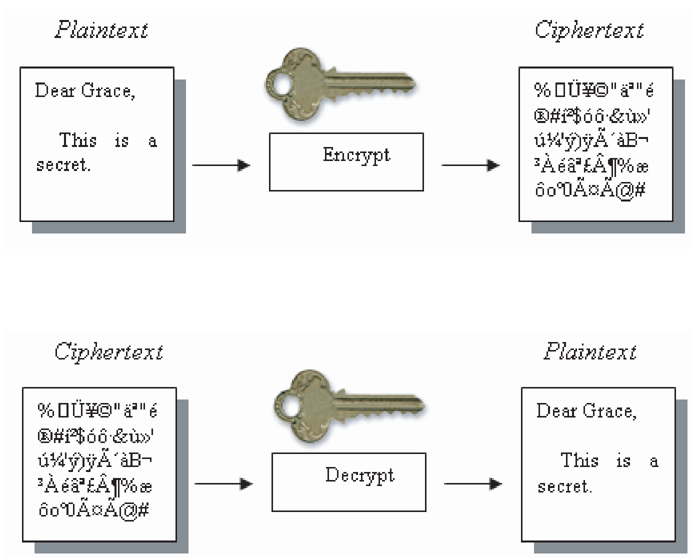
By using a secret key, the original message (plaintext) is encrypted into ciphertext. Once in this form, someone who happens across it would not be able to discern its meaning. In order to get back the original message, the same secret key is used to decrypt the ciphertext (Refer again to Figure 1).

One problem with symmetric algorithms though, is how to share the secret key with others whom you trust. Suppose you want to send an e-mail to your wife. By using a symmetric algorithm, you encrypt your email with a secret key. Then you send the encrypted email to your wife. The problem is how to let her know what is the value of the secret key that you used? You could call her up and whisper it over to her on the phone, but what if the phone line is tapped into? E-mailing the secret key to her is pointless because the fact that you do not trust the telephone line was why you wanted to encrypt your email in the first place.

Figure 1. (a) Symmetric encryption with a secret key; (b) symmetric decryption with the same secret key

(a)

(b)



Asymmetric (public-key) encryption algorithms overcome this problem by using two keys, called the public key and the private key. Each person has his own public key and private key. When you want to send an e mail to your wife, you use her public key to encrypt the e mail. Then when your wife wants to read the e-mail, she simply uses her private key to decrypt the e-mail. This is shown in Figure 2.

Anyone else who tries to decrypt the e-mail would obtain nonsense because only one private key, in this case your friend's private key, can correctly decrypt the e-mail. Your friend can tell everyone what his or her public key is so that anyone who wants to send e-mails to him or her can use th public key to encrypt the message. But knowing the public key does not help an unauthorized person to decrypt the e-mails because only his or her private key can do that.

Obviously, asymmetric encryption algorithms seem more desirable than symmetric encryption algorithms. However, they tend to be slower than symmetric algorithms, especially when the message to be encrypted is large. Due to this fact, the best solution then is to combine the advantages of both methods, as is the current practice by most e-mail security standards.

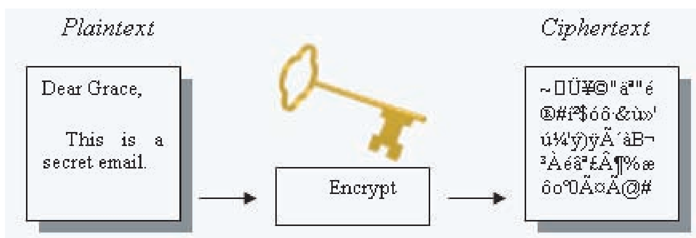
Whenever an e-mail message is to be sent, the following steps are taken, as illustrated in Figure 3:

1. A random secret session-key, K, is generated.
2. The email message is encrypted by a symmetric encryption algorithm with the secret session-key K.
3. The session-key K is encrypted using the recipient's public key.
4. The encrypted session-key K and the encrypted e-mail message are sent to the recipient.

Both the encrypted e-mail message and the encrypted session-key K would be sent together

Figure 2. (a) asymmetric encryption with the public key of the recipient; (b) asymmetric decryption with the private key of the recipient

(a)



(b)

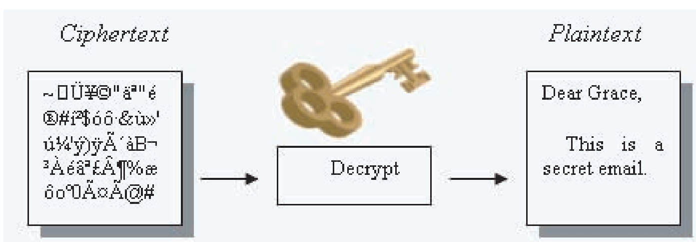
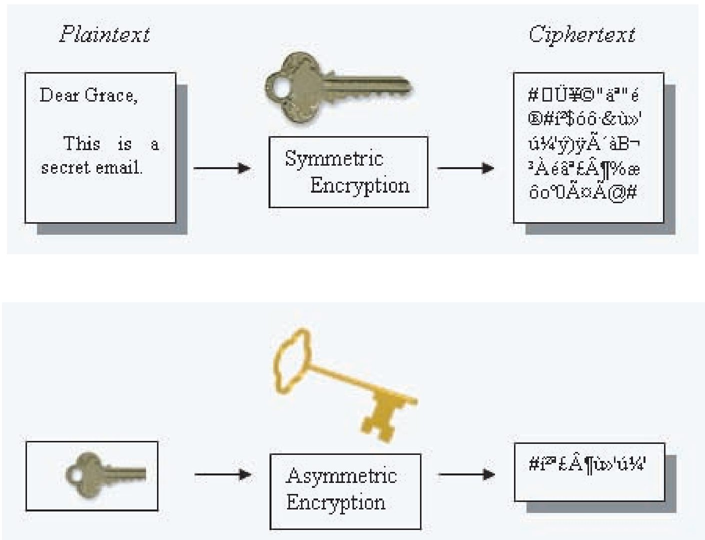


Figure 3. Encryption by the sender: (a) Symmetric encryption of the e-mail with a secret session-key, K; (b) Asymmetric encryption of the secret session-key, K, with the public key of the recipient

(a)

(b)



over the Internet as one e-mail to the recipient. This is shown in Figure 4.

When the e-mail is received by the recipient, the following is done, as in Figure 5:

1. The recipient uses her private key to decrypt the encrypted session-key, so that she can get back the session-key K that was used to encrypt the e-mail message.
2. She uses the session-key K to decrypt the e-mail message.

An e-mail message could be quite large, so it is encrypted by using symmetric encryption because symmetric encryptions are faster than asymmetric encryptions. Then, in order to solve the problem of having to inform the recipient of the value of the secret key used in the encryption, asymmetric encryption is used to encrypt the secret key. Since the secret key is small compared to the email message, it does not take up much time.

Digital Signatures

A digital signature is a way to ensure that an electronic document (your e-mail or MS Word document, for example) is authentic. Being authentic means two things:

1. You can verify the identity of the person who sent the document
2. You can verify that the contents of the document have not been altered by a third party in any way since it was written

This makes a digital signature analogous to its handwritten counterpart in the pen and paper world. Digital signatures therefore provide the authentication and non-repudiation services.

A popular method of making use of digital signatures is through a public-key encryption system. In such a system, each user has two keys, a public key and a private key. The public key is

Figure 4. Sending both the encrypted e-mail and encrypted session-key over the Internet

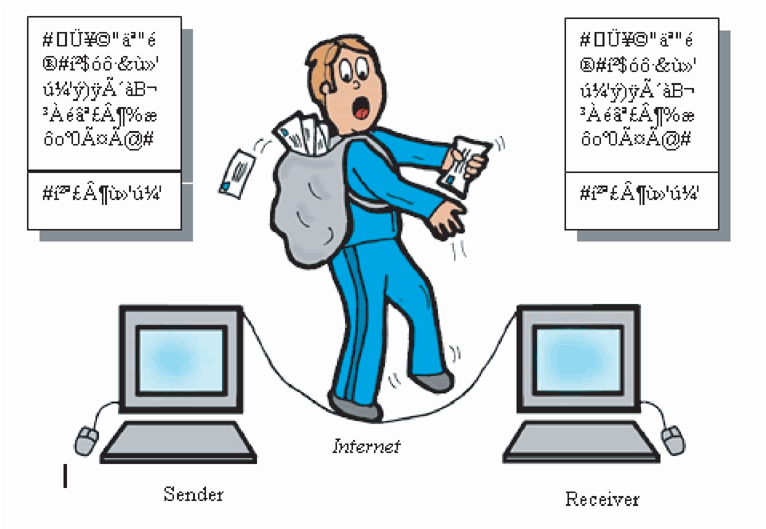
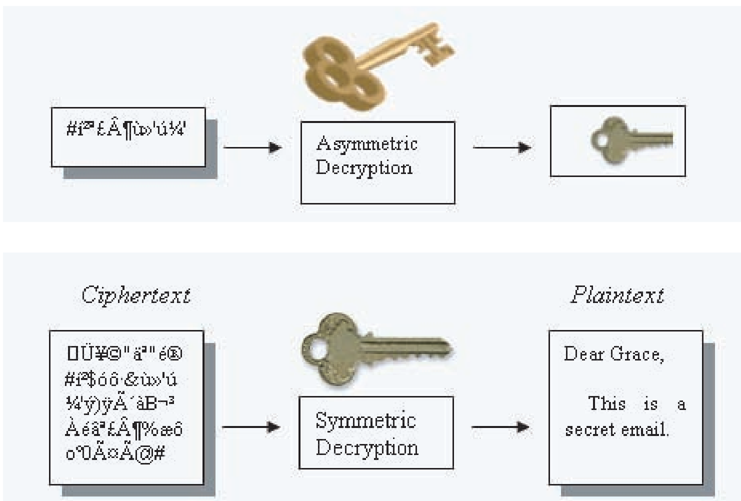


Figure 5. Decryption by the recipient: (a) Asymmetric decryption of the session-key, K, with the private key of the recipient; (b) Symmetric decryption of the e-mail with the secret session-key, K

(a)

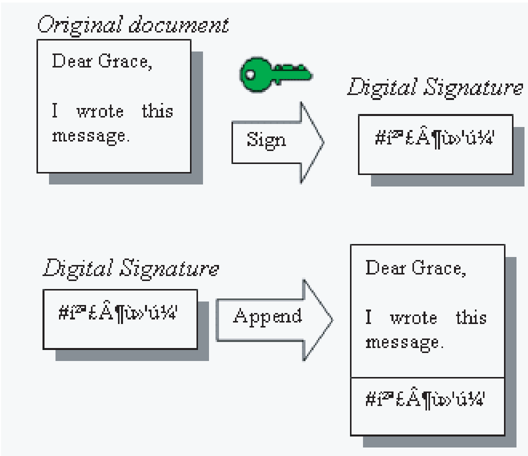
(b)



widely known to the public. However, the private key is secret and known only to the user.

Most of the time, since documents are quite large in size, they are first hashed to produce a compressed version of the document, called the message digest. The message digest is encrypted (signed) with your private key, and this will be your digital signature. The digital signature is then appended to the end of the document, as illustrated in Figure 6.

Figure 6. Digitally signing a document



The document, along with the appended digital signature, is then sent to the recipient, Grace. To verify the document, Grace first hashes the document to get the message digest. She then uses your public key to decrypt the appended digital signature. The decrypted digital signature should be the same as the message digest that she obtained by hashing the document (See Figure 7).

The fact that the digital signature is correctly decrypted into the message digest verifies that the document was written by you, since it was signed by using your private key, which only you will have. If the message digest obtained by hashing the document is the same as the decrypted value of the digital signature, it proves that the document has not been altered since it was sent, otherwise a different message digest would be obtained if you hash it.

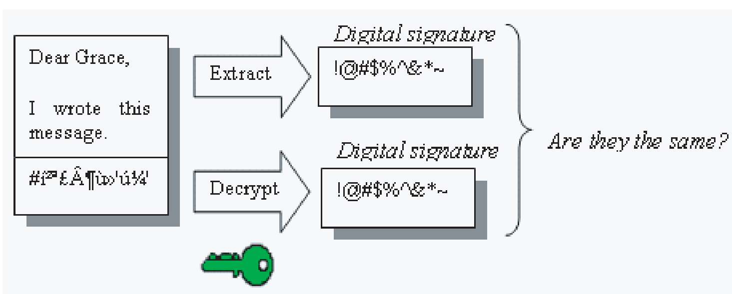
Notice how elegant a public-key encryption system is. You can have encryption or digital signatures depending on the way you use the public and private keys of the sender and recipient. It can be summarized as follows:

- For encryption, the sender encrypts with the recipient's public key. The recipient decrypts it back with her private key.
- For digital signatures, the sender encrypts with his own private key. Anyone who wishes to verify the digital signature uses the sender's public key to decrypt it.

Encryption of a document with the intended recipient's public key ensures that anyone can encrypt and send to the recipient since his public key is publicly known, and is meant to be so. Decryption of that document can only be done with the recipient's private key, and since this key is only known to the recipient, no one can decrypt back the document except the intended recipient himself.

As for digital signatures, a document to be signed is encrypted with the sender's private key.

Figure 7. Verifying the authenticity of a signed document



This ensures that only he can sign since his private key is known to him alone. On the other hand, anyone can verify whether the digital signature is authentic by using the sender's public key, which is again widely known.

Message Authentication Codes (MACs)

Message authentication codes (MACs) are used to ensure the integrity of messages communicated between two parties in order to prevent active attackers from modifying or tampering with them in any way. A MAC works similarly as the secret-key encryption since it also depends on a secret key. The only difference is that it generates a small encrypted output, called a MAC, in contrast to normal encryption where the output is the same size as the input.

Let's assume that two parties, Alice and Bob, share a common secret key. Then when Alice wants to send a message to Bob, she inputs the message into a MAC generator and also puts in the secret key. The result is a MAC with a size much smaller than the original message. Alice next appends this MAC to the message and sends it to Bob.

When Bob receives this, he uses the same secret key to regenerate the MAC from the received message and then compares this with the MAC he received from Alice. If they are the same, this means that the message has not been modified while it was being sent over, since if an attacker had done so, the two MACs would be different. The attacker would not have been able to alter the MAC to correspond to the modified message since he does not know the secret key used to generate the MAC. Therefore, this guarantees the integrity of the message.

Security Protocols and Standards

A protocol is a formal sequence of steps taken by two or more communicating parties. A security protocol specifies what the parties do in order to communicate securely. Security protocols make use of the primitives, Encryption, digital signatures, and MACs, in order to achieve this goal.

The de facto standard protocol for securing online transactions (i.e., buying things from the Internet, sending confidential information, etc.) is the Secure Sockets Layer (SSL) by Netscape Inc (Anderson, 2001). It allows a Web browser client and a visited Web server to authenticate each other, and to further exchange a secret session key for secure communication of sensitive information between them. Browsers secured with SSL would have a header of "https" instead of the normal "http." The Internet Engineering Task Force (IETF) is in the process (Stallings, 1999) of formalizing a similar standard, the Transport Layer Security (TLS), which is based on the SSL protocol.

The standard for secure credit card transactions on the Internet is the Secure Electronic Transaction (SET) standard developed by a consortium including Microsoft, Netscape, VISA, and MasterCard (Anderson, 2001; Stallings, 1999), basically allowing customers and merchants to authenticate each other via digital signatures, and to communicate confidentially via encryption. SET nevertheless does not seem to fully penetrate the market (Anderson, 2001) due to high costs and impracticality, and lack of response from customers.

A public key infrastructure (PKI) is basically a term given to systems that use public-key encryption and digital signatures, where each user (customer, merchant, etc.) has a pair of public and private keys, and where each has a digital certificate certified by a trusted Certification Authority (CA), containing the public key and personal details while the private key is kept secret. a party, Alice, wishing to communicate with another party, Bob, would access Alice's digital certificate for her public key, which can then be used to encrypt confidential information for Alice, or to verify digital signatures signed by Alice. In principle, the above SSL and SET protocols can be viewed as PKIs.

TOOLS FOR SECURITY TECHNOLOGIES IN SMART ORGANIZATIONS

The tools by which smart organizations could provide security technologies such as those described in the previous section could generally be classified into software-based and hardware-based approaches.

Software-Based Tools

The most common software-based tool that provides security services are security software developed by security-based software companies such as anti-viruses, or those that allow computer users to perform encryption, digital signatures, or MACs—for example, the Pretty Good Privacy (PGP) software (Stallings, 1999). Anti-viruses are commonly installed at individual computers and used to scan files commonly prone to viruses. Most anti-viruses these days are also able to be triggered into execution and remain in the background, monitoring the file activity and warning the user of suspicious actions by those files. Meanwhile, security software that provides encryption, digital signatures, and MACs are very useful in that they allow the computer user to protect the confidentiality of his files, authenticate other users, or check the integrity of received files for possible modifications. This software can also be used in relation to e-mail client software and hence help to provide these security services in e-mails, as well.

Another type of anti-virus software is the virus filter (Stallings, 1999), which sits at the server computer and scans files passing through the server for possible virus infections before they enter into the network. This helps to reduce the spread of viruses considerably, since virus filters are maintained by system and network administrators who have the technical know-how on viruses, in contrast to normal anti-virus software sitting on each computer, typically managed by users who sometimes even disable the real-time virus scanning feature in exchange for higher efficiency.

Other such security software tools include firewalls (Stallings, 1999). A firewall is a program running at a network gateway server that protects the files and other resources of the network from other outside networks. Such tools are especially important against active attackers such as hackers or crackers to prevent them from gaining access to computers within the network.

When one connects to a remote computer, the common Telnet session is known to be insecure as messages are transmitted in the clear. To combat (Anderson, 2001) network attacks and hacks, a secure alternative is the secure shell (SSH), which encrypts all messages and so whatever info such as login passwords that are transmitted will be save from eavesdroppers. Internet users also have the option of using encryption and authentication at the Internet Protocol (IP) layer, provided as IPSec in the IPv6 (IP version 6). Yet another alternative is using virtual private networks (VPNs), where several companies communicating with each other would have their firewalls arranged with each other to encrypt all traffic between them. Having said this, though both IPSec and VPNs prevent external network attacks, they do not tackle the issue of insider attacks, and so in general they should be used along with a complementing tool (such as multi layers of conditional access, security logs, frequent updates of keys) to also prevent insider attacks.

Hardware-Based Tools

Hardware-based security tools are gaining popularity these days, including password systems, magnetic stripe cards, smart cards, and biometric systems.

Password systems (Anderson, 2001) are the oldest hardware-based systems and these include those such as safes in banks and locks on briefcases. More advanced versions of these are those such as the automatic teller machines (ATMs) that employ both passwords and magnetic stripe cards to authenticate the legal party. Old versions of credit cards also use magnetic stripes for reading and verification. Nevertheless, the recent widespread cases of credit card cloning (Yunos, 2004) has raised concern on the security of magnetic-striped based cards.

Smart cards (Anderson, 2001) have been increasingly used in recent years in place of magnetic stripe cards since they are tamper-resistant and also contain a built-in microprocessor that processes and executes programs from within the smart card. The tamper-resistance of smart cards also appear to complicate active attackers from cloning them and using them for impersonations. The physical tamper-resistance in smart cards are usually implemented by using tamper-detection wires that immediately cause the memory within smart cards to be erased the moment illegal tampering is detected. Nevertheless, smart cards can still be hacked or cloned, though with a bit more effort compared to magnetic stripe cards, as clearly detailed in Anderson (2001).

Biometric systems (Anderson, 2001) are also widely used currently, and these make use of a person's fingerprints, eye pattern, face patterns, voices, hand geometry, and even typing behavior. These eliminate the need to carry a foreign object such as a smart card, since a person needs only to use his or her own body for authenticating himself to the system. Some important security issues (Anderson, 2001) regarding the proper use of biometrics include:

- False positives and false negatives: The former means a fake biometrics being falsely taken to be true, while the latter means a true biometrics being taken as a fake one. These are mostly due to careless biometrics laboratory procedure.
- Freshness: It is hard to tell the age of a biometrics print, and therefore there are issues of how fresh it is, or if it could have been planted there by someone else, since most biometrics such as voice, eye patterns, and fingerprints can be recorded and replayed at a later time.

In summary, it is preferred to use various tools such as smart cards and biometric systems in combination for extra security, and such that compromising one would still not compromise the entire system.

FUTURE TRENDS

The introduction of the computer caused a digital revolution where vast amounts of information are expressed, communicated, stored, and processed in digital form. This revolution was also propelled considerably by the popularity of the Internet. This was followed by the mobile phone revolution, leading to the popularity of instant messaging via mobile communication networks. The trend is emerging where multimedia-based services via mobile devices would be at the forefront of the communication process. Also looking very prospective is the trend toward interactivity in communication; for example, viewers being able to interact with cable TV services via their televisions, mobile service subscribers downloading packages onto their devices, customizing their devices, and even more flexibility and customization by the car owner in the latest designs of high-tech cars. With each new communication trend comes new potential threats against the communication process, hence this area of communications security is an ever-changing field that improves over time and would never remain stagnant.

CONCLUSION

In this chapter, we first discussed the communication process and various forms in which it can take place. We then proceeded to the possible threats that might be faced by the communication techniques and then described the basic security technologies that could be used to guard against the attacks. This was followed by a discussion of the different software and hardware tools used to provide the previously-mentioned security technologies. The concepts discussed in this chapter are essential since an appreciation of these concepts would help the reader to better understand how the security technologies can be provided in the communication process, and also help personnel (both the leaders and subordinates) in smart organizations to manage and handle such security technologies better.

REFERENCES

Amazon.com. (2003a). *Help/ordering from Amazon merchants/credit card security.* Retrieved March 4, 2003, from http://www.amazon.com/exec/obidos/tg/browse/-/468494/102-8032379-5145751

Amazon.com. (2003b). *Help privacy & security.* Retrieved March 4, 2003, from http://www.amazon.com/exec/obidos/tg/browse/-/551434/ref=br_lr_/102-8032379-5145751

Anderson, R. (2001). *Security engineering: A guide to building dependable distributed systems.* New York: John Wiley & Sons.

Bolivia Web. (2003). *Bolivia Web—the book club: Security & Amazon.com.* Retrieved March 4, 2003, from http://www.boliviaweb.com/books/security.htm

CSI. (2004). *CSI/FBI computer crime and security survey.* USA: Computer Security Institute (CSI). Retrieved March 28, 2005, http://i.cmpnet.com/gocsi/db_area/pdfs/fbi/FBI2004.pdf

Filos, E., & Banahan, E. (1997). Will the organization disappear? The challenges of the new economy and future perspectives. In L. M. Camarinha-Matos, H. Afsarmanesh, & R. J. Rabelo (Eds.), *E-business & virtual enterprises* (pp. 3-20). Dordrecht: Kluwer.

Garfinkel, S., & Spafford, G. (1997). *Web security and commerce.* O'Reilly & Associates.

Harris, L. (1998). *E-commerce and privacy survey.* Retrieved September 15, 2002, from http://www.msnbc.com/msn/427057.asp

Menezes, A., van Oorschot, P., & Vanstone, S. (1996). *Handbook of applied cryptography.* CRC Press.

Netsize. (2005). *Global mobile operators suffering from declining voice revenues look at mobile data services to come to the rescue.* Retrieved March 28, 2005, from http://www.netsize.com/?id=6&sid=4&rid=23

Personal Computer World. (2004). *OFT trawls uncovers 176 rogue Web sites.* Retrieved March 28, 2005, from http://www.pcw.co.uk/news/1154005

Rawal, D. (2003). *Response to Query on How Amazon.com Provides Online Security Services.* Personal communication via e-mail: form-info@amazon.com.

Stallings, W. (1999). *Cryptography and network security.* NJ: Prentice-Hall, Inc.

Tedeschi, R. (2000). *Sellers hire auditors to verify privacy policies and increase trust.* Retrieved September 15, 2002, from http://www.nytimes.com/2000/09/18/technology/18ECOMMERCE.html

VeriSign. (2002a). *Building an e-commerce trust infrastructure: SSL server certificates and online payment services.* Retrieved September,15, 2002, from http://www.verisign.com

VeriSign. (2002b). *Increase your competitive edge with a secure Web site.* Retrieved September 15, 2002, from http://www.verisign.com

Yunos, Z. (2004, November 5). *Protection on Malaysian cyberspace: An agenda for action*. Swinburne University Research Seminar Series, Malaysia.

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Chapter 2.26
Knowledge Visualization

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INTRODUCTION

Making knowledge visible so that it can be better accessed, discussed, valued, or generally managed is a longstanding objective in knowledge management (see Sparrow, 1998). Knowledge maps, knowledge cartographies, or knowledge landscapes are often heard terms that are nevertheless rarely defined, described, or demonstrated. In this article, we review the state of the art in the area of knowledge visualization, and describe its background and perspectives. We define the concept and differentiate it from other approaches, such as information visualization or visual communication. Core knowledge visualization types, such as conceptual diagrams or visual metaphors, are distinguished, and examples of their application in business are shown and discussed. Implications for research and practice are summarized, and future trends in this domain are outlined.

The Concept of Knowledge Visualization

Generally speaking, the field of knowledge visualization examines the use of visual representations to improve the creation and transfer of knowledge between at least two people. Knowledge visualization thus designates all graphic means that can be used to construct and convey complex insights. Beyond the mere transport of facts, people who employ knowledge visualization strive to transfer insights, experiences, attitudes, values, expectations, perspectives, opinions, and predictions, and this in a way that enables someone else to re-construct, remember, and apply these insights correctly. Examples of knowledge visualization formats are heuristic sketches (e.g., ad-hoc drawings of complex ideas), conceptual diagrams (such as Porter's Five Forces diagram), visual metaphors (such as Plato's cave metaphor of reality), knowledge animations (such as a rotating double helix), knowledge maps (such as a landscape of in-house experts), or domain structures (e.g., a co-citation network of knowledge management literature). All these formats capture not just (descriptive) facts or numbers, but prescriptive and prognostic insights, principles, and relations. They are used as indirect (and at times ambiguous) communication in order to trigger sense-making activities and to motivate viewers to re-construct meaning. Thus, the 'what' (object), the 'why' (goal), and the 'how' (methods) of knowledge visualization differ from information visualization. These differences are further described in the following section.

The Differences Between Knowledge and Information Visualization

A related field and precursor to knowledge visualization is information visualization. Information visualization is an advancing field of study both in terms of academic research and practical applications (Card, Mackinlay, & Shneiderman, 1999; Chen, 1999a; Spence, 2000; Ware, 2000). Information visualization offers novel visual applications for the interactive browsing and analysis of data with the aim to derive new insights by seeing trends, outliers, or clusters. Card et al. (1999) define information visualization, as "the use of computer-supported, interactive, visual representations of abstract data to amplify cognition." This definition is well established among computer scientists active in this field. The information visualization fields neglects, however, the potential of visualizations as a medium for the transfer of complex knowledge. Another neglected aspect relates to the integration of non-computer based visualization methods (e.g., posters, physical objects, etc.) as architects, artists, and designers use them. This is the objective of knowledge visualization and at the same time the main difference to information visualization: information visualization and knowledge visualization are both exploiting our innate abilities to effectively process visual representations, but the way of using these abilities differs in both domains. Information visualization aims to explore large amounts of abstract (often numeric) data to derive new insights or simply make the stored data more accessible. Knowledge visualization, in contrast, facilitates the transfer and creation of knowledge among people by giving them richer means of expressing what they know. While information visualization typically helps to improve information retrieval and access, and generally optimizes the presentation of large data sets—particularly in the interaction of humans and computers—knowledge visualization primarily is used to augment knowledge-intensive communication among individuals. Such visual communication of knowledge is relevant for several areas within knowledge management, as described in the next section.

Application Areas within Knowledge Management

Knowledge visualization can help to solve several predominant, knowledge-related problems in organizations. First, there is the omnipresent problem of knowledge transfer (or knowledge asymmetry). Knowledge visualization offers a systematic approach to transfer knowledge at various levels: among individuals, from individuals to groups, between groups, and from individuals and groups to the entire organization. To do so, knowledge must be recreated in the mind of the receiver (El Sawy, Eriksson, Carlsson, & Raven, 1997). This depends on the recipient's cognitive capacity to process the incoming stimuli (Vance & Eynon, 1998). Thus, the person responsible for the transfer of knowledge not only needs to convey the relevant knowledge at the right time to the right person, he or she also needs to convey it in the right context and in a way so that it can ultimately be used and remembered. Graphics such as rich but easily understandable visual metaphors can serve exactly this purpose, as the brain can process images often more easily than text. In this context, visualization can also facilitate the problem of inter-functional knowledge communication—that is, the communication among different stakeholders and experts with different professional backgrounds. Visual methods for the transfer of complex knowledge are thus one emergent sub-discipline within knowledge visualization.

Another application area of visualization within knowledge management is knowledge creation. Knowledge visualization offers great potential for the creation of new knowledge in groups, thus enabling innovation. Knowledge visualization offers methods to use the creative power of imagery and the possibility of fluid rearrangements and changes. It inspires and enables groups to create new knowledge, for instance by use of heuristic sketches or visual metaphors. Unlike text, these graphic formats can be quickly and collectively changed, and thus propagate the rapid and joint improvement of ideas.

A further, more general, application goal of knowledge visualization is its use as an effective strategy against information overload. Information overload (see Eppler, Mengis, 2004) is a major problem in knowledge-intensive organizations. Knowledge visualizations help to compress large amounts of reasoned information with the help of analytical frameworks, theories, and models that absorb complexity and render it accessible. This can be a vital prerequisite for the three application domains mentioned previously (transfer, creation, and communication).

Although these application fields have existed for several years, the potential of visual representations is often lost because there is little assistance for non-professional visualizers to make use of the power of complex visualization. Thus, a conceptual framework should be developed that enables practitioners to better use and apply visual representations of knowledge. In the next section, we briefly outline relevant background areas that have paved the way for knowledge visualization as a new discipline. Then, we will present a first general framework to guide the application of knowledge visualization.

BACKGROUND

The field of knowledge visualization is an emerging one, merging approaches from information visualization, didactic techniques, visual cognition, and visual communication research, as well as more practical approaches, such as business diagramming or visual programming languages. Below, we briefly review two of these central disciplines.

Visual Cognition and Perception

A majority of our brain's activity deals with processing and analyzing visual images. Several empirical studies show that visual representations are superior to verbal-sequential representations in different tasks (Larkin & Simon, 1987; Glenberg & Langston, 1992; Bauer & Johnson-Laird, 1993; Novick, 2001). Similarly, Miller (1956) reports that a human's input channel capacity is greater when visual abilities are used. The reason for this has been researched by Gestalt psychologists. Their findings indicate that our brain has a strong ability to identify patterns in graphics (Koffka, 1935). In addition, research on visual imagery (Kosslyn, 1980; Shepard & Cooper, 1982) suggests that visual recall seems to be better than verbal recall. It is still not entirely clear how images are stored and recalled, but it is clear that humans have a natural ability to remember and use images. Three related fields of research—instructional psychology, MIS, and media didactics—investigate the learning or performance outcomes of text-alone versus text-picture. Again, visualization seems to outperform text alone. Mandl and Levin (1989), Weidenmann (1989), and Swaab, Postmes, Neijens, Kiers, and Dumai (2002) present clearly different results in knowledge acquisition or task performance from text and pictures. All of these studies lead to one unambiguous conclusion: If visualization is applied correctly, it dramatically increases our ability to think and communicate.

Visual Communication Studies

Different isolated research fields contribute valuable results for the visual communication of knowledge. These are contributions in the field of visualizing information in print (Bertin, 1974; Tufte, 1990, 1997), cognitive art and hypermedia design (Horn, 1998), information architecture (Wurman, 1996), and contributions in the fields of graphics design, interface design, interaction design, and human-computer interaction. From a theoretical perspective, there are different contributions that help to improve the transfer of knowledge, particularly communication science (Fiske, 1982), visual communication sciences (Newton, 1998; Stonehill, 1995), and cognitive psychology (Farah, 2000). These contributions show how visual representations affect our social cognition processes both positively (improving understanding) and negatively (manipulating perception and interpretation). Many systematic approaches that examine visualization in communication, however, have so far been rooted in the mass media sector. They have primarily described how newspapers and television use graphic representations to convey meaning. How to use such formats actively for knowledge transfer is rarely discussed in these contributions. We use insights from these and other domains to categorize the main application parameters of knowledge visualization in the next section.

A Framework for Knowledge Visualization

For an effective creation and transfer of knowledge through visualization, at least three perspectives (Table 1) should be considered. These perspectives answer three key questions with regard to visualizing knowledge, namely:

1. What type of knowledge is visualized (object)?
2. Why should that knowledge be visualized (purpose)?
3. How can the knowledge be represented (method)?

The answers to these three questions are obviously highly interconnected. Listing possible answers to these key questions leads to a first conceptual framework that can provide an overview of the knowledge visualization field (see Table 1).

The knowledge type perspective can be used to identify the type of knowledge that needs to

Table 1. The three different perspectives of the knowledge visualization framework

Knowledge Type *(what?)*	**Visualization Goal *(why?)***		**Visualization Format *(how?)***
Know-what	Transferring (clarification, elicitation, socialization)	1.	Heuristic sketches
Know-how	Creating (discovery, combination)	2.	Conceptual diagrams
Know-why	Learning (acquisition, internalization)	3.	Visual metaphors
Know-where	Codifying (documentation, externalization)	4.	Knowledge animations
Know-who	Finding (e.g., experts, documents, groups)	5.	Knowledge maps
	Assessing (evaluation, rating)	6.	Domain structures

be transferred. For our framework we distinguish among five types of knowledge: declarative knowledge (know-what), procedural knowledge (know-how), experiential knowledge or experience (know-why), orientation knowledge (know-where), and people-related knowledge (know-who) (for this distinction, see for example Alavi & Leidner, 2001). Today, there is no validated prescriptive framework that links visualization formats to knowledge types and that offers specific representation formats for particular knowledge types.

With the help of the visualization goal perspective, we distinguish among several reasons why a visual knowledge representation is used. Goals for knowledge visualization use that can be anticipated are knowledge sharing through visual means, knowledge crafting or creation, learning from visual representations, codifying past experiences visually for future users, or mapping knowledge (Vail, 1999) so that experts, for example within a large organization, can be more easily identified.

The visualization format perspective structures the visualization methods to six main groups: heuristic sketches, conceptual diagrams, visual metaphors, knowledge animations, knowledge maps, and domain structures.

Having given an overview of the main formats of knowledge visualization, we will discuss each of the six types, and how they can be matched with adequate knowledge types and applied for specific application contexts.

Heuristic Sketches: Creating New Insights Individually or in Groups

Heuristic sketches are drawings that are used to assist the group reflection and communication process by making knowledge-in-progress explicit and debatable. Generally a sketch is defined as "a rough drawing or painting in which an artist notes down his preliminary ideas for a work that will eventually be realized with greater precision and detail."1 In the context of knowledge management, we call these sketches heuristic sketches to highlight their problem-solving potential. The main benefits of heuristic sketches are: (1) they represent the main idea and key features of a preliminary study; (2) they are versatile and accessible; (3) they are fast and help to quickly visualize emergent notions; (4) the use of a pen on a flipchart attracts the attention towards the communicator; and (5) heuristic sketches allow room for one's own interpretations and foster the creativity in groups. Examples of heuristic sketches are shown in Figures 1 and 2.

Figure 1. Freud's heuristic sketch for theory development [2]

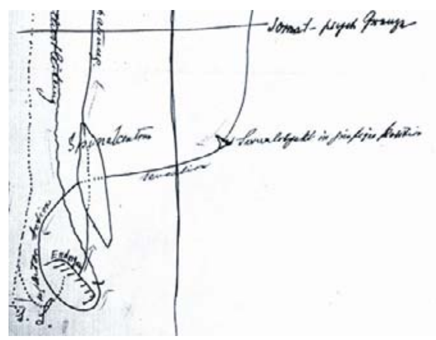
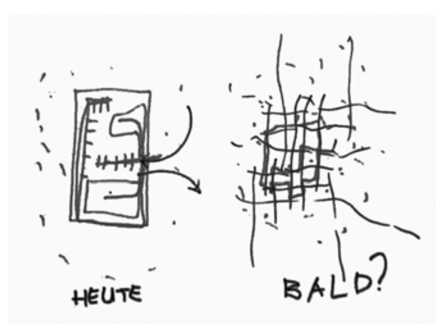


Figure 2. Various sketches helped to assist and inspire the group reflection processes in an urban planning workshop[3]



Conceptual Diagrams: Structuring Information and Illustrating Relationships

Conceptual diagrams as seen in Figure 3 are schematic depictions of abstract ideas with the help of standardized shapes (such as arrows, circles, pyramids, or matrices). They are used to structure information and illustrate relationships. For the transfer and creation of knowledge, conceptual diagrams help to make abstract concepts accessible, to reduce the complexity to the key issues, to amplify cognition, and to discuss relationships (Eppler, 2003).

An example of a particularly knowledge-intensive conceptual diagram is the Toulmin chart, based on the argumentation theory of Steven Toulmin (1964). Such a chart helps to breakdown an argument into different parts (such as claim, reasons, and evidence); this is useful when evaluating the validity of a claim.

Visual Metaphors: Relating Domains to Improve Understanding

A metaphor provides the path from the understanding of something familiar to something new by carrying elements of understanding from the mastered subject to a new domain. This is why Aristotle calls the metaphor a tool of cognition. A metaphor provides rapid information, is highly instructive, and facilitates the process of learning. As Worren, Moore, and Elliott (2002, p. 1230) have pointed out, metaphors can also improve memorability and coordination in groups. Visual metaphors used for knowledge transfer or creation can either be natural objects or phenomena (e.g., mountains, icebergs, tornado), or artificial, man-made objects (e.g., a bridge, a ladder, a temple), activities (e.g., climbing, etc.), or concepts (e.g., war, family). Their main feature is that they organize information meaningfully. In doing so, they fulfill a dual function. First, they position information graphically to organize and structure it. Second, they convey an implicit insight about the represented information through the key characteristics (or associations) of the metaphor that is employed.

In Figure 4 the metaphor of a bridge was used to convey how to lead successful negotiations.

Knowledge Animations: Dynamic and Interactive Visualizations

Knowledge animations are computer-supported interactive visualizations that allow users to con-

Figure 3. An overview of frequently used conceptual diagrams

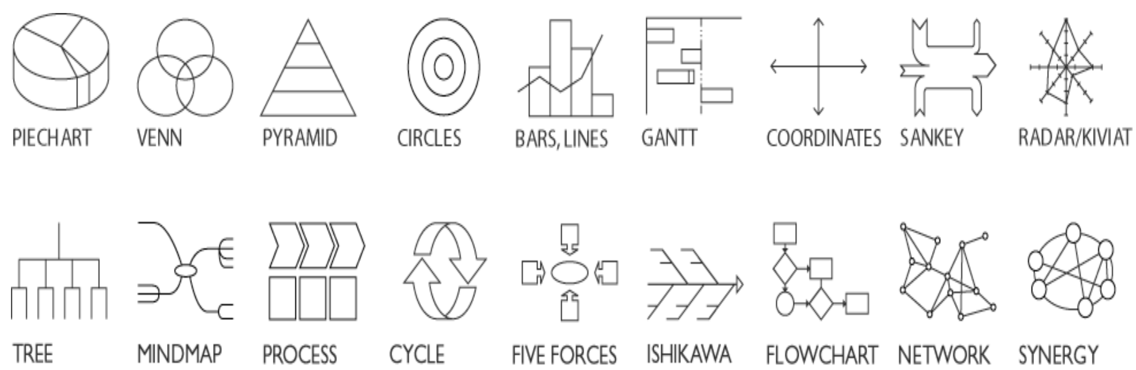


Figure 4. The negotiation bridge: A visual metaphor that outlines a negotiation method[4]

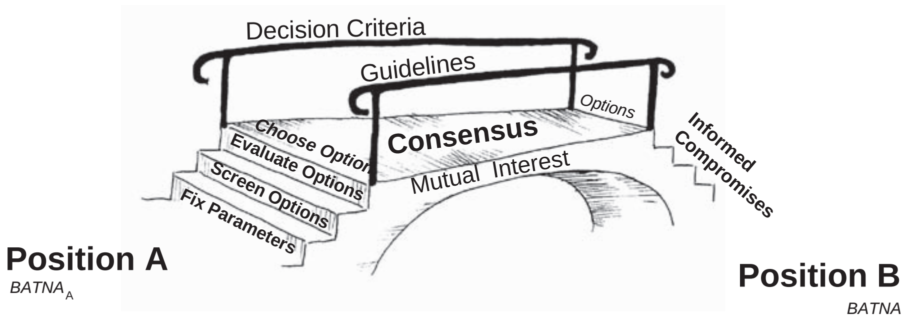
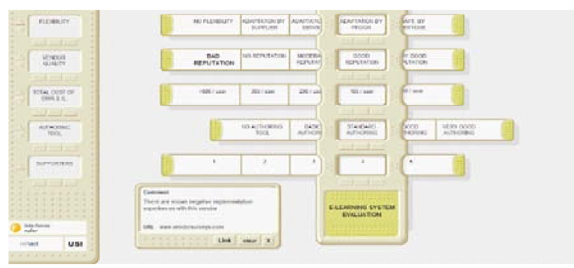


Figure 5. The Infoticle application allows exploring large-time varying datasets[5]

Figure 6. The interactive parameter ruler enables teams to explore alternatives in real time[6]



trol, interact, and manipulate different types of information in a way that fosters the transfer and creation of knowledge. By interacting with the information, new insights are created or shared. Knowledge animations help to fascinate and focus people, to enable interactive collaboration and persistent conversations, and to illustrate, explore, and discuss complex issues in various contexts. In the Infoticle application (Vande Moere, Mieusset, & Gross, 2004), the animation of data-driven particles (Infoticles) helps to explore large time-varying datasets and allows seeing the behavior of individual data entries in the global context of the whole dataset.

In similar ways, the interactive parameter ruler (Figure 6; Eppler, 2004) enables teams and individuals to explore alternatives in real time through sliders in the ruler application. As they enter evaluation criteria or decision options and move them into various positions, participants develop a common understanding regarding a complex issue. The joint visual interaction is thus a catalyst for collective knowledge development and transfer in groups.

Knowledge Maps: Navigating and Structuring Expertise

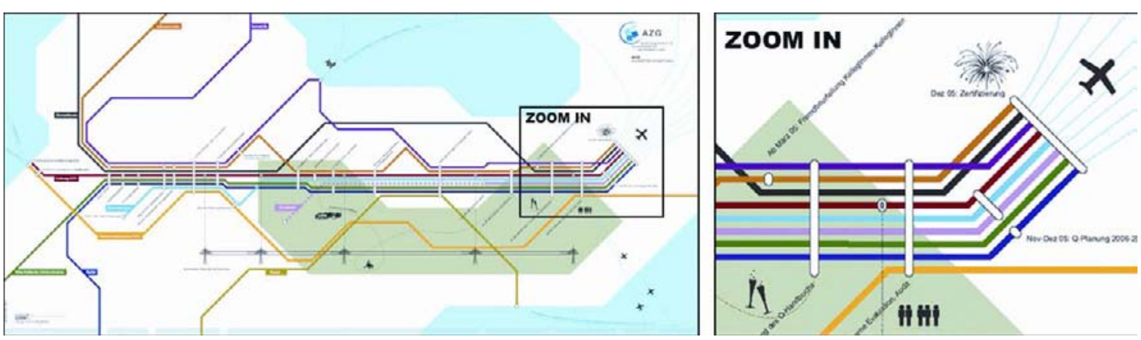
Knowledge maps (Eppler, 2002) are graphic formats that follow cartographic conventions to reference relevant knowledge. A knowledge map generally consists of two parts: a ground layer which represents the context for the mapping (such as an island), and the individual elements that are mapped within this context (e.g., towns). The ground layer typically consists of the mutual context that all employees can understand and relate to, such as a business model, a product, the competency areas, or a geographic map. The elements that are mapped onto such a shared context range from experts and communities of practice to more explicit and codified forms of knowledge such as articles, patents, lessons learned bases, or expert systems. Knowledge maps are thus graphic directories of knowledge-sources, -assets, -structures, -applications, or -development stages.

In Figure 7 the customized Tube Map Visualization7 illustrates a five-year quality development project. The subway-lines represent individual target groups and the stations milestones. The knowledge map was printed on a poster (2.4×1.2 meters) and located in front of an elevator to foster creativity and initiate discussion. An evaluation can be found in Burkhard and Meier (2004).

Domain Structures: Visualizing Intellectual Structures

Knowledge domain visualization focuses on identifying and visually representing the dynamics of scientific frontiers in a multidisciplinary context and allows new ways of accessing knowledge sources (authors, institutions, papers, journals, etc.) by visualizing linkages, relationships, and structures of scientific domains (Chen, 1998, 1999b, 2000, 2003). New algorithms can be integrated in novel interfaces for the exploration of digital libraries where new search paradigms become decisive (Kleiboemer, Lazear, & Pederson, 1996; Chen, Houston, Sewell, & Schatz, 1998; Sebrechts, Vasilakis, Miller, Cugini, & Laskowski, 1999; Sutcliffe, Ennis, & Hu, 2000). Examples for such systems are Envision (Fox et al., 1993, 2002) or Gridvis (Weiss-Lijn, McDonnell,

Figure 7. The tube map visualization (1.2×2.4 meter) presents an overview and details on a project. Each line represents one target group, each station a project milestone. Each line (target group) stops at the stations (milestones) where the target groups are involved. The stations are tagged with descriptions, dates, or instructions.



& James, 2001). An overview of such systems is presented by Nowell, France, Hix, Heath, and Fox (1996) and Börner and Chen (2002). While this knowledge visualization format is currently only used for knowledge management in scientific communities, future application in corporate settings can be envisioned (for communities of practice).

CONCLUSION

Knowledge visualization offers solutions for the transfer and creation of knowledge, and stresses an important and often neglected potential that knowledge management researchers and practitioners can exploit: our innate ability to effectively process visual representations. Knowledge visualization also offers new development roads for the discipline of information visualization, as it extends the field with regard to other knowledge types and knowledge processes other than information exploration (namely knowledge transfer and knowledge creation in groups), because: (1) it uses computer-based and non-computer based visualization methods; (2) it points to psychological, social, and cognitive factors of different recipients; and (3) it integrates findings from other research fields such as knowledge management, communication science, architecture, or psychology. This article presented both a theoretical framework and application examples to highlight the great potential of visualization for knowledge management. Specifically, this potential relates to cognitive (c), social (s), and emotional (e) benefits of visualization. These factors can be summarized in the CARMEN acronym:

- Coordination: Visual representations help to coordinate knowledge workers, and to structure communication and group processes (e.g., knowledge maps, visual tools for collaboration, heuristic sketches). (s)
- Attention: Visual representations allow users to gain attention by addressing emotions (e.g., advertising) and to keep attention (e.g., sketching on a flipchart) by identifying patterns, outliers, and trends (e.g., information visualization). (c)
- Recall: Visual representations improve memorability, remembrance, and recall, because we think in images (e.g., visual metaphor, stories, and conceptual diagrams). (c)
- Motivation: Visual representations inspire, motivate, energize, and activate viewers (e.g., knowledge maps, mutual stories, instructive diagrams). (e)
- Elaboration: Visual representations lead to further understanding and appreciation of concepts and ideas as one interacts with them (e.g., discussing scenarios of a new product by the use of heuristic sketches or a physical model). (c)
- New Insights: Knowledge visualizations can reveal previously hidden connections and lead to sudden insights—'a-ha' experiences. By visualizing experiences in a group, for example, root causes of certain errors can surface. Visual representations support the creation of new insights by embedding details in context and showing relationships between objects (e.g., information visualization, visual metaphors). (c)

As far as the limitations are concerned, there is evidence that visualization can have drawbacks with regard to specific contexts. One should thus not neglect the risks inherent in using such forms of visualization, namely the difficult maintenance of the diagrams and maps, the reification of (at times) invalid views, and hence the possible manipulation of users, or the possible distortion of reality through misinterpretations. Future research will have to investigate these potential negative effects empirically in authentic application contexts (e.g., Blackwell & Green, 1999). As a reminder, we summarize the potential drawbacks of knowledge visualization with the COMMA acronym:

- Confusion: If knowledge visualizations do not respect certain rules and conventions, or if the used metaphors or analogies are difficult to understand, they can be confusing and obstruct knowledge transfer.
- Overload or oversimplification: Knowledge visualization that does not respect the cognitive constraints of visual perception quickly becomes overloaded and de-motivating. On the other side of this spectrum, visualizations may also simplify ideas or concepts by leaving out too many vital elements.
- Misuse or misrepresentation: Visualizations may also be used where they are not really necessary and where a text may convey an insight (e.g., because of its sequential structure) more adequately than a text. They may misrepresent a given domain, for example, by employing an unfit metaphor or diagrammatic template. Misuse may also result from a haphazard look at a picture.
- Manipulation: As stated above, visualization is a powerful instrument that can be used to cover up logical flaws, incomplete reasoning, or distorted evidence. Consequently, visualizations must always be viewed critically.
- Ambiguity: As graphic symbols are typically open to various interpretations, compilations of such symbolic forms in knowledge visualizations may at times be ambiguous. Because of this, it is crucial to provide written or verbal explanations to accompany complex graphics.

In terms of future trends, knowledge visualization will evolve with regard to new formats and new application areas. The potential to combine various formats (such as diagrams, maps, and metaphors) in a complementary way (as architects use them) seems obvious. It also seems clear that knowledge visualization will be used in other settings than just the traditional computer desktop environment. Examples of new application areas for knowledge visualization can be found in the visual communication of corporate missions, strategies, value propositions, and business scenarios. New applications can also be envisioned by combining knowledge visualization with other innovative approaches in knowledge management, such as storytelling. Storytelling is in fact a closely related knowledge management tool, as it strives for rich, mental imagery (Loebbert, 2003). We believe that stories can be combined with knowledge visualization formats (as in visualized story trails) to trigger and accelerate the creation and dissemination of knowledge in organizations.

In conclusion, we believe that additional time and budget for knowledge visualization should be allocated in future corporate KM initiatives and in future research initiatives on knowledge management. Knowledge visualization clearly is an idea whose time has come. To put this idea into practice, however, requires not only imagination, but also dedication to continuous assessments and improvements.

REFERENCES

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Bauer, M., & Johnson-Laird, P. (1993). How diagrams can improve reasoning. *Psychological Science, 4*(6), 372-378.

Bertin, J. (1974). *Graphische Semiologie. Diagramme, Netze, Karten.* Berlin: Walter de Gruyter.

Blackwell, A.F., & Green, T.R.G. (1999). Does metaphor increase visual language usability?

Proceedings of the 1999 IEEE Symposium on Visual Languages (VL'99) (pp. 246-253).

Börner, K., & Chen, C. (2002). *Visual interfaces to digital libraries.* Heidelberg: Springer-Verlag (LNCS).

Burkhard, R., & Meier, M. (2004, June 30-July 2). Tube map: Evaluation of a visual metaphor for interfunctional communication of complex projects. *Proceedings of I-KNOW '04,* Graz, Austria (pp. 449-456).

Card, S.K., Mackinlay, J.D., & Shneiderman, B. (1999). *Readings in information visualization; Using vision to think.* Los Altos, CA: Morgan Kaufmann.

Chen, C. (1998). Bridging the gap: The use of pathfinder networks in visual navigation. *Journal of Visual Languages and Computing, 9*(3), 267-286.

Chen, C. (1999a). *Information visualisation and virtual environments.* London: Springer.

Chen, C. (1999b). Visualizing semantic spaces and author co-citation networks in digital libraries. *Information Processing and Management, 35*(3), 401-420.

Chen, C. (2000, July 19-21). Domain visualization for digital libraries. *Proceedings of the International Conference on Information Visualisation (IV2000)* (pp. 261-267). London.

Chen, C. (2003). *Mapping scientific frontiers: The quest for knowledge visualization.* London: Springer.

Chen, H., Houston, A., Sewell, R.R., & Schatz, B.R. (1998). Internet browsing and searching: User evaluations of category map and concept space techniques. *Journal of the American Society for Information Science, 49*(7), 582-603.

El Sawy, O.A., Eriksson, I., Carlsson, S.A., & Raven, A. (1997, November 6-8). Understanding the nature of shared knowledge creation spaces around business processes: An international investigation. *Proceedings of the Carnegie Bosch Institute Conference on Knowledge in International Corporations,* Rome.

Eppler, M. (2002). Making knowledge visible through knowledge maps. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (pp. 189-206). Berlin: Springer-Verlag.

Eppler, M. (2003). *Managing information quality. Increasing the value of information in knowledge-intensive products and processes.* Berlin: Springer-Verlag.

Eppler, M. (2004). Facilitating knowledge communication through joint interactive visualization. *Journal of Universal Computer Science, 10*(6), 683-690.

Farah, M.J. (2000). *The cognitive neuroscience of vision.* Malden, MA: Blackwell.

Fiske, J. (1982). Communication theory. In J. Fiske (Ed.)*, Introduction to communication studies* (pp. 6-24). London; New York: Methuen.

Fox, E., North, C., Wang, J., Abhishek, A., Anil, B., & Supriya, A. (2002). Enhancing the ENVISION interface for digital libraries. *Proceedings of the 2nd ACM/IEEE-CS Joint Conference on Digital Libraries* (pp. 275-276). Portland, OR: ACM Press.

Fox, E.A., Hix, D., Nowell, L.T., Brueni, D.J., Wake, W.C., Heath, L.S., & Rao, D. (1993). Users, user interfaces, and objects: ENVISION, a digital library. *Journal of the American Society for Information Science, 44*(8), 480-491.

Glenberg, A., & Langston, M. (1992). Comprehension of illustrated text: Pictures help to build mental models. *Journal of Memory and Language, 31*(2), 129-151.

Horn, R. (1998). *Visual language: Global communication for the 21st century.* Brainbridge Island, WA: MacroVU.

Kleiboemer, A.J., Lazear, M.B., & Pederson, J.O. (1996). Tailoring a retrieval system for naive users. *Proceedings of the 5th Symposium on Document Analysis and Information Retrieval (SDAIR96),* Las Vegas (pp. 209-216).

Koffka, K. (1935). *The principles of Gestalt psychology.* New York: Harcourt Brace.

Kosslyn, S.M. (1980). *Images and mind.* Cambridge, MA: Harvard University Press.

Larkin, J., & Simon, H. (1987). Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science, 11,* 65-99.

Lin, X., White, H.D., & Buzydlowski, J. (2001, August 6-12). Associative searching and visualization. *Proceedings of the International Conference on Advances in Infrastructure for Electronic Business, Science, and Education on the Internet (SSGRR01),* L'Aquila, Italy.

Lin, X., White, H.D., & Buzydlowski, J. (2003). Real-time author co-citation mapping for online searching. *Information Processing and Management: An International Journal, 39*(5), 689-706.

Loebbert, M. (2003). *Storymanagement—der Narrative Ansatz für Management und Beratung.* Stuttgart: Klett-Cotta.

Mandl, H., & Levin, J.R. (1989). *Knowledge acquisition from text and pictures.* Amsterdam: North-Holland.

Miller, G.A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81-97.

Novick, L.R. (2001). Spatial diagrams: Key instruments in the toolbox for thought. In D.L. Medin (Ed.), *The psychology of learning and motivation* (pp. 279-325). San Francisco: Academic Press.

Nowell, L.T., France, R.K., Hix, D., Heath, L., & Fox, E. (1996). Visualizing search results: Some alternatives to query-document similarity. *Proceedings of the ACM SIGIR Conference on Research and Development in Information Retrieval (SIGIR96),* Zurich, Switzerland (pp. 67-75).

Sebrechts, M.M., Vasilakis, J., Miller, M.S., Cugini, J.V., & Laskowski, S.J. (1999). Visualization of search results: A comparative evaluation of text, 2D, and 3D interfaces. *Proceedings of the 22nd Annual International ACM SIGIR Conference on Research and Development in Information Retrieval* (pp. 3-10). Berkeley, CA: ACM Press.

Shepard, R.N., & Cooper, L.A. (1982). *Mental images and their transformations.* Cambridge, MA: MIT Press.

Sparrow, J. (1998). *Knowledge in organizations.* Thousand Oaks, CA: Sage Publications.

Spence, B. (2000). *Information visualization.* San Francisco: ACM Press.

Sutcliffe, A.G., Ennis, M., & Hu, J. (2000). Evaluating the effectiveness of visual user interfaces for information retrieval. *International Journal of Human-Computer Studies,* (53).

Swaab, R.I., Postmes, T., Neijens, P., Kiers, M.H., & Dumai, A.C.M. (2002). Multiparty negotiation support: The role of visualization's influence on the development of shared mental models. *Journal of Management Information Systems, 19*(1), 129-150.

Toulmin, S. (1964). *The uses of argument.* Cambridge, UK: Cambridge University Press.

Tufte, E. (1990). *Envisioning information.* Cheshire: Graphics Press.

Tufte, E. (1997). *Visual explanations.* Cheshire: Graphics Press.

Vance, D., & Eynon, J. (1998). On the requirements of knowledge-transfer using information systems: A schema whereby such transfer is enhanced. *Proceedings of the 4th Americas Conference on Information Systems,* Baltimore (pp. 632-634).

Vande Moere, A., Mieusset, K.H., & Gross, M. (2004). Visualizing abstract information using motion properties of data-driven particles. *Proceedings of the Conference on Visualization and Data Analysis 2004, IS&T/SPIE Symposium on Electronic Imaging 2004*, San Jose, CA.

Ware, C. (2000). *Information visualization: Perception for design.* San Francisco: Morgan Kaufmann.

Weidenmann, B. (1989). When good pictures fail: An information-processing approach to the effect of illustrations. In H. Mandl & J.R. Levin (Eds.), *Knowledge acquisition from text and pictures*. Amsterdam: Elsevier, North.

Weiss-Lijn, M., McDonnell, J.T., & James, L. (2001). Visualizing document content with metadata to facilitate goal-directed search. *Proceedings of the 5th International Conference on Information Visualization (IV01)* (pp. 71-76).

White, H.D., Buzydlowski, J., & Lin, X. (2000). Co-cited author maps as interfaces to digital libraries: Designing pathfinder networks in the humanities. *Proceedings of the IEEE International Conference on Information Visualization (IV00)*, London (pp. 25-30).

Worren, N., Moore, K., & Elliott, R. (2002). When theories become tools: Toward a framework for pragmatic validity. *Human Relations, 55*(10), 1227-1250.

Wurman, R.S. (1996). *Information architects.* Zurich: Graphis Press Corp.

ENDNOTES

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2. Reproduced by permission of A.W. Freud et al./Paterson Marsh Ltd., London.
3. With permission from the Swiss Federal Institute of Technology (ETH): http://www.sciencecity.ethz.ch
4. BATNA in this context is an abbreviation for Best Alternative to a Negotiated Agreement. See Lewicki, R.J., Saunders, D.M., & Minton, J.W. (1997). Essentials of negotiation. Boston: Irwin McGraw-Hill.
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Chapter 2.27
Web GIS and Knowledge Management Systems:
An Integrated Design for Collaborative Community Planning

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ABSTRACT

Environmental problems are multidimensional and usually complex. Collaborative integration of multiple forms of knowledge is one approach used to develop meaningful solutions to complex problems. In this regard, spatial data and knowledge about the environment have been managed extensively with Web geographic information systems (Web GIS). However, past Web GIS research has focused mostly on using spatial tools to manage explicit (codified) knowledge. This has reduced the complementary contribution that tacit (experiential) knowledge can provide to environmental solutiodragns. In this study, Web GIS and knowledge management technologies are used to integrate multiple forms of spatial knowledge in support of collaborative community planning. The system design included a customized end-user interface for data entry, georeferencing tools for asynchronous collection of local data, and protocols for knowledge management dealing with species location, ecological habitats, and environmentally sensitive areas among others. The system enabled access, query, sharing, and updating of environmental knowledge using visual map-based tools. The utility of the integrated system design is discussed.

INTRODUCTION

Environmental problems are affected by many factors that can be classified along physical, ecological, socio-cultural, and political-legislative dimensions (Gunderson & Holling, 2002). These factors interact nonlinearly and with feedback such that the system outputs influence the system inputs. The emergent complexity is a challenge for environmental management, planning and decision making. The literature suggests that approaches that consider collaboration, data partnerships, and knowledge management can provide an effective means to manage the complexity of environmental systems (Andelman, Bowles, Willig, & Waide, 2004; Blumenthal & Jannink, 2000; Jankowski & Nyerges, 2001; Johnson & Singh, 2003). In this study, a collaborative Web GIS and knowledge management system is presented to support access, query, sharing, and updating of environmental knowledge using visual map-based tools.

Collaboration in a spatial context has its roots in the participatory planning literature, and involves the inclusion of a wide range of individual perspectives in the decision-making process (Hemmati, Dodds, Enatati, & McHarry, 2002; Jankowski & Nyerges, 2001). In order to facilitate partnerships and collaborative interactions among stakeholders and planners, extensive use has been made of community GIS (Ghose, 2001; Talen, 1999) and Web GIS (Houle, Dragicevic, & Boudreault, 2000; Kangas & Store, 2003; Rinner, 2003). One limitation of community GIS is that increasing the involvement of individuals demands more efficient management and spatial support tools to reduce process delays. Because the planning process is temporal, Web GIS has increasingly been used to continually engage a wider cross section of stakeholder groups. Moreover, the open source Web GIS movement has positively impacted the adoption and use of Web GIS among individuals and groups. As such, Web GIS can provide a robust infrastructure to support collaboration across multiple spatial and time scales.

Web GIS are designed to integrate the distributive capabilities of the Internet with the spatial analytical features of geographic information systems (Peng, 2001; Peng & Tsu, 2003). Web GIS uses the multimedia protocols of the Internet and forms a focused subset of Internet GIS. The early implementations of Web GIS were limited to static maps and simple navigation such as pan and zoom (Plewe, 1997). Web GIS has now rapidly evolved to offer a full suite of interactive spatial data management, analysis, and mapping capabilities (Dragicevic, 2004; Gitis, Andrienko, & Andrienko, 2004; Tsou, 2004). An advantage of Web GIS is that they integrate stakeholders, planners, and spatial data in synchronous and asynchronous implementations to search for joint solutions (Dragicevic & Balram, 2004; Kingston, Carver, Evans, & Turton, 2000). The research and applications of Web GIS have mostly focused on designing and using spatial tools to manage explicit (documented) knowledge. This has reduced the complementary contribution that tacit (personal experiences) knowledge can provide to environmental solutions. Extending current Web GIS to support knowledge processes requires that knowledge management systems (KMS) capabilities be integrated in complementary designs.

Knowledge management systems contain tools, techniques, and processes to elicit, assess, organize, expand, and share expertise (McElroy, 2003). Expertise is classified generally as tacit knowledge or explicit knowledge (Fuller, 2002). Tacit knowledge is personal knowledge that has evolved within individuals or communities and has been passed on from one generation to another. This type of knowledge is difficult to transfer to a spatial and digital environment because it is not easily codified. For example, the location of traditional hunting grounds for a First Nation community is common oral knowledge and difficult to translate into a map. The consequence is that tacit knowledge is usually excluded from the map-driven planning process. Researchers have also used the term "local knowledge systems" to describe frameworks for operationalizing tacit knowledge (Lawas & Luning, 1997). Local knowledge, traditional knowledge, and traditional ecological knowledge are other terms that describe tacit knowledge (Zurayk, el-Awar, Hamadeh, Talhouk, Sayegh, Chehab et al., 2001). Explicit knowledge is documented knowledge obtained by systematic means that can be transferred between sources. Explicit knowledge is derived from the formal scientific data collection and synthesis process (Robiglio & Mala, 2005). The aim of KMS in the environmental planning process is to combine tacit and explicit knowledge in order to develop more comprehensive knowledge bases that can improve problem understanding, create environmental learning forums, and enhance environmental sustainability (McElroy, 2003).

The integration of Web GIS and KMS provides benefits for the collection and management of multiple forms of knowledge in spatial contexts (Goran & MacGillivray, 2003). While both systems deal with data in general, they differ based on the attribute-spatial distinction. KMS are well suited to represent attribute data and corporate knowledge, but are not well suited to represent the spatial aspects of environmental knowledge. Web GIS is explicitly designed to deal with spatial data. Integrating Web GIS and KMS provides a useful approach to develop systems that can handle multiple forms of knowledge within a spatial context. Benefits of the integration include encouraging human interactions by the new perspectives gained from spatial data, promoting dialogue about future scenarios from past attribute data, and sharing and reusing knowledge for future planning (Goran & MacGillivray, 2003).

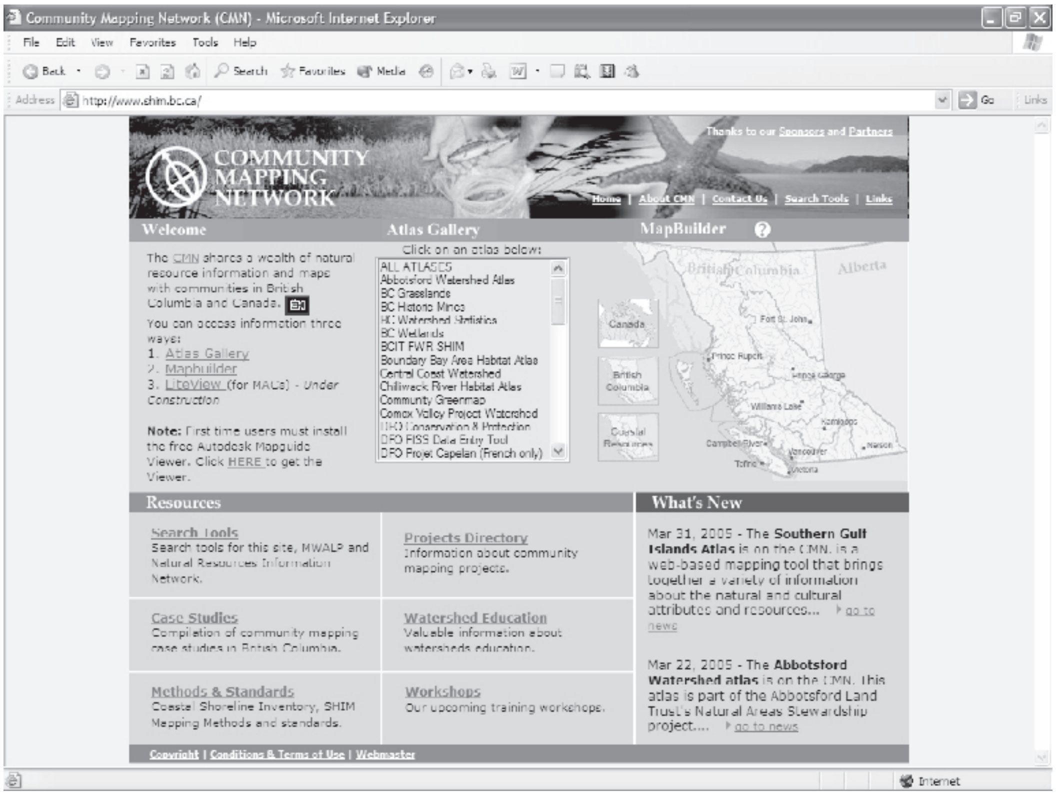
In this study, Web GIS and KMS were integrated to form a collaborative distributed system called the Community Mapping Network (CMN). The system design included a customized end-user interface for data entry, while the georeferencing tools enabled asynchronous collection of local knowledge about the location of species, ecological habitats, and points of interest, among others. The integrated system was implemented for collaborative community planning and management in British Columbia, Canada. This chapter begins by outlining the need for systems integration generally and the integration of Web GIS and KMS specifically, followed by the architecture and knowledge integration aspects of the CMN, then discusses implementation experiences, and finally concludes with future design improvements of the developed system.

INTEGRATED DESIGN FOR COLLABORATIVE PLANNING

The Community Mapping Network (http://www.shim.bc.ca) is an evolving knowledge base that provides a service to government agencies by integrating multiple natural resources information across jurisdictional boundaries (Figure 1). The system was created in response to demands from communities, stewardship groups, nongovernmental organizations, and governments (federal, provincial, local) in British Columbia, Canada to improve understanding about natural resources in the province. The integration of information through a single access point using data server links and access agreements is intended to build capacity within communities to compile local knowledge, access natural resource information, and promote sustainable community planning.

The focus of CMN is on data collection and knowledge integration for the province of British Columbia, Canada. In the arrangement, the CMN acts as a data steward for contributing organizations, with the data remaining the property of the contributor. Data updating and permission for downloading remains the responsibility of the data contributor. Data entry for new information requires password authorization for security and confidentiality reasons. Using the Web-mapping data entry tools, end users can add new and timely information. Although some information about British Columbia's coastal resources is available in multiple data warehouses, there is a much larger area of the province's coast for which there is no information. The cost of conducting detailed surveys along the entire BC coast is prohibitive, and one estimate is that it would take over 60 years with the best available technology to map the BC coastal seafloor and inshore (Berry, 2003). Using

Figure 1. The community mapping network Web site and access interface



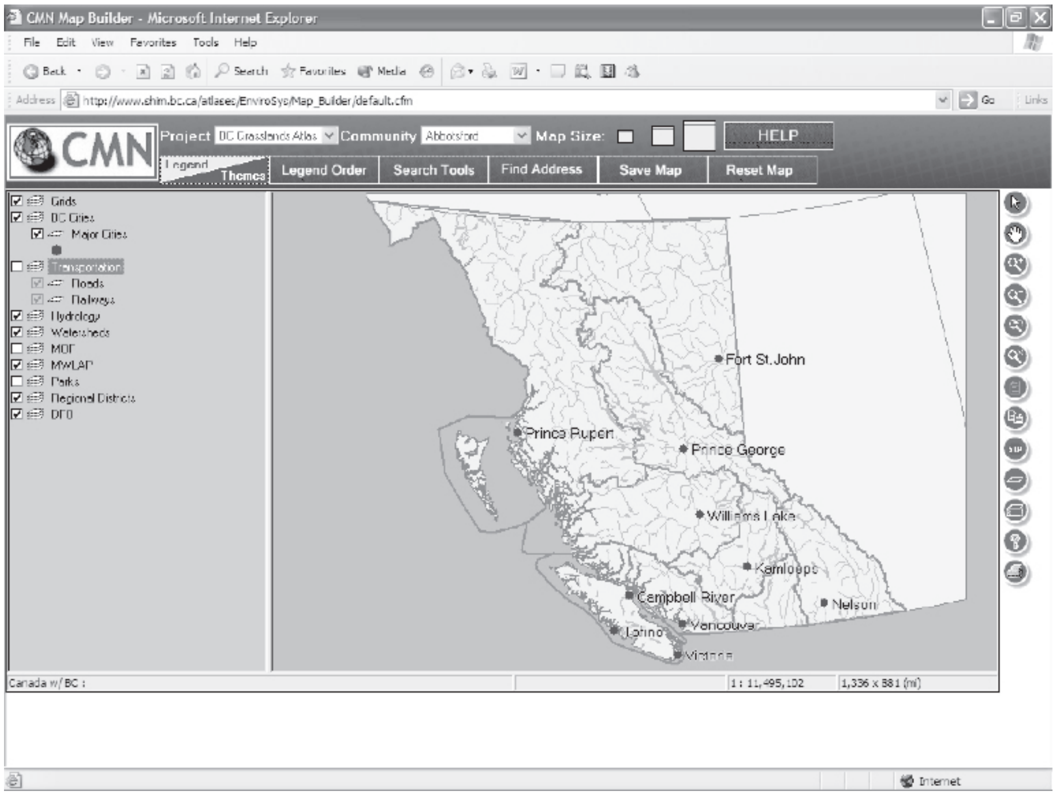
local knowledge is an attractive option that can also encourage residents to use natural resources responsibly.

Study Site and Context

The study area is the Lower Mainland of British Columbia (Figure 2), which is one of North America's most biologically diverse areas. The resources in these areas are especially valuable given the increasing trends and patterns towards human population expansion (Porter, 2002).

The roles and capabilities of the federal, provincial, regional, and municipal levels of government also need to be taken into consideration in these conservation efforts. At many levels of governments, sufficient funds are not available to acquire or manage all sensitive natural areas that need protection. Also, the ability of governments to regulate potentially detrimental activities on public or private lands is limited by a shortage of staff, political mandate, conflicting policies, and a complex array of regulations. Federal and provincial agencies are tasked with the environmental review of development projects, but this has been rather fragmented and municipal governments have often refused to accept the guidance of these review agencies. Moreover, the rapid growth and development in these areas often overwhelms the capacity of local planners to manage land and preserve sensitive habitats. Sometimes the development proposals are received late in the planning process and may be reviewed without detailed knowledge about the value of sensitive

Figure 2. Map showing the British Columbia study area from the CMN Map interface



habitats at the location. The levels of government are under increasing pressure to respond to the expanding resource development in current and emerging populated areas.

The information available from government sources alone is not comprehensive or detailed enough for land-use planning in settlement areas. Existing federal and provincial geospatial databases do not have adequate site-specific information about sensitive habitats, and are usually not available at a scale (1:5,000) required for local land-use planning. The process to update the government databases or to record observations about new species of concern or marginal habitats that are important to communities is also problematic. Valuable local knowledge and unpublished environmental surveys can be lost with time as people relocate. Sensitive habitats such as urban and smaller rural watercourses, eelgrass beds, riparian areas and wetlands remain unknown and poorly understood. There is a need to collect new information about the distribution and growth of invasive species as well as the location of wildlife, and rare and endangered species. Some groups have also started to collect local data to support community planning and management; for example, the Wildlife Tree Atlas hosted on the CMN Web site.

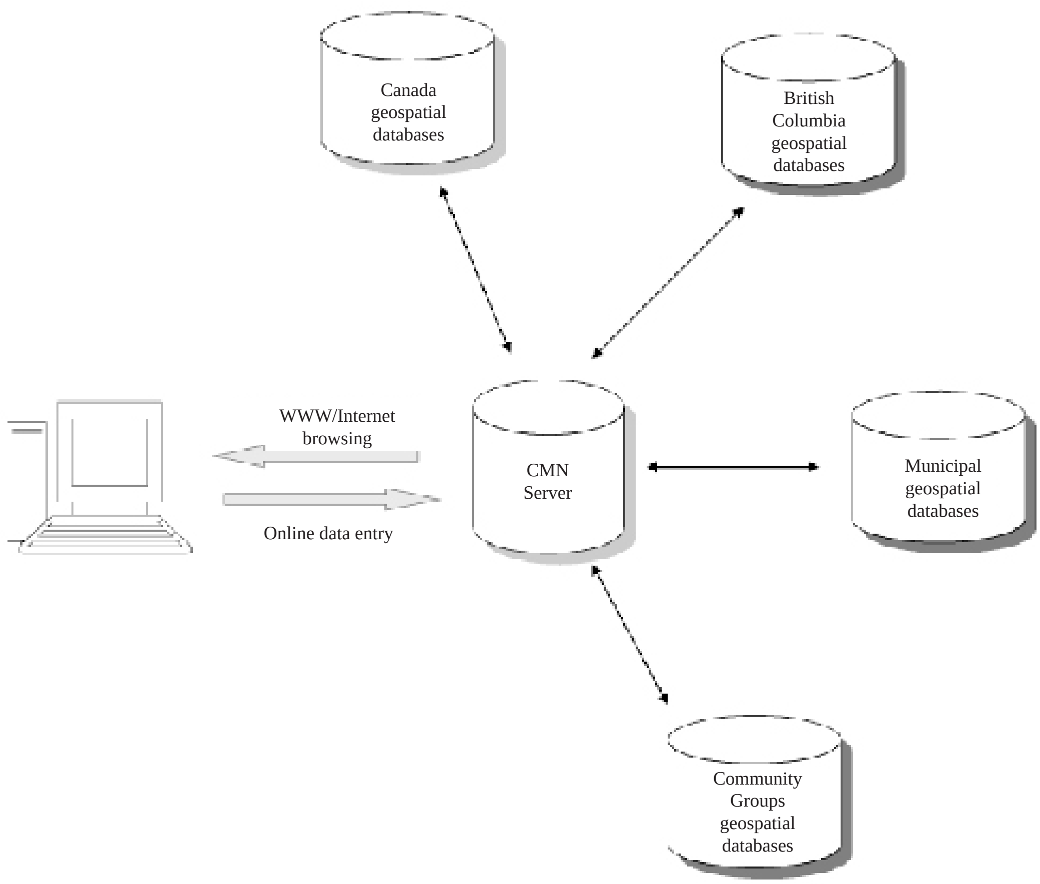
Establishing collaborative partnerships between local stakeholders and government is an effective means to complement available knowledge about the environment. This requires local communities to access, understand, and contribute relevant information and resources necessary to practice stewardship and conservation more effectively.

Web GIS System Design

The Web GIS system design integrates community-based and government natural resource information into geospatial databases for display on the Web using the Autodesk MapGuide GIS software (http://www.mapguide.com). There are three components to the MapGuide software that facilitate the Web GIS process. First, the MapGuide Server handles requests by the Web browser and returns map data in the form of image snapshots. Second, the MapGuide Author creates digital maps that can then be published on the Web server. Maps are published by copying the generated map file to the Web server, and either embedding the map in an HTML Web page, or pointing users directly to the map file. Third, the MapGuide Viewer allows client-side access and manipulation of the maps. The viewer requires a free plug-in to be installed at the client-side to enable the maps to be displayed in the Web browser.

The design included multiple Web servers to share the workload of serving province-wide base maps, high-resolution orthophotographs, and

Figure 3. The CMN distributed network of data and Web servers

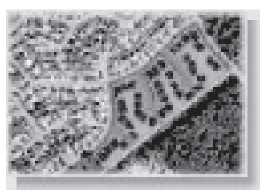


other thematic maps (Figure 3). The databases are hosted on several servers and connected by a computer network. For example, watercourse features on the CMN server are linked to the federal/provincial Fish Wizard and Fisheries Information Summary System. Reports are generated in real time from the federal and provincial systems by querying and selecting individual watercourses from the CMN server map interface. Also, the map display can be customized by choosing layers of information from among those available in both raster and vector GIS format. Navigation and mapping tools allow users to move around the map, query the data, add information, and edit existing data.

The CMN application is password controlled with four levels of users: government agencies who manage their own data, community data editors who enter information about local knowledge, system administrators and data verification personnel, and the general public.

The maps and natural resources data are "Web served" by CMN to assist communities and local governments with land-use planning, promote conservation and protection of sensitive habitats, and raise awareness about ecological values. There are currently over 33 separate atlases being developed and used on the CMN with different levels of support, functions, objectives, and audiences. The atlases vary in the amount and quality of information collected. Table 1 shows three of the atlases currently available as cases to demonstrate the general focus, content, and objectives of the CNM-community collaborations.

Table 1. Three CMN atlases developed with communities and stakeholders

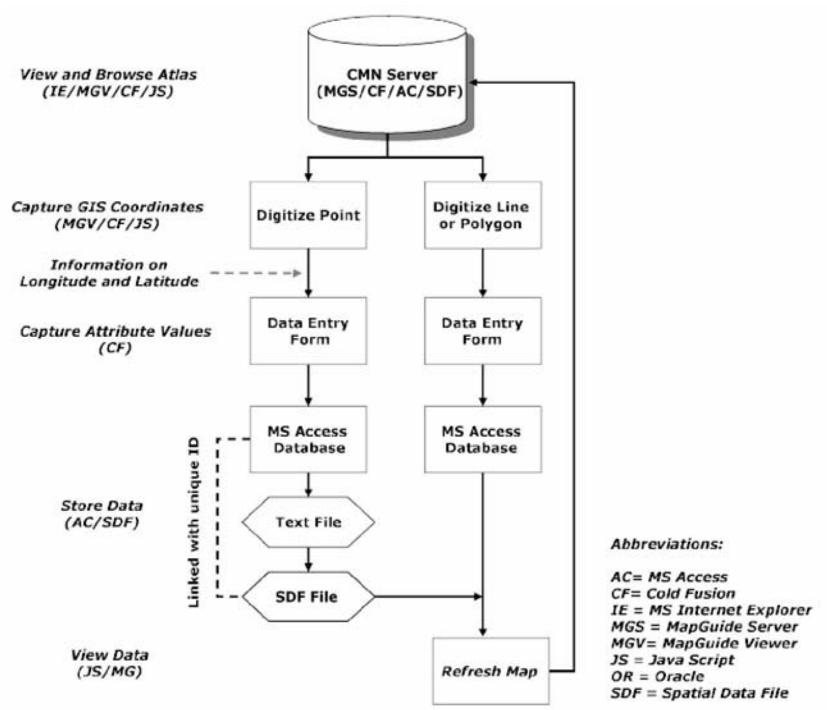
British Columbia Invasive Species (BCIS) Atlas The Langley Environmental Partners Society (LEPS), a non-government environmental organization, created this atlas to assist mapping invasive species that are jeopardizing the ecological balance in southwestern British Columbia. The purpose of this Atlas is to inform public of the growing concerns associated with invasive exotic, alien and noxious plants. Specifically, this site describes key features of ten common invasive plants, emphasizing identification and control techniques. Hopefully, the following information will be of use to community groups and individuals who are interested in taking an active response to the escalating problems associated with invasive plants.	
Sensitive Habitat Inventory and Mapping (SHIM) Atlas The SHIM Atlas allows users (with password access) to digitize new map layers and enter new information on local resources directly into the Atlas over the Internet. This user provided mapping information is intended to augment and potentially enhance local land use planning maps and/or specific site or detailed planning surveys. The primary functions of the atlas are to identify sensitive habitats, integrate spatial knowledge about sensitive areas, and establish partnerships with governments, stakeholders and the public.	
Wildlife Tree Stewardship (WTS) Atlas The Vancouver Island Wildlife Tree Atlas is an online database of known Wildlife Trees on Vancouver Island showing locations, observations, and productivity of Eagle nests. The Atlas helps to keep the community informed, interested, and participating in land stewardship. The Atlas leads to an increase in the protection of valuable wildlife habitats in the form of stewardship agreements, land covenants, municipal plans and bylaws, and enforcement of current provincial and federal wildlife tree protection.	

Knowledge Management Design

Knowledge management consists of the tools, techniques, and processes to collect, retain, analyze, organize, improve, and share understanding about data and information, and to use that understanding towards meaningful action (Wang, Hjelmervik, & Bremdal, 2001). The action that results is a consequence of understanding past experiences and potential solutions for addressing a particular problem. In this regard, the knowledge tools, techniques, and processes developed by CMN for two data entry workflow processes are presented and discussed.

In the first workflow (Figure 4), data entry can be initiated using the Internet Explorer browser by downloading and installing the MapGuide viewer or plug-in. The viewer or plug-in can automatically be installed when accessing a map from the CMN Web site, or loaded manually from the Autodesk MapGuide Web site. The viewer allows the end user to interact with the Cold Fusion (http://www.macromedia.com) functions of the CMN Web server. Password protection prevents unauthorized access to the data entry tools. Both vector and raster maps from various sources with different levels of resolution are provided to assist in locating a position of interest. The common

Figure 4. Example of a data entry workflow process for the CMN system



zoom, toggle, and go-to map queries allow users access to specific locations such as place names, map sheet numbers, and coordinates collected through global positioning surveys. Users can also request summary reports about the various spatial data on the map.

Users must zoom in below a predetermined scale before digitizing and data entry tools become functional to help improve precision (Figure 5). The data entry process is initiated by clicking with the computer mouse on the desired location on a map. A JavaScript function captures the latitude and longitude of the location and passes this information as text to a Cold Fusion data entry form. For points, lines, and polygons, all the coordinates are captured. Alternatively, another function is available to translate the latitude and longitude of the locations to the projection of the current map.

The end user must fill in the data about the new digitized feature and submit the form (Figure 6). Information entered in the form as well as the coordinates captured from the map are transmitted to a Microsoft Access database on the CMN server. For points, the latitude and longitude fields of the database are used to display them directly on the map. For lines and polygons, a spatial data file (SDF) is generated. This SDF is created by exporting a unique ID for each set of coordinates to a temporary text file. A batch file is then executed to activate the MapGuide SDF Loader program which then translates the text file to an SDF file. The SDF file contains lines or polygons coordinates with their unique ID used

Figure 5. Navigation tools to improve precision of digitizing and data entry

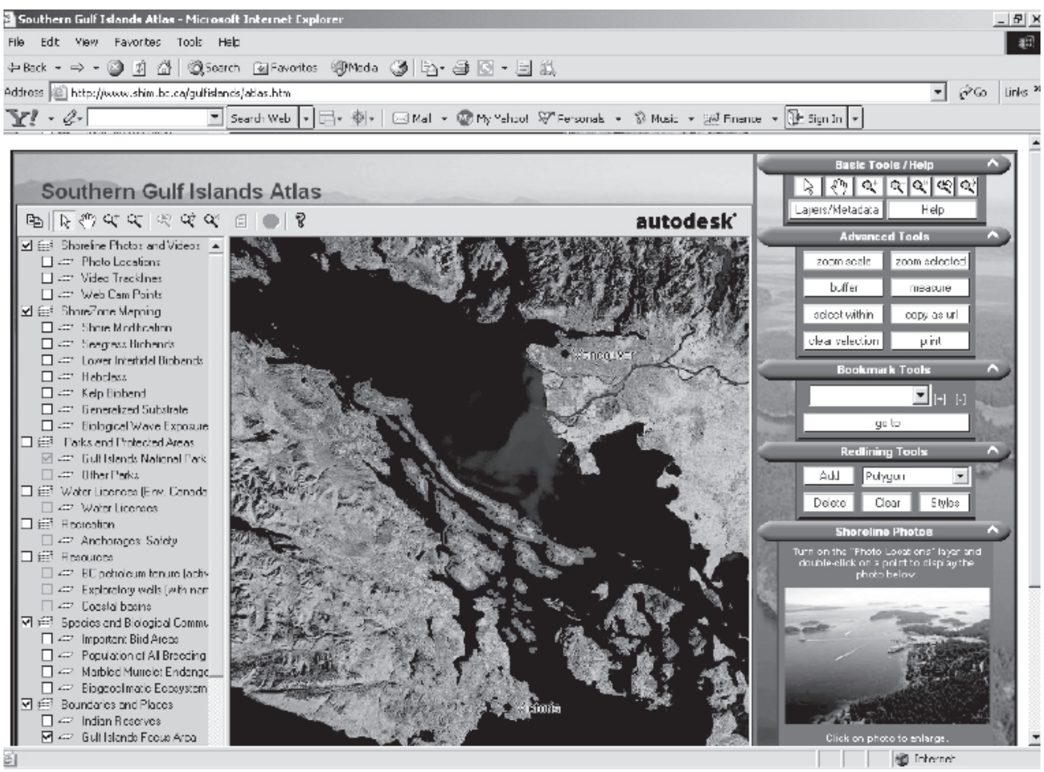
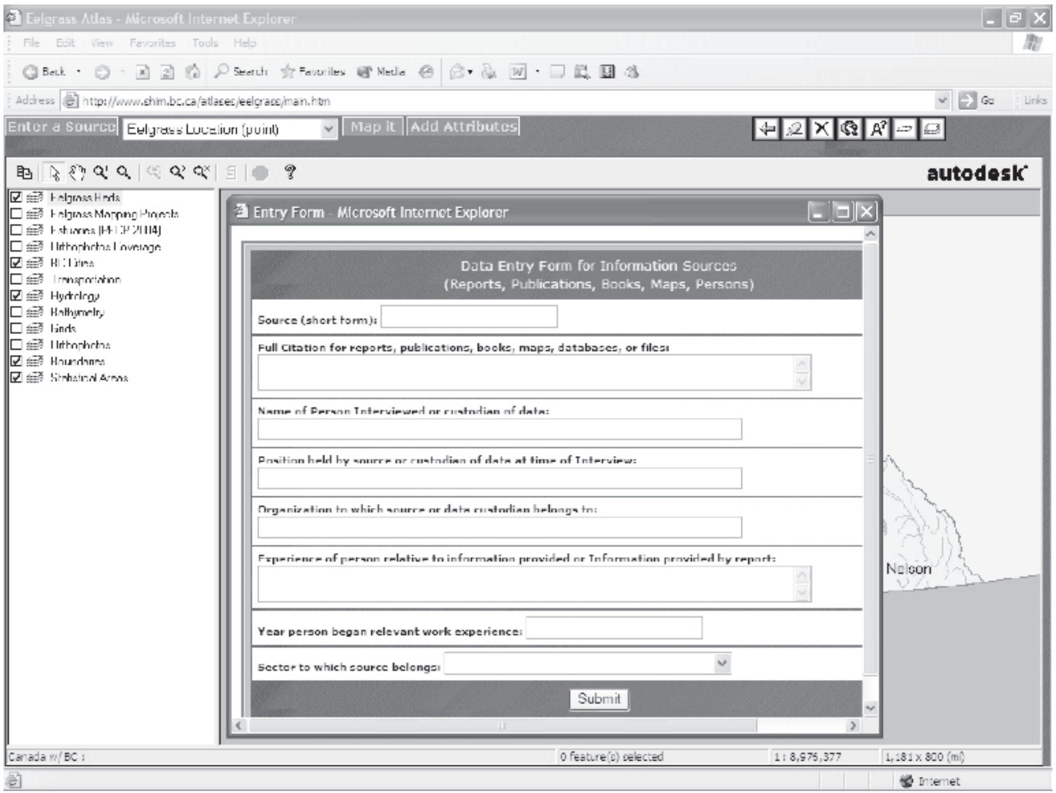


Figure 6. Data entry tools interface with the entry form and editing toolbar



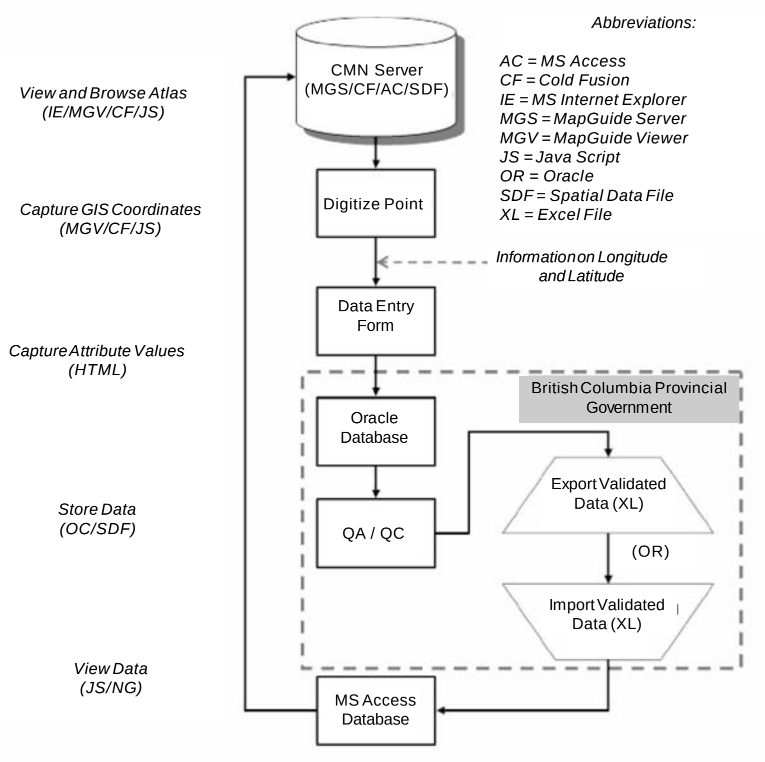
to link with the data in an MS Access database. The map is automatically refreshed and the new digitized features plotted on the Web map.

In the second workflow (Figure 7), the capability of the end user to install the MapGuide viewer and digitizes a point is shown. The Cold Fusion link starts an HTML form on the provincial government's Water, Land, and Air Protection web site using an embedded JavaScript function. The user completes the data about the new digitized feature and submits the form. The information entered in the form and the coordinates from the map are transmitted to an Oracle database on the province's server.

The data entered are validated before they are plotted. The provincial government further reviews and refines the data accuracy. Validation and quality control of the input data are accomplished by training of end users, password protection at multiple levels, data checks by CMN staff, and by correlations with orthoimagery and map overlay analysis. The validated data is then exported to a Microsoft Excel spreadsheet and sent to CMN. The CMN server imports the spreadsheet into a Microsoft Access database and displays the map data in a browser window.

The focus of the application is to represent and combine multiple forms of knowledge. The knowledge may be in the form of data, information, methods, tools, and processes that provide some understanding about a problem situation. The knowledge can be derived using scientific

Figure 7. Example of a data entry workflow with automatic file conversion



methods or can be based on individual experiences. The spatial framework of the Web GIS allows these forms of knowledge to be stored and related to a spatial entity on the map. In this study, the goal is on knowledge storage and not knowledge conversion or validation. Before "tacit knowledge" can be converted to "explicit knowledge" it must first achieve a state of "common knowledge" that is understood and accepted by the user community. The CMN facilitates the process of forming common knowledge as a pre-requisite to examine more closely in the future the issues related to knowledge conversion, validation, and transfer.

THE EELGRASS MAPPING APPLICATION: A CASE STUDY OVERVIEW

The CMN contains many mapping applications arranged according to ecological themes. The general knowledge collection and data integration processes are the same for all the mapping applications. The Eelgrass mapping application is discussed in more detail in this section.

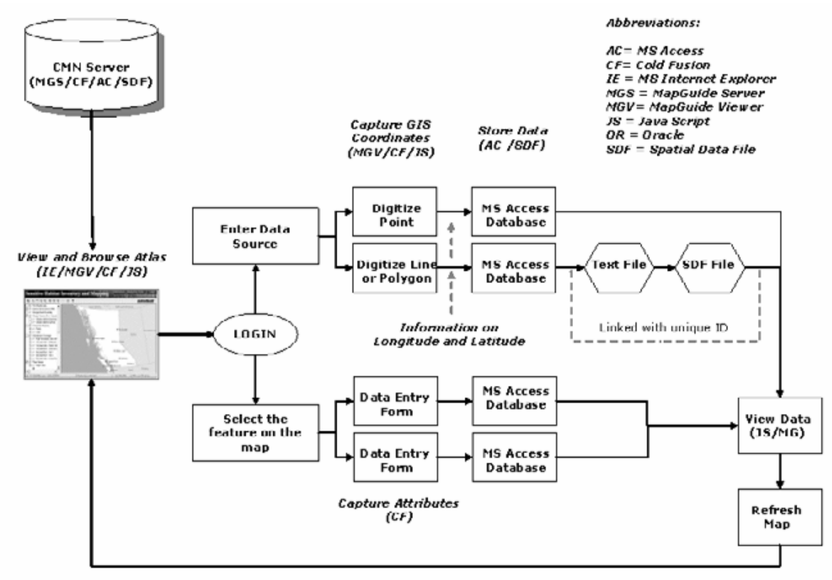
The Eelgrass beds such as those found in Boundary Bay, British Columbia (BC) provide complex and intricate food webs that rival the world's richest farmlands and tropical rainforests (NOAA Auke Bay Laboratory). Eelgrass beds grow on mud and sandy intertidal and subtidal areas and provide a diverse habitat of leaves that supply nutrients to fish, shellfish, waterfowl and numerous other faunal invertebrates. Many species use Eelgrass beds as nursery areas and others burrow in the sediments. Dungeness crabs, a valuable commercial species, often move into Eelgrass meadows to molt in the spring. Breeding occurs in the nearshore areas and females move to deeper water to hatch eggs. The juvenile crabs live in intertidal areas, hiding beneath and among plants, rocks, and Eelgrass beds. Threats to crab habitat include shoreline modifications and disruption of Eelgrass beds. Eelgrass beds help prevent erosion by cushioning the impact of waves and currents and hold sediments in place. This protection helps preserve highly productive bacteria in the sediments which nourish the invertebrate crab population. During low tides, eelgrass provides shelter for small animals and plants from extreme temperatures by retaining moisture and providing cover (Wright, 2002). Within the Eelgrass beds there is food and shelter for a wide variety of sea anemones, marine worms, snails, limpets, crabs, birds, and fishes.

There is now increasing interest among local communities in BC to map and monitor Eelgrass beds in the coastal parts of the province (Dunster, 2003). In 2003, the CMN developed the Eelgrass atlas to streamline the collection and dissemination of spatially geo-referenced information for coastal BC. Although much of our coastal resources knowledge still remains in the form of unwritten traditional ecological knowledge, there are also many databases and GIS layers that reside on different servers in a range of agency data warehouses (Booth, 2005). The Eelgrass atlas is designed to integrate this information and make it accessible to users using a central internet location. As such, local and regional agencies and non-government organizations can access the best available information for their area. There are many uses for mapping and monitoring eelgrass beds including habitat referrals for foreshore leases and licenses; oil spill contingency planning and response; community shoreline planning and zoning; provincial coastal planning; provincial and Federal Marine Protected Area analysis; and fisheries research which looks for correlation of marine resources with habitat.

In the Eelgrass mapping application, authorized users login to the web site and browse the contents using interactive maps containing detailed resource information. Users can digitize the location of new Eelgrass beds as a point, line or polygon, enter attribute information and submit the new information to the CMN server for validation (Figure 8). The new Eelgrass bed location is immediately published back to the Internet map for viewing and querying. This "real-time" application also provides other features including updating or deleting previously digitized data and generating customized data reports. When the shape of the new feature is digitized, a customizable HTML form is provided to enter attribute information. Features must be selected on a map to obtain an up-to-date report generated directly from the database.

The metadata for each observation is also collected with the location and attribute information (Figure 9). For example, the information source and mapping method must be provided. The system allows users to review the sources of the information and the relative accuracy of the observations. In time, any observation that does not have adequate ground-truth information can be subjected to more detailed examination and

Figure 8. Data entry workflow for the eelgrass example



updated. Nevertheless, the "suspected presence" (of any species or habitat) presents a foundation to begin coastal resource planning decisions.

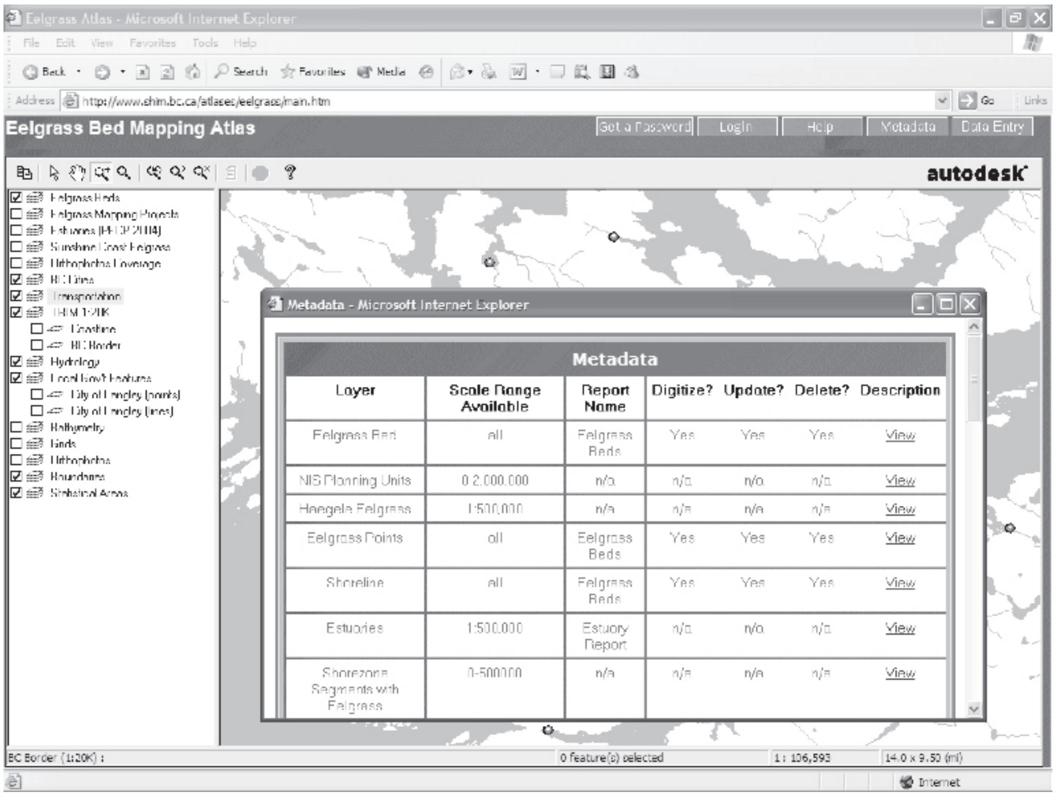
Training related to mapping Eelgrass beds and data entry was provided to over 20 coastal communities. At present there are 28 user accounts for data entry and 9 users have so far entered data online or provided spatial databases. Most Eelgrass beds data were initially geo-referenced as points using a GPS in the field as compared to using visual cues from memory. The GPS points were digitized online using the data entry tools of the CMN application. Some Eelgrass data was submitted on disk in various file formats including Microsoft Excel and ESRI shapefiles. These were integrated into the application. Once the Eelgrass beds are shown on the map, users can update the attributes and metadata information on individual Eelgrass beds.

One benefit of this work is that the provincial government has now acknowledged the presence of data gaps in the coverage of critical resources and will use the data collected by communities if the data is accurate and to some standard. CMN has created a number of standards to ensure that the collected data is of a good quality. The foundation is now in place for communities to work closely with government in managing local resources.

CHALLENGES AND FUTURE DEVELOPMENT

The development of online tools that connect spatial observations to attributes is a large step towards improving data collection efficiency. The CMN applications provide a suite of tools for data

Figure 9. Metadata tools interface for an observation in the eelgrass atlas



collection, access and query, sharing, and updating of environmental knowledge. However, a challenge for users is digitizing the geographic features online when the UTM projection coordinates are obtained from sources such as a hard copy map, Microsoft Excel spreadsheet or ESRI shapefile. The coordinates must be integrated into the web application and this represents a tedious task. A function to upload a set of coordinates and automatically generate lines or polygons would be an ideal solution. Also, creating a function to upload a background ESRI shapefile or a geo-referenced image can enhance the digitization process (Hu, Gabriel, & Bodensteiner, 2003). General issues of importance when integrating community participation and mapping technology for planning and decision making include institutional conflicts, the lack of end user training, no consistent standards for data collection, and the need for more data and information (Al-Kodmany, 2000; Balram, Dragicevic, & Meredith, 2004; Kyem, 2004). The feedback obtained from the forms available on the CMN website together with comments and suggestions gathered at community workshops were used to refine and update the application.

The ability to easily access existing digital databases is essential for timely planning and decision making (Laitinen & Nuevonen, 2001). However, this can be a challenge because of copyright, privacy and security reasons (Foo, Leong, Hui, & Liu, 1999). In the CMN infrastructure, existing information is made available and an understanding of data gaps is highlighted to encourage more collection and updates. It is important that new environmental information is added to the system. When end users see that their contributions are integrated into the system, they can be motivated to continue providing more information. User-interface design is also an important factor to be given continuous consideration when modifying existing systems (Guttler, Denzer, & Houy, 2001). Another issue is expertise level needed to use the system. User interface and expertise level can affect the choice users make about digitizing real world features as points, lines, or polygons. Login procedures, databases and attributes needed, and internet access speeds are other factors influencing how users interact with the technology.

The use of GPS field measurements allows easy data entry and integration. However, compiling information especially spatial information from interviews or from memory is problematic. It is difficult to digitize the location of features for a number of reasons including the concern that the information provided may not be accurate. Error estimates can be incorporated in the metadata.

Developing knowledge management systems (KMS) from the ground up and for long term sustainability require that these systems are embedded in the community. Communities depend on information from sources such as a KMS to make informed planning choices and management decisions. Also, communities understand the issues involved in the local planning processes (Pettit & Nelson, 2004). Hence, building a system to address local issues is much easier than building a regional or provincial system. The CMN has a role in building regional and provincial systems and integrating them with community data. This raises the issue of system and data standardization that is suitable for all interested participants. A system design that meets the needs of all communities is more difficult than customizing applications for local use. The process of building a system within a community ensures buy-in as opposed to getting people to conform to a pre-built system (Kelsey, 2003; Lewan & Soderqvist, 2002).

CONCLUSION

The Community Mapping Network provides a robust infrastructure for spatial data collection, access and query, sharing, and updating of environmental knowledge. The system was developed and customized to meet the specific needs of local community planning. The Autodesk MapGuide software was used as an "out of the box" solution for publishing digital maps on the Internet. Further, additional data entry, query, and update functionality were embedded in the application using the Cold Fusion, Javascript and Visual Basic programming languages.

New methods and standards were developed by the Community Mapping Network and included a Sensitive Habitat Inventory and Mapping methods for fresh water and coastal areas. These methods and standards are freely available; new projects are also assisted with the provision of training, loaning of equipment, and securing of funds (CMN, 2005). The standards and quality assurance procedures ensure that any new information about knowledge becomes fully integrated within existing systems and serve the needs of a wide user community. Additional information about the standards and methods are available on the CMN website.

The CMN facilitated the sharing of basemaps and natural resource information related to communities in British Columbia, Canada. The growth of the system depends on continuing efforts to build and serve local databases and integrating them with province-wide basemaps and databases. This also depends on the ability to establish new partnerships and data sharing arrangements and building community capacity to manage local datasets. Community groups and natural resource managers are always being encouraged to form partnerships with the CMN to continue building new systems and expanding the knowledge base about the region. The sharing of basemaps and databases among partners using a distributed data model allows a more seamless display of information layers.

The CMN is built incrementally for targeted end uses and is sensitive to users' needs. By streamlining data distribution and decision support across communities in British Columbia, operational costs can be reduced and maps and data delivered to communities that need them. Computer code is re-used to build on existing applications and so reduce costs for new application development. Reducing decision times will allow communities to better address development proposals and planning initiatives. The CMN is designed to improve planning and decisions by making information and knowledge more easily accessible and available.

There are many ongoing mapping projects. These projects provide an opportunity to refine and modify the overall CMN approach. Local habitat atlases, customized for use by local government planners and developers, have been used to support Local Resource Management Plans, Official Community Plans, and Watershed Management Plans in a number of BC regional districts (CMN, 2005). The resulting atlases have helped to define Development Permit Areas and have been used to identify candidate areas for protection, enhancement or restoration. The atlases have also assisted local regulators in administering the Forest Practices Code, the Water Act, the Land Development Guidelines, and the Local Government Act, and will assist in future implementations of the Riparian Area Regulation (BC Reg. 376, 2004). Placing environmental information in the hands of the communities and local governments can encourage a sense of ownership and more collaborative stewardship of natural resources. If governments, planners and decision makers are to leverage the information society for the benefit of society, then they must lead by example. The CMN is an ongoing initiative and is being aligned to address this need.

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REFERENCES

Al-Kodmany, K. (2000). Using Web-based technologies and geographic information systems in community planning. *Journal of Urban Technology, 7*(1), 1-30.

Andelman, S. J., Bowles, C. M., Willig, M. R., & Waide, R. B. (2004). Understanding environmental complexity through a distributed knowledge network. *Bioscience, 54*(3), 240-246.

Balram, S., Dragicevic, S., & Meredith, T. (2004). A collaborative GIS method for integrating local and technical knowledge in establishing biodiversity conservation priorities. *Biodiversity and Conservation, 13*(6), 1195-1208.

Berry. (personal communication, 2003)

Blumenthal, D., & Jannink, J. L. (2000). A classification of collaborative management methods. *Conservation Ecology, 4*(2), ART.13.

Booth. (personal communication, 2005)

CMN. (2005). *Methods and Standards*. Retrieved 2005-08-30, from http://www.shim.bc.ca/methods/method.html

Dragicevic, S. (2004). The potential of web-based GIS. *Journal of Geographical Systems, 6*(2), 79-81.

Dragicevic, S., & Balram, S. (2004). A Web GIS collaborative framework to structure and manage distributed planning processes. *Journal of Geographical Systems, 6*(2), 133-153.

Dunster. (2003). Personal Communication.

Foo, S., Leong, P. C., Hui, S. C., & Liu, S. (1999). Security considerations in the delivery of Web-based applications: A case study. *Information Management & Computer Security, 7*(1), 40-49.

Fuller, S. (2002). *Knowledge management foundations.* Boston: Butterworth-Heinemann.

Ghose, R. (2001). Use of information technology for community empowerment: Transforming geographic information systems into community information systems. *Transactions in GIS, 5*(2), 141-163.

Gitis, V. G., Andrienko, G. L., & Andrienko, N. V. (2004). Exploration of seismological information in analytical web GIS. *Izvestiya-Physics of the Solid Earth, 40*(3), 216-225.

Goran, W., & MacGillivray, A. E. (2003). GIS and knowledge management: Explore the intersections. *GeoWorld,* November, 40-43.

Gunderson, L. H., & Holling, C. S. (2002). *Panarchy: Understanding transformations in human and natural systems.* Washington, DC: Island Press.

Guttler, R., Denzer, R., & Houy, P. (2001). User interfaces for environmental information systems - Interactive maps or catalog structures? Or both? *Advances in Environmental Research, 5,* 345-350.

Hemmati, M., Dodds, F., Enatati, J., & McHarry , J. (2002). *Multi-stakeholder processes for governance and sustainability: Beyond deadlock and conflict.* London: Earthscan Publications.

Houle, M., Dragicevic, S., & Boudreault, F. (2000). *A Web-based GIS tool for accessing spatial environmental data on the St. Lawrence River.* Paper presented at the 4th International Conference on Integrating GIS and Environmental Modelling (GIS/EM4): Problems, Prospects and Research Needs, Banff; Alberta, Canada.

Hu, S., Gabriel, A. O., & Bodensteiner, L. R. (2003). Inventory and characterization of wetland habitat on the Winnebago Upper Pool Lakes, Wisconsin, USA: An integrated multimedia-GIS approach. *Wetlands, 23*(1), 82-94.

Jankowski, P., & Nyerges, T. (2001). *Geographic information systems for group decision making: Towards a participatory geographic information science.* New York: Taylor and Francis.

Johnson, B. D., & Singh, J. (2003). Building the National GeoBase for Canada. *Photogrammetric Engineering and Remote Sensing, 69*(10), 1169-1173.

Kangas, J., & Store, R. (2003). Internet and teledemocracy in participatory planning of natural resources management. *Landscape and Urban Planning, 62*(2), 89-101.

Kelsey, E. (2003). Integrating multiple knowledge systems into environmental decision-making: Two case studies of participatory biodiversity initiatives in Canada and their implications for conceptions of education and public involvement. *Environmental Values, 12*(3), 381-396.

Kingston, R., Carver, S., Evans, A., & Turton, I. (2000). Web-based public participation geographical information systems: An aid to local environmental decision-making. *Computers Environment and Urban Systems, 24*(2), 109-125.

Kyem, P. K. (2004). On intractable conflicts and participatory GIS applications: the search for consensus amidst competing claims and institutional demands. *Annals of the Association of American Geographers, 94*(1), 37-57.

Laitinen, S., & Nuevonen, A. (2001). BALTIC-SEAWEB: an information system about the Baltic Sea environment. *Advances in Environmental Research, 5,* 377-383.

Lawas, C. M., & Luning, H. A. (1997). Farmer's knowledge and GIS. *Indigenous Knowledge and Development Monitor, 4*(1), 12-19.

Lewan, L., & Soderqvist, T. (2002). Knowledge and recognition of ecosystem services among the general public in a drainage basin in Scania, Southern Sweden. *Ecological Economics, 42*(3), 459-467.

McElroy, M. W. (2003). *The new knowledge management: Complexity, learning, and sustainable innovation.* Amsterdam; Boston: Butterworth-Heinemann.

NOAA Auke Bay Laboratory.Fish Use of Eelgrass and Kelp Habitat. Retrieved 2005-08-30, from http://www.afsc.noaa.gov/abl/habitat/Eelgrass.htm

Peng, Z. R. (2001). Internet GIS for public participation. *Environment and Planning B: Planning and Design, 28*(6), 889-905.

Peng, Z. R., & Tsu, M. H. (2003). *Internet GIS: Distributed geographic information services for the Internet and wireless networks.* New Jersey: John Wiley & Sons.

Pettit, C. J., & Nelson, A. (2004). Developing an interactive web based public participatory planning support system for natural resource management. *Spatial Science, 49*(1), 61-70.

Plewe, B. (1997). *GIS Online: Information retrieval, mapping, and the Internet.* Santa Fe, NM: OnWord Press.

Porter, G. L. (2002). *Planning Sustainable Communities: A compilation of Community Mapping Case Studies from the Lower Mainland and Sunshine Coast of British Columbia.* Retrieved 2005-08-30, from http://www.cmnbc.ca

Rinner, C. (2003). Web-based Spatial Decision Support: Status and Research Directions. *Journal of Geographic Information and Decision Analysis, 7*(1), 14-31.

Robiglio, V., & Mala, W. A. (2005). Integrating local and expert knowledge using participatory mapping and GIS to implement integrated forest management options in Akok, Cameroon. *Forestry Chronicle, 81*(3), 392-397.

Talen, E. (1999). Constructing neighborhoods from the bottom up: the case for resident-generated GIS. *Environment and Planning B-Planning & Design, 26*(4), 533-554.

Tsou, M. H. (2004). Integrating Web-based GIS and image processing tools for environmental monitoring and natural resource management. *Journal of Geographical Systems, 6*(2), 155-174.

Wang, K., Hjelmervik, O. R., & Bremdal, B. (2001). *Introduction to knowledge management: Principles and practice.* Tapir Academic Press: Trondheim, Norway.

Wright, N. (2002). Discussion paper for BC Coast on Eelgrass Conservation: B.C. Coastal Eelgrass Stewardship Project.

Zurayk, R., el-Awar, F., Hamadeh, S., Talhouk, S., Sayegh, C., Chehab, A. G., et al. (2001). Using indigenous knowledge in land use investigations: a participatory study in a semi-arid mountainous region of Lebanon. *Agriculture Ecosystems & Environment, 86*(3), 247-262.

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Chapter 2.28
Building a Dynamic Model of Community Knowledge Sharing

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INTRODUCTION

Many case studies have been undertaken about how informal, sponsored, and supported communities of practice operate within private and public sector organizations. To date, however, no examination has been made of how informal communities of practice operate within the third sector, the sector of community, and voluntary organizations. The third sector has a long history of using community space, in various forms, either physical or notional, to engage individuals in discourse and informal learning. The rise of the network society has added value to this process by allowing active individuals to personalize networks through the use of technologies which enhance communication. The third sector is now demonstrating that individuals and groups are seeking to create open access knowledge-sharing spaces which attempt to combine face-to-face networks with computer-mediated communications to support informal learning between community development practitioners.

This article examines the role of Sunderland Community Development Network in the creation of informal communities of practice. It pays particular attention to three key areas:

1. Community space: How core, active, peripheral, and transactional community spaces within third sector partnerships create an ebb and flow of informal communities of practice.
2. Personalized networking: How issue-based activity, inside and outside communities, can lead to the rapid appearance and disappearance of informal communities of practice.
3. Knowledge-sharing space: How core members of a third sector organization can create a dynamic model of roles within informal communities of practice capable of impacting upon processes of governance beyond the organization.

BACKGROUND: SUNDERLAND AND THE COMMUNITY DEVELOPMENT NETWORK

Sunderland is a new city in the North East of England with a population of 300,000. Toward the end of the last century, it suffered adversely from the post-industrialization process. Both shipbuilding (ships had been built on the River Wear for over 1,500 years) and coal mining (Monkwearmouth Colliery was one of the largest deep mines in Europe) went into terminal decline. The dawn of the new millennium, however, has witnessed an economic, social, and cultural renaissance in the city. Sunderland's Nissan car plant is now the largest in the UK with 12,000 employees. Sunderland University has a new riverside campus adjacent to a thriving marina and an emerging shellfish industry. Sunderland Football Club has a new arena (built on the former site of Monkwearmouth Colliery), boldly titled "The Stadium of Light", and there is an award-winning museum and winter gardens in the heart of the city center.

Sunderland Community Development Network (SCDN) forms the neighborhood-based component of the city's renaissance and is open to community groups, community networks, voluntary sector organizations, volunteers and residents who are, or want to be, active in their communities.

The aims of SCDN are to link together neighborhood renewal (Social Exclusion Unit 2000) areas of the city in communities of practice; maximize the power of communities to shape the future of the city; provide a decision-making and discussion forum for communities; provide effective, meaningful, and coordinated representation at all levels of the city council's Local Strategic Partnership (LSP); and provide a structure of accountability for community representation and the communication of information. The concept of partnership working in this manner was first suggested in a document produced by the Neighbourhood Renewal Unit (2001). In summary, SCDN aims to capture, store, and transfer the wide range of knowledge contained within Sunderland's community-based organizations and make this knowledge accessible to other sectors.

THE EMERGENCE OF SCDN

SCDN has been emerging as a meta-network since September 2001 under the innovatory leadership of VOICES. VOICES was originally established as Sunderland Voluntary Sector Partnership (VSP) in 1994, and since September 1994, has played an active role on the City of Sunderland Partnership (CoSP). Three community development workers were appointed in May 1998 to develop networks in areas where there was no existing infrastructure and to build the community and voluntary sector in the city. In 2000, the VSP gained charitable company status in the name of Sunderland Voluntary and Community Sector Partnership. The official launch of the new company was held in October 2000 to coincide with the signing of the local compact between the CoSP and the voluntary and community sector. The name VOICES was adopted to reflect the role of the VSP in ensuring local people's needs, views, and opinions are integral to the decision-making processes of policy makers at local, regional, and national levels.

The core group of VOICES has many years of experience of community development activity, stretching back to the 1970s, long before the introduction of the Internet and other network technologies. Some members of the core group have taken readily to e-mail and other network technologies while others struggle with it. All, however, are very skilled face-to-face networkers and demonstrate a high level of trust in the communities they support.

The meta-network provides a range of knowledge-sharing platforms through which dialogue can flow, both formally and informally. These platforms include formal strategy meetings, informal lunches, events and residential conferences, and seminars as well as sharing documents and discussion via e-mail and the Internet. Key informants constantly refer to the informal dialogue, which takes place before, after, and around meetings. The informal sharing of knowledge is seen to lie at the hub of the collective learning and knowledge-sharing process, which takes place within the meta-network. Access to knowledge is sought in a seamless way by combining face-to-face informality with document sharing and the use of e-mail, firmly grounded in the needs of communities. Knowledge is also accessed via the mobile telephone and text messaging which adds value to the use of other technologies. A high level of trust is placed upon individuals with key skills and competencies within the network, as containers and carriers of knowledge on community development.

SCDN has been debating, for more than 2 years, the importance of legitimizing peripheral participation (Lave & Wenger, 1997) within the network and the LSP. Legitimate peripheral participation provides a way to speak about the relations between newbies, veterans, activities, identities (Wenger, 1998), communities of knowledge (Brown & Duguid, 1991), and practice. It is concerned with the process by which newcomers become part of a community of practice (Wenger et al., 2002). As a result of this debate, a model has been devised which aims to provide a means of legitimizing peripheral participation within it.

In this model, members of the network are divided into a tripartite framework of community development responsibilities within each of the 12 themed and 6 area-based neighborhood renewal groups of the LSP, as follows:

1. Capacity-builder: With previous partnership-working experience, well-developed informal and formal meeting skills and knowledge of decision-making structures.
2. Mentor: With experience of representation or other partnership working.
3. Learner: With experience of meetings at a neighborhood level but no previous representation experience.

Clearly, individuals tend to exhibit all of these roles to a greater or lesser degree. In terms of the meta-network, however, these three roles form a dynamic learning framework for the community participants within the 18 working groups of the LSP. It is clear that this tripartite framework creates a dynamic model for developing informal communities of practice as the three roles constantly combine and disperse leaving critical masses of knowledge which can be accessed in a number of ways through:

1. The manipulation of the spaces where communities are formed.
2. The establishment of personalized networks.
3. The creation of knowledge-sharing spaces.

COMMUNITY SPACE

The traditional gathering place of community activists for centuries has been the village hall, community center, or their physical equivalent: the place of democratic engagement and dialogue on issues affecting the community. Community activists often put forward the view that it is possible to create an equitable community space, both mental and physical, where the views of individuals and groups can be freely exchanged in a form of true participatory democracy. Such a belief can be seen as an extension of the concept of agora where the creation of a level playing field, by definition, leads to engagement in the free expression of ideas, opinions, and innovation.

Does such a shared mental and physical community space exist, however, when the barriers to effective use of place, space, and cyberspace are manifold?

Several commentators have grappled with the concept of community space. They have revealed a complexity, which goes far beyond that manifest in village halls and community centers. In order to understand this complexity, the following concepts are now examined in turn: community space, liminal space, reproduction of space, defensible space, the space of flows, and the semiotics of global space.

Wenger (1998) talks of community space in which groups operate. The facilitators, innovators, and leaders occupy the core space. Active, interested individuals inhabit the active space. Interested individuals who are not necessarily active occupy peripheral space, and the transactional space is where partnerships are forged. This paradigm suggests the existence of four distinct community spaces. It does not, however, explain how groups apparently move with ease from one space to another or alternatively occupy several spaces simultaneously. For example, individuals may well occupy core space in one group, active space in another, and so on. SCDN's tripartite framework means that the dynamic roles cut across the boundaries of community space.

By introducing the concept of liminal space, we can envisage how individuals and groups journey between the spaces outlined above. Liminal space, an anthropological term, refers to the limbo which an individual inhabits while performing a rite of passage between one space and another. A physical example of this space is the Aboriginal "Walkabout" where teenage aborigines must spend time alone surviving in the outback prior to acceptance as an adult member of the group. A comparison can be made here with the concept of a lurker in an electronic environment or a learner within SCDN. Lurking in an electronic environment would be considered a form of situated learning by Lave and Wenger (1997) and, as such, a legitimate form of peripheral participation. Adding the concept of liminal space to the paradigm creates a new dynamic, which does, at least, appear to go some way toward illustrating how individuals and groups occupy several spaces simultaneously.

Puttnam (2000) refers to the bridging and bonding of social capital within communities. Social capital is created either by forming bridges between communities or bonding communities where they share common characteristics. It is, therefore, legitimate to suggest that social capital is formed in liminal space.

Lefebvre's (1991) discourse on the relationship between mental and physical space highlights not only the production of community space but also the reproduction of this space:

The problematic of space, which subsumes the problems of the urban sphere…and of everyday life, has displaced the problematic of industrialisation. It has not, however, destroyed that earlier set of problems: the social relationships that obtained previously still obtain; the new problem is, precisely, the problem of their reproduction. (p. 89)

In physical terms, former British Prime Minister, Winston Churchill, went some way to expressing the relationship when he said:

There is no doubt whatever about the influence of architecture and structure upon human character. We shape our buildings and afterwards our buildings shape us.

SCDN, like many other networks, has experimented extensively with variations in physical space in order to facilitate knowledge sharing. However, are there human and psychological constructs which influence individual and group behavior in community spaces?

Building upon the idea of human structures, Goffman (1959) derived the concept of defensible space, the cognitive space between individuals where they form opinions and assumptions of others. In physical space, we can visibly assess people's changing opinions through human interaction, which is supported by body language. In cyberspace, however, where body language can play a different part, defensible space becomes the space of legitimate peripheral participation. Discourse and dialogue in cyberspace can often be viewed as significantly more reflective than that which takes place in physical space. The roles of capacity-builder, mentor, and learner assist discourse and dialogue through enabling conversations on who is learning what, from whom, and the impact of this upon the network.

Castells (1989) argues that access to flows of information and resources is the key to participation in the networked society. He refers to a subtle interaction between physically colocated resources and virtual information-based resources. He calls this space the space of flows. He suggests a further dimension to community space. The space of flows is the personal space, which individuals manipulate, in and around the groups they populate. They create this space by constructing complex problem-solving, personal, social networks. These networks manipulate information and resources on a personal level through a complex web of digital technologies and face-to-face interactions.

Due to the constant and rapid evolution of community space within networked society, SCDN has attempted to create dynamic issue and area-based thematic communities of practice which accommodate the informality of the relationships created. Each member of an issue or area-based group has to relate to other members of the groups in terms of their ability to act as capacity-builder, mentor, and learner. This interaction leads to semiotic relationships between communities of practice with high levels of synergy capable of rapid transformation and dissolution around a particular theme or issue. Such interaction also relies on high levels of personal interaction within networks and meta-networks.

PERSONALIZED NETWORKING

Human networks are hugely complex phenomena. We are only just beginning to understand the implications of understanding networks:

Today we increasingly recognize that nothing happens in isolation. Most events and phenomena are connected, caused by, and interacting with a huge number of other pieces of a complex universal puzzle. We have come to see that we live in a small world, where everything is linked to everything else. We are witnessing a revolution in the making as scientists from all different disciplines discover that complexity has a strict architecture. We have come to grasp the importance of networks. (Barabasi, 2003, p. 7)

In this small world, individuals and groups are as likely to reach out around the globe for knowledge as they are to visit their next door neighbor in search of information (Watts, 2003).

Given this complexity, how do we provide a platform for a networked community?

While face-to-face contact is paramount within SCDN and often cannot be replicated in electronic systems, the constraint of time and space on active individuals has led to the network accepting that the community is not necessarily located in a fixed space. The idea of community being with you wherever you are is a welcome and reassuring idea associated with the trust, strengths, and connections needed for effective networking. As a result, SCDN has begun to use ICT to add value to human systems in a personalized manner, often referred to as personalized networking.

Research into personalized networking (Wellman, 2001a, b) has shown that knowledge transfer and the idea of communities of practice (groups of people that create, share, and exchange knowledge) is relative to situated learning (how useful the knowledge is within a particular situation or toward a particular end). This requires multi-faceted means of creating dialogue where meaning flows through individuals and groups. Initially, however, the quality of the dialogue may not be as important as the process of democratic engagement, as it is often about allowing people to explore new ideas and discarding those that are not fit for purpose. Evidence also suggests that network identity can also emerge through consensual agreement on what is community-based knowledge in the emerging dialogue.

The division of responsibility into capacity-builder, mentor, and learner creates dynamic spaces within personalized networks where knowledge can be shared informally.

Personalized networks appear to vary not only with regard to the skills and experience of capacity-builders, mentors, and learners but also in relation to where the networker is located within community space. It would be relatively easy to map personalized networks if community spaces were mutually exclusive and static. However, such spaces are mutually reliant and dynamic; as such, they are capable of potential highly complex topologies of personalized networks.

Social network analysis tools prove difficult to deploy in such a complex context. A high reliance on subjective and qualitative analysis is needed to understand the complexity of personalized networks within meta-networks. SCDN has attempted to create matrices of cross-cutting usage of technologies such as e-mail, Web, and text-messaging within the tripartite framework. This has proved difficult to progress in a collaborative computer-mediated environment, and progress has been limited to face-to-face workshops.

FUTURE: KNOWLEDGE-SHARING SPACE

In partnership with Sunderland City Council's E-government Unit, SCDN is developing an appropriate architecture for a community technology, into which its collective knowledge can be filtered and codified (http://www.sunderland-communitynetwork.org.uk). Data, information, and knowledge is drawn from a wide range of cross-cutting sources emanating from core groups, activists, peripheral groups, and transactional partners at varying levels. Taxonomies and topologies are created which are dynamic and organic, developed through user-defined language in detailed consultations with network members. For example, knowledge is coded as theme-based, issue related, or network representation related and, in turn, validated through dynamic use by members. All types of knowledge are upheld as equally valid. As more and more people search and use the network's knowledge, the more common definition naturally surfaces according to the emerging dialogue. The key is to build intelligence into analysis of the use of language in the dialogue that emerges.

From the outset of the project, it was clear that a cultural shift was required to get beyond data and information and move toward knowledge sharing among network members. Such cultural problems are widely recognized by academics and practitioners, as most individuals and groups within organizations are comfortable dealing with hard facts and figures rather than soft outcomes as a starting point. This marks the first phase of development of cultural shift and is only useful in the network's thinking if it is accompanied by a roadmap toward appropriate and effective management of knowledge in the long term.

SCDN's first stage of developing a knowledge base consists of compiling information on the actors within the network. This is the point at which the architecture of shared learning space is structured through recognizing the interaction of actors with the emerging architecture. Such structuration (the structuring of social relations across time and space), however, must contain the flux, which allows actors within the network to customize their own personalized networking structures. Understanding the degree of flexibility that actors need to interpret their personalized networks is paramount.

The second stage is referred to as profiling the key skills and experiences which members bring to the network. Profiling is a mix of knowledge supplied by professional community development workers and network members themselves about the network itself. This extends to a need to determine performance according to both external and internal transactional criteria with other partners. The profiling stage begins the process of monitoring and evaluating the level of participation and reification within the dialogue that populates the shared learning space.

The final stage is tooling of network members to meet the increasing demands of personalized networking. This is the stage at which members' skill gaps are identified and filled. As noted previously, SCDN has divided participants in the shared learning space into three key roles: capacity-builders, mentors, and learners. Each actor-role compliments the other around a particular theme such as, health, diversity, and community safety.

Although paper-based forms of communication and telephone calls may not be easily codified, the idea of a meta-network means that these conversations are likely to become embedded within an online application provided that the dialogue is ongoing, regular, and frequent. This is dependent on the overall utility of the knowledge base that can only be determined through the level of usage. Part of the work of Sunderland City Council's E-government Unit is to allow 60 members of the network access to a portable computer and to the Sunderland E-government Web site. In the short term, these people will be able to use the community-based Web portal to see what they might expect in an online environment run by and for themselves. If this enthusiasm is cascaded throughout the network and access is widespread, most members could be accessing their knowledge base most days to add value to their personalized networking.

CONCLUSION

This article has examined SCDN's role in the creation of informal communities of practice. In particular, it has analyzed the part played by the tripartite framework of capacity-builder, learner, and mentor in progressing flexible and dynamic communities of practitioners. The tripartite framework has been examined within the context of community space, personalized networking, and knowledge-sharing spaces. Outcomes to date, as to the robustness of this dynamic model of community knowledge-sharing, are positive; however, the model has not yet reached a significant level of maturity, and the possibility of long-term success remains uncertain.

While the article offers a positive and transferable model of the creation of informal communities of practice, the development of the model has been subject to a number of barriers:

1. The time spent gaining agreement on the model (almost 18 months) in the meta-network. For people who are unfamiliar with informal, dynamic, and flexible working relationships, the model appears simultaneously complex and radical.
2. Agreeing knowledge-sharing protocols with transactional partners where the shared vision did not appear to be as advanced as that of SCDN. The LSP has a wide range of partners, all from different sectors of the economy and all appear to be at different levels of skills and experience in partnership working.
3. The protracted discussions on the creation of a critical mass for the development of the model within the meta-network was hampered by turnover in key personnel. It was recognized from the outset that champions of the model would play a key role in the creation of this critical mass. The skills acquired by the champions in the dynamic working environment led to their rapid

progression to roles within other networks and organizations with a loss of skills and experience to SCDN.

4. The lack of an education program on the tripartite framework for newbies which makes significant connections with veterans. This has developed on an ad hoc basis. There is now a recognition of the need for a strategy which connects skills and knowledge which is evident in the work with Sunderland City Council's E-government Unit.

REFERENCES

Barabasi, A. L. (2002). *Linked: The new science of networks.* Cambridge, MA: Perseus.

Brown, J. S., & Duguid, P. (1991). Organisational learning and communities of practice: Towards a unified view of working, learning and innovation. *Organization Science, 2,* 40-57.

Castells, M. (1989). *The informational city: Information technology, economic restructuring and the urban-regional process.* Oxford: Blackwell.

Goffman, E. (1959). *The presentation of self in everyday life.* London: Penguin.

Lave, J., & Wenger, E. (1997). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lefebvre, H. (1991). *The production of space.* Oxford: Blackwell.

Neighbourhood Renewal Unit. (2001). *Local strategic partnership guidance.* London: HMSO.

Putnam, R. D. (2000). *Bowling alone: The collapse and revival of American community.* New York: Simon & Schuster.

Social Exclusion Unit. (2000). *A national strategy for neighbourhood renewal.* London: HMSO.

Watts, D. J. (2003). *Six degrees: The science of a connected age.* London: Norton.

Wellman, B. (2001a). Physical place and cyberplace: The rise of personalised networking. International *Journal of Urban and Regional Research, 25.*

Wellman, B. (2001b). Computer networks as social networks. *Science, 293,* 2031-2034.

Wenger, E. (1998). *Communities of practice.* Cambridge: University Press.

Wenger, E., et al. (2002). *Cultivating communities of practice.* Boston: Harvard Business School Press.

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Chapter 2.29
KAFRA:
A Context-Aware Framework of Knowledge Management in Global Diversity

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ABSTRACT

Multiple case studies in India, The Gambia, and Nigeria are the background for an empirically grounded framework of knowledge management (KM). Cultural diversity and gaps in the provision of infrastructure make managing knowledge challenging but necessary in developing countries. These cultural and infrastructural issues are also related to governmental, educational, political, social, and economic factors. These environmental factors interact with organizational variables and information technology to enable or constrain knowledge management processes in the creation and protection of knowledge resources. The framework can help organizations to prepare their KM projects, to reveal problems during the project, and to assess its outcomes.

INTRODUCTION

KM frameworks assist us in establishing a focus for KM efforts (Earl, 2001). These frameworks can also help organizations to approach KM methodically and consciously. They can help to identify a specific approach to KM, to define goals and strategies, to understand the various knowledge management initiatives, and then to choose the best ones for the particular circumstances (Earl, 2001; Maier & Remus, 2001). There have been several proposed frameworks to guide KM efforts in organizations. However, these frameworks do not address KM across the full spectrum of organizational needs (Calaberese, 2000) but instead address certain KM elements. There is, therefore, a need for a comprehensive KM framework that considers the full range of organizational dimensions.

Three reviews (Holsapple & Joshi, 1999; Lai & Chu, 2000; Rubestein-Montano, Liebowitz, Buchwalter, McCaw, Newman, & Rebeck, 2001) have discussed the components and assumptions of the frameworks proposed to date. There appears to be a consensus on the need for a more generalized framework, and, consequently, these authors also outline recommendations regarding such a framework. All agree that the basic components should be knowledge resources, KM processes, and influences. Even though the existing and the suggested frameworks recognize varying organizational contexts, they have not considered differences in the operating environmental contexts. This is similar to the information systems (IS) literature, where very few studies address global diversity (Avgerou, 2002; Walsham, 2001).

The importance of the local operating environmental context has already received some attention in e-commerce (Simon, 2001), ERP (Wassenar, Gregor, & Swagerman, 2002), and IS development methodology research (INDEHELA Project, 1999). Also, King, Gurbaxani, Kraemer, McFarlan, Raman, and Yap (1994) comprehensively discuss institutional factors in information technology innovation. In knowledge management, however, there is a basic need for consideration of the diverse environmental context and how it could influence other issues involved. The framework described here is designed to address that need, by focusing on the local cultural and infrastructural factors that could interact with organizational factors and information technology and the resultant effect on knowledge processes and resources.

GLOBAL DIVERSITY AND SIGNIFICANCE OF A NEW FRAMEWORK

Our view on global diversity recognizes the existence of different organizational contexts and that assumptions cannot be simply made about the pattern of organizational performance and innovations (Avgerou, 2002). For example, the wide gap in the availability and use of ICT across the world, and the influences ICT exerts on globalization, raise questions about the feasibility and desirability of efforts to implement the development of ICT through the transfer of best practices from Western industrialized countries to developing countries, and whether organizations can utilize such ICT in accordance with the socio-cultural requirements of the contexts (Avgerou, 1998; Morales-Gomez & Melesse, 1998; Walsham, 2001). Previous research (Avgerou, 2002; Bada, 2000; Walsham, 2001) concludes that diversity and local context does matter, and that the global techniques employed in western industrialized countries should not be implemented mechanically in developing countries without consideration for the local context (Bada, 2000).

The concept of description proposed by Akrich (2000) also expresses our understanding of global diversity and the significance of a context-aware framework. Akrich argues that when technologists define the characteristics of their object, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted. They also assume that the designers define actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest. They assume that morality, technology, society, and the economy will evolve in particular ways. In a nutshell, they inscribe their vision, or prediction about the world, into the technical content of the new object. Karsten (2000, p. 21) also suggests that "the functions of these (technical) systems1 are not predetermined, but only evolve within specific, socio-political contexts." Focusing on specific contexts will help to move away from unfruitful general claims and all-encompassing pictures, enabling us to see a technical change as embedded in a larger system of activity, having consequences that depend on peoples' actual behavior, and taking place in a social world in which the history of related changes may influence the new change.

We are aware of the force of globalization and its assumed homogeneity. However, globalization does not mean imposing homogenous solutions in a pluralistic world. It means giving a global vision and strategy, but it also means cultivating roots and individual identities. It means nourishing local insights, but it also means re-employing communicable ideas in new geographies around the world (Das, 1993). The adoption and usage of such a technology framework will vary according both to local socio-cultural and organizational contexts, and to the national context, including government, economic, and political systems, educational systems, and history, culture, and infrastructure (Schneider & Barsoux, 1997).

A KM framework can be seen as an IS innovation (Avgerou, 2001), a technology (Walsham, 2001), or a technical object (Akrich, 2000). Considering the context in which they are designed and their designers, it can be argued that some basic assumptions (to be discussed later) about the KM processes and influences have been inscribed into these frameworks. An attempt to describe and apply the framework in another context might be problematic. Hence, a context-aware framework, with specific consideration for the operating environmental factors and for the organizational factors that are closely related to the environment, could help to move us toward a more universally applicable KM framework, as well as increasing our sensitivity to the importance of global diversity.

TOWARD A CONTEXT-AWARE FRAMEWORK

Theoretical Background

In this paper, we synthesize some of the insights from our studies to build a context-aware framework, including an explanation of its components. The framework is called KAFRA (an abbreviation of Kontext Aware FRAmework). In building KAFRA, we relied on some well-known concepts and theories in organization studies in order to support our arguments. Leavitt (1965) calls for interdependence of organizational variables for effective organizational change, and Scott (1998) asserts that environment and organization are inseparable. The institutionalist perspective of Powell and DiMaggio (1991) also supports the argument on the need to consider the operating environment in a KM framework. Following Pettigrew's contextualist approach (1987), for a study on change to contribute toward a robust theory or framework that can guide practice, it must examine change as a process and in a historical and contextual manner (Bada, 2000). Hofstede's (1997) cultural model and Galbraith's (1977) concept of organization design are also brought in to strengthen the arguments for the KAFRA framework. Initially, the design of the study, data collection and analysis and subsequent theorizing and building of the framework was influenced by socio-technical systems (STS) theory. Thus, we next present a brief overview of the STS theory and knowledge management.

Socio-Technical Systems Theory and Knowledge Management

A socio-technical system is defined as a combination of a social and a technical subsystem (Trist, 1981). Rather than insisting that individual and social units must conform to technical requirements, the socio-technical systems theory emphasizes the needs of both (Scott, 1998). One of the guiding premises of this approach is that work involves a combination of social and technical requisites and that the object of design is to jointly optimize both components without sacrificing one to others. This approach provides a broad conceptual foundation as well as insights into the nature of routine and non-routine work design. STS has been applied both in systems development practice and in the analysis of ICT functionality and organizational changes (Avgerou, 2002; Lyytinen Mathiassen, & Ropponen, 1998; Mumford & Weir, 1979). There has also been application of socio-technical systems theory in KM (Coakes Willis, & Clarke, 2002; Pan & Scarbrough, 1998; Sena & Shani, 1999).

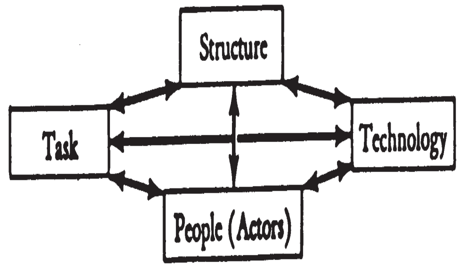
In a similar manner, Leavitt (1965) recognized the complexity and diversity of organizations by identifying four socio-technical variables (structure, task, technology, and people) that need to interact together in a balanced way to bring about organizational change. Scott (1998) added environment as another element, suggesting that organizations and environments are interdependent in terms of information systems and cognitive processes and in terms of environmental effects on organizational outcomes. They are also interdependent in more direct ways, since organizations attempt to directly influence environments and vice versa.

Leavitt's Diamond Organization Model

The Leavitt Diamond (Figure 1) gives a balanced view of the complexities that affect KM framework by positioning technology in strong relationships to the tasks carried out, the people participating in these, and to the organization of the tasks and the people, for example, the structure. It has been widely adopted and cited (e.g., El Sawy, 2001; Mumford, 1993; Schäfer, Hirschheim, Harper, Hansjee, Domke, & Bjorn-Andersen, 1988; Wiggins, 2000) as a basis for understanding organizational changes.

Leavitt's Diamond shows four sets of organizational variables: task, people (actors), technology, and structure. According to Leavitt (1965), these four groups of variables are highly interdependent, as indicated by the arrowheads, so that change in any one usually results in compensatory or retaliatory change in others. Technologies are considered tools that help organizations to get work done and mechanisms for transforming inputs to outputs.

Figure 1. Leavitt's diamond organization model (Leavitt, 1965)



This view corresponds to ours: knowledge management is not only about managing knowledge-work processes or the people that carry out these processes, since technology and organizational structure are also affected. A position explored in the framework is that by studying the balance of all these variables, it is possible to bring out the value of the knowledge management efforts in an organization. Therefore, rather than trivializing any one of the variables or neglecting one set (such as technology), the framework considers all equally and gives priority to all the variables so that knowledge management efforts can achieve maximal success.

Summary

The work of knowledge-based organizations is usually non-routine and needs to be supported by balancing all the variables mentioned earlier. Thus KM from the socio-technical perspective will require all activities that support the social subsystems (the nature of human capital, i.e., the people with knowledge, competencies, skills, experience, and attitudes), a technical subsystem (the production function, i.e., the inputs and the technology that convert inputs into outputs), and an environmental subsystem (including customers, competitors, and a host of other outside forces) (Sena & Shani, 1999). Any framework to support KM should integrate these main variables and put proper emphasis and consideration to diversity in various environments, since all organizations exist in a specific geographical, cultural, technological, and social environment to which they must adapt.

To these general theoretical perspectives on the influence of local diversity in an organization's environment, we add our own insights concerning cultural and infrastructure diversity and their influences on KM based on findings from the multiple case study. The diversity in our study organizations — which include national and international organizations in different research fields — formed the basis for the evidence on contextual issues in organizational variables and information technology. We next present the methodology and approaches to data collection.

The Study

Most of the studies that form the basis of the existing frameworks have been carried out in organizations in Western industrialized countries where there can be similar assumptions about the components of the framework. To add a new perspective, we conducted our study in developing countries. These countries afford us an opportunity to see the differences in culture (Hofstede, 1997) and infrastructure provision (The World Bank Group, 2004) at the local level. An empirical study was conducted on KM in six research organizations in Nigeria and The Gambia and two research organizations in India. Nigeria is representative of countries in sub-Saharan Africa due to its large population and huge natural resources. Oil exploration has particularly attracted many multinational companies that are characterized by Western management styles. The Gambia presents a contrast to Nigeria as one of the smallest countries in sub-Saharan Africa but with a reliable infrastructure. India is representative of countries in South Asia, by population, culture, and business environment. India is a major site for offshore software production (Lateef, 1997), and it was anticipated this would be evident in both the environmental context and the organizational variables. The advances of India in software business and the commitment of government in knowledge-based activities make it a strategic place to study KM. However, these industries are in the minority and could not be viewed completely as indigenous. The methodology used was a multiple case study (Yin, 1994) with data analysis carried out on the organizational level (Korpela, Mursu, & Soriyan, 2001). Both quantitative and qualitative data was collected using questionnaires, interviews, nonparticipant observation, and reviews of historical documents.

The discussion in this paper summarizes relevant aspects of these studies. The results show differences in assumptions on the influence of KM, especially when the local operating environment context is considered. Our study shows how the availability and use of information and communication technologies could support KM processes and how the Internet especially appears to provide a gateway to the international research community. This would suggest raising IT to be a major component in a comprehensive KM model. These findings also indicated some issues about leadership, structure, and culture that are contextual to each organization and the environment in which they operate. A conclusion of our study is that a KM framework needs to have contextual relevance for organizations in diverse social-cultural environments. It should align information technology, people, structure, knowledge processes, and socio-cultural and organizational influences to make knowledge management sustainable.

Research Methods

The contextual issues in a KM framework were studied through a multiple-case study and analysis of eight different research organizations. Yin (1994) observed that the triangulation of multiple sources of evidence permits convergence and corroboration of findings and building a stronger, more convincing basis for conclusions. While the conduct of a multiple-case study can require extensive resources and time, the evidence is often considered more compelling than from a single case, and the study can be regarded as more robust. We carried out our study in two countries in sub-Saharan Africa, in Nigeria and The Gambia, and in two organizations in India. These countries have different levels of infrastructure and cultural differences. For example, in telecommunications, The Gambia has a significantly higher penetration (The World Bank Group, 2004). We assumed there would also be differences in organizational infrastructures across countries.

The Case Organizations

Of the six organizations in Nigeria, three are international: International Institute of Tropical Agriculture (IITA), Medical Research Council Laboratories (MRC), and International Trypanotolerance Center (ITC). Three are national: National Agricultural Research Institute (NARI), Nigeria Institute of Social Economic Research (NISER) and Nigerian Institute of Medical Research (NIMR). The national organizations are mainly dependent on the national government for their basic funding. Usually the international organizations have a substantial number of expatriates working in them for the duration of their project. Three of the organizations are large, with more than 500 staff members. The smaller three have 100-200 staff members. All of the organizations carry out their research within several sites. Also, all of them have in-country and international collaboration with other institutions. Thus, they all work in a wide network of sponsors, customers, and cooperating institutions. India's two organizations are International Crop Research Institute for the Semi Arid Tropics (ICRISAT), an international organization with a staff of more than 500, and National Institute of Mental Health and Neuroscience (NIMHANS), a national organization also with a staff of more than 500.

The study used several methods of data gathering. The two main questionnaires were the KM diagnostic and the information technology infrastructure (ITI) services assessment instrument (see Okunoye & Karsten, 2001 for more details). These were complemented by semi-structured interviews and short-time on-site observations of knowledge management enablers.

Organizational documents and presentations by senior management about their KM-related initiatives were collected and analyzed. A similar approach in data gathering has been applied in a study on the relationship between IT infrastructure and business process re-engineering (Broadbent, Weill, & St. Clair, 1999). Between January and March 2001, we visited all six organizations in Nigeria and during the summer of 2002, we visited the two organizations in India. The visits lasted for about two weeks each. Some of the research sites of each organization were visited and as many as possible of the relevant people were interviewed, especially the heads of sections, the IT managers, and the librarians, to fill out the questionnaires and to provide the documents. Individual researchers provided valuable insight into the actual work processes. In the Nigeria study, a total of 48 people participated in the research: 29 were interviewed and did the questionnaire, eight did the questionnaire only, and 11 were interviewed only. However, only 31 out of the 37 questionnaires were included in the final analysis, because six of them had to be eliminated due to low responses to the questions. In India, 26 people participated: 16 people were interviewed and completed the questionnaire, six did the questionnaire only, and four were interviewed only; 19 out of 22 questionnaires were included in the final analysis and three had to be eliminated due to low responses to the questions. The interviews were recorded on audiotape and in a field diary and later transcribed. As the visits were brief and as all instruments had to be filled out with the researcher present, the time was only sufficient for observation of some KM practices (see Okunoye & Karsten, 2002a, 2002b, 2003; Okunoye, Innola, & Karsten, 2002 for detailed results).

COMPONENTS OF KAFRA FRAMEWORK

Environmental Factors

Environmental factors include those factors outside the organization that directly influence its activities. Holsapple and Joshi (2000) include governmental, economic, political, social, and educational factors (GEPSE) here. There are also indirect factors such as culture and national infrastructure. The operating environment varies from organization to organization, between countries, and also from one site to another within a country. Yet many frameworks that guide organizational strategies and development simply assume a homogeneous environment and thus exclude it from their design. A common assumption is that organizations will consider the GEPSE factors that have a direct economic impact on their operation but that indirect factors such as the culture and the infrastructure are irrelevant2. However, our empirical studies tell us that these indirect factors also significantly influence organizational variables. This is consistent with a growing literature in the U.S. that documents the importance of managing cultural diversity factors to improve organizational systems (Cox, 2001; Thomas, Roosevelt, Thomas, Ely, & Meyerson, 2002).

Infrastructural Issues

The national infrastructure can be said to include education, banking, cooperatives, transportation, and communication systems. Scholars have pointed out the influence that these systems have on the organizational IT infrastructure (Weill & Vitale, 2002). The infrastructural issues are derivatives of several other environmental factors, and this discussion thus cuts across many other issues. The infrastructural capability of a country is likely to influence the kind of technology the organization can deploy. It could also determine the extent of the application and sustainability of this technology. The extent to which countries provide infrastructure at the national level clearly affects the infrastructure of organizations in these countries. Most of the technological problems associated with environmental factors are beyond

Table 1. Infrastructural differences between Nigeria, The Gambia, India, and the USA (The World Bank Group, 2004)

ICT infrastructure, computers and the Internet	Nigeria	The Gambia	India	USA
Telephone mainlines/1000 people	4	26	32	700
Mobile phones/1000 people	0	4	4	398
Personal computers/1000 people	6.6	11.5	4.5	585.2
Internet users (‘000)	200	4	5,000	95,354
Internet speed and access[1]	2.5/7		3.6/7	6.6
Internet effect on business[2]	3.3/7		3.2/7	5.0

the control of single organizations. There are considerable differences in the IT infrastructures globally between countries, that is, between Western and developing countries (The World Bank Group, 2004). The differences within developing countries are also wide, as illustrated in Table 1. Specifically, in our study and as evidenced in the literature (Barata, Kutzner, & Wamukoya, 2001; Darley, 2001; Odedra, Lawrie, Bennett, & Goodman, 1993) and available statistics (The World Bank Group 2004), the problem with the IT infrastructure is more pronounced in sub-Saharan Africa (SSA) than in India, where the government has invested heavily in it. Most of the problems in SSA can be attributed to the government's lack of preparedness to commit sufficient resources to develop the national infrastructure, which could as a consequence improve the infrastructures available to organizations. The low availability and utilization of IT infrastructure in sub-Saharan Africa and the lack of expertise to support the physical infrastructure has been widely discussed (e.g., Moyo, 1996; Odedra et al., 1993). According to our study, while the availability of IT infrastructure has the expected significant effect on the knowledge management efforts, its under-utilization and the lack of technical expertise to support its proper application to the knowledge management processes becomes an even bigger problem.

For example, in Nigeria, individuals were expected to bear the cost associated with Internet use in the national research organizations we studied:

…if you understand, it [Internet] is not widely available for some reasons, cost, which implies that cost of access is high, even though you have opened it up to everybody, the cost is scaring them off and they are not using it. That is why I was a bit eh eh, but there is access. You have to pay N200 (about $2) for 15 minutes of browsing, some of them use it when it is very important and critical… (Mr. B, NISER)

This was not the case in India and The Gambia. Also, the Indian government's long-term investment in educational and social infrastructures has provided a large pool of qualified IT practitioners (Lateef, 1997; Tessler & Barr, 1997). This has a high impact on the kinds of technology they are able to use in their organizations. They have been able to design the required KM applications and to provide adequate support, sometimes at a cheaper cost when compared to Nigeria and The Gambia. This was not the case in SSA, where getting qualified IT support and management personnel continue to be a major problem (Odedra et al., 1993).

These examples show the kind of influence the provision of infrastructure in a particular environmental context can exert on the information technology that can be deployed within an organization. It also shows the effect on usage; where individuals are responsible for the cost of using technology, it is likely to discourage the use of this technology. Thus, a framework that could be applicable in this context should provide for the assessment of infrastructural provision in the environment where the organization operates.

Cultural Issues

Several authors have demonstrated how national culture influences management practices. For example, Schneider and Barsoux (1997) relate culture to each of the organizational variables that have been identified as having a great influence on KM (American Productivity and Quality Center, 1996). Weisinger and Trauth (2002) have argued that cultural understanding is locally situated and negotiated by actors within a specific context. In information systems research, national culture has been noted to influence, among others, IT utilization (Deans et al., 1991), IT diffusion (Straub, 1994), and technology acceptance (Anandarajan, Igbaria, & Anakwe, 2000; Straub, Keil, & Brenner, 1997). As noted, earlier KM frameworks (Holsapple & Joshi, 1999; Lai

& Chu, 2000; Rubenstein-Montano et al., 2001) recognize different organizational cultures, but they are generally silent on the effect of different national cultures.

The best-known and most widely used cultural model was developed by Hofstede based on a study conducted among IBM employees working in different countries in the late 1960s (Hofstede, 1997). Hofstede included four dimensions of national culture: power distance, uncertainty avoidance, individualism-collectivism, and masculinity-femininity. He later added a fifth dimension, long- versus short-term orientation, based on a study carried out in Asian countries. The model helps bring out issues related to cultural differences, and it provides some universal measures with which to analyze them. According to Walsham (2001), however, such measures are too general and cannot be used to explain some cultural differences.

According to Hofstede, countries in West Africa differ culturally from the USA, especially in the power distance and individualism-collectivism dimensions. This study and our earlier experiences, however, report some differences within and between the countries in West Africa. In western Nigeria, where three of the study organizations are located, every village has a well-defined hierarchy and family structure. It is a societal norm to treat senior members with absolute respect and obedience. Their views and opinions are often accepted and their judgments are not to be publicly questioned.

…To certain extent, given that for any particular area, the programme leader is the expert in that area, It is a requirement for whoever is heading a particular programme to try during the course of his tenure as the programme leader and get the team under him involve in the day to day activities…the people under you [the leaders] are really undergoing apprenticeship so to say…and they need to show respect. (Dr. SBO, NARI)

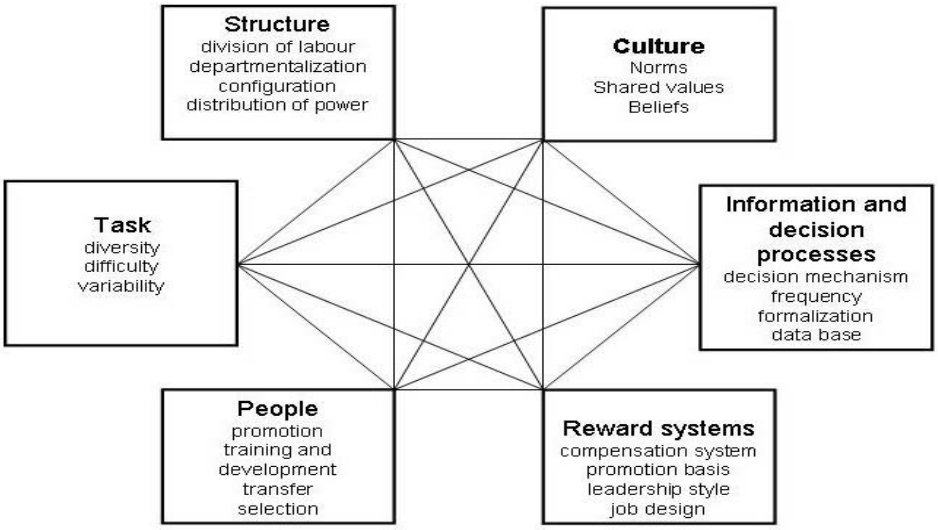
There is thus a substantial gap between the leaders and their subordinates. Contrary behavior (even when not necessarily wrong) by any member of the community can be interpreted as disloyalty and attract punishment. In the Nigerian national research organizations located in western Nigeria, it was very easy to recognize the leaders and people in positions of power. Without careful attention to this, implementing a framework that assumes that everyone has freedom of expression and equal rights could yield undesirable outcomes in these settings. Our argument here is that each organization should be studied in its own cultural context, and thorough knowledge of this should influence the application of the KM framework.

Organizational Variables

The organizational variables as a necessary concern are recognized in our study as well as several other studies and frameworks (Holsapple and Joshi, 2000; APQC 1996). To succinctly describe all organization issues that could influence KM, the conceptual framework (Figure 2) developed by Galbraith (1977) is adopted and modified by adding organizational culture, which is another important component in organizational design (Schein, 1985). Task, culture, structure, information and decision processes, reward systems, and people are the commonly included organizational variables. These need to be aligned for optimal results (Galbraith, 1977; Leavitt, 1965).

Organizational structure is the distribution of power and the shape of the organizational form. People have competence, nature, and attitudes. Information and decision processes include especially the availability and accessibility of information. Reward systems tell how the organization compensates its members for effective performance (Nathanson, Kazanjian, & Galbraith, 1982). The task is the link between choices of strategy and organization structure; decision processes and individual personality vary systemati-

Figure 2. Organizational variables (adapted from concept of organization design, Galbraith, 1977)



cally with the uncertainty of that task (Galbraith, 1977). The organizational culture includes the shared values, beliefs, norms, expectations, and assumptions that bind people and systems. The organizational culture is particularly important in KM because it gives people a basis for stability, control, and direction and helps them to adapt and integrate other variables and technology with the operating environmental factors. This framework enables a complete representation of all the identified organizational enablers of knowledge management. Organizational changes could depend on how well the interrelationship of these variables can support an organization's core activities, considering the available information technology (Markus & Robey, 1988) and the influence of environmental factors.

Organizational variables and knowledge management processes are mutually dependent. For the success of a KM project, Davenport and Prusak (1998) include many of the organizational variables as important factors. We cannot be talking about KM even with all the processes without the organizational variables to support them (APQC, 1996). Due to several factors, such as strategic alliance, internationalization of firms and services, technology transfer, globalization, and recent advances in ICT, Western management styles and forms of organization have a great influence across the world. The success of multinational corporations and consulting firms add to the assumptions about the universality of management strategies, including KM. Nevertheless, significant differences due to cultural diversity exist, as illustrated in subsequent paragraphs.

The people dimension of KM enablers can be problematic in several respects; for example, in our case, the international, expatriate staff members tended to come and go and take their knowledge with them. This had resulted in discontinuity: knowledge could not be assessed, sustained, or divested in any systematic way, as illustrated by the quotes that follow:

…When I came there was a tremendous knowledge gap… because there was no documentation at

all…there was no written information, there was no information on the computer, the people who were there, were only able to provide a little bit of information, but there was an awful knowledge gap. (Dr. SDL, MRC)

…That's true, that sort of information rests with the individual involved. To handle this problem, we want people to be appointed before the previous person has already left to avoid creation of gap. It is a problem. You are right, most of that information is with people that left…Yes that is very true. I think you are right but the knowledge and the expertise is linked to some people. That is certainly true. Not only for us but also for other similar research institutions and local organizations. Institutional knowledge seems to be very fragile. I think that is right. But we have the infrastructure that is required to make sure that knowledge is stored and accessible without really depending on people… (Dr. SA, MRC)

The local staff members were often discouraged from ambitious projects as they were not considered able to perform beyond a certain level. They also often lacked the personal funds that the expatriates might have for supplementing the possibly meager resources at the institutes.

…Surely there is a lot of obvious difference. For instance, the national research institutes and the universities, which we called NARS, we put them under NARS. They are handicapped by funding. Their budgets are in Naira which keeps depreciating every time. And for them to procure materials and whatever, they have to purchase from abroad in dollar which is not available to them, they have to convert, and buy at very high rates and which may not be available. Apart from the facts that they are under-funded, the little they have, they can't convert it to dollars, secondly, most of them do not have the expertise we have, thirdly they lack IT systems …Even they don't have up-to-date books. Because they don't have enough funds to buy them, if you go to their library, they have outdated materials. So, that is why if you go to our library, you find many of them coming to use the library here. Many of their scientists and the lecturer of university come to use the library here… (Mr. YA, IITA)

The people working in an organization are directly influenced by their own identity (Walsham, 2001), which could be influenced by societal norms and values and controlled by social, economic, and educational factors. For example, while training and learning without any formal certification could be acceptable for employees in Western industrialized countries, we found that employees in sub-Saharan Africa would normally like to have a certificate for their training. The reason is the importance attached to a certificate as evidence of knowledge and the prospect of getting a well-paid job, based on the extent of certified training.

…I think the financial incentive has mainly attracted people initially to do the on-the-job training (OJT) and it is also slightly more popular. But some of the main problems of OJT are still there. In the culture here, and I think in Africa in general, people don't see the same value in training unless there is a certificate or qualification attached to it. So that's one big part. Having a qualification attached to OJT is a big issue in giving OJT the credibility that it needs. (Dr. SA, MRC)

Similarly, knowledge as a source of power has a different meaning to Western employees and their developing countries counterparts. In many developing countries, due to high unemployment rates, lack of social security and benefits, and the scarcity of well-paid jobs, employees may wish to protect their source of competitiveness and thus view sharing knowledge as giving away their power.

…they should be jealous of their means of livelihood [their knowledge]… (Professor HOTA, NIMR)

The basic concept of knowledge varies from one culture to another. This could impact the effectiveness of organizational KM initiatives. In each of the countries in our study, there is a long tradition of recognizing some people as a repository of knowledge; for example, the griot in The Gambia, the babalawo in Yorubaland, and the guru in India. Although it may not be formally recognized in research organizations, since it is basically overridden by the professional culture, attention needs to be paid to differences in people's notions of knowledge and the effect of this on organizations.

…The Gurus are those with true knowledge and gives only to his beloved student, only one student. So since you ask about the knowledge and the India traditional culture, let us talk about "AMRITA" [Nectar of life], which if you drink you never die. The people who know the AMRITA never tell anybody. It automatically dies with them. Likewise the gurus committed, unknowingly, they committed…I cannot say sin, they just did not see the importance of their knowledge and never share it widely. They never share their full knowledge, if they did, we would have the entire traditional medicinal things we had in the past… (Mr. Raju, ICRISAT)

One scientist in a national organization explained how ascription is being used to rate people's contributions instead of achievement; that is, people are judged by who they are and not necessarily by what they do.

…There are some people who should be regarded as a source [of knowledge] and not a threat [to the leaders], but when you turn source to a threat, people become discouraged …People are not always evaluated and promoted by what they know but by who they know. (Professor HOTA, NIMR)

As research organizations, our case organizations shared many similar cultural features, and the scientists also shared a similar professional culture. Yet there are notable differences in the organizational culture of national versus international organizations. While international organizations exhibit combinations of cultures (Weisinger & Trauth, 2002), which include corporate culture, industrial culture, professional culture, and some national culture of the local environment, the national organizations are greatly influenced by the regional culture (e.g., western vs. northern Nigeria). Also, the diversity in workforce of international organizations reduces the effect of the interaction of national or societal culture with organizational culture when compared to national organizations.

…The people here are highly educated. The illiterate thinks the moment they share the information, the value is lost. But ours is a different organization. Ours is a multicultural organization and this culture is influenced by western culture and there is free flow of information… (Mr. V, ICRISAT)

The task and structure dimensions had to do with management, which was in some institutes better than in others, and with ability to carry out the tasks planned. Here the external circumstances had their strongest impact: If there is no electricity, no working phone, and very slow mail, work in general is slowed down. Communication between people not working at the same site is greatly hampered. Visiting and sending messengers are the only possibilities, and they take time.

…Of course, when we have electricity blackout and telecommunication breakdown, we can't reach anywhere and we can't physically travel, we just have to wait… (Dr. GE, MRC)

The organizational structure is closely related to the societal structure, and the style of leadership could be influenced by the orientation of the people (Korpela, 1996). In the leadership pattern in western Nigeria, we also observe that superiors are often inaccessible and the power holders are entitled to privileges in the organization. The hierarchies in the community are also reflected in the organization. This is in contrast to organizations in The Gambia. This has implications for KM, as the organizational structure could affect knowledge sharing and communication (Davenport & Prusak, 1998).

Taken together, each of these has implications for KM efforts in organizations. In KM research and practice, it has typically been suggested that particular attention be paid to organizational variables (often called enablers or influences), without which the success of KM cannot be guaranteed. With evidence that the assumptions about these variables are contextual, we contend here that any framework to support KM needs to consider each variable in the context of each organization, with due consideration also for the interaction with the operating environment.

Information Technology

Information technology can support the processes for knowledge creation, sharing, application, and storage (Alavi & Leidner, 2001). It can also enhance the interaction of individual, group, organizational, and inter-organizational knowledge (Hedlund, 1994; Nonaka & Takeuchi, 1995). Information technology availability and use varies between countries, but also within countries and between organizations. When there is little funding for an organization, there are fewer computers and software applications for use, with less access time to the Internet and other IT services.

…The researchers are willing to learn but in a situation where resources are not available, research cannot be carried out without money. It is a money gulping thing, it takes a lot of money and you don't expect immediate results, particularly medical research. It is not something like industrial research where you have a very big breakthrough and you publicize that you have been able to invent these things. I think medical research is not like that. I think the past government was not too keen on that. They didn't make money available for our researchers to work with. They keep on searching for funding, except some of them that are ready to spend their own money. Somebody was just telling me that she needed a reagent for her research work, she had to take a cooperative loan to get it, the loan is not meant for that kind of thing, but she had no alternative for her research work, so that is a kind of problem we have. Maybe with this present government, things may improve. (Mr. A, NIMR)

In contemporary organizations, IT is not only considered to support other organizational processes but a source of competitive advantage and even organizational core capability. IT enables changes in the organizational structure and supports communication within and between organizations. IT can make the information and decision-making processes easier. There is hardly any aspect of organizations that IT has not affected, including the way people think and carry out their work processes (Lau, Wong, Chan, & Law; 2001).

According to Orlikowski and Barley (2001), the transformation in the nature of work and organizing cannot be understood without considering both the technological changes and the institutional (specifically environmental) context that are reshaping economic and organizational activities. They thus emphasize the interrelationship of the environment, organizational variable, and technology. They argue that collaboration between organizational issues and information technology could increase the understanding of changes taking place in the organization. In our study, we found that organizations with high information technology capability were generally able to support knowledge processes better. The application of technology also depends on skills and abilities of individuals and the support of management, which are also organizational issues.

Many technologies can support KM processes. However, these technologies require a basic IT infrastructure, such as local area networking and Internet connectivity, to function optimally. There is also a need for basic hardware and software. The provision of these IT infrastructures varies between organizations (Broadbent et al., 1999), and its use depends on the context of each organization. Apart from the statistic evidence, we also found in our study differences in level of IT capability between national and international organizations, which we attribute to differences in level of funding and other factors (discussed earlier):

…An expatriate usually managed the IT units of the international organizations. The expatriate heads of the IT units were generally more experienced, and had knowledge of relevant modern technologies, due to their training in and access to the Western market. This usually had a positive influence on the performance of the IT unit and the adoption of technologies. The only international organization without a computer unit had an effective outsourcing strategy, which indirectly resulted in better services than national organizations with higher IT infrastructure services. The IT units of the international organizations were better staffed than the national organizations. Most of the staff had a university degree and had received some other special training. LAN and Intranet were only available in the international organizations… (Okunoye & Karsten, 2003)

There were also differences in expertise to support these technologies. Although IT skill shortage is a global phenomenon, its extent varies between countries. Thus, it is important that a framework to support KM efforts in an organization recognizes these different levels of IT availability and use, and that it supports the organization in making the right decision of which technology is most appropriate in their circumstances.

Knowledge Management Processes

Knowledge management processes are socially enacted activities that support individual and collective knowledge and interaction (Alavi & Leidner, 2001). These activities vary depending on which knowledge resources that the organization aims at improving. It is these activities that must be supported by the influences discussed earlier. Since each organization has a different focus, KM processes take place also in different contexts. These processes can be summarized as knowledge creation, knowledge storage/retrieval, knowledge transfer, and knowledge application. Thus the organization should consciously choose which of these activities they intend to support in order to choose appropriate organizational variables and technology to enable them.

For example, research organizations in SSA are particularly interested in knowledge creation and transfer, and they found the Internet to be an effective technology to support this process. One of our case organizations in India focuses on knowledge sharing among the scientists and the rural community, and they also are using a global intranet (ICRISAT, 2001).

Knowledge Resources

The main targets of the knowledge management processes are the knowledge resources. Holsapple and Joshi (2001) present a comprehensive framework of organizational knowledge resources where they consider, including employee knowledge, knowledge embedded in physical systems (Leonard-Barton, 1995), human capital, organizational capital, customer capital (Petrash, 1998), external structures, internal structures, and employee competencies (Sveiby, 1996). Knowledge resources also include intellectual capital (Stewart, 1998). The main goal of knowledge management is the effective marshalling and use of these resources (Lai & Chu, 2000).

The benefit and strategic importance of KM is in the ability of an organization to correctly identify which knowledge resources it can improve to gain sustainable competitive advantage. This is a reason for the popularity of KM, as the process of identifying the resources and subsequent selection of processes are never the same. In addition, organizational variables and technology need to support these processes with varying complexity and with different levels of influence by the operating environment.

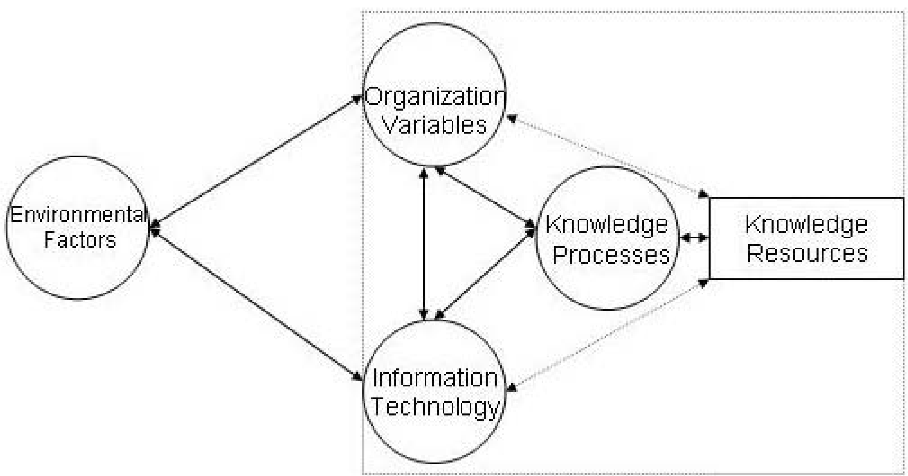
CONTEXT-AWARE FRAMEWORK OF KM

In a context-aware KM framework, KM is seen as an effort to properly put all the organizational variables into best use, with the support of relevant information technology, in order to facilitate the knowledge processes. The main overall goals center on organizational productivity, responsiveness, innovation, and competency through the creation and protection of knowledge resources.

This framework (Figure 3) differs from those presented earlier in that it considers the relationships between and interdependency of all components with particular attention to the environmental context. This framework enables organizations to pay attention to the local context and how this affects the assumptions about each component. The method and research approach used to arrive at the assumption about the components also ensure that the projected users are the actual users and the gap between the world inscribed in it and the world that will be described by its displacement can be expected to be narrowed.

As explained earlier, all the organization-related influences that could enable or constrain KM can be put together as organizational variables. IT is a separate component due to its strategic importance in supporting the knowledge processes of knowledge creation, storage, sharing, and application. All these are directly affected by the environmental factors (e.g., culture and

Figure 3. KAFRA (Kontext Aware FRAmework), a context-based framework of knowledge management



infrastructure in our discussion) where the organization operates. The organizational variables and information technology can influence each other, and they are both enablers of knowledge processes. On the other hand, the kind of knowledge to be created could determine which kind of information technology to be used and which variables in the organization need to be adjusted. Effective handling of knowledge processes yields the main aim of the KM, which is improving the knowledge resources in which the competitive advantage and all other benefits of KM lie. Also, knowledge resources could effectively affect knowledge processes. The double arrow that joins the organizational variables and the technology to the operating environment shows the interdependency between the organization and the environment, ensuring that KM processes are consistent with the external environment in which the organization operates and that those activities meant to improve knowledge resources are undertaken in a coordinated manner. Each component is linked to the others in a cyclic manner, which indicates the continuous dependency and influence between them. There is also a possibility of direct interaction between knowledge resources and organizational variables and also with information technology.

CONCLUSION

The KAFRA presented here represents a move toward a more universally applicable KM framework, one that increases our sensitivity to global diversity. The framework agrees with the recommendations of Leavitt (1965) that call for interdependence of the variables and with Scott (1998) in acknowledging that organizations and their environment affect each other. The consideration for environmental factors agrees with the institutionalist perspective of organizational challenges (Powell & DiMaggio, 1991). The emphasis on the importance of context within which the framework will be applied is informed by Pettigrew's contextualist approach (1987). Our framework recognizes the diversity in the organization's operating environment and utilizes it in its basic design. This framework not only achieves unification both within and across each component (Holsapple & Joshi, 1999) but also addresses the contextual issues at organizational and national levels. The application of this framework requires thorough understanding of the issues related to each component, that is, pre-knowledge of organizational variables and an ability to handle problematic areas are required. Knowledge of the technology and which knowledge processes it can support are also essential for the successful application of the framework. The organization also needs to identify the knowledge resources that are crucial to improving competitive advantage and which knowledge processes could best support this. The framework also requires cultural sensitivity, including cultural knowledge of the environment and a realistic assessment of the available infrastructure. The GEPSE factors are often assessed with easily obtained statistics, but such statistics do not reveal many important qualitative details. Thus, input from local sources and local people are essential.

The KAFRA framework could serve as a link between the organization and its environment, ensuring that KM is approached with consideration to the environment in which the organization operates. The framework also helps to ensure that the activities involved in KM are carried out in a well-guided manner. This framework shows the need for a multidisciplinary team when undertaking a KM project. In a multinational organization, a multicultural team is also required. As long as the world economy continues to tilt toward knowledge-based products and processes, developing countries will increasingly see the importance of KM. This framework could be a good starting point for them. The problems associated with inscription of the outsiders' beliefs, perception, and norms are addressed in the framework. The correct operationalization of the framework, with support from the in-built performance measures, represents a further challenge. For KM practice, this paper has sought to contribute to our understanding of the cultural and infrastructural interaction with organizational variables and technology. It also forms a basis for the composition of a KM team as well as a means of control and balance. For researchers, it contributes to the conceptualization of a more universal framework, which allows for localized specific assumptions.

REFERENCES

Akrich, M. (2000). The description of technical objects. In W. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 205-224). Cambridge: The MIT Press.

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

American Productivity and Quality Center (APQC). (1996). *Knowledge management: Consortium benchmarking study final report.* Retrieved on April 3, 2000, from http://www.store.apqc.org/reports/Summary/know-mng.pdf

Anandarajan, M., Igbaria, M., & Anakwe, U. (2000). Technology acceptance in the banking industry: A perspective from a less developed country. *Information Technology and People, 13*(4), 298-312.

Avgerou, C. (1998). How can IT enable economic growth in developing countries? *Information Technology for Development, 8*(1), 15-29.

Avgerou, C. (2001). The significance of context in information systems and organizational change. *Information Systems Journal, 11*(1), 43-63.

Avgerou, C. (2002). *Information systems and global diversity.* Oxford: Oxford University Press.

Bada, A. (2000). *Global practices and local interests: Implementing technology-based change in a developing country context.* Unpublished doctoral dissertation, London School of Economics and Political Science, London.

Barata, K., Kutzner, F., & Wamukoya, J. (2001). Records, computers, resources: A difficult equation for sub-saharan Africa. *Information Management Journal, 35*(1), 34-42.

Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23*(2), 159-182.

Calaberese, F. (2000). *A suggested framework of key elements defining effective enterprise knowledge management programs.* Unpublished doctoral dissertation, George Washington University, Washington, DC.

Coakes, E., Willis, D., & Clarke, S. (Eds.). (2002). *Knowledge management in the sociotechnical world: The graffiti continues*. London: Springer-Verlag.

Cox, T. (2001). *Creating the multicultural organization: A strategy for capturing the power of diversity.* San Francisco, CA: Jossey-Bass.

Darley, W. (2001). The Internet and emerging e-commerce: Challenge and implications for management in sub-saharan Africa. *Journal of Global Information Technology Management, 4*(4), 4-18.

Das, G. (1993, March-April). Local memoir of a global manager. *Harvard Business Review*, 38-47.

Davenport, T., & Prusak, L. (1998). *Working knowledge: how organizations manage what* *they know.* Cambridge, MA: Harvard Business School Press.

Earl, M. (2001). Knowledge management strategies: Towards taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

El Sawy, O. (2001). *Redesigning enterprise processes for e-business.* Boston: Irwin/McGraw-Hill.

Galbraith, J. (1977). *Organizational design*. Reading, MA: Addison Wesley.

Hedlund, G. (1994). A model of knowledge management and the N-Form corporation. *Strategic Management Journal*, *15,* 73-90.

Hofstede, G. (1997). *Cultures and organizations — Software of the mind.* New York: McGraw Hill.

Holsapple, C., & Joshi, K. (1999, January 3-6). Description and analysis of existing knowledge management frameworks. In *Proceedings of the Thirty-Second Hawaii International Conference on System Sciences.*

Holsapple, C., & Joshi, K. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information System, 9*(2-3), 235-261.

Holsapple, C., & Joshi, K. (2001). Organizational knowledge resources. *Decision Support Systems, 31*(1), 39-54.

International Crops Research Institute for Semi-Arid Tropics (ICRISAT). (2001). *People first!* (Medium Term Plan 2002-2004). Patancheru AP, India.

INDEHELA-Methods project. (1999). Retrieved on March 2, 2003, from http://www.uku.fi/atkk/indehela/

Karsten H. (2000). *Weaving tapestry: Collaborative information technology and organizational change*. Doctoral dissertation, Jyvaskyla Studies in Computing, No 3.

King, J., Gurbaxani, V., Kraemer, K., McFarlan, F., Raman, K., & Yap, C. (1994). Institutional factors in information technology innovation. *Information Systems Research, 5*(2), 139-169.

Korpela, M. (1996). Traditional culture or political economy? On the root causes of organizational obstacles of IT in developing countries. *Information Technology for Development, 7,* 29-42.

Korpela, M., Mursu, A., & Soriyan, H. A. (2001). Two times four integrative levels of analysis: A framework. In N. Russo, B. Fitzgerald, & J. DeGross, (Eds.), *Realigning research and practice in information systems development. The social and organizational perspective* (pp. 367-377). Boston: Kluwer Academic Publishers.

Lai, H., & Chu, T. (2000, January 4-7). Knowledge management: A theoretical frameworks and industrial cases. In *Proceedings of the Thirty-Third Annual Hawaii International Conference on System Sciences* [CD/ROM].

Lateef, A. (1997). *A case study of Indian software industry.* International Institute for Labor Studies, New Industrial Organization Programme, DP/96/1997.

Lau, T., Wong, Y., Chan, K., & Law, M. (2001). Information technology and the work environment — Does IT change the way people interact at work? *Human Systems Management, 20*(3), 267-280.

Leavitt, H. J. (1965). Applied organizational change in industry: structural, technological, and humanistic approaches. In J. March (Ed.), *Handbook of organizations* (pp. 1144-1170), Chicago: Rand McNally & Co.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation.* Cambridge, MA: Harvard Business School Press.

Lyytinen, K., Mathiassen, L., & Ropponen, J. (1998). Attention shaping and software risk — A categorical analysis of four classical risk management approaches. *Information Systems Research, 9*(3), 233-255.

Maier, R., & Remus, U. (2001, January 3-6). Toward a framework for knowledge management strategies: Process orientation as strategic starting point. In *Proceedings of the 34th Hawaii International Conference on Systems Sciences* [CD/ROM].

Markus, L., & Robey, D. (1998). Information technology and organizational change: Causal structure in theory and research. *Management Sciences, 34*(5), 583-598.

Morales-Gomez, D., & Melesse, M. (1998). Utilizing information and communication technologies for development: the social dimensions. *Information Technology for Development, 8*(1), 3-14.

Mumford, E. (1993). *Designing human systems for health care: The ETHICS method.* Chesire: Eight Associates.

Mumford, E., & Weir, M. (1979). *Computer systems in work design — The ETHICS method: Effective technical and human implementation of computer systems.* Exeter: A. Wheaton & Co.

Nathanson, D., Kazanjian, R., & Galbraith, J. (1982). Effective strategic planning and the role of organization design. In P. Lorange (Ed.), *Implementation of strategic planning* (pp. 91-113). Englewood Cliffs, NJ: Prentice Hall, Inc.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press.

Odedra, M., Lawrie, M., Bennett, M., & Goodman, S. (1993). International perspectives: Sub-saharan Africa: A technological desert. *Communications of the ACM, 36*(2), 25-29.

Okunoye, A., Innola, E., & Karsten, H. (2002, September 24-25). Benchmarking knowledge management in developing countries: Case of research organizations in Nigeria, The Gambia, and India. In *Proceedings of the 3rd European Conference on Knowledge Management,* Dublin, Ireland.

Okunoye, A., & Karsten, H. (2001, June 10-12). Information technology infrastructure and knowledge management in sub-saharan Africa: Research in progress. In *Proceedings of the Second Annual Global Information Technology Management (GITM) World Conference*, Dallas, TX.

Okunoye, A., & Karsten, H. (2002a). Where the global needs the local: Variation in enablers in the knowledge management process. *Journal of Global Information Technology Management, 5*(3), 12-31.

Okunoye, A., & Karsten, H. (2002b, January 7-10). ITI as enabler of KM: Empirical perspectives from research organisations in sub-saharan Africa. In *Proceedings of the 35th Hawai'i International Conference on Systems Sciences*, Big Island, Hawaii.

Okunoye, A., & Karsten, H. (2003). Global access to knowledge in research: Findings from organizations in sub-saharan Africa. *Information Technology and People, 16*(3), 353-373.

Orlikowski, W., & Barley, S. (2001). Technology and institutions: What can research on information technology and research on organizations learn from each other. *MIS Quarterly, 25*(2), 145-165.

Pan, S., & Scarbrough, H. (1998). A socio-technical view of knowledge — Sharing at Buckman Laboratories. *Journal of Knowledge Management, 2*(1), 55-66.

Pettigrew, A. M. (1987). Context and action in the transformation of the firm. *Journal of Management Studies, 24*(6), 649-670.

Powell, W. W., & DiMaggio, P. J. (Eds.). (1991). *The new institutionalism in organizational analysis.* Chicago, University of Chicago Press.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., Rebeck, K., & The Knowledge Management Methodology Team. (2001). A systems thinking framework for knowledge management. *Decision Support Systems, 31*(1), 5-16

Schäfer, G., Hirschheim, R., Harper, M., Hansjee, R., Domke, M., & Bjorn-Andersen, N. (1988). *Functional analysis of office requirements: A multiperspective approach.* Chichester: Wiley.

Schein, E. (1985). *Organizational culture and leadership.* San Francisco: Jossey-Bass

Schneider, S. C., & Barsoux, J.-L. (1997). *Managing across cultures.* London: Prentice Hall.

Scott, W. (1998). *Organizations: Rational, natural and open systems.* Upper Saddle River, NJ: Prentice-Hall.

Sena, J., & Shani, A. (1999). Intellectual capital and knowledge creation: Towards an alternative framework. In J. Liebowitz, (Ed.), *Knowledge management handbook.* Boca Raton: CRC Press.

Simon, S. (2001). The impact of culture and gender on Web sites: An empirical study. *The DATA BASE for Advances in Information Systems, 32*(1), 18-37.

Stewart, T. (1997). *Intellectual capital: The new wealth of organization.* New York: Double Day.

Straub, D. (1994). The effect of culture on IT diffusion: Email and fax in Japan and the US. *Information Systems Research, 5*(1), 23-47.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. *Information & Management, 31*(1), 1-11.

Sveiby, K. (1996). *What is knowledge management?* Retrieved on March 4, 2000, from http://www.sveiby.com.au/KnowledgeManagement.html

Tessler, S., & Barr, A. (1997). *Software R&D strategies of developing countries* (Position Paper). Stanford Computer Industry Project.

The World Bank Group, Data and Map. (2004). Retrieved December 27, 2004, from http://www.worldbank.org/data/countrydata/ictglance.htm

Thomas, R., Roosevelt, R., Thomas, D., Ely, R., & Meyerson D. (2002). *Harvard Business Review on managing diversity.* Boston: Harvard Business Review Publishing.

Trist, E. (1981). The socio-technical perspective. The evolution of sociotechnical systems as conceptual framework and as an action research program. In A. Van de Ven, & W. Jotce (Eds.), *Perspectives on organization design and behavior* (pp. 49-75). New York: John Wiley & Sons.

Walsham, G. (2001). *Making a world of difference: IT in a global context.* New York: John Wiley and Sons.

Wassenar, A., Gregor, S., & Swagerman, D. (2002). ERP implementation management in different organizational and cultural settings. In *Proceedings of the European Accounting Information Systems Conference*, Copenhagen Business School, Copenhagen, Denmark.

Weill, P., & Vitale, M. (2002). What IT infrastructure capabilities are needed to implement e-business models? *MIS Quarterly Executive, 1*(1), 17-34.

Weisinger, J., & Trauth, E. (2002). Situating culture in the global information sector. *Information Technology and People, 15*(4), 306-320.

Wiggins, B. (2000). *Effective document management: Unlocking corporate knowledge.* Gower: Aldershot.

Yin, R. K. (1994). *Case study research: Design and methods* (2nd ed.). Newbury Park, CA: Sage Publications.

ENDNOTES

[1] Framework in the context of this thesis.

[2] Multinational organizations now selectively consider some infrastructure when considering location of new subsidiaries; nevertheless, they often have the capability and resources to come with their own infrastructure. Thus, they pay more attention to other factors beyond their control.

[3] Ratings from 1 to 7; 7 is highest/best.

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Chapter 2.30
Identifying Knowledge Flows in Communities of Practice

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INTRODUCTION

Knowledge sharing is a collective process where the people involved collaborate with others in order to learn from them (Huysman & de Wit, 2000). This kind of collaboration creates groups of people with common interest called communities of practice where each member contributes knowledge about a common domain (Wenger, 1998).

Communities of practice enable its members to benefit from the knowledge of each other (Fontaine & Millen, 2004). To achieve this, different techniques and technologies can be used, such as shared documentation, groupware tools, lessons learned systems, and so forth. Therefore, to increase and improve knowledge sharing in communities of practice, it is important to study the mechanisms used by a particular community and understand how the knowledge flows through its members (Guizzardi, Perini & Dignum, 2003).

This article presents a qualitative approach for studying and understanding how knowledge flows in communities of practice within organizations. The goal is to provide a methodological guide for obtaining useful information for the development of knowledge management tools for supporting knowledge flows in these communities.

The content of the article is organized as follows. First the importance of supporting knowledge flows in communities of practice is highlighted. Then, a qualitative methodology for identifying knowledge flows in communities of practice is described, followed by some examples from a study conducted in the field of software maintenance. Finally, we present our conclusions of this work and future research.

MAIN BODY: KNOWLEDGE FLOWS IN COMMUNITIES OF PRACTICE

In a knowledge-intensive organization, employees constantly have to deal with a changing environment where knowledge is crucial to make decisions and adapt to these changes. To obtain the required knowledge for making those decisions, employees generate communities where each member collaborates with the others sharing knowledge about a common domain. On the other hand, to facilitate their adaptation, the organization's processes must become dynamic, that is, they must be designed to change based on the knowledge involved and on the activities performed by the members of the organization. Knowledge management (KM) can help address this issue, since it provides methods, techniques, and tools for facilitating organizations to become adaptable to these changing environments (Davenport & Prusak, 2000; Tiwana, 2000).

One of the main objectives of KM is to make available the appropriate knowledge, in the right place, at the right moment, to whoever needs it; therefore the flow of knowledge is very important for managing the knowledge of an organization (Nissen & Levitt, 2002). In fact, it has been considered the central component of a KM system (Borghoff & Pareschi, 1998). Communities of practice stimulate this flow of knowledge through organizations, since knowledge flows easily in these communities because they enable face-to-face interaction between their members (Brown, 2002; Fontaine & Millen, 2004). Even though direct interaction between members of the community is very important for sharing their tacit knowledge, other kinds of knowledge transfer must be considered such as documents sharing. Hence, provision of mechanisms that facilitate, increment, and improve the transfers of both tacit and explicit knowledge into communities of practice it is required. Therefore, knowledge flow must be one of the most important issues for supporting KM in these communities, since the goal is that the knowledge of each member can be used by the others (Borghoff & Pareschi, 1998; Guizzardi et al., 2003).

To provide support to the knowledge flow of a community, it is important to identify specific issues of the dynamics of knowledge flows in the processes and activities performed by the members of that community, as well as the social, cultural, and technological aspects which can affect those flows, in order to provide useful insights for the definition of requirements for designing KM systems that support the flow of knowledge in the community (Rodríguez, Martínez, Favela, Vizcaíno & Piattini, 2004a). A process modeling approach, as used in business processes reengineering (Curtis, Kellner & Over, 1992), can be appropriate for this purpose, since it provides techniques for analyzing technological and social aspects in organizations, as well as for modeling the dynamics of their processes. Once identified and understood how the knowledge flows through the community and which are the main elements that affect that flow, other approaches can be used for implementing the support systems—for example, an agent-oriented approach such as the proposed by Guizzardi et al. (2003, 2004).

In the following section we present a qualitative methodology for identifying knowledge flows in communities of practice; this is a methodology that we have defined and followed to obtain requirements for the design of a KM support system for a software maintenance group.

KOFI: A METHODOLOGY FOR KNOWLEDGE FLOWS IDENTIFICATION

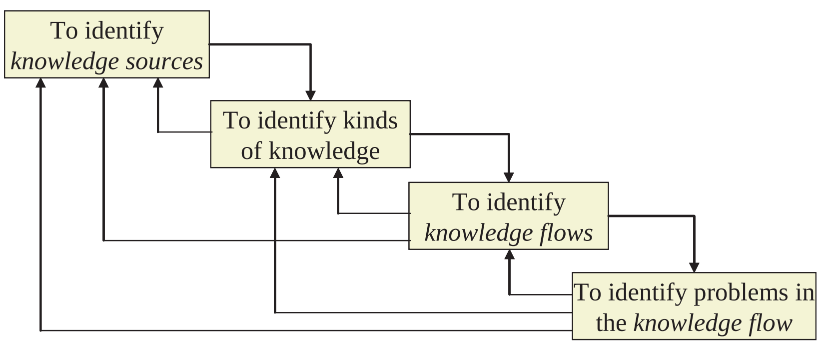
To design and develop support systems, such as for KM, for communities of practice, it is important to consider the contextual issues of the customers or those who will use the system (Beyer & Holtzblatt, 1998). We think knowledge flow must be a central aspect for supporting communities of practice; therefore, to understand the context of those communities, it is important to understand which kinds of knowledge are important for the community, which knowledge sources they share and how to obtain that knowledge, which mechanisms they use to consult the sources, and how all of these interact in the processes and activities performed by the members of the community—in general, how the knowledge flows through the community (Rodríguez et al., 2004a). To obtain answers for these questions, we have defined a qualitative methodology to guide the process of identifying how knowledge flows in a community of practice, and how to provide support to facilitate, increment, and improve the flow of knowledge in the community by identifying the problems that affect that flow.

THE METHODOLOGY

The methodology is composed of four stages, as shown in Figure 1. In stage one the main sources of knowledge and information are identified and classified (documents and people); then, in stage two, the knowledge contained in those sources is also defined and classified; in the third stage the main processes and activities performed by the members of the community are modeled to identify the people involved, how they collaborate to complete their tasks, and how the knowledge and sources interact in those activities; finally, in stage four the main problems that can affect the flow of knowledge are highlighted through the definition of scenarios. The process proposed to carry out the above stages is iterative, since each stage could generate information to complement the others. For example, if we identify a new kind of knowledge source while we are modeling flows of knowledge, we can add the source kind to the ontology and then identify the kinds of knowledge that can be obtained from it.

In the following subsections we describe more details about each stage and present some examples about how they can be carried out. These examples have been obtained from a case study in a software maintenance organization,

Figure 1. Stages of the methodology for identifying knowledge flows



where a multi-agent knowledge management system was designed with requirements obtained from the results of the study (Rodríguez et al., 2004a; Rodríguez, Vizcaino, Martínez, Piattini & Favela, 2004b).

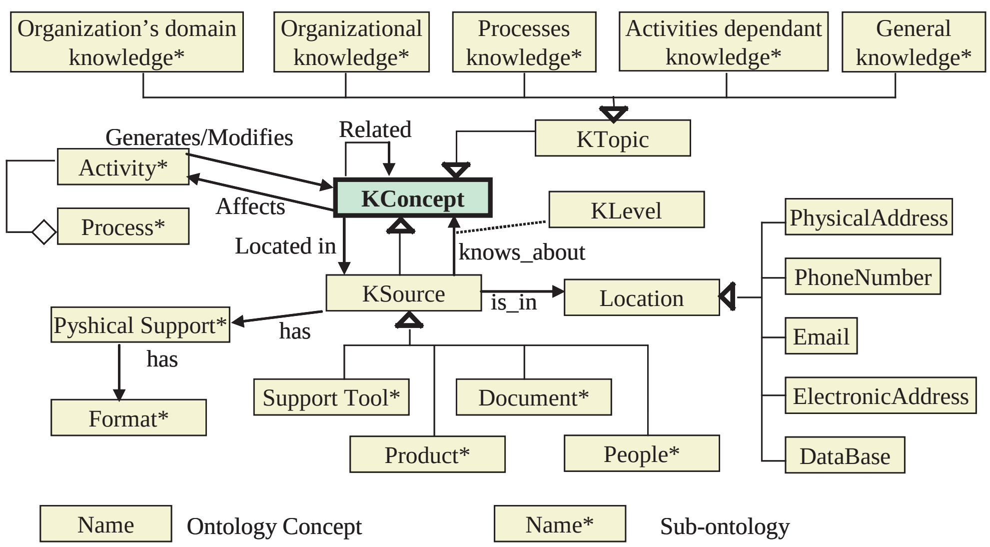
IDENTIFYING AND CLASSIFYING KNOWLEDGE AND KNOWLEDGE SOURCES

The first step starts by identifying the main documents and people involved in the community. Then, in stage two, the documents are analyzed in order to define the kinds of knowledge that can be obtained from those, together with the kinds of knowledge that the people involved can have or require for their activities. Taxonomies can be defined to classify the knowledge sources found and the kinds of knowledge these sources have; also an ontology can be designed to help define the relations between the sources and the kinds of knowledge.

Ontologies are conceptual models for specifying meanings or knowledge about a common domain; they can be used to provide a framework for sharing these meanings or knowledge (Gruber, 1995; Maedche, Motik, Stojanovic, Studer & Volz, 2003). Therefore, ontologies can be used for specifying information sources and the knowledge they can have, as well as the connections between them, in order to develop a conceptual framework of these relations.

Figure 2 presents a general ontology used for classifying knowledge and its sources in the case study carried out. This ontology is used for identifying knowledge concepts (KConcept) which can be both knowledge sources (KSource) or knowledge topics (KTopic). The knowledge concepts involved in an activity can affect that activity in some way; for example, in order to perform an activity, some knowledge topics can be necessary or some knowledge sources can be required; moreover, an activity can generate or modify some topics or sources of knowledge. Some elements of the ontology have been defined as sub-ontologies, and their structure must be specified for the particular needs of the studied organization or community.

Figure 2. A generic ontology of knowledge sources and knowledge topics



Knowledge sources can be people, documents, support tools (such as organizational memories, experience repositories, etc.), and the products developed or built by the organization. For example, in a software organization, the systems developed (source code and executable program) can be a very useful source of knowledge. Each knowledge source can have a specified physical support (such as paper, electronic file, audiotape, videotape, etc.) and a format (such as Word document, PowerPoint presentation, etc.); they can also have one or more locations which define how they can be consulted; and finally, the sources have a level of knowledge about knowledge topics or other knowledge sources.

Knowledge topics have been classified in five main groups:

1. those related to the organization's domain knowledge, for example, if the organization develops software for telephonic services management, it must know about the call fees of the different kinds of calls of each telephone company;
2. knowledge about the structure of the organization, its norms, its culture, and so forth;
3. knowledge about the processes of the organization, for example, the activities, the people involved, and so forth;
4. knowledge dependent of specific activities, for example the procedures or support tools used for performing the activity, and so forth; and
5. other kinds of knowledge that can be important, for example, it can be useful to know which employees speak foreign languages or have other skills that are not used in their daily work.

This ontology can be used for defining and classifying the kinds and sources of knowledge and how all these are related. This information can be later used for defining the structure of a knowledge base, for example, by specifying the most important knowledge topics for the organization, the sources of knowledge available and the kinds of knowledge that can be obtained from those sources.

In the third stage of the methodology, we have followed a process modeling approach to identify the flows of knowledge by modeling the activities performed by the community, the knowledge required and generated in the activities, the people in charge of them, and the sources of knowledge used, modified, or generated during the activities. This approach is presented in the following section.

KNOWLEDGE FLOWS MODELING

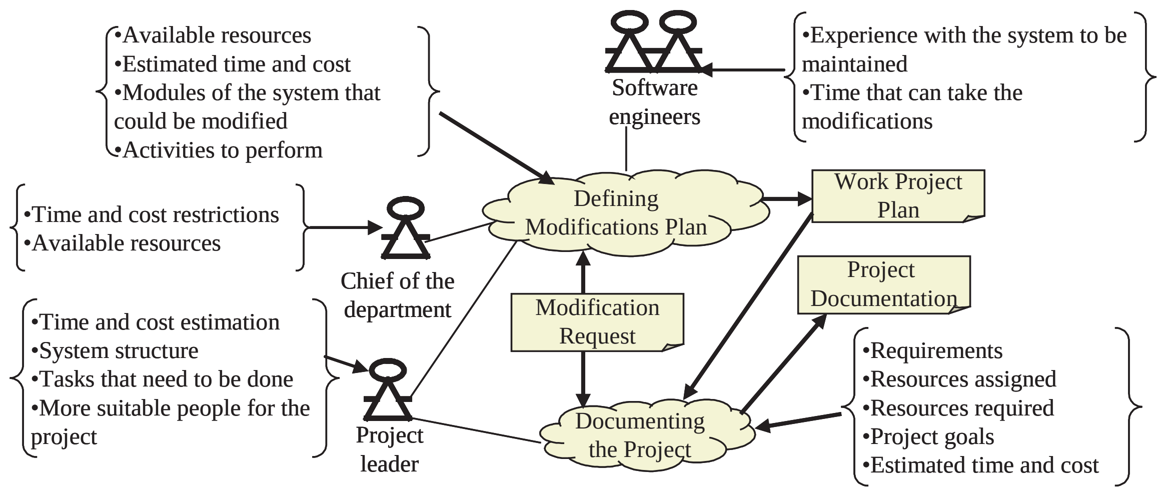
A process modeling (Curtis et al., 1992) approach can be very useful to identify how the knowledge and sources of information are involved in the activities performed by the community. To do this, the main activities of the processes carried out by the community must be identified, as well as the decisions that the people involved must make while they perform those activities. A graphical modeling technique, such as rich picture (Monk & Howard, 1998), can be used to model these activities. Rich pictures are cartoon-like representations that identify actors, roles, their concerns, and some of the structure underlying the work context. Thus, these kinds of representations can be useful to model the people and roles involved in some activities, the knowledge required by them to perform the activities, and the sources they consult or those that could have information to help them to complete their activities. These models can be later used to analyze how the knowledge flows through the group while its members perform their activities.

Figure 3 illustrates an example of a graphical model, which shows the main activities performed in the definition of the modification plan carried out by the group studied. The model shows the people involved in those activities, the knowledge

Table 1. Schema used to identify knowledge in decision making

Role	Project leader	
Activity	To define modification plan	
Decision	To define required resources	
	To define main tasks to perform	
	To assign tasks to the participants of the project	
	To estimate the time the project would consume	
Knowledge	Previous projects experiences	
	Requirements and restrictions of the project	
	Abilities and experience of each of the possible participants of the project	
Sources of information		
Name	**Information**	**Consulted at**
Chief of the department	Available resources; time and cost restrictions	Telephone, Physical address, Email
Software engineers	Experience with the system that will be modified; time that could consume the modifications; time availability	Telephone, Physical address, Email
Previous projects documentation	Resources required by previous projects	Documents' files, modifications' logbook

Figure 3. An example of a model of activities performed by members of a maintenance group



they have together with their relevance to the activities modeled, and the main sources used, created, or modified in the activities.

Once the activities have been modeled, the next step is to define the decisions that must be made by the people involved. To do that, we used the schema shown in Table 1. This schema helps to identify the knowledge that the people in charge of the activities must have to make the decisions required, and the sources they consult to obtain information that helps them to make those decisions. At this step, it is important to identify the mechanisms that people can use to consult the sources, as well as those used to share the knowledge generated in the activities—for example, the documentation of the modifications' plan in Figure 3.

The analysis of the activities performed by the members of the community, using the graphical model and the information from the tables, are later used to understand how the knowledge flows through the community, and what techniques they use to share and obtain that knowledge. Finally this analysis can help to identify the problems that are affecting that flow. We next describe how scenarios can be used for this purpose.

SCENARIOS FOR IDENTIFYING FAULTS IN THE KNOWLEDGE FLOWS

In the fourth stage of the methodology, the models generated in the previous phase are analyzed to find the problems that could be affecting the flow of knowledge—for example, if the information generated from the activities is not captured, or if there are sources that could help in performing some activities, but they are not consulted by the people in charge. In this stage, problem scenarios can help identify how the problems detected affect the knowledge flow, and how these could be addressed. These problem scenarios could be later used to obtain design requirements to the development of tools to address these problems, since scenarios enable the identification of design requirements for software systems and make feasible the participation of users during the requirements specification stage (Chin, Rosson & Carroll, 1997).

A scenario is a textual description of the activities that people might engage in while pursuing a particular concern (Carroll & Rosson, 1992). Hence, the problem scenarios can be structured as a story of particular problems detected from the analysis of the information obtained in the previous stages. Then these scenarios can be studied in order to discuss how those problems

Table 2. An example of a problem description scenario and an alternative scenario

Kind:	Expert finding (knowledge sources management)
Problem description:	
Mary is a software engineer that must make some changes in the finances system. Since her knowledge in the domain of finances is not good enough, the changes to the system are taking more than a week of the estimated time. At the end of the week, Susan, the chief of the department, while she was checking the advances of the project, detects the delay and asks Mary the reasons of that delay. Mary tells Susan the problem and since Susan has experience with finances, she tells Mary how the problem could be solved. Finally, Mary solves the problem the same day.	
Alternative:	
When Mary decides to solve the problem of the finances system, the tool where Mary manages her tasks detects this action. This tool knows about Mary's knowledge, and identifies the kind of knowledge that Mary needs to make the changes in the finances system, so the tool identifies that Mary probably will need to consult some sources of knowledge and decides to search for those sources to help Mary do her Job. The tool founds some sources that can be relevant to the task Mary will perform, thus the tool informs Mary about it. Then, Mary decides to see the kind of knowledge those sources can have, and based on that, decides to consult Susan who is one of the sources found by the tool.	

can be tackled. Table 2 presents an example of the description of a problem scenario obtained from the group studied and an alternative scenario where the knowledge sources are provided by a system. These kinds of descriptions can provide insights, which can later be used for defining requirements for developing support tools focused on addressing the problems identified.

As we mentioned before, the methodology has been applied in a case study in the software maintenance field (Rodríguez et al., 2004a). The first two phases of the methodology helped us to identify the main knowledge sources available for the members of the maintenance groups, as well as the kinds of knowledge these sources have. This information was useful for developing a knowledge base to help find knowledge sources for maintainers to do their jobs. Then, the third phase guided us in identifying the activities where these sources are involved, the kinds of knowledge required or generated in those activities, and the mechanisms maintainers used to consult those sources or to obtain the required knowledge; that is, this last phase helped us to identify how the knowledge was flowing in the maintenance community. Finally, the scenarios defined in the fourth phase were used to obtain design requirements to develop a knowledge management system for helping maintainers to reduce the loss and waste of knowledge by facilitating the search of knowledge sources related to the activities they perform (Rodríguez et al., 2004a, 2004b).

CONCLUSION AND FUTURE POSSIBILITIES

The flow of knowledge is a very important factor for communities of practice, since one of the goals of these communities is to provide an environment where their members could share knowledge with others in order to learn together. Thus, for providing support to these communities, we think that the flow of knowledge through their members must be considered a central aspect of the design of the support tools. To address these issues, in this article we presented a qualitative methodology for studying how the knowledge flows through communities of practice in organizations, and how to identify the problems that can be affecting that flow, in order to use all this information to provide tools to support the flow of knowledge between the members of a community. The proposed methodology has been applied in a case study in a software maintenance group, where an appropriate knowledge management system according to the results obtained in this study has been designed.

We think it is important to consider the particular aspects of each community to provide better support for its particular needs. Thus, it is important to identify the knowledge needed by the members of the community, the sources they use to obtain that knowledge, the particular processes and activities carried out by them, as well as the main decisions they must make. All these aspects are considered by the proposed methodology.

Nevertheless, in order for the methodology to be more useful, we consider it necessary to provide tools for managing the information obtained by applying it—for instance, tools for defining the structure of the ontology of knowledge and knowledge sources, and for capturing information about the specific knowledge topics and sources in a knowledge base that could be later used by the tools developed to support the community. At the moment, we are working on providing this kind of support for the methodology.

REFERENCES

Beyer, H., & Holtzblatt, K. (1998). *Contextual design.* San Francisco: Morgan Kaufmann.

Borghoff, U.M., & Pareschi, R. (1998). *Information technology for knowledge management.* Berlin: Springer-Verlag.

Brown, J.S. (2002). *How does your knowledge flow? An interview with John Seely Brown*. CSC World, (Spring/Summer), 24-25.

Carroll, J.M., & Rosson, M.B. (1992). Getting around the task-artifact cycle: How to make claims and design by scenario. *ACM Transactions on Information Systems, 10*(2), 181-212.

Chin, G.J., Rosson, M.B., & Carroll, J.M. (1997). Participatory analysis: Shared development of requirements from scenarios. *Proceedings of the Conference on Human Factors in Computing Systems (CHI97),* Atlanta, GA.

Curtis, B., Kellner, M.I., & Over, J. (1992). Process modeling. *Communications of the ACM, 35*(4), 75-90.

Davenport, T.H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Fontaine, M.A., & Millen, D.R. (2004). Understanding the benefits and impact of communities of practice. In P. Hildreth & C. Kimble (Eds.), *Knowledge networks: Innovation through communities of practice* (pp.1-13). Hershey, PA: Idea Group Publishing.

Guizzardi, R.S.S., Perini, A., & Dignum, V. (2003). *Using intentional analysis to model knowledge management requirements in communities of practice* (pp. 3-53). CTIT Technical Report, University of Twente, The Netherlands.

Guizzardi, R.S.S., Perini, A., & Dignum, V. (2004). Providing knowledge management support to communities of practice through agent-oriented analysis. *Proceedings of the 4th International Conference on Knowledge Management (I-KNOW'04),* Granz, Austria.

Gruber, T.R. (1995). Towards principles for the design of ontologies used for knowledge sharing. *International Journal on Human-Computer Studies, 43*(5/6), 907-928.

Huysman, M., & de Wit, D. (2000). *Knowledge sharing in practice* (vol. 4). Dordrecht: Kluwer.

Maedche, A., Motik, B., Stojanovic, L., Studer, R., & Volz, R. (2003). Ontologies for enterprise knowledge management. *IEEE Intelligent Systems, 18*(2), 26-33.

Monk, A., & Howard, S. (1998). The rich picture: A tool for reasoning about work context. *Interactions, 5*(2), 21-30.

Nissen, M.E., & Levitt, R.E. (2002, November). *Dynamic models of knowledge-flow dynamics.* Working Paper #76, Center for Integrated Facility Engineering, Stanford University, USA.

Rodríguez, O.M., Martínez, A.I., Favela, J., Vizcaíno, A., & Piattini, M. (2004a). Understanding and supporting knowledge flows in a community of software developers. In de Vreede et al. (Eds.), *Groupware: Design, implementation, and use* (pp. 52-66). Berlin: Springer-Verlag (LNCS 3198).

Rodríguez, O.M., Vizcaino, A., Martínez, A. I., Piattini, M., & Favela, J. (2004b). How to manage knowledge in the software maintenance process. In G. Melnik & H. Holz (Eds.), *Advances in learning software organization* (pp. 78-87). Berlin: Springer-Verlag (LNCS 3096).

Tiwana, A. (2000). *The knowledge management toolkit: Practical techniques for building a knowledge management system.* Englewood Cliffs, NJ: Prentice-Hall.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge, UK: Cambridge University Press.

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Chapter 2.31
IS Design for Community of Practice's Knowledge Challenge

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INTRODUCTION

The last decade of the 20th century saw explosive growth in discussions about knowledge—knowledge work, knowledge management, knowledge-based organizations, and the knowledge economy (Cortada & Woods, 2000). Against this backdrop, enterprises including educational institutes are challenged to do things faster, better, and more cost-effectively in order to remain competitive in an increasingly global environment (Stalk, Evans & Shulman, 1992). There is a strong need to share knowledge in a way that makes it easier for individuals, teams, and enterprises to work together to effectively contribute to an organization's success.

This idea of knowledge sharing has well been exemplified in the notion of a learning organization (LO) (Senge, 1990; Garvin, 1993; King, 1996; Levine, 2001). Essentially, a learning organization could be considered as an organization that focuses on developing and using its information and knowledge capabilities in order to create higher-value information and knowledge, to modify behaviors to reflect new knowledge and insights, and to improve bottom-line results. Consequently, there are many possible instances of information system (IS) design and realization that could be incorporated into a learning organization. The acronym "LOIS" (Learning Organization Information System) (Williamson & Lliopoulos, 2001) as applied to an organization is often used as a collective term representing the conglomeration of various information systems, each of which, being a functionally defined subsystem of the enterprise LOIS, is distinguished through the services it renders. For example, if a LOIS could support structured and unstructured dialogue and negotiation among the organizational members, then the LOIS subsystems might need to support reflection and creative synthesis of information and knowledge, and thus integrate working and learning. Also, if each member of an organization is believed to possess his or her own knowledge space, which is subject to some level of description, and thus may be integrated into an organization's communal knowledge space (Wiig, 1993; Davenport & Prusak, 1998; Levine, 2001), the LOIS subsystems should help document information and knowledge as it builds up, say, by electronic journals. Or, they have to make recorded information and knowledge retrievable, and individuals with information and knowledge accessible. Collectively, a LOIS can be considered as a scheme to improve the organization's chances for success and survival by continuously adapting to the external environment. That way, we stand a better chance of increasing social participation and shared understanding within the enterprise, and thus foster better learning. More importantly, the philosophy underlying the LOIS design should recognize that our knowledge is the amassed thought and experience of innumerable minds, and LOIS helps capture and reuse those experiences and insights in the enterprise. Indeed, the cultivation of an organization's communal knowledge space—one that develops new forms of knowledge from that which exists among its members, based on seeing knowledge as a social phenomenon, and not merely as a 'thing'—is fundamental to enterprises that intend to establish, grow, and nurture a learning organization, be it physical or digital (Hackbarth & Groven, 1999), where individuals grow intellectually and expand their knowledge by unlearning inaccurate information and relearning new information.

The theme of this article is to examine the knowledge processes required of the learning organization viewed from the community of practice viewpoint, to develop and sustain the communal knowledge space through the elaboration of suitable LOIS support so as to expand an organization's capacity to adapt to future challenges.

THE BACKGROUND OF COMMUNITIES OF PRACTICE

According to Wenger, McDermott, and Snyder (2002, p. 4), communities of practice are groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise by interacting on an ongoing basis. As they spend time together, they typically share information, insight, and advice. They help one another solve problems; they ponder common issues, explore ideas, and accumulate knowledge. Oftentimes, they become informally bound by the value that they find in learning together. This value is not merely instrumental for their work. It also accrues in the personal satisfaction of knowing colleagues who understand each other's perspectives and of belonging to an interesting group of people. Over time, they develop a unique perspective on their topic, as well as a body of common knowledge, practices, and approaches. They also develop personal relationships, a common sense of identity, and established ways of interacting.

Indeed, communities of practice are not a new idea (Wenger, 1998). They were our first knowledge-based social structures, back when we lived in caves and gathered around the fire to discuss strategies for cornering prey, the shape of arrowheads, or which roots were edible. They have captured our focus today because organizations have come to realize that knowledge has become the key to success (OECD, 1996), and their competitive edge is mostly the intellectual capital of their employees (Stewart, 1997), and they need to be more intentional and systematic about managing knowledge through harnessing their human resources in order to stay ahead of the pack. Undeniably, in today's knowledge-intensive economy, organizations are increasingly expecting their employees to continually improvise and invent new methods to deal with unexpected difficulties and to solve immediate problems, and to share these innovations with other employees through some effective channels.

In this regard, the idea of the community of practice has inspired many an organization to initiate their collective learning based not so much on delineated learning paths, but rather on experience sharing, the identification of best practices, and reciprocal support for tackling day-to-day problems in the workplace. Cultivating communities of practice in strategic areas is considered as a practical way to manage knowledge in terms of critical knowledge domains; organizations need to identify the people and the specific knowledge needed for their work, and explore how they connect them into suitable communities of practice so that together they could steward the necessary knowledge. From this viewpoint, the cultivation of an organization's communal knowledge space is literally the cultivation of the various communities of practice throughout the organization.

UNDERSTANDING THE KNOWLEDGE CHALLENGE FOR LEARNING ORGANIZATIONS

Nowadays, enterprises need to understand precisely what knowledge will give them a competitive advantage. They then need to keep this knowledge on the cutting edge, deploy it, leverage it in operations, and spread it across the organization. However, many an organization still has no explicit, consolidated knowledge strategy to steward the required knowledge. Instead, many attempts at knowledge management have simply counted on new information technologies to capture all the possible knowledge of an organization into databases that would make it easily accessible to all employees (King, 1999; Levine, 2001). This philosophy of regarding knowledge as a "thing" that can be managed like other physical assets has not been quite successful for several obvious reasons. One is the apparent difficulty concerned with knowledge capture and the issue of tacit-to-explicit transformation. Another is the question of intellectual asset management. Third is the myopic interpretation of knowledge management in terms of information management, which involves breaking information into smaller chunks that can be detected throughout the organization, stored for later use, manipulated by being combined with other chunks, and transferred where they are needed. The ultimate goal of such knowledge management efforts is to get the right information to the right people at the right place with the right information technologies. It is believed that a knowledge strategy must be based on understanding what the knowledge challenge is. The essence of this challenge comes down to a few key points about the nature of knowing (Nonaka & Takeuchi, 1995; O'Leary, 1998; Wenger, 1998, 2002).

- Knowledge lives in the human act of knowing: In many instances of our daily living, our knowledge can hardly be reduced to an object that can be packaged for storage and retrieval. Our knowledge is often an accumulation of experience—a kind of residue of our actions, thinking, and conversations—that remains a dynamic part of our ongoing experience. This type of knowledge is much more a living process than a static body of information.
- Knowledge is tacit as well as explicit: Not everything we know can be codified as documents or tools. Sharing tacit knowledge requires interaction and informal learning processes such as storytelling, conversation, coaching, and apprenticeship. The tacit aspects of knowledge often consist of embodied expertise—a deep understanding of complex, interdependent elements that enables dynamic responses to context-specific problems. This type of knowledge is very difficult to replicate. This is not to say that it is not useful to document such knowledge in whatever manner serves the needs of practitioners. But even explicit knowledge is dependent on tacit knowledge to be applied.
- Knowledge is dynamic, social, as well as individual: It is important to accept that though our experience of knowing is individual, knowledge is not. Much of what we

> know derives from centuries of understanding and practice developed by long-standing communities. Appreciating the collective nature of knowledge is especially important in an age when almost every field changes too much, too fast for individuals to master. Today's complex problem solving requires multiple perspectives. We need others to complement and develop our own expertise. In fact, our collective knowledge of any field is changing at an accelerating rate. What was true yesterday must be adapted to accommodate new factors, new data, new inventions, and new problems.

In short, what makes managing knowledge a challenge is that it is not an object that can be stored, owned, and moved around like a piece of equipment or a document. It resides in the skills, understanding, and relationships of its members, as well as in the tools, documents, and processes that embody aspects of this knowledge. In response to such knowledge challenge in a learning organization, it is interesting to observe some of the interpretations from the standpoint of the communities of practice (CoPs).

Firstly, it is not a CoP's practice to reduce knowledge to an object. They often make it an integral part of their activities and interactions, and they serve as a living repository for that knowledge. Secondly, a CoP is in the best position to codify knowledge since their members can combine its tacit and explicit aspects. They also can produce useful documentation, tools, and procedures because they understand the needs of practitioners. Such CoP products are often not considered as just objects by themselves, but are part of the life of the community. Thirdly, what counts as collective knowledge is often produced through a process of communal involvement, including all the possible controversies, so as to develop the specific body of knowledge. This collective character of knowledge creation does not mean that individuals do not count. In fact, the best communities welcome strong personalities and encourage disagreements and debates. Besides, that knowledge is not static does not mean that a domain of knowledge lacks a stable core. One of the primary tasks of a community of practice is to establish a common baseline of knowledge and standardize what is well understood so that people can focus their creative energies on the more advanced issues.

CONCEIVING KNOWLEDGE PROCESSES FOR COMMUNITIES OF PRACTICE

In order to create the communal knowledge space through cultivating various communities of practice for the entire organization, it is important to have a vision that orients the entire organization to the kind of knowledge it must acquire, and wins spontaneous commitment by the individuals and groups involved in knowledge creation (Dierkes, Marz & Teele, 2001; Kim, 1993; Stopford, 2001). It is top management's role to articulate this knowledge vision and communicate it throughout the organization. A knowledge vision should define what kind of knowledge the organization should create in what domains. It helps determine how an organization and its knowledge base will evolve in the long run (Leonard-Barton, 1995; Nonaka & Takeuchi, 1995). On the other hand, the central requirement for organizational knowledge synthesis is to provide the organization with a strategic ability to acquire, create, exploit, and accumulate new knowledge continuously and repeatedly. To meet this requirement, we need an actionable framework, which could facilitate the development of this strategic ability through the communities of practice. It is likely that there are at least three major processes constituting this synthesis framework of a learning organization, including the personal process, the social process, and the organizational process. What follows is our appreciation of these three important knowledge processes considered as indispensable in the daily operations of the learning organization. Of particular interest here is the idea of appreciative settings, which according to Vickers (1972, p. 98) refer to the body of linked connotations of personal interest, discrimination, and valuation which we bring to the exercise of judgment and which tacitly determine what we shall notice, how we shall discriminate situations from the general confusion of ongoing events, and how we shall regard them. The word "settings" is used because such categories and criteria are usually mutually related; a change in one is likely to affect others.

- The Personal Process: Consider a human being as an individual conscious of the world outside his or her physical boundary. This consciousness means that we can think about the world in different ways, relate these concepts to our experience of the world, and so form judgments that can affect our intentions and, ultimately, our actions. This line of thought suggests a basic model for the active human agent in the world. In this model we are able to perceive parts of the world, attribute meanings to what we perceive, make judgments about our perceptions, form intentions to take particular actions, and carry out those actions. These change the perceived world, however slightly, so that the process begins again, becoming a cycle. In fact, this simple model requires some elaborations. First, we always selectively perceive parts of the world, as a result of our interests and previous history. Secondly, the act of attributing meaning and making judgments implies the existence of standards against which comparisons can be made. Thirdly, the source of standards, for which there is normally no ultimate authority, can only be the previous history of the very process we are describing, and the standards will themselves often change over time as new experience accumulates. This is the process model for the active human agents in the world of individual learning, through their individual appreciative settings. This model has to allow for the visions and actions, which ultimately belong to an autonomous individual, even though there may be great pressure to conform to the perceptions, meaning attributions, and judgments which belong to the social environment, which, in our discussion, is the community of practice.
- The Social Process: Although each human being retains at least the potential selectively to perceive and interpret the world in his or her own unique way, the norm for a social being is that our perceptions of the world, our meaning attributions, and our judgments of it will all be strongly conditioned by our exchanges with others. The most obvious characteristic of group life is the never-ending dialogue, discussion, debate, and discourse in which we all try to affect one another's perceptions, judgments, intentions, and actions. This means that we can assume that while the personal process model continues to apply to the individual, the social situation will be that much of the process will be carried out inter-subjectively in discourse among individuals, the purpose of which is to affect the thinking and actions of at least one other party. As a result of the ensuing discourse, accommodations may be reached which lead to action being taken. Consequently, this model of the social process which leads to purposeful or intentional action, then, is one in which appreciative settings lead to particular features of situations, as well as the situations themselves, being observed and interpreted in specific ways by standards built up from previous experience. Meanwhile, the standards by which judgments are made may well be changed through time as our personal and

social history unfolds. There is no permanent social reality except at the broadest possible level, immune from the events and ideas, which, in the normal social process, continually change it.

- The Organizational Process: Our personal appreciative settings may well be unique since we all have a unique experience of the world, but oftentimes these settings will overlap with those of people with whom we are closely associated or who have had similar experiences. Tellingly, appreciative settings may be attributed to a group of people, including members of a community, or the larger organization as a whole, even though we must remember that there will hardly be complete congruence between the individual and the group settings. It would also be naïve to assume that all members of an organization share the same settings, those that lead them unambiguously to collaborate together in pursuit of collective goals. The reality is that though the idea of the attributed appreciative settings of an organization as a whole is a usable concept, the content of those settings, whatever attributions are made, will never be completely static. Changes both internal and external to the organization will change individual and group perceptions and judgments, leading to new accommodations related to evolving intentions and purposes. Subsequently, the organizational process will be one in which the data-rich world outside is perceived selectively by individuals and by groups of individuals. The selectivity will be the result of our predispositions to "select, amplify, reject, attenuate, or distort" (Land, 1985, p. 212) because of previous experience, and individuals will interact with the world not only as individuals but also through their simultaneous membership of multiple groups, some being formally organized and others informally. Perceptions will be exchanged, shared, challenged, and argued over, in a discourse that will consist of the inter-subjective creation of selected data and meanings. Those meanings will create information and knowledge which will lead to accommodations being made, intentions being formed, and purposeful action undertaken. Both the thinking and the action will change the perceived world, and may change the appreciative settings that filter our perceptions. This organizational process is a cyclic one and a process of continuous learning; it should be richer if more people take part in it. And it should fit into the context of a learning organization.

AN ORGANIZATION SCENARIO OF KNOWLEDGE SYNTHESIS FOR COMMUNITIES OF PRACTICE

From the discussion built up so far, we can understand that knowledge synthesis is a social as well as an individual process. Sharing tacit knowledge requires individuals to share their personal beliefs about a situation with others (Nonaka, 2002). At that point of sharing, justification becomes public. Each individual is faced with the tremendous challenge of justifying his or her beliefs in front of others—and it is this need for justification, explanation, persuasion, and human connection that makes knowledge synthesis a highly dynamic process (Markova & Foppa, 1990; Vat, 2003).

To bring personal knowledge into a social context, within which it can be amplified or further synthesized, it is necessary to have a field that provides a place in which individual perspectives are articulated, and conflicts are resolved in the formation of higher-level concepts. In the organizational context of our investigation, this field for interaction is provided in the form of a community of practice, made of members perhaps from different functional units.

It is a critical matter for an organization to decide when and how to establish such a community of interaction in which individuals can meet and interact. This community triggers organization knowledge synthesis mainly through several stages. First, it facilitates the building of mutual trust among members, and accelerates creation of an implicit perspective shared by members as tacit knowledge. Second, the shared implicit perspective is conceptualized through continuous dialogue among members. Tacit field-specific perspectives are converted into explicit concepts that can be shared beyond the boundary of the community. It is a process in which one builds concepts in cooperation with others. It provides the opportunity for one's hypothesis or assumption to be tested. As Markova and Foppa (1990) argue, social intercourse is one of the most powerful media for verifying one's own ideas. Next comes the step of justification, which determines the extent to which the knowledge created within the community is truly worthwhile for the organization. Typically, an individual justifies the truthfulness of his or her beliefs based on observations of the situation; these observations, in turn, depend on a unique viewpoint, personal sensibility, and individual experience. Accordingly, when someone creates knowledge, he or she makes sense out of a new situation by holding justified beliefs and committing to them. Indeed, the creation of knowledge, from this angle, is not simply a compilation of facts, but a uniquely human process that cannot be reduced or easily replicated. It can involve feelings and belief systems of which we may not even be conscious. Nevertheless, justification must involve the evaluation standards for judging truthfulness. There might also be value premises that transcend factual or pragmatic considerations. Finally, we arrive at the stage of cross-leveling knowledge (Nonaka, 2002). During this stage, the concept that has been created and justified is integrated into the knowledge base of the organization, which comprises a whole network of organizational knowledge.

CRITICAL CHALLENGES OF ARCHITECTING IS SUPPORT FOR COMMUNITIES OF PRACTICE

Undeniably, setting up an organizational IS support for various communities of practice is a social act in itself, requiring some kind of concerted action by many different people (Vat, 2004a); and the operation of any LOIS subsystem entails such human phenomena as attributing meaning to manipulated data and making judgments about what constitutes a relevant category (Vat, 2004b). Subsequently, an organization is often seen at core as a conversational process in which the world is interpreted in a particular way which legitimates shared actions and establishes shared norms and standards. There is no single body of work which underlies this soft approach to IS, but the works of Sir Geoffrey Vickers (1965) provide quite an interesting reference. For Vickers, organizational members set standards or norms rather than goals, and the traditional focus on goals is replaced by one on managing relationships according to standards generated by previous history of the organization. Furthermore, the discussion/debate, which leads to action, is one in which social action is based upon personal and collective sense making (Weick, 1995). Thereby, organizations are also regarded as networks of conversation or communicative exchanges in which commitments are generated (Ciborra, 1987; Winograd & Flores, 1986). And LOIS support should be thought of as making such exchanges easier—the exchange support systems.

Consequently, a strategy for IS support needs to be thought of, through which desirable change and organizational learning are often considered as the aims. Its stages of development could be characterized as follows with plausible iterations in stages 3, 4, and 5 (Wilson, 2002, pp. 6-10):

1. define the situation that has provoked concerns;

2. express the situation with different sets of concerns;
3. select concepts that may be relevant;
4. assemble concepts into an intellectual structure;
5. use this structure to explore the situation;
6. define changes to the situation as the challenges to be explored; and
7. implement the change processes.

Given the great variety of organizational design problems for CoP-based LOIS support, considerable flexibility must exist in the concepts and structures available to the analysts. It is believed that unless the particular methodology is assembled as a conscious part of the analysis, it is very unlikely that the changes and solutions identified will represent an effective output of the analysis. More importantly, the specific methodology needs to be explicit in order to provide a defensible audit trail from recommendations back to initial assumptions and judgments.

Thereby, thinking about how to think in designing LOIS support is about planning the intellectual process to follow up with the design itself. And there are numerous challenges (Carroll, 1995, 2000) in the underlying process. First, there is often an incomplete description of the problem to be addressed, but it is always necessary to identify the relevant description of the current situation that is to be altered by the design work. Secondly, the problem space of allowable and possible moves is often not determined beforehand. In fact, there is often no guidance on possible design moves in reasoning from a description of the current situation toward an improved version of the situation. Thirdly, design problems themselves characteristically involve many trade-offs; any move creates side effects, such as impacts on human activities. Accordingly, it is by no means a routine process in the IS design for organizational communities of practice.

FUTURE TRENDS OF IS DESIGN FOR COP-BASED KNOWLEDGE SYNTHESIS

According to Checkland and Holwell (1995), the main role of an information system is that of a support function helping people in their purposeful actions. Many of today's information systems are difficult to learn and awkward to use; they often change our activities in ways that we do not need or want. The problem lies in the IS development process. Oftentimes, IS designers have to face convoluted networks of trade-off and inter-dependence, the need to coordinate and integrate the contributions of many kinds of experts, and the potential of unintended impacts on people and their social institutions. It has been observed that traditional textbook approaches to IS development (Checkland & Holwell, 1998) seek to control the complexity and fluidity of design using techniques which filter the information considered, and weakly decompose the problems to be solved. In contrast, the scenario-based design approach (Vat, 2004a, 2004b; Carroll, 1995, 2000) belongs to a complementary tradition that seeks to exploit the complexity and fluidity of design by trying to learn more about the concrete elements of the problem situation. Thereby, John Carroll characterizes scenarios as concrete stories about use through which IS architects could envision and facilitate new ways of doing things and new things to do. Specifically, scenarios provide a vocabulary for coordinating the central tasks of systems development—understanding people's needs, envisioning new activities and technologies, designing effective systems and software, and drawing general lessons from systems as they are developed and used. Namely, scenarios help IS designers analyze the various possibilities by focusing first on the human activities that need to be supported and allowing descriptions of those activities to drive the quest for correct problem requirements. It is expected that through maintaining a continuous focus on situations of and consequences for human work and activities, IS designers could become more informed of the problem domains, seeing usage situations from different perspectives, and managing trade-offs to reach usable and effective design outcomes (Carroll, 1994, 1995).

Consequently, through the appropriate use of design scenarios, the problems of designing CoP-based LOIS support for knowledge work should never be thought of as something to be defined once and for all, and then implemented. Instead, it must be based on the observation that all real-world organizational problem situations contain people interested in trying to take purposeful action (Checkland, 1999). Pragmatically, the idea of a set of activities linked together so that the whole, as an entity called the human activity system (HAS) from the viewpoint of soft systems methodology (SSM) (Checkland & Holwell, 1998; Checkland & Scholes, 1999) could pursue a purpose, could indeed be considered as a representative organizational scenario for architecting LOIS support, which is never fixed once and for all. In practice, given a handful of the HAS models, namely, models of concepts of purposeful activity built from a declared point of view, we could create a coherent structure to debate about the problem situation and what might improve it (Checkland, Forbes & Martin, 1990; Checkland, 1981, 1983).

Subsequently, from the IS architect's point of view, while conceiving the necessary IS support to serve the specific organizational knowledge requirements, the fundamental ideas could be integrated as follows: Always start from a careful account of the purposeful activity to be served by the system. From that, work out what informational support is required (by people) to carry out the activity. Treat the creation of that support as a collaborative effort between technical experts and those who truly understand the purposeful action served. Meanwhile, ensure that both system creation and system development and use are treated as opportunities for continuous learning. In this way, models of purposeful human activities can be used as scenarios to initiate and structure sensible discussion about LOIS support for the people undertaking the real-world problem situations. Thereby, the process of IS development needs to start not with attention quickly focused on data and technology, but with a focus on the actions served by the intended organizational system. Once the actions to be supported have been decided and described, which can usefully be done using activity models, we can proceed to decide what kind of support should be provided. The key point is that in order to create the necessary IS support which serves the intended organizational scenario, it is first necessary to conceptualize the organizational system (different communities of practices) that is to be served, since this order of thinking should inform what relevant services would indeed be needed in the IS support.

CONCLUSION

This article describes an initiative to develop an actionable framework of knowledge processes, which are aimed to facilitate the creation and sustenance of communities of practice in the context of a learning organization. Our discussion has paid particular attention to the design issues in support of participatory knowledge construction, which is essential for the growth of any CoP in the organizational workplace. In particular, we have elaborated the design issues of three important knowledge processes (the individual, the social, and the organizational), which have tremendous implications for the design of suitable IS support (Vat, 2004b) to help structure and facilitate knowledge creation in the specific organizational setting, where a community of people can conceptualize their world and hence the purposeful action they wish to undertake. This renders a perspective of a knowledge context in a learning organization in which social reality is continually defined and re-defined in both the talk and action of the various communities within the organization. The article concludes by reiterating the challenge of designing LOIS support so that the purposeful actions of the CoPs can be accommodated. It is important that the examination of meanings and purposes should be broadly based, and its richness will be greater the larger the number of people who take part in it. This consequently provides the basis for ascertaining the development of an organization's communal knowledge space: namely, what IS support is needed by those undertaking their actions, and how modern information technologies can help to provide that support to the various communities of practice.

REFERENCES

Carroll, J.M. (1994). Making use a design representation. *Communications of the ACM, 37*(12), 29-35.

Carroll, J.M. (2000). *Making use: Scenario-based design of human-computer interactions.* Cambridge, MA: MIT Press.

Carroll, J.M. (Ed.). (1995). *Scenario-based design: Envisioning work and technology in system development.* New York: John Wiley & Sons.

Checkland, P. (1981). *Systems thinking, systems practice.* Chichester, UK: John Wiley & Sons.

Checkland, P. (1983). Information systems and systems thinking: Time to unite? *International Journal of Information Management, 8*, 230-248.

Checkland, P. (1999). Systems thinking. In W.L. Currie & B. Galliers (Eds.), *Rethinking management information systems.* Oxford University Press.

Checkland, P., Forbes, P., & Martin, S. (1990). Techniques in soft systems practice, part 3: Monitoring and control in conceptual models and in evaluation studies. *Journal of Applied Systems Analysis, 17*, 29-37.

Checkland, P., & Holwell, S. (1995). Information systems: What's the big idea? *Systemist, 17*(1), 7-13.

Checkland, P., & Holwell, S. (1998). *Information, systems, and information systems: Making sense of the field.* Chichester, UK: John Wiley & Sons.

Checkland, P., & Scholes, J. (1999). *Soft systems methodology in action.* Chichester, UK: John Wiley & Sons.

Ciborra, C.U. (1987). Research agenda for a transaction costs approach to information systems. In Boland and Hirschheim (Eds.), *Critical issues in information systems research*. Chichester, UK: John Wiley & Sons.

Cortada, J.W., & Woods, J.A. (Eds.). (2000). *The knowledge management yearbook 2000-2001.* Butterworth-Heinemann.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dierkes, M., Marz, L., & Teele, C. (2001). Technological visions, technological development, and organizational learning. In M. Dierkes, A.B. Antal et al. (Eds.), *Handbook of organizational learning and knowledge* (pp. 282-304). Oxford University Press.

Garvin, D.A. (1993). Building a learning organization. *Harvard Business Review, 71*(4), 78-91.

Hackbarth, G., & Grover, V. (1999). The knowledge repository: Organization memory information systems. *Information Systems Management, 16*(3), 21-30.

Kim, D. (1993). The link between individual and organizational learning. *Sloan Management Review*, (Fall), 37-50.

King, W.R. (1996). IS and the learning organization. *Information Systems Management, 13*(3), 78-80.

King, W.R. (1999). Integrating knowledge management into IS strategy. *Information Systems Management, 16*(4), 70-72.

Land, F. (1985). Is an information theory enough? *The Computer Journal, 28*(3), 211-215.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Levine, L. (2001). Integrating knowledge and processes in a learning organization. *Information Systems Management,* (Winter), 21-32.

Markova, I., & Foppa, K. (Eds.). (1990). *The dynamic of dialogue.* New York: Harvester Wheatsheaf.

Nonaka, I. (2002). A dynamic theory of organizational knowledge creation. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge* (pp. 437-462). Oxford University Press.

Nonaka, I., & Takeuchi, H. (1995). The knowledge creating company: *How Japanese companies create the dynamics of innovation.* Oxford University Press.

OECD. (1996). *The knowledge-based economy*. Organization for Economic Co-operation and Development, OCDE/GD(96)102, Paris.

O'Leary, D.E. (1998). Enterprise knowledge management. *IEEE Computer, 31*(3), 54-61.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization.* London: Currency Doubleday.

Stalk, G. Jr., Evans, E., & Shulman, L.E. (1992). Competing on capabilities: The new rules of corporate strategy. *Harvard Business Review*, (March-April).

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations.* New York: Doubleday.

Stopford, J.M. (2001). Organizational learning as guided responses to market signals. In M. Dierkes, A.B. Antal et al. (Eds.), *Handbook of organizational learning and knowledge* (pp. 264-281). Oxford University Press.

Vat, K.H. (2004a, July 21-25). Conceiving scenario-based IS support for knowledge synthesis: The organization architect's design challenge in systems thinking. *Proceedings of the 10th International Conference on Information Systems Analysis and Synthesis (ISAS2004),* (pp. 101-106), Orlando, FL.

Vat, K.H. (2004b, November 4-7). Systems architecting of IS support for learning organizations: The scenario-based design challenge in human activity systems. *CD-Proceedings of the 2004 Information Systems Education Conference (ISECON2004),* Newport, RI.

Vat, K.H. (2003, June 24-27). Toward an actionable framework of knowledge synthesis in the pursuit of learning organization. *CD-Proceedings of the 2003 Informing Science + IT Education Conference (IsITE2003),* Pori, Finland.

Vickers, G. (1965). The art of judgment. London: Chapman and Hall.

Vickers, G. (1972). Communication and appreciation. In Adams et al. (Eds.), *Policymaking, communication and social learning: Essays of Sir Geoffrey Vickers.* New Brunswick, NJ: Transaction Books.

Weick, K.E. (1995). *Sense-making in organizations.* Thousand Oaks, CA: Sage Publications.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W.M. (2002). *Cultivating communities of practice: A guide to managing knowledge.* Boston: Harvard Business School Press.

Wiig, K.M. (1993). *Knowledge management: The central management focus for intelligent-acting organizations.* Arlington, TX: Schema Press.

Williamson, A., & Lliopoulos, C. (2001). The learning organization information system (LOIS): Looking for the next generation. *Information Systems Journal*, *11*(1), 23-41.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design.* Reading, MA: Addison-Wesley.

Wilson, B. (2001). *Soft systems methodology: Conceptual model building and its contribution*. New York: John Wiley & Sons.

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Chapter 2.32
Knowledge Management Strategy Formation

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INTRODUCTION

Knowledge-based organizations (Holsapple & Whinston, 1987; Paradice & Courtney, 1989; Bennet & Bennet, 2003) are intentionally concerned with making the best use of their knowledge resources and knowledge-processing skills in the interest of enhancing their productivity, agility, reputation, and innovation (Holsapple & Singh, 2001). A key question that confronts every knowledge-based organization is concerned with how to approach the task of forming a KM strategy. Beyond aligning KM strategy with an organization's vision and overall strategy for achieving its mission, how does the creator of a KM strategy proceed? How is the created (or adopted) KM strategy communicated and evaluated? What can be done to avoid blind spots, gaps, and flaws in the strategy?

One way to begin to answer such questions is to study successful cases of organizational knowledge management (e.g., see Smith & McKeen, 2003; O'Dell et al., 2003; van der Spek, Hofer-Alfeis, & Kingma, 2003; Bennet & Porter, 2003; Oriel, 2003; Wolford & Kwiecien, 2003; Kelly & Bauer, 2003; DeTore & Balliet-Milholland, 2003). Such cases can give specific KM strategies to consider emulating or adapting. They can lead to an understanding of various issues to consider in the act of forming a KM strategy. Other cases can even identify dysfunctional elements to avoid during KM strategy formation and use (Malhotra, 2003).

A complementary approach to answering such questions is to employ a general-purpose model as a guide for KM strategy formation. This can be used regardless of the nature of the organization or its particular circumstances. It guides the strategy formation process in the sense of providing a structure for identifying the KM activities that a strategy can or should address in its efforts to maximize performance. A KM director uses the model to assess where the organization presently stands with respect to each of the identified activities, to consider new initiatives for each of the activities (customized to the organization's particular circumstances), and to furnish dimensions for evaluating competitive standing.

Here, we examine the Knowledge Chain Model for guiding KM strategy formation. It is important to understand that this is not a process model that specifies some sequence of steps to be followed in devising KM strategies. Rather, it is a model that identifies key factors that need to be considered in the development of KM strategies. These factors are "key" in the sense that they are potential sources of greater competitiveness. They are areas of activity that, if performed better than competitors, will yield superior organizational performance through better productivity, agility, innovation, and/or reputation. Creators of KM strategies need to pay close attention to the techniques and technologies selected and deployed in each of the key activity areas in both their own organizations and in other (e.g., competing) organizations.

BACKGROUND

The notion of a strategy has varied meanings (Mintzberg & Quinn, 1996). Here, we regard strategy as being a systematic plan of action for deliberately using an organization's resources in ways that fulfill its purpose (e.g., mission, duty, vision). A knowledge management strategy, then, is a plan for marshaling and applying knowledge-oriented resources in the interest of supporting the organization's purpose. These knowledge-oriented resources include the organization's knowledge processing capabilities and its knowledge assets (Holsapple & Joshi, 2004). The classes of knowledge assets include knowledge held by an organization's participants, various artifacts belonging to the organization (e.g., documents, manuals, videos), the organization's culture, and its particular infrastructure of roles, relationships, and regulations. The knowledge processing capabilities include the skills of both individual participants (both human and computer-based processors) and collective participants (e.g., groups, teams, communities) in the organization.

Knowledge Processing Capabilities

An organization's knowledge processing capabilities can be categorized into those that are technologically based and those that are practice based. Capabilities can depend on a combination of these two. In any case, knowledge processing capabilities manifest in the actual activities that an organization performs as it operates on its knowledge assets. KM strategy determines what technologies and practices will be adopted in any given instance of a KM activity.

Information technology (IT) is being subsumed by knowledge technology. IT systems for automated transaction handling, record storage, and reporting remain important. However, the emphasis going forward is on technological systems that support knowledge amplification within and across organizations. This knowledge technology involves the use of computer and communication technologies to automatically acquire, derive, or discover knowledge needed by decision makers and researchers on a just-in-time basis. Knowledge technology fosters knowledge sharing and unleashes the creative potential inherent in knowledge-worker collaboration. It includes technology that measures and coordinates the activities of knowledge workers. Knowledge technology provides a basis for organizational memory and learning. It also involves technology to personalize timing and presentation of knowledge delivery according to knowledge-worker profiles.

Human cognitive and communicative acts are the other part of the KM equation. This part comprises knowledge practices and their alignment with an organization's vision and plans. These practices are based on knowledge ontologies, methods, techniques, metrics, incentives, and processes. They are concerned with issues of organizational infrastructure (roles, relationships, regulations), culture, ethics, training, skills, and core competencies.

Knowledge Assets

One way for an organization to begin developing a KM strategy is to ascertain the competitiveness of its present knowledge position. Zack (1999) suggests that competitive knowledge position can be categorized in terms of the degree of innovation relative to its competitors within an industry:

- Core Knowledge: The basic body of knowledge required of all players in an industry in order to remain competitive.
- Advanced Knowledge: Knowledge that distinguishes an organization from other players in its industry in a degree sufficient for achieving a competitive edge.
- Innovative Knowledge: Knowledge held/applied by an organization that is so distinctive that it is the basis for being a market leader in the industry.

By evaluating its knowledge assets relative to these three categories, an organization's competitive knowledge position becomes evident. Zack goes on to advocate using a strength-weakness-opportunity-threat (SWOT) analysis to recognize deficiencies in an organization's knowledge position, as well as knowledge strengths that can be leveraged. Of course, organizations will differ in both their knowledge positions and in the strategies that they devise for working from these positions within their environments.

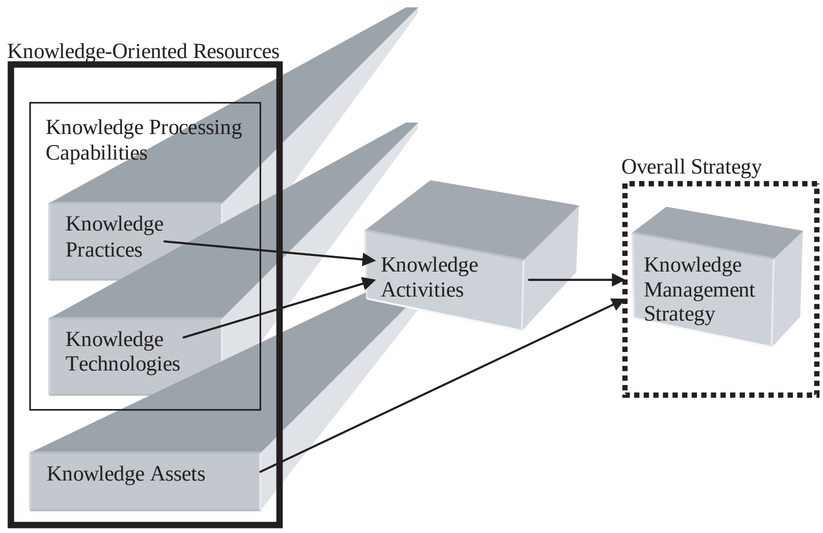
Zack (1999) advises that to find its own unique connection between strategy and knowledge assets, an organization should be alert for the need to increase knowledge assets in a particular area (e.g., ensuring sufficient core knowledge, fending off threats), opportunities to more fully exploit existing knowledge assets, the potential to generate new knowledge internally (especially advanced or innovative knowledge), and the potential of acquiring knowledge from external sources.

Developing KM Strategy

An organization should recognize that its KM strategy can be connected not only to its knowledge assets, but also to its knowledge processing capabilities (see Figure 1). Thus, in addition to guiding KM strategy formation through an analysis of an organization's actual and potential knowledge assets, there needs to be an analysis of possible practices and technologies that may be adopted for operating on those assets. This analysis of knowledge processing capabilities may follow the format used for knowledge assets. The capabilities can be classified into core, advanced, and innovative categories to understand the organization's knowledge processing capabilities relative to those of competitors. Further, via a SWOT approach, an organization needs to ascertain whether to increase knowledge processing capabilities in a particular area such as assimilating knowledge, whether opportunities to more fully exploit existing knowledge processing capabilities exist, whether new practices/technologies can be developed in-house, or whether the practices/technologies can be implemented via outsourcing, alliances, and/or purchase.

What is missing from this consideration of KM strategy development is an appreciation of the fundamental kinds of KM activities that are candidates for strategic focus. More broadly, fundamental kinds of business activities for strategic focus are known. In management theory, the Value Chain Model identifies the basic kinds of business activities that can be focal points for competitiveness (Porter, 1985). The value chain is composed of distinct activities (called "value activities") that an organization performs in the course of doing business. These value activities fall into nine generic categories: five primary and

Figure 1. Aspects of knowledge management strategy



four secondary, and translate an organization's broad competitive strategy into specific action steps required to achieve competitiveness.

By formulating a strategy to perform one or more of the value activities better than competitors, the organization can attain a competitive advantage. Analogously, it would be helpful for KM strategists to have a model that identifies basic kinds of KM activities that can be focal points for competitiveness. By formulating a plan involving practices and/or technologies to perform one or more of these KM activities better than competitors, the organization can attain a competitive advantage. The Knowledge Chain Model identifies these activities, thereby offering guidance to those who formulate KM strategy.

THE KNOWLEDGE CHAIN MODEL

Although it is analogous to the Value Chain Model, the Knowledge Chain Model (KCM) is not derived from the Value Chain Model (Holsapple & Singh, 2000, 2001). Rather, it is derived from a collaboratively engineered ontology of knowledge management. Moreover, the KCM is supported by empirical studies that show a connection between each of its KM activities and organizational competitiveness. It is important to understand that (like Porter's Value Chain Model), the KCM is not a process model. Rather, it identifies activities of particular interest to persons formulating strategy. Instances of the activities occur simultaneously, serially, in parallel, and in loops combining to form various patterns in the course of organizational operations.

Several researchers have proposed models derived from the Value Chain Model to help understand various aspects of IT (e.g., Rockart & Short, 1991). One of these, called the Information/Knowledge Value Chain, adapts the value chain to propose a linear process model that describes stages in an organization's processing of information and knowledge (King & Ko, 2001). The authors use this model as a basis for developing a framework that can be used to evaluate KM efforts in terms of cognitive, post-cognitive, behavioral, learning, and organizational impact assessments (King & Ko, 2001). They briefly suggest another use of the model: namely, that planners sequentially consider each stage in the Information/Knowledge Value Chain to design strategic systems. This consideration can involve brainstorming or other approaches to stimulating ideas about the stage, with the aim of uncovering better ways to implement it. Brainstorming and similar approaches can also be applied to any of the Knowledge Chain Model's activities.

Here, we first present highlights of the original KCM. Because the original model has been further developed, we then describe this more detailed version of the KCM.

The Original Knowledge Chain Model

The Knowledge Chain Model identifies nine crucial activities that knowledge-driven enterprises can perform in ways that yield competitive advantage (Holsapple & Singh, 2000, 2001). These activities are derived from an ontology of knowledge management phenomena that was collaboratively engineered with an international array of KM practitioners and researchers (Joshi, 1998; Holsapple & Joshi, 2002, 2003, 2004). Like Porter's Value Chain Model, it is a basic tool for diagnosing competitive advantage and finding ways to enhance it.

The Knowledge Chain Model includes five primary activities that an organization's knowledge processors perform in manipulating knowledge assets. These five activities are identified in the KM ontology as the five generic KM activities involved within knowledge management episodes: acquiring, selecting, generating, assimilating, and emitting knowledge. In addition, the KCM includes four secondary activities that support and guide performance of the primary activities. These four KM activities are identified in the KM ontology as managerial influences on the conduct of knowledge management: leading, coordinating, controlling, and measuring knowledge management initiatives. The KMC recognizes four ways in which improvements in the design and execution of KM activities can aid competitiveness: better productivity, greater agility, greater innovation, and enhanced reputation (i.e., the PAIR approaches to competitiveness).

Figure 2. The original Knowledge Chain Model

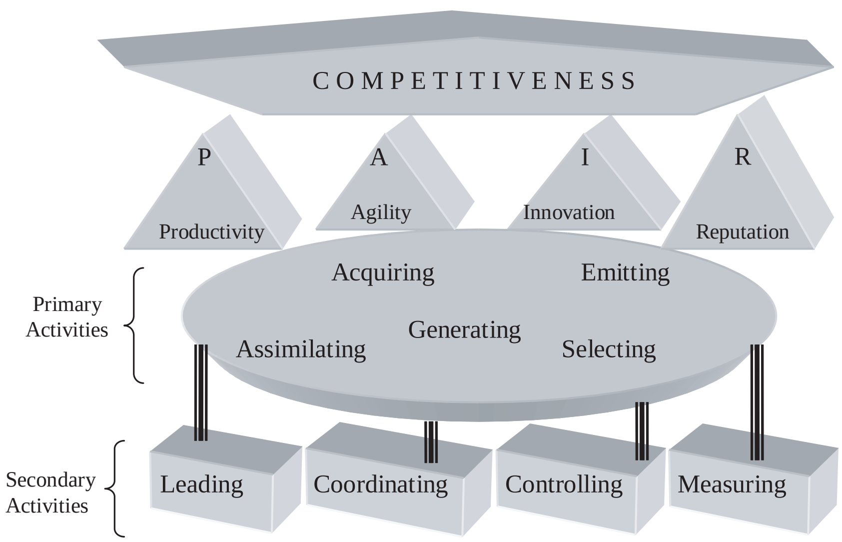


Figure 2 shows how the elements of the Knowledge Chain Model are related. Observe that no process is specified in the model. As with the Value Chain Model, the impetus is on identification of key activities on which to concentrate in formulating strategies for adding value and improving competitiveness. The fact that the Value Chain Model and the KCM each have nine activities appears to be coincidental, as the KCM is not derived from the Value Chain Model and there is no particular correspondence between any KCM activity and any value chain activity. Indeed, all of the KCM activities can be applied to the study or implementation of knowledge processing within any one of the value chain activities.

The KCM disaggregates a knowledge-based firm's knowledge processing and systematically examines all the discrete but interrelated primary and secondary KM activities that the firm performs. The result is a means for analyzing the sources of competitive advantage. The economics of how each KM activity is performed will affect whether a firm's cost structure is high or low relative to competitors. How each KM activity is performed will also affect its contribution to meeting customer needs and hence its degree of differentiation from other firms. Comparing the knowledge chains of competitors can reveal differences that determine competitive advantage.

Table 1 summarizes the KM activities that comprise an organization's knowledge chain. Anecdotal evidence indicates that this set of interrelated knowledge activities appears to be common across diverse organizations, appears to be capable of being performed with various practices and technologies so as to promote competitiveness, and appears to do so in the four PAIR directions (Holsapple & Singh, 2001). Moreover, a survey of KM practitioners indicates that each of the knowledge chain activities can be performed in ways that contribute to competitiveness along the PAIR directions (Singh, 2000).

Table 1. KM activity classes in the Knowledge Chain Model (adapted from Holsapple & Singh, 2001)

Category	Activity Class	Description
Primary	Knowledge Acquisition	Acquiring knowledge from external sources and making it suitable for subsequent use
Primary	Knowledge Selection	Selecting needed knowledge from internal sources and making it suitable for subsequent use
Primary	Knowledge Generation	Producing knowledge by either discovery or derivation from existing knowledge
Primary	Knowledge Assimilation	Altering the state of an organization's knowledge resources by distributing and storing acquired, selected, or generated knowledge
Primary	Knowledge Emission	Embedding knowledge into organizational outputs for release into the environment
Secondary	Knowledge Measurement	Assessing values of knowledge resources, knowledge processors, and their deployment
Secondary	Knowledge Control	Ensuring that needed knowledge processors and resources are available in sufficient quality and quantity, subject to security requirements
Secondary	Knowledge Coordination	Managing dependencies among KM activities to ensure that proper processes and resources are brought to bear adequately at appropriate times
Secondary	Knowledge Leadership	Establishing conditions that enable and facilitate fruitful conduct of KM

KM skills of an organization's participants need to be cultivated and applied in the performance of these activities. When a specific instance of a KM activity occurs in an organization, it is performed by one or more knowledge processors, some human and others computer based. Multiple processors may be able to perform a given type of KM activity. Conversely, multiple types of KM activity may be performed by a given processor.

Knowledge acquisition refers to the activity of identifying knowledge in the organization's external environment and transforming it into a representation that can be assimilated, and/or used for knowledge generation or emission. Selecting knowledge refers to the activity of identifying needed knowledge within an organization's existing knowledge resources and providing it in an appropriate representation to an activity that needs it (i.e., to an acquiring, assimilating, generating, and emitting activity). Generation is an activity that produces knowledge by discovering it or deriving it from existing knowledge, where the latter has resulted from acquisition, selection, and/or prior generation. Derivation involves the use of process knowledge (e.g., procedures, rules) and descriptive knowledge (e.g., data, information) to generate new process and/or descriptive knowledge employing KM skills that are of an analytical, logical, and constructive nature. Although the result is "new" to the processor that derives it, it may have previously existed but not have been assimilated, or it may already exist elsewhere in the organization but not be subject to facile selection. Discovery generates knowledge in less structured ways, via skills involving creativity, imagination, and synthesis.

Assimilating is an activity that alters an organization's knowledge resources based on acquired, selected, or generated knowledge. It receives knowledge flows from these activities and produces knowledge flows that impact the organization's state of knowledge. Emitting knowledge is an activity that uses existing knowledge to produce organizational outputs for release into the environment. It yields projections (i.e., embodiments of knowledge in outward forms) for external consumption, in contrast to assimilation which may also yield projections, but which are retained as knowledge assets. Emission is only partially a KM activity because it also can involve physical activities such as production through raw material transformation.

In characterizing the KCM's primary activities, we have strictly adopted the activity definitions existing in the underlying KM ontology. Some KM authors use some of the same terms but with different meanings. For instance, Davenport and Prusak (1998) use the term "knowledge generation" to mean not only generation as it is defined in Table 1, but to also include knowledge acquisition activity. However, just as there is a fundamental distinction between making something and buying something, the distinction between generating knowledge oneself and obtaining knowledge from external sources deserves to be made. As another example, some authors use the term "knowledge acquisition" to include not only acquisition as recognized in the ontology, but to include knowledge selection as well. However, this suggests that it is possible to acquire what we already possess, as well as what we do not possess. Like the ontology on which it is based, the KCM holds that the distinction between acquiring knowledge that is not possessed and selecting from knowledge that is possessed is an important one. Thus, in using the Knowledge Chain Model, it is important to be true to the definitions of its activities rather than confusing them with alternative definitions that are not as sharp in making distinctions.

Secondary activities support and guide the performance of primary KM activities. Measurement involves the valuation of knowledge resources and knowledge processors, including quantitative methods, qualitative assessment, performance review, and benchmarking. It is a basis for evaluation of control, coordination, and leadership; for identifying and recognizing value-adding processors and resources; for assessing and comparing the execution of KM activities; and for evaluating the impacts of an organization's conduct of KM on bottom-line performance. Control is concerned with ensuring that needed knowledge resources and processors are available in sufficient quantity and quality subject to required security and constraints on integrity and privacy. Quality is controlled with respect to two dimensions: knowledge validity (accuracy and consistency) and knowledge utility (relevance and importance). Controlling the quality of knowledge is a significant issue for KM, because the value of knowledge and returns achieved from knowledge resources depend on its quality. Protection involves protection from loss, obsolescence, unauthorized exposure, unauthorized modification, and erroneous assimilation.

Coordination refers to guiding the conduct of KM in an organization. It involves managing dependencies among knowledge resources, among knowledge manipulation activities, between knowledge resources and other resources (i.e., financial, human, and material), and between knowledge resources and KM activities. It involves marshaling sufficient skills for executing various activities, arranging those activities in time, and integrating knowledge processing with an organization's operations. An organization's approach to problem solving, decision making, experimentation, and organizational learning, all of which are knowledge-intensive endeavors, can depend on how it coordinates its KM activities. Of the four secondary KM activities, leadership is central. It sets the tone (i.e., shapes the culture) for coordination, control, and measurement that manifest. It qualifies the expression of each primary activity. In short, leadership establishes enabling conditions for achieving fruitful KM through the other eight activities. The distinguishing characteristic of leadership is that of being a catalyst through such traits as inspiring, mentoring, setting examples, engendering trust and respect, instilling a cohesive and creative culture, establishing a vision, listening, learning, teaching, and knowledge sharing.

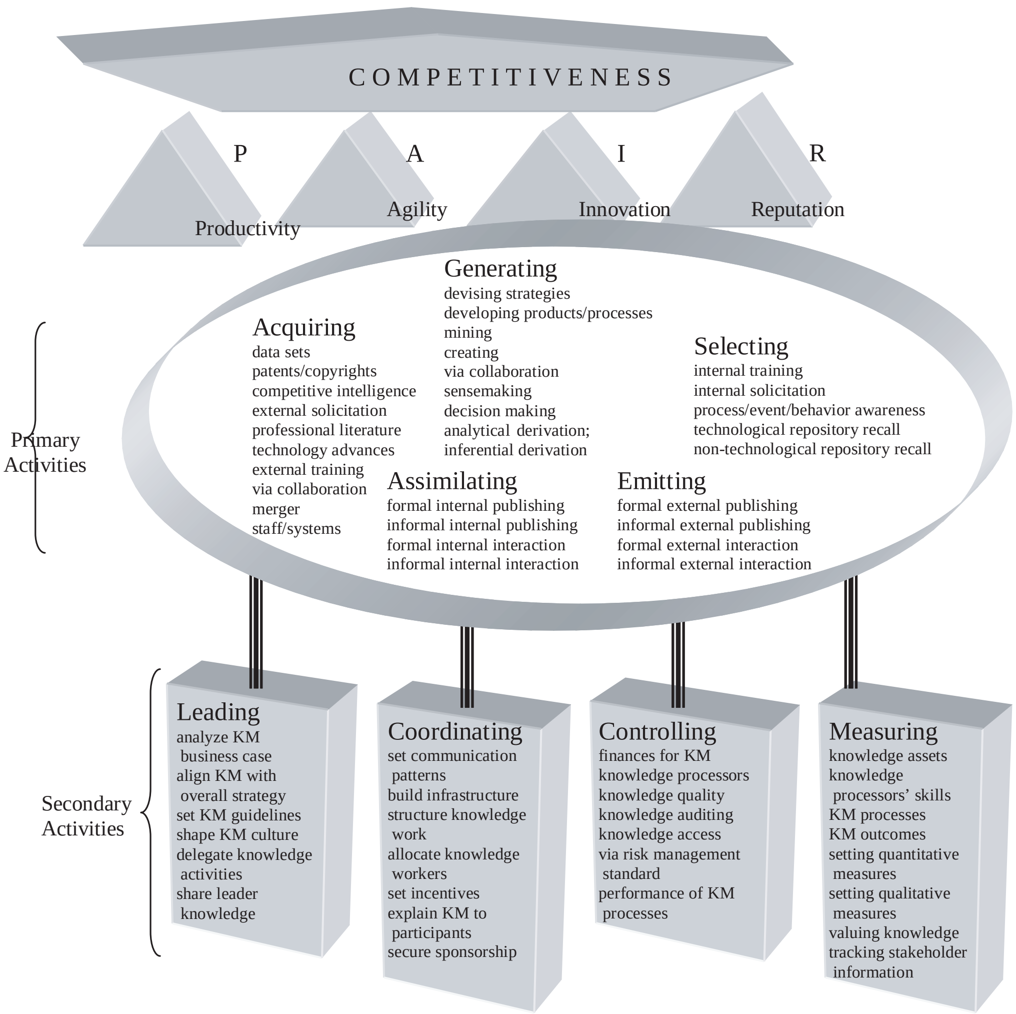
The Extended Knowledge Chain Model

The Knowledge Chain Model can be developed in further detail by identifying specific KM activity types that belong to each of the nine classes shown in Table 1 (Holsapple & Jones, 2003, 2004, 2005). In all, over 60 specific KM activities, organized into the nine classes, have been determined to yield this extended version of the KCM. These more detailed activities have been developed from an interpretive analysis of the knowledge management literature and have been judged in a survey of practitioners who lead KM initiatives as capable of being performed in ways that contribute to organizational competitiveness (Jones, 2004). The distinct KM activity types for each class are illustrated in Figure 3. For full descriptions and examples of each of the detailed KM activities, refer to Jones (2004) and Holsapple and Jones (2004, 2005). These elaborations also include taxonomies for organizing the specific KM activity types within each of the nine KCM classes.

Using the Knowledge Chain Model to Guide KM Strategy Formation

Clearly, formulating a KM strategy is not a trivial task. Moreover, it needs to be developed in concert with other aspects of an organization's overall strategy (e.g., marketing strategy, financial strategy). This development could be after the fact, devised to be aligned with and supportive of pre-existing business strategy. Alternatively, KM strategy formulation may be an integral part of an organization's overall strategy development. In either event, KM strategy is concerned with design and deployment of a suitable mix of practices and technologies for performing the knowledge management activities that can

Figure 3. The extended Knowledge Chain Model



contribute to organizational performance and competitiveness. But exactly what are these crucial KM activities? The extended version of the Knowledge Chain Model answers this question in considerable detail. As such, it can help guide KM strategy formation.

Knowledge technologies, knowledge practices, and knowledge assets are the building blocks of a KM strategy (recall Figure 1). As discussed previously, Zack (1999) has provided a way of analyzing knowledge assets that can guide KM strategy formation. The KCM provides a structure for dealing with the practice and technology aspects of KM strategy. An appropriate combination of the possibilities for these two factors needs to be determined in formulating a plan for implementing each of the KM activities identified by the Knowledge Chain Model. For a given organization, the determination of what specific technology/practice mix is appropriate for each of the KM activities depends on two classes of situational factors: the organization's available assets (i.e., human, financial, knowledge, material) and the nature of the environment (e.g., social, political, regulatory, market, industry) in which the organization finds itself.

As a starting point, the KM strategist needs to understand where the organization presently is with respect to each of the KCM activities. A SWOT analysis for each activity can be helpful. For a particular KCM activity, what are the current practices and technologies (if any) that are being used, to what extent does this approach to implementing the activity contribute to PAIR, what practices/technologies do competitors use to implement the activity? Next, the KM strategist needs to brainstorm and develop insights about possibilities for performing the KCM activity in ways that enhance organizational performance (e.g., in one or more of the PAIR directions). What alternative practices/technologies are feasible candidates for implementing the activity in light of the organization's asset situation and environment situation? Do available knowledge assets (e.g., patents, culture, infrastructure, data warehouses), human assets (e.g., knowledge processing skills), or material assets (e.g., automated knowledge processing skills) allow the strategist to plan on value-adding practices/technologies for implementing the activity? Do present or anticipated environmental factors suggest competitive threats or opportunities in the performance of the activity? These should be factored into KM strategy development relative to the KCM activity.

Another way to look at KM strategy formation is more of a top-down approach. Here, the strategist settles on one (or more) of the PAIR directions as being most consistent with or important to the overall business plan. Suppose that it is agility that the organization most wants to compete on. Each of the KCM activities is then examined from the standpoint of how the present way of performing it contributes to agility. The KM strategist asks whether there are practices/technologies that can be economically adopted as part of the plan to make the organization better able to respond to rapid, perhaps unexpected, changes in its environment or assets. The KM strategy then becomes tied to the overall strategy of excellent response-ability. Empirical study of the original KCM gives clues as to which of the nine activity classes are likely to have greatest potential for impacts on agility (Singh, 2000).

FUTURE DIRECTIONS

While the KMC offers guidance to KM strategists in structuring both the planning and the plan for driving KM initiatives, it does not offer prescriptions about what practices/technologies to adopt in specific asset/environment situations or for achieving results in a specific PAIR dimension.

The KM activities identified by the KMC are not the only determining factors that can lead to competitiveness. There are other forces that influence how the conduct of KM ultimately unfolds in an organization: resource influences (e.g., knowledge assets) and environmental influences (Joshi, 1998). This suggests that the KCM could be extended to include resource and environmental factors, which both constrain and enable the execution of KM activities. One future research direction is to investigate this extension.

The KMC is descriptive in nature. Its intent is to identify KM activities that researchers and practitioners need to consider in managing knowledge to enhance organizational performance. An obvious next step is prescriptive, further developing the KMC to lay out candidate practices and technologies for each of the KM activities.

CONCLUSION

In the interest of being competitive, a knowledge-based organization must adopt, design, and implement knowledge management activities better than other organizations. The Knowledge Chain Model identifies nine classes of KM activities and over 60 specific KM activities that appear to be common across diverse organizations. The KMC holds that individually, and in combination, these KM activities can be contributors to competitiveness. Evidence from the literature provides support for this assertion, as do results of surveys of leaders of KM initiatives. Thus, rather than simply saying that KM can yield a competitive advantage, the Knowledge Chain Model provides structure to designers of KM strategy, ensuring full consideration of the varied KM activities that can be sources of competitiveness in the directions of better productivity, agility, innovation, and/or reputation.

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REFERENCES

Bennet, A., & Porter, D. (2003). The force of knowledge: A case study of KM implementation in the Department of Navy. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

Bennet, D., & Bennet, A. (2003). The rise of the knowledge organization. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge matters.* Berlin/Heidelberg: Springer-Verlag.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

DeTore, A., & Balliet-Milholland, J. (2003). Transforming theory into fact: Hands-on knowledge management initiatives built on a reinsurer's pile of junk. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions*. Berlin/Heidelberg: Springer-Verlag.

Holsapple, C.W., & Jones, K.G. (2003, August). Toward an elaboration of the Knowledge Chain Model. *Proceedings of the Americas Conference on Information Systems,* Tampa, FL.

Holsapple, C.W., & Jones, K.G. (2004). Exploring primary activities of the knowledge chain. *Knowledge and Process Management, 11*(3).

Holsapple, C.W., & Jones, K.G. (2005). Exploring secondary activities of the knowledge chain. *Knowledge and Process Management, 12*(1).

Holsapple, C.W., & Joshi, K.D. (2002). A collaborative approach to ontology design. *Communications of the ACM, 45*(2).

Holsapple, C.W., & Joshi, K.D. (2003). A knowledge management ontology. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge matters.* Berlin/Heidelberg: Springer-Verlag.

Holsapple, C.W., & Joshi, K.D. (2004). A formal knowledge management ontology conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7).

Holsapple, C.W., & Singh, M. (2000, March 31-April 2). The Knowledge Chain Model. *Proceedings of the 3rd Annual Conference of the Southern Association for Information Systems,* Atlanta, GA.

Holsapple, C.W., & Singh, M. (2001). The Knowledge Chain Model: Activities for competitiveness. *Expert Systems with Applications, 20*(1).

Holsapple, C.W., & Whinston, A.B. (1987). Knowledge-based organizations. *The Information Society, 5*(2).

Jones, K.G. (2004). *An investigation of activities related to knowledge management and their impacts on competitiveness.* PhD Dissertation, Carol

M. Gatton College of Business and Economics, University of Kentucky, USA.

Joshi, K.D. (1998). *An investigation of knowledge management characteristics: Synthesis, Delphi study, analysis.* PhD Dissertation, Carol M. Gatton College of Business and Economics, University of Kentucky, USA.

Kelly, T., & Bauer, D. (2003). Managing intellectual capital, via e-learning, at Cisco. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

King, W.R., & Ko, D. (2001). Evaluating knowledge management and the learning organization: An information/knowledge value chain approach. *Communications of the AIS, 5*(14).

Malhotra, Y. (2003). Why knowledge management systems fail: Enablers and constraints of knowledge management in human enterprises. In C.W. Holsapple (Ed.)*, Handbook on knowledge management: Knowledge matters.* Berlin/Heidelberg: Springer-Verlag.

Mintzberg, H., & Quinn, J. (1996). *The strategy process: Concepts, contexts, cases.* Englewood Cliffs, NJ: Prentice-Hall.

O'Dell, C., Hasanali, F., Hubert, C., Lopez, K., Odem, P., & Raybourne, C. (2003). Successful KM implementations: A study of best practice organizations. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

Oriel, S.L. (2001). From inventions management to intellectual capital management at the Dow Chemical Company: A 100+ year journey. In C.W. Holsapple (Ed.)*, Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

Paradice, D.B., & Courtney, J.F. Jr. (1989). Organizational knowledge management. *Information Resources Management Journal, 2*(3).

Porter, M. (1985). *Competitive advantage: Creating and sustaining superior performance.* New York: The Free Press.

Rockart, J., & Short, J. (1991). The networked organization and the management of interdependence. In M. Scott Morton (Ed.), *The corporation of the 1990s: Information technology and organizational transformation.* Oxford: Oxford University Press.

Singh, M. (2000). *Toward a knowledge management view of electronic business: Introduction and investigation of the Knowledge Chain Model for competitiveness.* PhD Dissertation, Carol M. Gatton College of Business and Economics, University of Kentucky, USA.

Smith, H.A., & McKeen, J.D. (2003a). Knowledge management in organizations: The state of current practice. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions*. Berlin/Heidelberg: Springer-Verlag.

van der Spek, R., Hofer-Alfeis, J., & Kingma, J. (2003). The knowledge strategy process. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

Wolford, D., & Kwiecien, S. (2003). Driving knowledge management at Ford Motor Company. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Knowledge directions.* Berlin/Heidelberg: Springer-Verlag.

Zack M.H. (1999). Developing a knowledge strategy. *California Management Review, 41*(3).

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Chapter 2.33
Knowledge Structure and Data Mining Techniques

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INTRODUCTION

Considerable research has been done in the recent past that compares the performance of different data mining techniques on various data sets (e.g., Lim, Low, & Shih, 2000). The goal of these studies is to try to determine which data mining technique performs best under what circumstances. Results are often conflicting—for instance, some articles find that neural networks (NN) outperform both traditional statistical techniques and inductive learning techniques, but then the opposite is found with other datasets (Sen & Gibbs, 1994; Sung, Chang, & Lee, 1999: Spangler, May, & Vargas, 1999). Most of these studies use publicly available datasets in their analysis, and because they are not artificially created, it is difficult to control for possible data characteristics in the analysis. Another drawback of these datasets is that they are usually very small.

With conflicting empirical results in the knowledge discovery/data mining literature, there have been numerous calls for a more systematic study of different techniques using synthetic, well-understood data. The rationale for synthetic data is that various factors can be manipulated while others are controlled, which may lead to a better understanding of why technique X outperforms technique Y in some, but not all, circumstances (Scott & Wilkins, 1999).

This call for research dates back to Quinlan's seminal work in inductive learning algorithms. In his 1994 study that analyzed the difference between neural networks and inductive decision trees, Quinlan conjectures the existence of what he called S-problems and P-problems. In his definition, S-problems are those that are unsuited for NN's, while P-problems are those unsuited for decision tree induction. More recently, the review work on neural networks by Tickle, Maine, Bologna, Andrews, and Diederich (2000) propose that determining whether a classification task belongs to the P-problem or S-problem set is a very important research question.

Recently, other researchers have proposed that the composition of the underlying knowledge in a dataset, or knowledge structure (KS), may be pertinent in understanding why knowledge discovery techniques perform well on one dataset and poorly on others. This term has been used by Hand, Mannila, and Smyth (2001), and Padmanabhan and Tuzhilin (2003) to refer to this phenomenon, while Scott and Wilkins (1999) used a similar term, structural regularities, to describe the same concept.

The goal of this article is to explore in more detail how the existence of a database's underlying knowledge structure might help explain past inconsistent results in the knowledge discovery literature. Management scholars will recognize the term knowledge structure, as Walsh (1995) refers to it as a "mental template…imposed on an information environment to give it form and meaning." Therefore, for the knowledge discovery context, we propose that knowledge structure is analogous to the form and meaning of the knowledge to be discovered in a database. Though we will not explore the concept too deeply, one also can define knowledge structure through the use of a parameter set P as proposed by Hand et al. (2001). The parameter set would be attribute-value pairs that detail the existence of a specific knowledge structure for a given knowledge concept/database pair.

This knowledge structure concept is an abstract concept, which may make it hard to visualize. Typically, when a knowledge worker is using a technique to extract knowledge from a database, they will not have any idea about the underlying knowledge structure of the concept of interest. But, researchers have hypothesized that knowledge discovery in a database is optimized when the formalism of the tool matches this underlying structure of the knowledge (Hand et al., 2001). Based on this, we conjecture that if a knowledge worker did know the knowledge structure parameter values prior to exploring the data, he or she could find the optimal tool for the knowledge discovery process.

From a historical perspective, past knowledge discovery and data mining research results could be explained by whether a particular knowledge discovery tool was or was not a good "match" with the underlying knowledge structure. The idea of matching the tool to the structure is somewhat analogous to the concept of task-technology fit, studied in the MIS literature during the mid 1990s (Goodhue, 1995).

Recent research in other related areas has found that contradictory or difficult to explain results could be related to the concept of knowledge structure (Wilson & Rosen, 2003). In this study, the well-known IRIS and BUPA Liver datasets were used to examine the efficacy of knowledge discovery tools in protected (by data perturbation) confidential databases. The IRIS dataset is known to possess linearly separable classes, while the BUPA Liver dataset cases has been historically difficult to correctly classify for all knowledge discovery tools. An outcome of this research was the proposal that knowledge discovery tool effectiveness in a protected (perturbed) database could be impacted by both the database's underlying knowledge structure and the noise present in the database. The concept of noise is simply the degree to which the different classes can be separated or differentiated by the optimal tool, or, alternatively, a surrogate measure of how difficult cases are to classify (e.g., Li & Wang, 2004).

Through a simple example, the article will attempt to provide some evidence that the underlying knowledge structure present in a database could have significant impacts on the performance of knowledge discovery tools. Building on past postulation, the example also will explore whether the so-called "match" between the knowledge structure and the knowledge discovery tools' own formalism is important to the classification accuracy of the knowledge discovery task.

BACKGROUND

To investigate the possible impact of what has previously been defined as knowledge structure, a hypothetical database/classification task will be formulated. Thus, the investigation of knowledge structure in this article will be limited to a classification domain. The concepts of knowledge structure can be extended to all kinds of knowledge discovery tasks: prediction/regression, clustering, and so forth. We choose classification as our focus because it is a well-studied area and is easily illustrated in this experiment.

To this end, a 50,000 record fictitious bank database, previously used in another work (see Muralidhar, Parsa, & Sarathy, 1999), will serve as the database for the study. The data, in its original form, has five attributes (Home Equity, Stock/Bonds, Liabilities, Savings/Checking, and CD's) with known means, standard deviations, and so forth.

To simulate the existence of an important knowledge concept, a sixth binary categorical (class) variable was systematically added to the database, representing some important knowledge to a data analyst (perhaps differentiating between profitable customers and not-so-profitable customers). How the class variable was systematically created is addressed and is related to the knowledge structure parameters.

We chose a very simplistic definition of knowledge structure types in our continuing example. Two different knowledge structures were employed, decision tree and linear. The decision tree (DT) structure means that the researchers created a decision tree using all five variables, and then the data was applied to the tree to determine class membership (either '0' or '1') in the sixth variable, for each individual case. The specific tree used was chosen such that all variables were found in the tree and that there were an equal number of the two distinct classes created (25,000 cases each of 'class 0' and 'class 1'). The tree itself was obviously somewhat arbitrary, but does represent a scenario where the underlying structure of the knowledge concept was in a decision tree form.

The second structure used was a linear format (LINEAR). A strictly linear relationship was created using all five variables, to determine class membership (either '0' or '1') in the sixth variable for each individual case. Again, the resulting values for the sixth variable included 25,000 cases for each 'class 0' and 'class 1.' This again represents the situation where the underlying knowledge concept of interest is in a linear form.

While these two structures may be overly simplistic, their choice allows us to explore the possible impact of the concept of knowledge structure with minimal moderating factors. Ultimately, the notation of Padmanabhan and Tuzhilin (2003) may be a more formal and more accurate approach to describe this phenomenon, and we will return to this later in the article.

For each of the two exemplar knowledge structures (DT and LINEAR), we created another database that involved adding "noise" to the class variable. The purpose of adding noise is to have the synthesized datasets replicate knowledge discovery situations where a perfect discrimination between classes is not possible, as is true in the case of the previously mentioned BUPA Liver dataset. One could argue that real-world databases are more likely than not to have a high degree of noise. To introduce noise into each of the noise-free datasets (referred to as the 0% noise case), the class variable of 25% of the cases in each class were randomly switched. Thus, the balance of the two different classes was preserved (25,000 of each), and 25% of the cases were now put into the wrong class.

Thus, four different datasets were synthesized—a dataset where the underlying knowledge structure was a decision tree with 0% noise, a dataset where the underlying knowledge structure was a linear relationship with 0% noise, and the complimentary datasets where inaccuracy, in the form of 25% noise, was added into the class variable. These four different datasets represent a diverse spectrum of knowledge discovery scenarios.

In our quest to investigate how knowledge discovery tools may be impacted by the structure of knowledge, there are many possible tools that could be utilized. To try to get a wide view of possible impacts, we present the results from four "standard" approaches: discriminant analysis, the decision tree procedure CART (Classification and Regression Tree Analysis), logistic regression, and a standard feed-forward back-propagation neural network.

Discriminant analysis was selected because it uses (for the two class case) a linear regression-based approach for classifying cases. Thus, from Hand et al.'s (2001) contention that classification/knowledge discovery is optimized when the formalism of the tool matches the underlying structure of the knowledge, one would expect discriminant analysis to perform the best when the underlying knowledge structure was linear.

However, there are many citations in the statistics literature that state when dealing with binary (or categorical) dependent variables, logistic regression is superior in performance to discriminant analysis. Thus, we study both approaches, since they represent tools whose underlying formalism is linear. Both were implemented using standard statistical routines in SPSS.

Using the same rationale, the CART algorithm was selected, as it is a well-known and well-documented inductive decision tree algorithm (see Weiss & Kulikowski, 1991). Given the contention of matching structure to tool formalism, one would expect CART to perform better for those datasets with a decision tree knowledge structure. Again, this tool was implemented using standard defaults in the SPSS package Answer Tree.

Finally, feed-forward, back-propagation neural networks were implemented and used in this study. As another non-parametric technique (like CART), neural networks are often times compared to traditional statistical tools in classification problems. Many claim that they are universally the best classifiers, though results do not necessarily support this claim. Neural network researchers might postulate that they may be immune to knowledge structure impacts since they are alleged to be able to find all types of classification knowledge patterns. The neural network software used in this study was SPSS's Neural Connection, again using standard default values for training, network structure, and the like.

The dependent measure of interest in this study was the classification accuracy of the knowledge discovery tool. Since we had datasets of equal class membership, individual class accuracy was not of particular interest. Ten-fold cross-validation (with stratified samples) was used to ensure a robust measure of tool classification accuracy (see Weiss & Kulikowski, 1991, for more details). An instance was labeled as correctly classified when the tool classification matched the actual class value of the database instance. The correct number of classifications was assessed both for the training (development) and testing partitions. Due to the large size of our simulated dataset and the use of cross-validation, the accuracy of the tools for the training and testing set were nearly identical. Therefore, for simplicity, we report only the results of the testing sets.

RESULTS

Table 1 shows the average classification accuracy over the 10 trials for the experiment. The rows represent the four different knowledge discovery techniques used: logistic regression (LR), multiple discriminant analysis (MDA), the decision tree

Table 1. Average classification accuracy

	Noise	Level
KS=Tree	Zero	Twenty Five
LR	72.9	61.2
MDA	72.6	61.2
CART	100	75
NN	98.7	72.5

KS=Linear	Zero	Twenty Five
LR	100	74.3
MDA	98.7	74.2
CART	87.1	68.5
NN	99.9	74.7

inductive learning algorithm of CART, and back propagation neural networks (NN). The columns represent the two different levels of Noise (0% and 25%). The top half of Table 1 shows the results when the decision tree knowledge structure was used to create the synthetic database, the bottom half, the results when a linear structure was used. Figures 1 and 2, respectively, show the results in graphical format.

Knowledge Structure: Decision Tree

For the datasets whose knowledge was generated via decision trees, the CART decision tree approach had 100% classification accuracy for the 0% noise case, and 75% accuracy for the 25% noise case. As the formalism of the knowledge discovery approach exactly matches the knowledge structure, these results are not surprising.

The poor performance of the linear-based methods, multiple discriminant analysis and logistic regression may be surprising. They do a very poor job of classification when applied to the decision tree knowledge structure (approximately 73% correct in the 0% noise case). Thus, the unmatched approaches were approximately 27% worse than the matched approaches. This is fairly strong evidence of the potential impact of matching the knowledge discovery approach to the true underlying knowledge structure. Similar results are also true for the 25% noise rate; however, the impact is dampened in magnitude due to the already poor performance of MDA and LR.

The results of the neural network for both noise levels are very good but are statistically

Figure 1. Tree KS

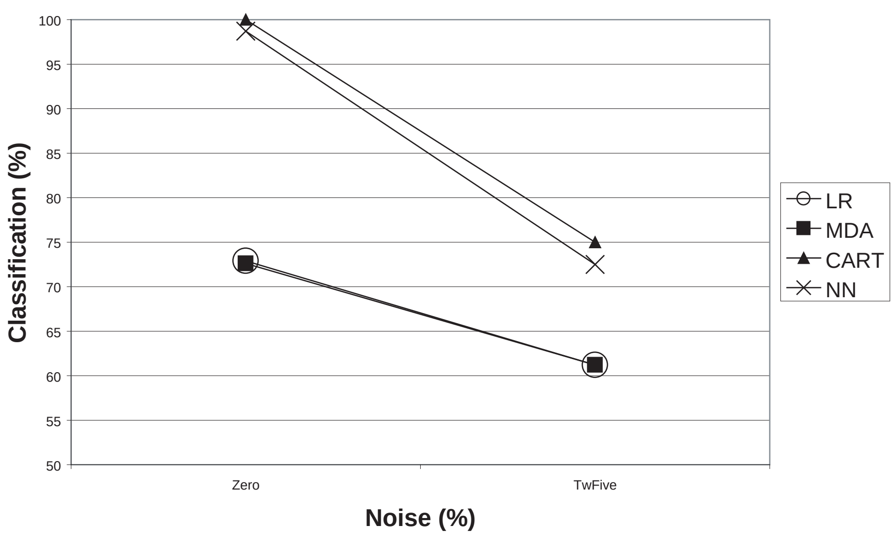
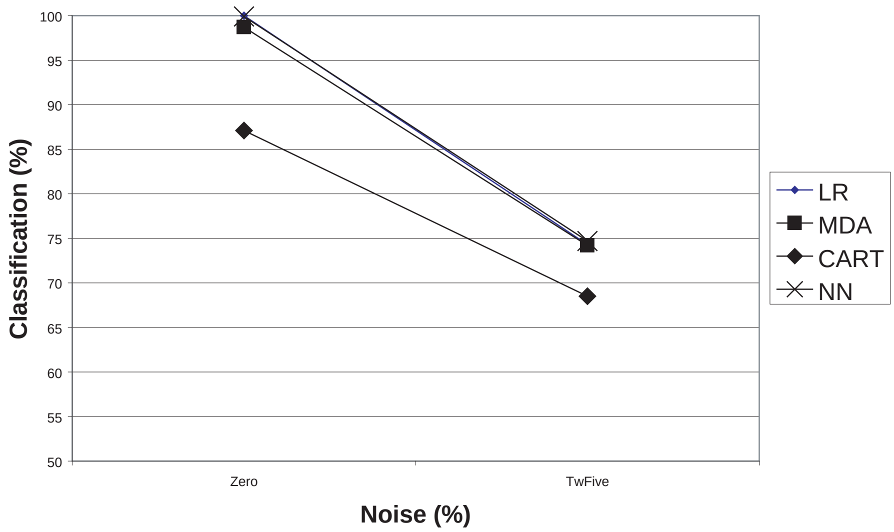


Figure 2. Linear KS



significant different (worse) than CART. Even considering this, the neural network seems less susceptible to performance impact than the linear knowledge discovery techniques. Summarizing from a statistically statistical standpoint, CART performs statistically better than all three other techniques, neural networks performs better than discriminant analysis and logistic regression, and the two linear approaches are equivalent performers.

Knowledge Structure: Linear

Interestingly, for the linear knowledge structure and 0% noise, logistic regression performs perfectly (100% average correctly classifications). Discriminant analysis has just a small average "miss" rate (1.3%). Neural networks also perform very close to perfect (an average of 99.9% correct), while CART performs significantly worse (practically and statistically) at an 87.1% average correct classifications. Of importance is the finding that CART's performance when applied to a database with an unmatched knowledge structure is not nearly as poor as the performance of the linear tools when applied to databases with an unmatched knowledge structure.

With the noise level at 25%, it is surprising to see that neural networks perform better than all other techniques (though their classification accuracy is not statistically different from the two linear approaches). These results provide some credence to the robustness of neural networks when considering potential impacts of knowledge structure. Of course, this may be true only for this study.

Overall, for the linear knowledge structure databases, the two linear approaches and neural networks show no statistical differences, while all three perform statistically significantly better than the performance of CART. This is true for both with and without noise.

FUTURE TRENDS AND DISCUSSION

The results provide some evidence that knowledge structure and its relationship to the tools used could impact the results of knowledge analysis. Certainly, the small study undertaken could not claim to be comprehensive, but the evidence found would suggest consideration should be given to this concept of knowledge structure by practitioners and researchers alike.

Of course, the knowledge possessed by a database will likely never perfectly fit one specific knowledge structure (or at least as generically as they have been defined here). Similarly, the inclusion of noise into the synthetic database is at best a surrogate measure of the inherent difficulty to find hidden knowledge in a set of database cases. This difficulty could stem from relevant attributes not appearing in the database (missing information) or just because the knowledge/relationships resist easy quantification.

How might this knowledge structure concept be implemented or further quantified? Using the notation used in Padmanabhan and Tuzhilin (2003), perhaps the knowledge structure of a database can be identified as an n-tuple of the knowledge concept itself plus some measure (say on a continuous 0 to 1 scale) of how similar the knowledge structure is to a set of exemplars. This 0 to 1 scale also could be a measure of noise as it relates to the exemplar structures.

As a continuing example, consider the database already analyzed here, with five continuous attributes, one class variable indicating good/bad customer (noted by abbreviation GB), and suppose we also have another class variable indicating whether the customer is considered a likely target (0/1 value) for a new marketing campaign for a new product (noted by NP). Let us also assume (unrealistically) that there are four specific exemplar knowledge structures in the universe of knowledge discovery: decision trees (DT), linear (L), type 3 (T3), and type 4 (T4).

The four versions of the synthetic database used in the article might then be defined by a parameterized function KS = f(database, DT, L, T3, T4), such that the database with KS=DT and no noise would be KS=(GB,1,0,0,0), and with 25% noise KS=(GB, .75, 0,0,0). Likewise, the two datasets with underlying knowledge being linear would have parameterized KS values of (GB,0,1,0,0) and (GB, 0,.75,0,0), respectively.

Continuing with the example, if the knowledge structure of the concept new product target (NP) had mixed components of decision tree, linear and Type 4 structure, it might have a parameterized value of (NP, .3, .4, 0, .1). In summary, assuming that knowledge structure does continue to show promise as an explanatory factor in knowledge discovery results, future studies working to formalize and further operationalize this knowledge structure concept seem very important.

Some might view this problem of trying to quantify a database knowledge structure as not useful. We would argue that better understanding the dynamics of data mining and knowledge discovery is exactly the kind of problem that should be studied in academic research. The field needs better ways of ensuring the correct or best tool is used in knowledge discovery rather than depending upon pure chance. The use of multiple tools (and multiple variations of individual tools, such as ensembles of neural networks) is certainly a good strategy, but researchers should continue to look for new and innovative ways to help guide the data mining practitioner. Researchers should help practitioners better understand when and where these tools are most useful, and not just simply continue to deploy new tools.

The results of this article are another example of the potential of neural networks to seemingly approximate many types of functions (or knowledge structures), unlike the other three tools employed. Unfortunately, we cannot yet consider using only neural networks as a knowledge discovery tool given their present inability to explain the knowledge the tool has discovered

(Li & Wang, 2004). There is an ongoing stream of research (e.g, Tickle et al., 2000) focusing on developing techniques whereby neural network knowledge is made more understandable for the decision-maker, but it is still at primitive stages of development. Should this research lead to further enhancement of neural networks to better explain their results, then perhaps the search for the "holy grail" of knowledge discovery tools has been found. Unfortunately, the maturity of this research indicates this is not reasonable over the next few years.

However, neural networks may play an expanded role in knowledge structure determination through this same "natural" ability to learn any function. Perhaps they can somehow be trained to recognize exemplar and combined knowledge structures in various synthetic databases, and then the results of this trained network can be applied to real datasets under analysis. In this way, the decision-maker would have an improved idea on which knowledge discovery tool will likely optimize their results.

CONCLUSION

Many researchers have long been seeking the penultimate knowledge discovery technique. This article has provided evidence that the underlying knowledge structure that exists in a specific database could impact knowledge discovery results. It seems reasonable to further expand and clarify our definition of knowledge structure, work at further understanding how to operationalize this concept, and then merge this with ongoing streams of research that seek to enhance knowledge discovery tools, all resulting in providing better tools for the practitioner. Through this multifaceted approach we can continue to add deeper understanding to the operation of the many powerful analytic tools on the desktops of today's knowledge workers.

REFERENCES

Goodhue, D. (1995). Understanding user evaluations of information systems. *Management Science, 41*(12), 1827-1844.

Hand, D., Mannila, H., & Smyth, P. (2001). *Principles of data mining.* Cambridge, MA: MIT Press.

Li, R., & Wang, Z. (2004). Mining classification rules using rough sets and neural networks. *European Journal of Operations Research*, forthcoming.

Lim, T.S., Low, W.Y., & Shih, Y.S. (2000). A comparison of prediction accuracy, complexity, and training time of thirty-three old and new classification algorithms. *Machine Learning, 40*(3), 203-229.

Muralidhar, K., Parsa, R., & Sarathy, R. (1999). A general additive data perturbation method for database security. *Management Science, 45*(10), 1399-1415.

Padmanabhan, B., & Tuzhilin, A. (2003). On the use of optimization for data mining: Theoretical interactions and eCRM opportunities. *Management Science, 49*(10), 1327-1343.

Quinlan, J.R. (1994). Comparing connectionist and symbolic learning methods. In R. Rivest, (Ed.)*, Computational learning theory and natural learning systems: Constraints and prospects* (pp. 445-456). Cambridge, MA: MIT Press.

Scott, P.D., & Wilkins, E. (1999). Evaluating data mining procedures: Techniques for generating artificial data sets. *Information and Software Technology, 41*(9), 579-587.

Sen, T.K., & Gibbs, A. M. (1994). An evaluation of the corporate takeover model using neural networks. *Intelligent Systems in Accounting, Finance and Management, 3*(4), 279-292.

Spangler, W., May, J.H., & Vargas, L.G. (1999). Choosing data-mining methods for multiple classification: Representation and performance measure implication for decision support. *Journal of Management Information Systems, 16*(1), 37-62.

Sung, T.K., Chang, N., & Lee, G. (1999). Dynamics of modeling in datamining: Interpetive approach to bankruptcy prediction. *Journal of Management Information Systems, 16*(1), 63-85.

Tickle, A., Maine, F., Bologna, G., Andrews, R., & Diederich, J. (2000). Lessons from past, current issues, and future research directions in extracting the knowledge embedded in artificial neural networks. In S. Wernster & R. Sun (Eds.), *Hybrid neural systems* (pp. 226-239). Heidelberg: Springer-Verlag Telos.

Walsh, J. (1995). Managerial and organizational cognition: Notes from a trip down memory lane. *Organizational Science, 6*(3), 280-321.

Weiss, S., & Kulikowski, C. (1991). *Computer systems that learn*. San Mateo: Morgan Kauffman.

Wilson, R.L., & Rosen, P.A. (2003). The impact of data perturbation techniques on data mining accuracy. *Journal of Database Management, 14*(2), 14-26.

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Chapter 2.34
Integrated QFD and Knowledge Management System for the Development of Common Product Platform

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ABSTRACT

This paper provides a framework to implement quality function deployment (QFD) with knowledge management (KM) in the form of an integrated quality and knowledge management system (IQKS). This inter-organizational information system enables the sharing of information among customers, manufacturers and suppliers in the new product development process. It links up various strategically independent and autonomous business entities together in a common product platform (CPP). Up to now little has been published academically on sharing vital information involving the give-away of a firm's bargaining position about customers, product specification and process requirement. The common product platform facilitates an innovative organization to persuade like-minds in coming together and opening up useful and relevant information to all parties interested in creating a new level of competitive advantage in assessing the dynamics of market realities. They share knowledge and learn to support new organizational capabilities to leverage information technology that incorporate market knowledge, design knowledge, process knowledge and production knowledge.

INTRODUCTION

In the new economy, customers, manufacturers and suppliers dispersed across various geographical locations use information technology to talk to each other to coordinate engineering design and the flow of materials through different manufacturing operations. Hence, a product can have a choice to be made in various processes across organizations, at different geographical locations and utilizing different logistics for delivery. This enables the entire operational process to be linked up across organizations for customization by the participating firms. A new level of competitive advantage may be achieved when the operational processes of different firms can be adapted with the dynamic market environment.

Such advantage can be crucial to the development of new products. A product is manufactured through subassemblies and parts that can be put together. Each subassembly is represented by bills-of-materials (BOM). They can be deployed in a common product platform (inter-organizational information system) by partnering firms linked together with an information technology network. The coordination, marketing, design, engineering and production control can be more effective.

This chapter is divided into four sections. The first section addresses the view on contract manufacturing. It suggests how a manufacturing organization can leverage IT to compete in the information age. In the second section, relevant literature is reviewed on the area of extended enterprise. It portrays that knowledge has become an important consideration in developing extended enterprise architecture. For the third section, a conceptual framework of extended enterprise architecture is derived from observation on contract manufacturing. It reflects the necessary components and the linkage of quality function deployment (QFD) and knowledge management system (KMS) to form a framework for developing an integrated inter-organization information system. A case study is used to illustrate how the conceptual framework can be operationalized in the form of a common product platform making use of the bill-of-material (BOM) modules.

LITERATURE REVIEW

Contract Manufacturing

Contract manufacturing is more than a firm subcontracting out its manufacturing process and is about a strategy on positioning the firm in the future of providing a service of value. The firm operating with a contract manufacturing strategy is adopting a management paradigm that has far-reaching implications in terms of ownership, management succession planning and resources deployment.

Contract manufacturing is a phenomenon occurring in various manufacturing industries. It extensively aligns partners for collaboration in serving the customers. The firm in focus will only keep those processes that it is strong in and outsource the rest of the processes to suppliers or competitors. Without a good understanding of its implication on the nature of business and investments in appropriate technology, knowledge and research, manufacturing firms are likely to miss business opportunities in the ventures that create wealth and create customers for growth and profits.

Currently, views on contract manufacturing are diversified. In here we summarize a few points that are purported to be the key enablers of contract manufacturing. They are:

1. Changed view of international production strategy from “stand alone” operations to “deep integration” of operations with partners in a supply chain.
2. The increasing separation between the supply side and demand side of business: e.g.,

supply-side consolidation for economies of scale; demand side fragmentation enabled by e-commerce.

3. Knowledge separation enabled by digital factory concept. Manufacturing knowledge can be separated from design knowledge; or marketing knowledge can be separated from design knowledge.
4. The transition from a "command and control" style of management to a "one-stop shopping" self-adaptive supply chain style of management to enable customization of value.

The Change of International Production Strategy

A "stand-alone" operation for control is leveraging on a level of technology investment that encourages the moving of production facilities to a low-wage manufacturing environment for competitiveness. (Most Hong Kong manufacturing companies have relocated their production bases to Mainland China after China announced its open door policy in 1978). However, a "deep integration" operation is about the strategy of developing an integrated production system to support disserting the different steps of a production process and have different parts undertaken by different countries according to their relative cost and logistical advantages. (UNCATDA, 1993, 1999).

Increasing Separation Between Supply and Demand Side

The advance in information technology and networking economy, the development of electronic commerce and the proliferation of B2B online exchanges further separate the supply and demand sides of many industries. On the demand side, there is a rise of customer expectation. Customer relationships or learning relationships are being developed to retain future business value and growth (Peppers & Rogers, 1997). On the supply side the pressure of getting economies of scale and scope lead to changes in the traditional industry structure. Many companies are now consolidating to realize economies of scale and scope to recoup their investment in business infrastructure (Hagel & Singer, 1999).

The Observation of Knowledge Separation

In many industries, design knowledge is being separated from manufacturing knowledge. This knowledge was once difficult for articulation but now can be made explicitly with substantial organizational implications. Manufacturing organizations can outsource even more to a network of suppliers (Magretta, 1998a). Central to this development is the development of "connected assets" (Blitz, 1999). Today contract manufacturing thrives on this trend with the development of subsystems template and the setting up of a common product platform that can be readily integrated upon customers' desire (Meyer & Lehnerd, 1997). The ability to develop and quantify these assets is the key for future business development.

The Self-Adaptive Supply Chain Style of Management

The ability for a team of organizations working as an extended enterprise through dynamics partnerships is the key for future success. The existence of a partnership ties the stakeholders of organizations together in developing commitments and sharing a risk-taking culture. Corporate competence will have to be integrated to address changing market opportunities. The cost of maintaining a set of vertically integrated competencies is prohibitive for many businesses (Agility Forum, 1997). The ability to interface with others within a value net is the key for future success.

Table 1. A summary of recent contract manufacturing activities

Case	
2001 Ericsson and Flextronics (Gartner, 2001)	
Outsourcing	Outsource the manufacturing of mobile phone to Flextronics by transferring plants and employees from Ericsson
2000 Motorola and Flextronics (Thurm, 2000)	
Outsourcing	Motorola hire Flextronics to manufacture consumer electronics
Alliance	Cross investment in stake-holdings
2000 Arima and Compaq–Notebook Contract Manufacturer in Taiwan (Baum, 1999)	
Partnering	Notebook research centre assists the manufacturing of notebook computers
1999 Nortel Network(Royal, 1999)	
Outsourcing	Outsourcing the manufacturing of telecommunication equipment
1999 Sara Lee (Royal, 1999)	
Outsourcing	Selling factories and outsourcing manufacturing of food products. Concentrate on servicing brand name

Table 1 illustrates some of the contract manufacturing activities recently found in various manufacturing organizations and industries.

The reported contract manufacturing scenarios revealed that manufacturers organize themselves to leverage IT to share information and compete more effectively. The reported cases led manufacturing management to a new era of competition. The new competition is not based on economies of scale, but much depends on how quickly enterprises are aligned together to come up with new business processes tailored to the market requirement. This resembles the business model of mix and match in a real-time exchange market. Thus, contract manufacturing here is defined as a partnership among manufacturing organizations, customers and suppliers working together as an extended enterprise using IT links. Such an alignment model requires the support of extended enterprise architecture.

Modeling Extended Enterprise

An extended enterprise can be described as a partnership between enterprises where the goal is to achieve competitive advantages by forming formal linkages (contracts) and maintaining cooperation distributed throughout the network. In the extended enterprise the collaborating firms are encouraged to focus on their core competencies (Szegheo & Andersen, B, 1999). With the partnering elements becoming more important, extended enterprise modeling seeks a holistic view to avoid the optimization of one partner at the expense of the others.

Activities are used as the basic elements for modeling an extended enterprise. The challenge is that the activities are dispersed across the network, crossing organizational boundary, making information collection and modeling very difficult. IT linkages will have to be deployed more systematically to collect the necessary information to enable such a model to become a reality.

CONCEPTUAL FRAMEWORK

A knowledge-based view is proposed as the basis for the formulation the extended enterprise architecture, hence the term "knowledge-based extended enterprise architecture." The idea is to encourage partnering in the extended enterprise to form the basis of developing a knowledge-sharing practice. Four core components of the extended enterprise architecture have been identified. They are market knowledge, design knowledge, process knowledge and production knowledge.

Market Knowledge

Market knowledge such as customer lists, market research, data on service or demand patterns are considered to be an important element for the existence of an extended enterprise. Market knowledge serves as the primary input to the extended enterprise and is translated into specific customer needs, perception and preferences. It is a conduit to enable the extended enterprise to interact with the market in order to reconfigure itself for the market. Sometimes, discovering hidden value propositions of the market can assist extended enterprise to move away from manufacturing a "me-too" product.

Design Knowledge

Design knowledge is associated with research and development efforts. It embraces the technological content of the product, essential to a business, and is supplied by knowledge workers within the participating firms of the extended enterprise. The design knowledge is very important in supporting the product requirement derived from market knowledge. In many circumstances, combining market and design knowledge uncovers hidden value propositions for new customers. Early involvement with customers to design a new product can be beneficial to reduce design lead-time. Thus, participating extended enterprise organizations that contribute or invest in activities to make instrumental goods early in new product development can improve overall extended enterprise performance.

Process Knowledge

Process knowledge is a derivative of manufacturing knowledge. It is concerned with workflow management, capacity management, logistic arrangement and scheduling arrangement. Knowledge workers contributing these kinds of knowledge can be sourcing managers, supply chain managers and schedulers. They ensure the order fulfillment process is in place for delivery purposes. The knowledge in this area is generated and acquired through extensive work and know-how in infrastructure management.

Production Knowledge

Production knowledge is also a derivative of manufacturing knowledge. It is associated with production of physical goods. Investment in manufacturing technologies and management helps develop such knowledge in a manufacturing organization. Smart use of manufacturing technologies and management of knowledge work give insights into the development of instrumental goods that can be deployed for improving realization activities. The performance is usually associated with volumes, quality and cost. When material costs and overhead costs represent a large proportion of overall product costs, product knowledge is essential in trying to keep the cost structure under control. Production knowledge can combine with other types of knowledge in the extended enterprise architecture to improve performance. For example, early supplier involvement enables the sharing of knowledge by both manufacturers and suppliers, and they can benefit by shortening the time to market.

Common Product Platform—Embedding Knowledge in Product

A common product platform is proposed as a vehicle to establish a knowledge-sharing routine within the extended enterprise. This provides participants a reference model of a product that can be modified by the different partners of the extended enterprise architecture.

Figure 1 shows the concept of a common product platform supporting the use of different knowledge to customize a product. As a knowledge-sharing routine, the common product platform allows knowledge from different areas to interact with each other to create new ones. For example, design knowledge can interact with manufacturing knowledge in a way that the product can be designed more effectively for production.

Develop a System to Leverage the "Voice of Customers" with Knowledge Management

Based on the common product platform, a system for integrating quality function deployment (QFD) with a knowledge management system (KMS) is to be developed. It incorporates the QFD and the KMS systems. The QFD is a tool for enterprise modeling that allows internal as well as external staff to communicate and contribute knowledge in a systematic manner. It is a useful modeling approach to discover the interrelationship among customer demands, engineering requirements and manufacturing processes. Central to the QFD is the house of quality that defines the WHAT and HOW as part of the relationship. The WHAT and HOW is captured by a knowledge management system (KMS). Conceptually thinking, the captured interrelationship can be shared and reused. The knowledge management component is to facilitate sharing and reuse by providing functions such as capture, filter, storage, distribution and applications.

Figure 2 illustrates the concept of Integrated QFD and KMS (IQKS). To operationalize the common product platform, the BOM can be built into different phases of the quality function deployment to support the phased operation of the QFD process. The four phases of QFD are linked together for information and through sharing of embedded knowledge. The KMS provides the knowledge repository to share information regarding the captured QFD interrelationship.

Figure 1. The concept of a common product platform (CPP)

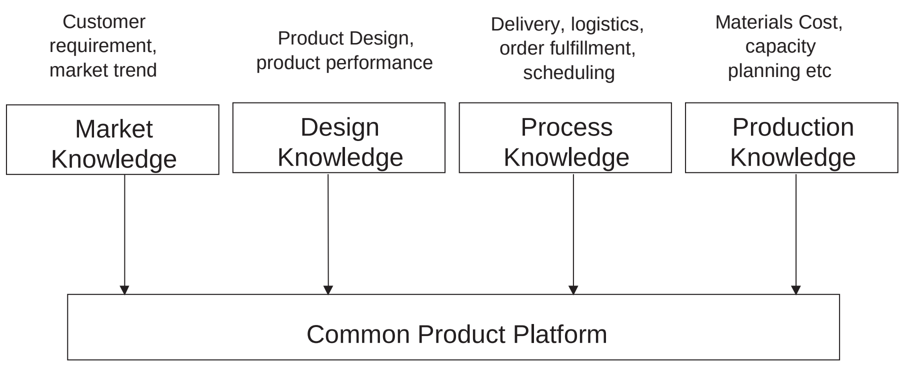
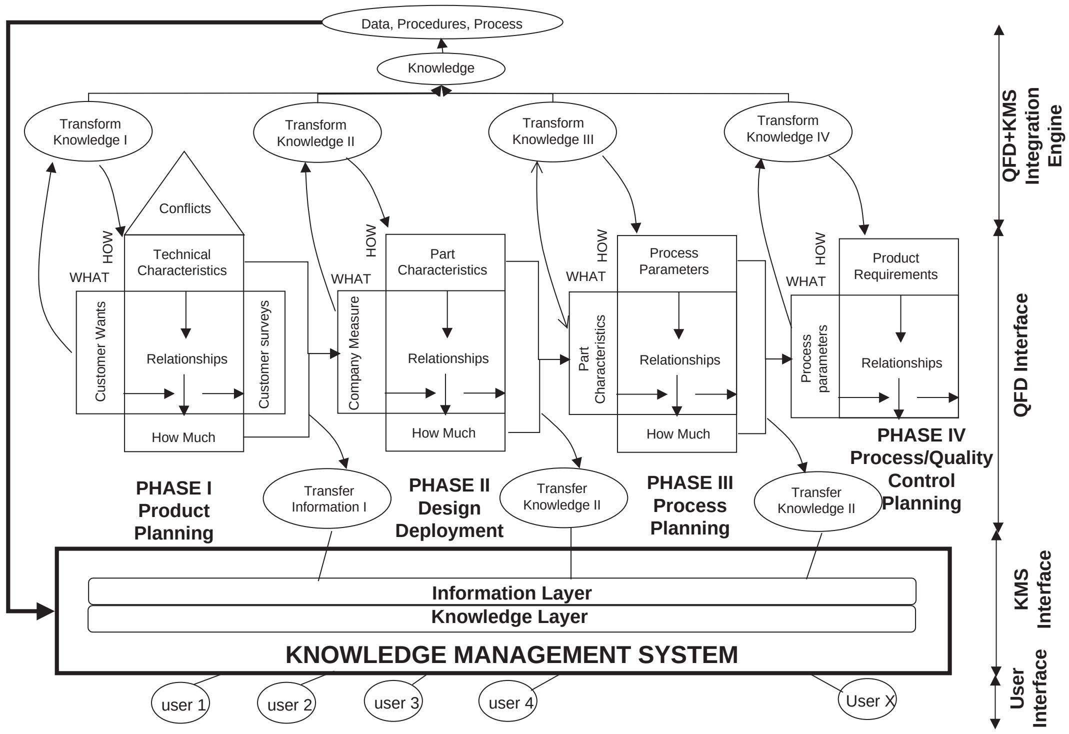


Figure 2. The common product platform architecture (IQKS) supported by QFD and KMS



The migration from HOW to WHAT, and the translation of information from one phase to another in QFD, indicates transform knowledge. The information collected and processed serves a common language for exchange in product and process information. As a result, guiding the collection of useful information (transfer information) gradually builds up the knowledge management system.

The knowledge layer is an open-type pool, which allows user interface involvement to collect, retrieval knowledge for specific application. The layer captures the relationship within the QFD matrix. The accumulation of this captured knowledge is stored in the knowledge layer embedded within the KMS.

CASE STUDY

Background

The motor fabrication company (MFC) is one of the world's largest component manufacturers. It manufactures a range of electric motor products to cater for industries like automotive, home appliance, personal goods, consumer electronics, etc. Their existing customers are associated with well-known brands with their products for worldwide distribution.

MFC is engaged with their customers extensively in contract manufacturing initiatives such as outsourcing, partnering and alliance. MFC provides customer support to serve the needs of their customers in new product development. The customers are getting enhanced services from MFC rather than the product itself, and these services include co-design, R&D, engineering, logistics, etc. MFC customers do not need to be concerned with supply chain management, procurement and shipment logistics of the motor products, because all these functions are taken care of by MFC. In many instances, there are a range of products that are similar. For example, MFC manufactures the moving components for the consumer printers' market. MFC makes assessment on each of the product within the market based on each of their customer's product mapping.

MFC gains competitive advantage through providing better services to customers. By establishing the position of the customer in the product map (Figure 3), the company interacts with customers and gives tailored services of attractive value. Interacting with customers at MFC is a very complex task. It involves contributions from numerous parties from sales, research and development, costing, engineering and procurement to the external suppliers. Figure 4 shows the complexity involved.

Interacting with the customers and providing support by answering their queries involves the participation of executives in the organization engaged in knowledge-intensive work. The interaction pattern typically starts with receiving the "customer voice" to the actual commitment of production of electric motors. It is not limited to communication with customers but to a range of parties, including suppliers and logistics services providers.

Interactions with the customers at this stage are complicated, and information flow has significant impact on most manufacturing organizations. Success in the venture very much depends on leveraging the use of knowledge for a speedy response.

It is critical to embed information into the product. By offering services of value in the value chain, each customer concern may be addressed differently. Products that do not appear as high-value to one customer may appear to be

Figure 3. Customer-product mapping in consumer printer market

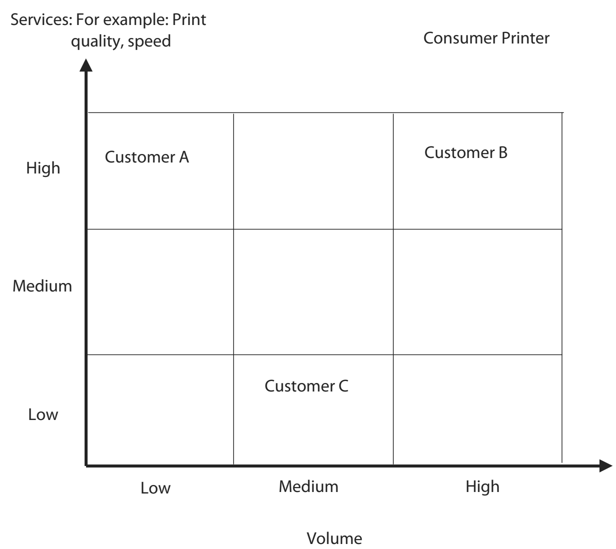
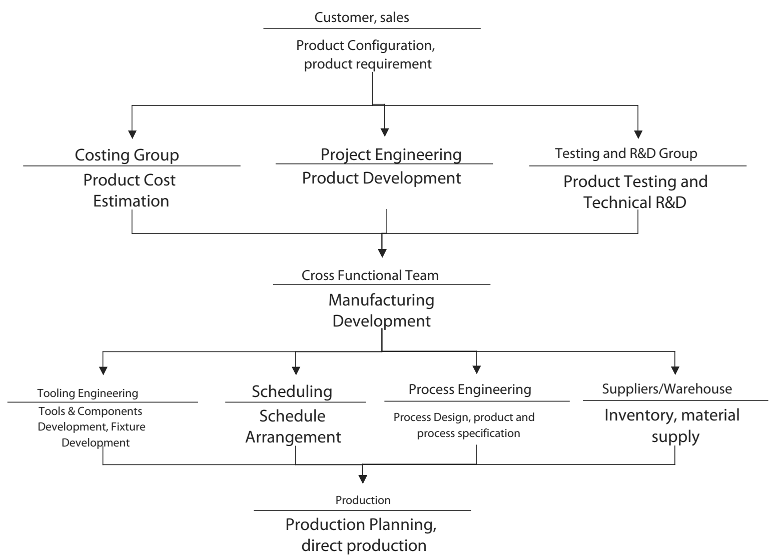


Figure 4. Organising to provide a service of value to the customers



highly valued to another. Furthermore, a previous customer may provide misleading data to MFC in handling other customers. Since the number of parts and associated fixtures proliferate, it requires huge efforts to coordinate.

The erosion of value-adding activities creates difficulties for MFC in integrating their performance with the value chain. They can be seen as the limiting factors for higher performance from the perspective of customers. There is an urgent need to streamline the information flow for managing the interactions with customers.

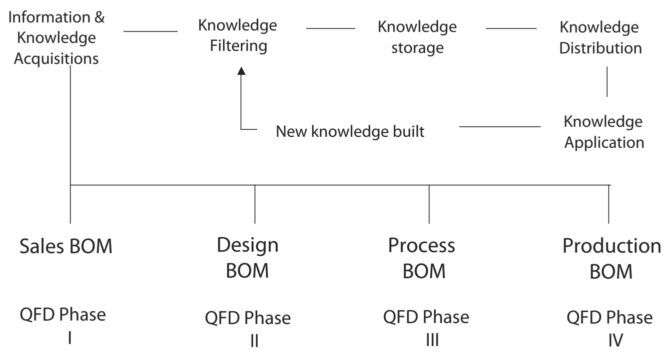
A Knowledge Management Process Model

An integrated quality knowledge System (IQKS) is conceived at MFC to link all the knowledge silos with the bills-of-materials (BOM) structure of electric motors. The knowledge silos are represented by the pools of knowledge accumulated as a result of specialization in sales and marketing, product design, process planning and production. Each knowledge silo corresponds to a phase of the quality function deployment (QFD). When arranged in this way, the knowledge silos enable knowledge input into the WHAT and HOW of the QFD tool. The BOM information model combines the data in a structure for sharing. The BOM information is embedded into a knowledge management system to support the four core activities of value creation: 1) information and knowledge acquisitions; 2) knowledge filter; 3) knowledge storage; and 4) knowledge distribution (see Figure 5).

The BOM information models are run with the support of databases, intranet, extranet and internet. The purpose is to physically enable the communication of more accurate customer requirements, including target price, development cost and product attributes.

In Figure 2, the architecture of the IQKS system consists of information the layer and the knowledge layer. The information layer has BOM databases for internal and external users. The internal BOM databases collect the product

Figure 5. A learning model to link up knowledge silos



design phase information, which is captured from each QFD phase migration under a FORMAL practice. The external BOM databases differ from the internal ones in that they are used to collect any INFORMAL information, which at the collecting moment may not be very useful to anyone but its owner; however, it might also make a difference in the long term. The users can get access to the information using simple searching and browsing criteria.

The knowledge layer is a combination of information, data and graphical display. The accumulation of the captured knowledge is stored under the knowledge layer. This knowledge layer is an open-type pool, which allows user interface involvement to collect and retrieve knowledge for specific application. A pre-defined search criterion is created to capture queries. The system is linked with internal departments, customers and suppliers. Users are granted with different access rights depending on their status.

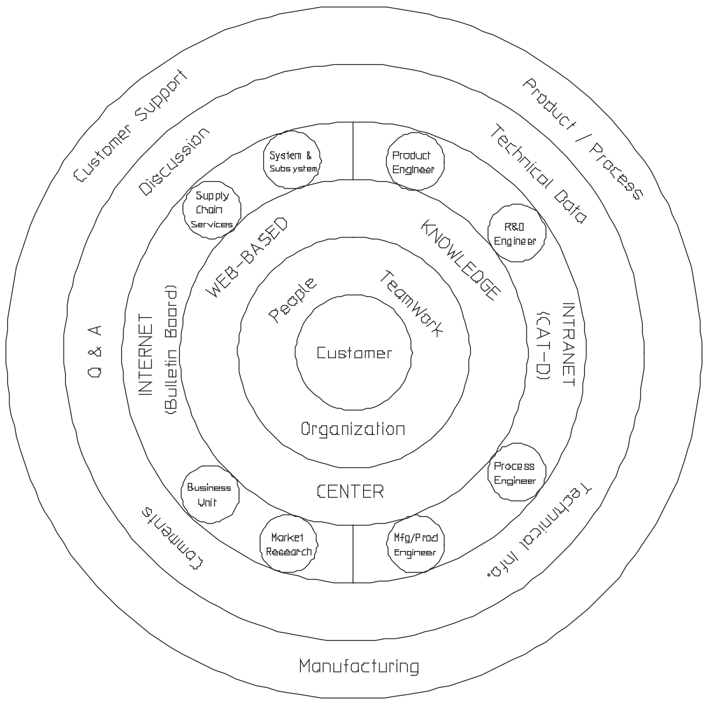
The information layer allows the users with a knowledge perspective to add into the BOM databases (under the QFD structure) for knowledge capture and retrieval. The QFD structure enables transition of information on the nature and underlying links between WHAT and HOW.

At MFC, the implementation of an integrated QFD knowledge system (IQKS) represents an achievement of leveraging knowledge-based manufacturing technologies to bring in the needed information at the early stage of the internal business operations. The implementation has the steps:

a. To link up each QFD phase.
b. To link up every individual or department and show the detail job progress, under a common information technology platform.
c. To capture the employees' routine deliverables and output to fulfill the knowledge acquisition
d. To share the useful information and knowledge for corporate growth.
e. To provide a freedom searching under web-based infrastructure.

The IQKS defines the tasks that a knowledge worker needs to perform at each phase of the QFD. These tasks are, as mentioned previously, product planning (house of quality), design deployment (parts deployment), and manufacturing planning (process planning) and production planning (production operations planning) in relation to customer's want (requirement). The WHAT and HOW govern the formalization of knowledge by introducing a common platform to synchro-

Figure 6. Knowledge management infrastructure model



nize the use of information. These represent the knowledge that can be captured and disseminated as the means of future production. The means of production also serves as the manufacturing input to internal business operations in order to make the operation more responsive to the external environment.

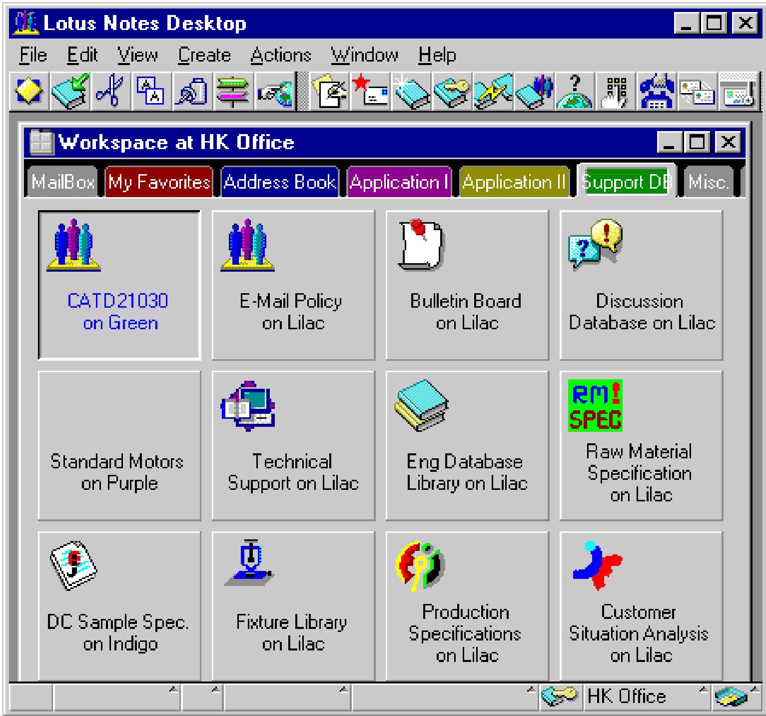
The knowledge management infrastructure is to be overlaid on the existing corporate environment. It utilizes the IT network to link up the different personnel together including sales, design engineers, process engineers and production engineers (see Figure 6).

A Knowledge Management Prototype

This section describes the user's interface for using the system of Web-based knowledge center. The internal portion (intranet) is rolled out first to structure the group use of the knowledge framework, thus allowing the QFD phase IV of information (Figure 2) to be shared and distributed on a daily basis. Next is to establish the web-based knowledge center via the Internet portion. The illustration is shown in Figure 7.

The core of the prototype was produced under Lotus Domino Notes environment as shown in Figure 7. While the Lotus Domino Notes enables data to be captured under an Internet framework, the user interface of the IQKS system includes certain database classifications with respect to the usage nature under QFD phases. Figure 7 shows the basic database icons, which formulate the basic IQKS system's components and are defined below. Different manufacturers (due to product nature's variance) could have more or less or different icons but the database must be under the common-BOM-platform with monitor and control by a centralized system (IQKS: CAT-D).

Figure 7. The IQKS system interface on Lotus Notes



CAT-D

CAT-D is the component architecture technology database. It serves as the global common-BOM platform to link communications of each QFD phase. It is a tool for global transparency of information. Throughout the input from various persons and departments, information is able to be shared and distributed as knowledge through this layer. CAT-D is divided into internal and external portion with support from intranet (organization users) and Internet (customers) respectively.

E-mail Policy

E-Mail Policy states and clarifies the company policy as well as security warning to all users, internal and external to MFC.

Bulletin Board

This is essential for organization cross-communication (geographical aspects and business unit nature) purposes, as well as capturing and sharing the external information. The board is pre-defined by expert team and it stipulates what kinds of information are allowed to be placed in the system. Since employees or customers already "think" (filter) what should be put on the board, filtered and valued information can be stored.

Discussion Database

Discussion Database acts as an Information Record Buffer to temporarily collect and store communication information such as meeting minutes. The users are allowed to write down discussion about anything, but IQKS classifies these as vast unstructured information and are stored for general discussion only. The inside contents are cleaned every two months to free up server space. Any information considered valuable for permanent storage is transferred into Bulletin Board for corporate distribution.

Standard Product

Standard Product (motor) holds the records of company standard products. It is linked with the Internet for customer selection or for placing an order. Considered to be the primary form of electronic business over the web, it facilitates the transactions of "commodity" motor products of MFC. It also acts as a product catalog. The "hit-rate" shall be recorded for sales and marketing in support of customer relationship management to analyze the number of interests and demands from real-time market.

Technical Support

Technical Support directs question and answer services from internal and external customers. This database has links with standard product databases. This is because a customer, having once selected their favorite products and who might like further customizations, would like to receive direct confirmation of technical possibilities. It is part of introducing engineering services to the front line of customer services.

Engineering Database Library

Under the CAT-D framework, Engineering Database Library captures and stores the engineering information such as product testing record and characteristics. It facilitates the empowerment of internal staff by sharing critical engineering knowledge.

Raw Material Specification

This is a library of raw material specifications and is shared among staff at MFC. The main users of such library include supply chain department, purchasing department, engineering department, R&D, and design & product engineers. Each of them uses the information in a very different perspective.

DC Sample Specification

This stores product sample records, BOM, specifications and quality test results. Engineers routinely input their design specifications and the BOM information. Product-testing workers and testing engineers input the quality test records. The information is combined in such a way that any new knowledge arising from the know-how in routine capturing can be articulated through some pre-defined information transformation criteria.

Fixture Library

Fixture Library facilitates process planning through hyper-linkage to engineering database that contains the process details such as fixture design and setting and so on. The engineering database is dynamically linked with other databases to derive information stored under the fixture library.

Production Specification

Production Specification facilitates production and workflow design by recording the production line layout, workflow design, existing line utilization rate and capacity.

Customer Situation Analysis

Customer Situation Analysis facilitates quality control. It captures planning records of product complaint history, its subsequent quality improvement analysis along with the failure report. A group sharing of failure know-how from quality audit is preferred to traditional handling by a single person, from a learning perspective.

The IQKS Phases

The sales, agent or customer service can use the IQKS system and input the customer requirement into the CAT-D system (through Internet portion). The "hit-rate" for specific items and products reflects the market trends and demands and fulfills the QFD phase I where information is retained for future searching and references. The senior management (sales & marketing, business manager) derives appropriate actions.

Figure 8 shows internal staff accessing the customer historical inquiries through an internal Lotus Notes system. The information regarding customer requirement is stored as list of requirements (LOR), which defines customer specifications of the motor product. The LOR is a combination of information from database and various documentation including drawings and associated graphical presentation on performance. The Lotus Notes system supports these documents with its document management system.

In product design phase (QFD phase II), the LOR (or Sales BOM) from phase I is linked to the product design BOM using the same project number. Basically, LOR is translated into product design BOM by a group of experts and stored under a database accessible in the Lotus Notes environment (see Figure 9). This BOM is able to match and merge with the product information; Figure 10 exemplifies the result.

Searching and selecting is allowed by referring to product models, component part names or part number. Referring to these keys allows associated information to be extracted. This directly shows whether the product design is capable of

Figure 8. IQKS phase I

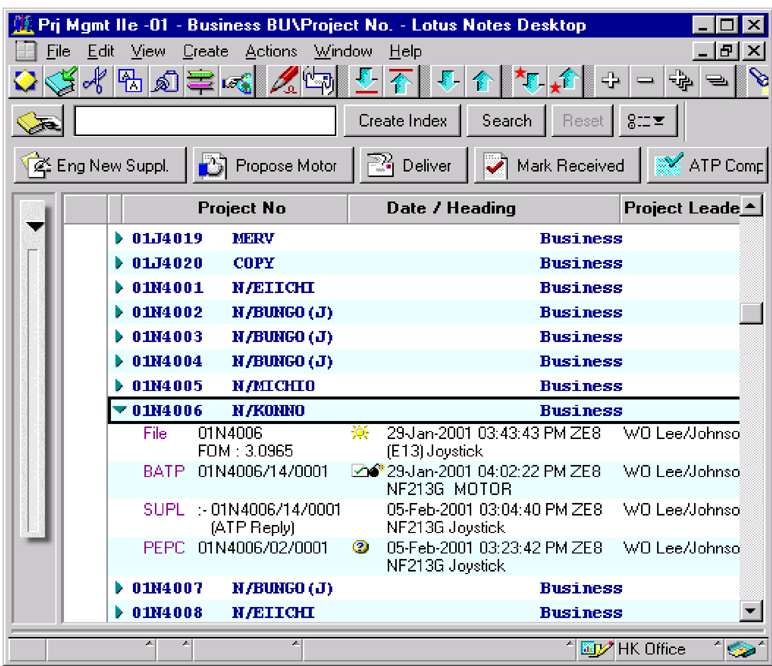
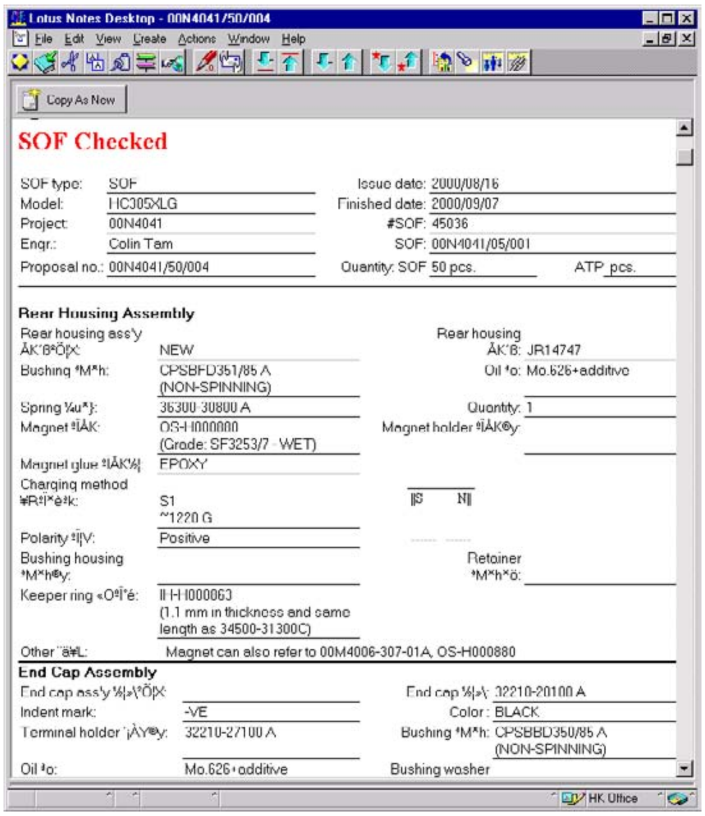


Figure 9. The translation of LOR to design BOM, QFD phase II



fulfilling the customer requirements. With the Lotus Notes documents sharing environment, file attachment and graphical presentation is technically feasible.

The following scenario demonstrates what key deliverables can be provided by showing what was known and what was unknown on a daily basis.

1. A standardized terminology of products, product attributes (process/production, planning quality) can be mapped out, particularly to products of similar nature (see Figure 10). This serves as a common basis of knowledge sharing as part of the common product platform. Design lead-time can be reduced because inexperienced staff can pick up the product design by using the appropriate information. In short, the common basis of knowledge enables self-learning to occur among inexperienced staff.
2. What is known can be captured explicitly under a structured format. Design processes on product characteristics, causes and solutions can also be captured.

The process BOM equivalent to QFD phase III can be accessed under the Lotus Notes environment (see Figure 11). The information is stored in the database dynamically linked with design BOM information. The project numbers, product models and components all serve as the common searching criteria. Documents regarding fixtures,

Figure 10. Integrated LOR with design BOM to facilitate learning

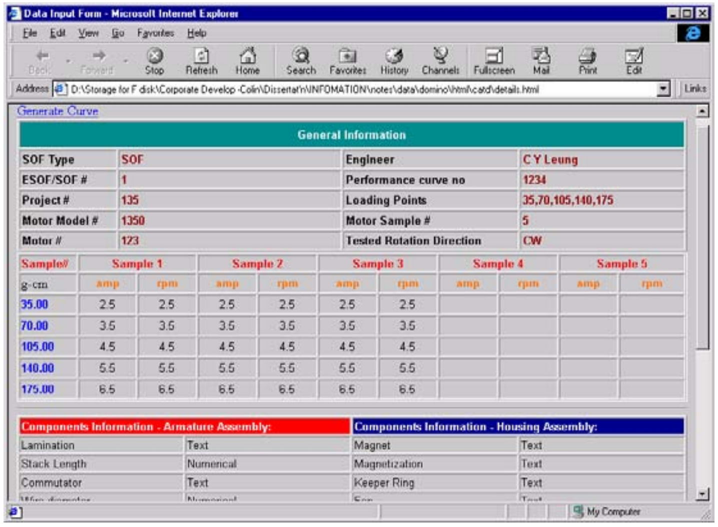
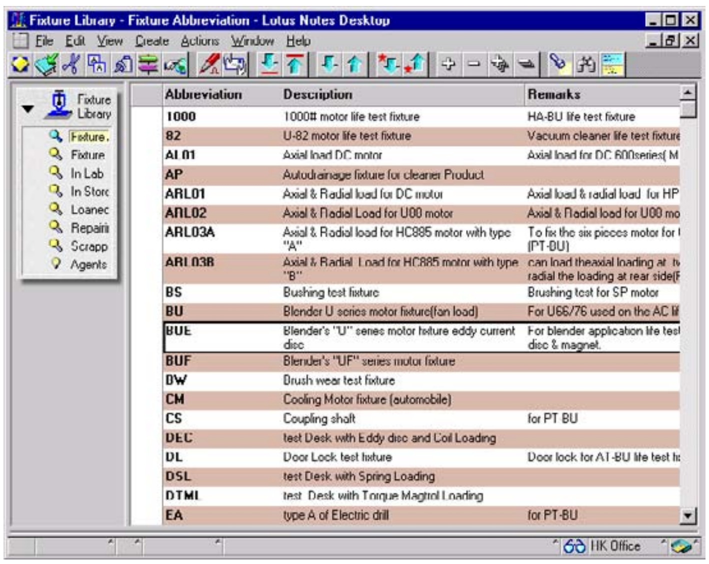


Figure 11. Process BOM



machines settings, maintenance record and application records are shared within the document management system of Lotus Notes.

The last phase of QFD phase IV gives the production BOM that is linked to the IQKS architecture. It deliberately combines quality control with product specification information together as production and quality control information. The commonly used searching criteria are also supported by the Lotus Notes.

Figure 12. Production BOM and QFD phase IV

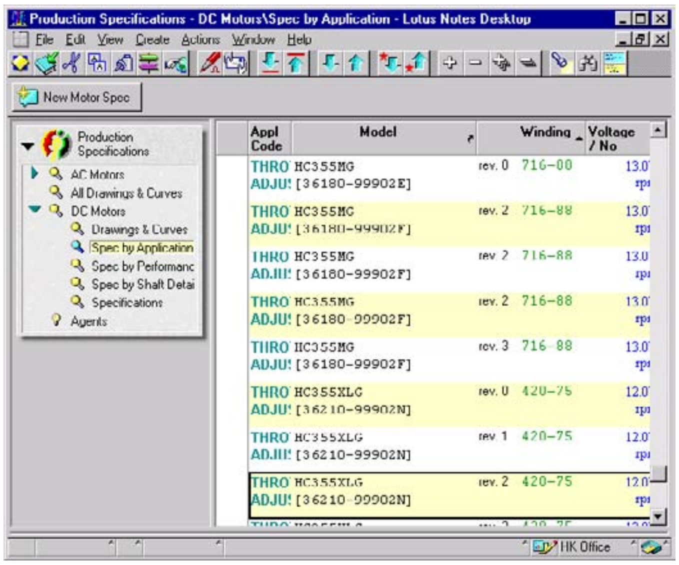


Figure 12 illustrates the production BOM interface under the Lotus Notes environment. Traditional practice may only share pieces of information, and it is up to the staff to put them together in a meaningful way. Performance information can be presented in a graphical format important to the user.

DISCUSSION

The prototype of the common product platform is currently being expanded to cover suppliers and customers in order to enable a true collaborative mode in the customization of business process. However, since separate organizations are different in many ways (for example, the difference in part specification), the difference in manufacturing environment can very much compromise the progress of the common product platform. If the participating organizations are not quickly realizing the potential benefits of the platform, the implementation team can lose control of the project with a consequence of budget overruns and resulting cooling down of interests of sponsors from senior management.

The central accomplishment of this common product platform is the idea to facilitate extended enterprise responsiveness, which in turn represents a large portion of competitive advantage for the participating organizations. Extended enterprise responsiveness focuses on change and dynamic business reconfiguration at the process level. Each participating organization must manage their performance for the benefits of the entire value network through the exchange of information.

Since each participating organization must manage their own performance, this means they will perform activities that are most likely to be in their best interest. For example, suppliers that aim to utilize low-cost labor for manufacturing will most likely incline towards economies of scale, thereby producing product in large quantities. Low cost is their order-winning criteria, and they can squeeze reasonable profit margin from the low-cost commodity parts or suppliers. When complex products require the support of these commodity parts, other participating organizations within the extended enterprise can join in the collaboration to deliver complex products while retaining product performance such as low cost or time-to-market. The only challenge is that they must be previously aligned together to allow such business configuration to be engaged.

Since manufacturing organizations must manage their own manufacturing environment for performance, more understanding is needed in how collaboration can be materialized in different conditions. More importantly, these conditions govern the coordination of economic activities dispersed across enterprises. Therefore the attempts to make individual enterprise systems compatible to each other are the key concern for extended enterprise operations. New understanding should focus on how the market knowledge, design knowledge, process knowledge and production knowledge impact on different manufacturing environments: make to stock, make to order and engineer to order. A lack of protocol or standardization is the major attributing factor that inhibits individual enterprise systems from being more compatible with each other.

SUMMARY AND CONCLUSION

The challenge of managing information for product development must be addressed for many manufacturing organizations entering into the new economy. The creative nature of work or "not invented here syndrome" inherited in generating new products or new services discourages knowledge workers to reuse information and lures them into solutions that involve redesigning the entire part which ultimately affect the efficiency of partnering with suppliers during early supplier involvement. The excessive amount of time spent and cost involved in searching for right information and assuring their relevancy are unnecessary in the first place because parts can be reused with slight modification.

This chapter operationalizes the concept of common product platform for contract manufacturers to manage the product development. It makes use of databases to facilitate the reduction of a wide variety of parts in order to simplify communication and to provide speedy customer responses. The platform merges the concepts of QFD and knowledge management to form an integrated IQKS system. The core is a knowledge-based system aimed at facilitating communication with customers and empowering knowledge workers. The bill-of-material becomes the backbone of the system in managing knowledge for use and reuse.

ACKNOWLEDGMENT

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REFERENCES

Agility Forum. (1997). *Next Generation Manufacturing.*

Blitz, A. (1999). *Connected manufacturing enterprise.* Ernst & Young. Retrieved from www.businessinnovation.ey.com

Baum. J. (1999). Small is beautiful. *Far Eastern Economic Review,* November 18.

Deighton, N. (2001). *Ericsson to stop terminal manufacturing.* Retrieved from Gartner Group at: www.gartner.com

Hagel III, J., & Singer, M. (1999). Unbundling the corporation. *Harvard Business Review,* March-April.

Hill, T. J. (1990). *Manufacturing strategy: Developments in approach and analysis.* PhD Thesis.

Yorkshire, UK: The British Library British Thesis Service.

Magretta, J. (1998a). The power of virtual integration: An interview with Dell Computer's Michael Dell. *Harvard Business Review,* March-April.

Magretta, J. (1998b). Fast, global and entrepreneurial: A supply chain management, Hong Kong style. *Harvard Business Review*, September-October.

Meyer, M. H., & Lehnerd, A. P. (1997). *The power of product platform: Building value and cost leadership.* New York: The Free Press.

Peppers, D., & Rogers, M. (1997). *Enterprise one to one*. New York: Doubleday.

Royal, W. (1999). Contract manufacturing: Perils and profits. *Industry Week,* November.

Szegheo, O., & Andersen, B. (1999). *Modeling the extended enterprise.* International Enterprise Modeling Conference, Verdal, Norway.

Thurm, S. (2000). Motorola to hire flextronics to make consume electronics. *Asian Wall Street Journal,* June 1.

UNCATDA. (2000). *World Investment Report Investment, Cross-Border Mergers and Acquisitions and Development.*

Zuckerman, A. (2000). Compaq switches to pre-position inventory model. *World Trade,* April.

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Chapter 2.35
Data Semantics

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INTRODUCTION

Almost every organization, public or private, for profit or non-profit, manages data in some way. Data is a major corporate resource. It is produced, analyzed, stored, and disseminated. And, it is poorly documented.

Descriptions of data are essential for their proper understanding and use by people inside and outside the organization. For instance, systems for disseminating data on the Internet require these descriptions (Census Bureau, n.d.). Either inside or outside the organization, functions of the system support finding the right data for a study, understanding data from a particular source, and comparing data across sources or time (Gillman, Appel, & LaPlant, 1996).

Descriptions of data and other resources are metadata (Gillman, 2003). Metadata are part of the corporate memory for the organization, and preserving corporate memory is one of the basic features of knowledge management (King, Marks, & McCoy, 2002). Metadata include the meaning, or semantics, of the data. In some countries, such as the U.S., a large percentage of the population is reaching retirement age. As a result, recording the memories of these workers, including the meaning of data, is increasingly important. Preserving metadata is crucial for understanding data years after the data were created (Gillman et al., 1996).

Traditionally, the metadata for databases and files is developed individually, without reference to similar data in other sources. Even when metadata exist, they are often incomplete or incompatible across systems. As a result, the semantics of the data contained in these databases and files are poorly understood. In addition, the metadata often disappear after the data reach the end of the business lifecycle.

Techniques for documenting data are varied. There are CASE (Computer-Aided Software Engineering) tools such as Oracle Designer® (Oracle, n.d.) or Rational Rose® (IBM, n.d.). These tools produce models of data in databases (Ullman, 1982). The models provide some semantics for the data. For social science data sets, metadata is described in an XML (eXtensible Markup Language) specification (ICPSR, n.d.). For geographic data sets, the U.S. Federal Geographic Data Committee developed a metadata framework, clearinghouse, and supporting software (FGDC, n.d.).

Metadata are data, too. They are structured, semi-structured, or unstructured (Abiteboul, Buneman, & Suciu, 2000), just as data are. Data are structured if one knows both the schema and datatype, semi-structured if one knows one of them, and unstructured otherwise. From the perspective of their content, documents are unstructured or semi-structured data. Their schemas come from presentation frameworks such as HTML (Hyper-Text Mark-up Language) (W3C, 1997) or word processor formats. Documents with the content marked up in XML (W3C, 2004) are semi-structured. When using the full datatyping capability of XML-Schema, the document is structured with respect to the content. However, the colloquial use of the term "document" begins to lose its meaning here.

In describing some resource, the content is more important than the presentation. The content contains the semantics associated with the resource. If the content is structured data, this increases the capability of performing complex queries on it. Retrieving unstructured documents using search engine technology is not as precise.

It turns out there are structured ways to represent the semantics of data. Ontologies (Sowa, 2000) are the newest technique. Traditional database (or registry) models are examples of ontologies. This article describes the constituents of the semantics of data and a technique to manage them using a metadata registry. The process of registration—an approach to control the identification, provenance, and quality of the content—is also described and its benefits discussed.

SEMANTICS OF DATA

Terminology

To begin, we describe some useful constructs from the theory of terminology. These come from several sources (Sager, 1990; ISO, 1999, 2000). We use these constructs to describe the semantics of data. The terms and definitions follow in a list below:

- Characteristic: Abstraction of a property of a set of objects.
- Concept: Mental constructs, units of thought, or unit of knowledge created by a unique combination of characteristics.
- Concept system: Set of concepts structured according to the relations among them.
- Definition: Expression of a concept through natural language, which specifies a unique intension and extension.
- Designation: Representation of a concept by a sign, which denotes it.
- Extension: Set of objects to which a concept refers.
- General concept: Concept with two or more objects that correspond to it (e.g., planet, tower).
- Generic concept: Concept in a generic relation having the narrower intension.
- Generic relation: Relation between two concepts where the intension of one of the concepts includes that of the other concept and at least one additional distinguishing characteristic.
- Individual concept: Concept with one object that corresponds to it (e.g., Saturn, Eiffel Tower).
- Intension: Sum of characteristics that constitute a concept.
- Object: Something conceivable or perceivable.

- Property: Attribute used to describe or distinguish an object (e.g., "Dan has blue-gray eyes" means "blue-gray eyes" is the property of Dan associated with the characteristic "eye color" of people.)
- Specific concept: Concept in a generic relation having the broader intension.

Designations come in three types: an appellation is a verbal designation of an individual concept; a term is a verbal designation of a general concept; and a symbol is any other designation.

The ancient Greek philosophers began the study of terminology and concept formation in language (Wedberg, 1982), and they discovered a useful relationship between designation, concept, object, and definition which is illustrated in Figure 1 (CEN, 1995).

Figure 1 shows that concepts, designations, objects, and definitions are related but separate constructs. Each plays a role in our understanding (i.e., the semantics of) data.

An important observation is that concepts are human constructions (Lakoff, 2002). No matter how well we define a concept, a complete description is often impossible. Identifying the relevant characteristics is culturally dependent. So, some objects in the extension of a concept fit the characteristics better than other, so-called prototypes.

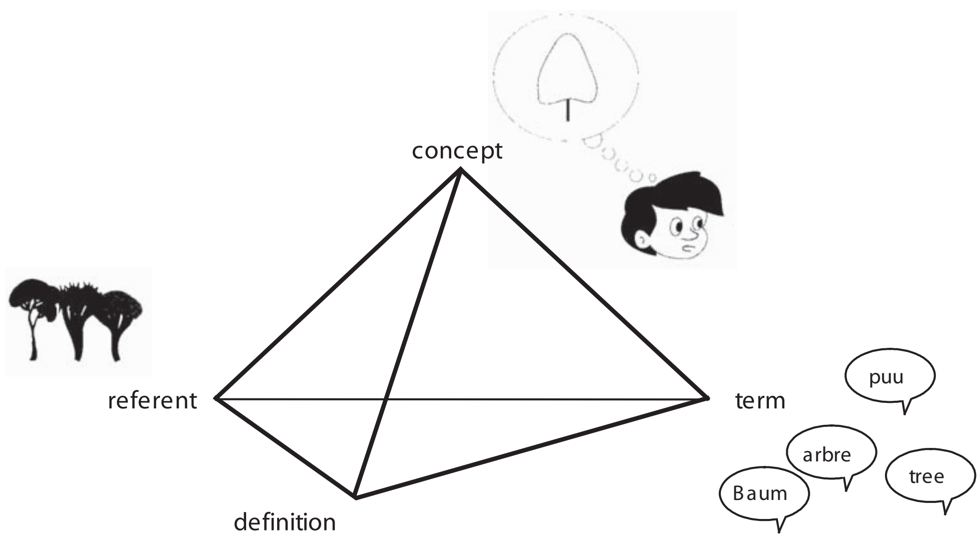
Framework for Understanding Data

Here, we present a general framework for understanding data. Some terminology comes from the area of statistics. Statisticians view a datum as a designation of a class in a partition of a population of objects, where the partition1 is defined for some characteristic of the population (Froeschl, Grossmann, & Del Vecchio, 2003). Here, the population is either a general or individual concept, and the objects are the extension of that concept. Four examples illustrate the ideas:

Example 1

- Population: Adults age 16 and older in the U.S.

Figure 1. Illustration of the differences between a referent (an object), a concept, a term (more generally a designation), and a definition in language



- Characteristic: Sex
- Partition: {Male, Female}
- Designations: 0 for Male 1 for Female

Example 2

- Population: The set of adults age 16 and older in the U.S.
- Characteristic: Proportion of females
- Partition: {x | 0 <= x <= 1}
- Designations: Real numbers between 0 and 1, with precision to 3 decimal places

Example 3

- Population: Shoe sales
- Characteristic: Type of shoe
- Partition: {Basketball, Business, Casual, Formal, Running, Tennis}
- Designations: Ba for Basketball
  Bu for Business
  C for Casual
  F for Formal
  R for Running
  T for Tennis

Example 4

- Population: Stars of the Milky Way Galaxy
- Characteristic: Number of known planets
- Partition: {n | n >= 0 and n is an integer}
- Designations: 0 for no known planets
  1 for one known planet
  etc.

Populations

The idea of a population requires some additional explanation. In one sense, it is a concept represented by a definition or description. In another sense, it is the extension of the concept, the set of objects about which we collect or observe data. We refer to both the concept and its extension as a population.

Also, a population is either an individual concept or a general one. In the ordinary sense, populations are general concepts (see Examples 1, 3, and 4). However, aggregate data requires a population with one object. In Example 2, the characteristic "proportion of females" applies to the entire set of adults age 16 or older in the U.S., not to each person. So, the set consisting of "the set of adults age 16 or older in the U.S." has one element. It is a set whose lone element is a set! But, it is this entirety (an aggregate) that has the characteristic "proportion of females," not the individual people. So, "proportion of females" is not a characteristic of people, "sex" is. Likewise "sex" is not a characteristic of the aggregate, "proportion of females" is.

Every object has an individual concept associated with it. When one thinks of a particular object, the conception of that object is an individual concept. Data associated with a particular object is descriptive of that object. This characterization is necessary but not sufficient to be metadata. Data are only metadata when they are used to describe some object. However, metadata are similar to aggregate data, their populations are individual concepts.

Types of Semantics

Characteristics applied to populations are concepts themselves. So, the characteristic of a population is a concept, and it represents, in part, the contextual semantics of the data (e.g., the sex of U.S. people). The designations denoting the classes of the partition defined for the characteristic represent the symbolic semantics—for example, M is for male and F is for female. Therefore, data have both contextual and symbolic semantics (Gillman, 2003).

The contextual semantics describe, in part, the kinds of objects for which data are collected and the particular characteristic of those objects being measured. The symbolic semantics describe the set of categories, not necessarily finite, representing the meaning of the values that data take.

The set of values that data take has additional descriptions, in particular a computational model for the values, which is called the datatype (ISO, 1995).

Value Domains

As defined above, the set of designations for the classes of a partition determined by a characteristic is called a value domain. In a value domain, a designation is known as a value, the associated class of the partition is described by a concept called the value meaning, and each value and associated value meaning pair is a known as a permissible value (ISO, 2004).

A set of value meanings is called a conceptual domain. It is a concept, and its value meanings are its characteristics. Every value domain is in the extension of some conceptual domain.

Value domains and conceptual domains come in two (non-exclusive) sub-types:

- Enumerated: A domain specified by a list of its elements.
- Non-Enumerated: A domain specified by a description of its elements.

An enumerated value domain contains a list of all its permissible values. An enumerated conceptual domain contains a list of all its value meanings. Non-enumerated value domains and non-enumerated conceptual domains are specified by descriptions. The non-enumerated value domain description describes precisely which permissible values belong and which do not belong to the value domain. The non-enumerated conceptual domain description describes precisely which value meanings belong and which do not belong to the conceptual domain.

Some value domains contain very similar permissible values from one domain to another. Similarity is based on how much the value meanings overlap. When these similarities occur, the value domains are in the extension of one conceptual domain. The following two examples taken from ISO (2004) illustrate several things:

- Example of non-enumerated value domains and a non-enumerated conceptual domain
- Example of enumerated value domains and an enumerated conceptual domain
- Use of conceptual domains to manage similarities between value domains

Example 5: Similar Non-Enumerated Value Domains

- Conceptual domain name: Probabilities
- Conceptual domain definition: Real numbers greater than 0 and less than 1
- Value domain name (1): Probabilities—2 significant digits
- Value domain description: All real numbers greater than 0 and less than 1 represented with 2 digit precision.
- Precision: 2 digits to the right of the decimal point
- Value domain name (2): Probabilities—5 significant digits
- Value domain description: All real numbers greater than 0 and less than 1 represented with 5 digit precision.
- Precision: 5 digits to the right of the decimal point

Example 6: Similar Enumerated Value Domains

- Conceptual domain name: Marital Status Categories
- Conceptual domain definition: Lists of categories for marital status

- Value domain name (1): Marital Status Codes (1)
- Permissible values: <S, Not married>
  <M, Married>
- Value domain name (2): Marital Status Codes (2)
- Permissible values: <1, Not married>
  <2, Married>

Data Element Concepts

A data element concept is a concept that contains a population and one of its characteristics. It is the conceptual part of data, that is, independent of the values (i.e., the value domain). The classes (or entities) and attributes in data models approximate populations and characteristics.

A concept may be both a population and a characteristic, depending on its use. For instance, "occupation" is a characteristic of a person. On the other hand, as a population we care about its characteristics, such as physical requirements for a job in that occupation.

Populations and characteristics often are specialized to account for data associated with domains (of populations) or narrower properties. The generic relation is used, and value meanings from enumerated conceptual domains (i.e., classifications) provide the additional characteristics to narrow the concept. Here is an example:

Example 7: Specializing Populations and Characteristics

- Population: Persons of the U.S.
- Classification: Sex {Male, Female}
- Specialized Population: Male Persons of the U.S.
- Characteristic: Income
- Classification: Income Type {Wages, Retirement, Dividends, Interest, Inheritance, Other}
- Specialized Characteristic: Income derived by wages only

Data Elements

Data elements are containers for data, and in some sense, they are indivisible (i.e., elemental). A data element is the association between a data element concept and a value domain. Both data element concepts and value domains may be associated with many data elements.

The term data element is synonymous with the term variable, as it is understood by programmers. Thus, the datatype associated with a data element is important. The data element concept and the value domain provide a semantic model for a data element. The datatype provides a computational model.

METADATA REGISTRIES

Introduction

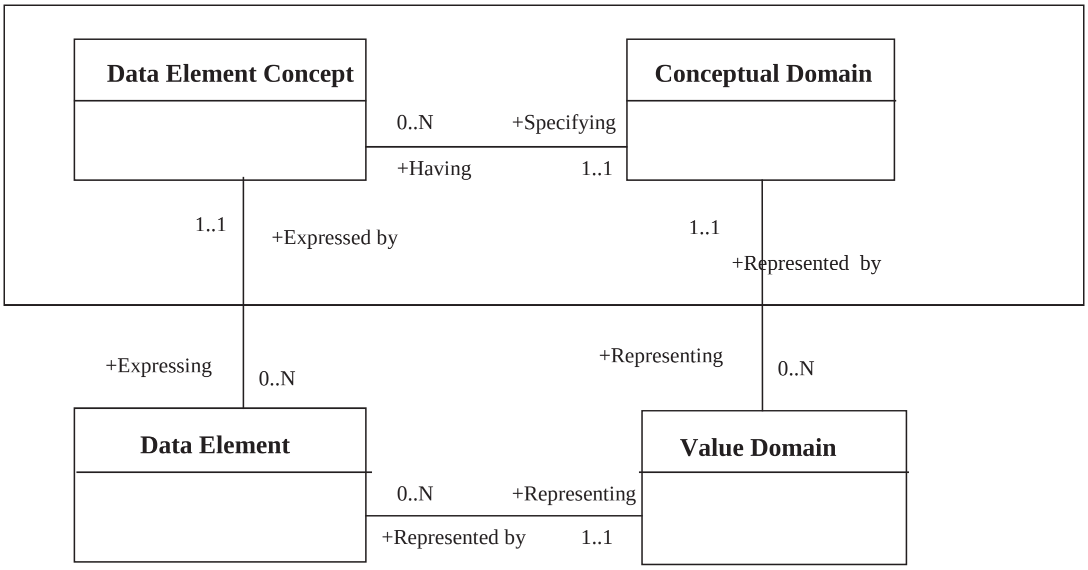
A database of metadata that supports the functionality of registration is a metadata registry. A metadata registry contains metadata describing data constructs (i.e., data elements, data element concepts, value domains, conceptual domains, populations, characteristics, and value meanings) that retain data semantics.

Of course, the metadata registry contains descriptions of data constructs, not the constructs themselves. This is analogous to the registries maintained by governments to keep track of motor vehicles. A description of each motor vehicle is entered in the registry, but not the vehicle itself.

Metadata Registry Model

The international standard ISO/IEC 11179 (ISO, 2003) contains a metadata registry model for data semantics. It contains two main parts: the conceptual level and the syntactical level. The conceptual level contains the data element concept and conceptual domain. Both are concepts as described above. The syntactical level contains

Figure 2. Overview of basic metadata registry model for data semantics (adapted from ISO/IEC 11179)



the data element and value domain. Both are containers for data values.

Figure 2 pictorially represents the following facts, some of which were previously mentioned:

- A data element is the association between a data element concept and a value domain.
- Many data elements may share the same data element concept.
- Many data elements may share the same value domain.
- Value domains are not necessarily related to any data element.
- Two value domains that share all the value meanings are conceptually equivalent and share the same conceptual domain.
- Two value domains that share some value meanings are conceptually related and share the same conceptual domain in a concept system containing each of their conceptual domains.
- Many value domains may share the same conceptual domain.
- A data element concept is related to a single conceptual domain, so all the data elements sharing the same data element concept share conceptually related representations.
- In addition to the facts illustrated in the Figure 1, there are two other important facts that need stating:
    - Relationships among data element concepts may be maintained in a metadata registry, which implies that a concept system of data element concepts may be maintained.
    - Relationships among conceptual domains may be maintained in a metadata registry, which implies that a concept system of conceptual domains may be maintained.

Registration

Registration functions separate a metadata registry from a database of metadata. Registration is the set of rules, operations, and procedures that apply to a metadata registry. The three most important outcomes of registration are the ability to monitor the quality of metadata, provenance (the source of the metadata), and assigning an identifier to each object described.

Registration also requires a set of procedures for managing a registry, submitting metadata for registration of objects, and maintaining subject matter responsibility for metadata already submitted. For actual implementations of a metadata registry, there may be additional requirements.

Each description of a data construct is maintained in a uniform and prescribed manner. Identifiers, quality measures, responsible organizations, names, and definitions are recorded for every data construct.

There are several purposes to monitoring metadata quality. The main purposes are:

- Monitoring adherence to rules for providing metadata
- Monitoring adherence to rules for forming definitions and following naming conventions
- Determining whether a description still has relevance
- Determining the similarity of related data constructs and harmonizing their differences
- Determining whether it is possible to ever get higher quality metadata for some data constructs

Every data construct registered in a metadata registry is assigned a unique identifier. Identifiers are a means to keep track of descriptions for administration purposes, to refer to descriptions by remote users of the registry, and to aid in metadata transfer between registries.

The registration authority is the organization responsible for setting the procedures, administering, and maintaining a registry. The submitting organization is responsible for requesting that a new description be registered in the registry. The steward is responsible for the subject matter content of each registered item. Each of these roles is described in ISO/IEC 11179 (ISO, 2003).

Implementations

Organizations for which data is a major corporate asset or share that data outside the organization have a need to describe the semantics of their data. Many organizations around the world use metadata registries. Some of these exist, and others are under construction. The U.S. Environmental Protection Agency (EPA, n.d.) and the Australian Institute for Health and Welfare (AIHW, n.d.) have functioning metadata registries on the Web. Statistics Canada (Johanis, 2000) and the Australian Bureau of Statistics (Oakley, 2004) are building metadata registries for internal use to support the business lifecycle.

CONCLUSION

This article describes how to manage the semantics of data. It incorporates ideas from statistics that generalize to all data. Data have conceptual and representational components. The conceptual component has contextual and symbolic semantics. The contextual semantics describes the population of objects being described and a characteristic of that population. The symbolic semantics describes the meaning of the categories defined for the characteristic. The representational component includes the values used to represent the categories in the symbolic semantics.

Metadata registries, such as those that conform to the international standard for metadata registries, ISO/IEC 11179, describe and manage data semantics. Many organizations are building metadata registries, and some are available on the Web.

REFERENCES

Abiteboul, S., Buneman, P., & Suciu, D. (2000). *Data on the Web.* San Francisco: Morgan Kaufman.

AIHW. (n.d.). *Australian Institute for Health and Welfare Knowledge Base.* Retrieved July 2004, from http://www.aihw.gov.au/knowledgebase

CEN. (1995). *Medical informatics: Categorical structures of systems of concepts.* Draft. Brussels: European Committee for Standardization.

Census Bureau. (n.d.). *American Fact Finder.* Retrieved July 2004, from http://factfinder.census.gov/

EPA. (n.d.) *Environmental Protection Agency Environmental Data Registry.* Retrieved July 2004, from http://www.epa.gov/edr

FGDC (Federal Geographic Data Committee). (n.d.). *Content Standard for Digital Geospatial Metadata.* Retrieved July 2004, from http://www.fgdc.gov/metadata/metadata.html

Froeschl, K., Grossmann, W., & Del Vecchio, V. (2003). *The concept of statistical metadata.* Deliverable #5 for MetaNet Project. Retrieved July 2004, from http://www.epros.ed.ac.uk/metanet/deliverables/D5/IST-1999-29093_D5.doc

Gillman, D. (2003). Metadata registries, data harmonization, and maximizing use of a warehouse. *Proceedings of the Statistical Input Data Warehouse Workshop.* Canberra, Australia: Australian Bureau of Statistics.

Gillman, D., Appel, M., & LaPlant, W. (1996). Design principles for a unified statistical data/metadata system. *Proceedings of the 8th International Conference on Scientific and Statistical Database Management* (pp. 150-155). Los Alamitos, CA: IEEE Computer Society Press.

IBM. (n.d.). *Rational Rose®.* Retrieved July 2004, from http://www.rational.com

ICPSR (Inter-University Consortium for Political and Social Research). (n.d.). *Data Documentation Initiative*. Retrieved July 2004, from http://www.icpsr.umich.edu/ddi

ISO. (1995). *ISO/IEC 11404: Language independent datatypes.* Geneva: International Organization for Standardization and International Electrotechnical Commission.

ISO. (1999). *ISO 704: Principles and methods of terminology*. Geneva: International Organization for Standardization.

ISO. (2000). *ISO 1087-1: Terminology: Part 1: Vocabulary*. Geneva: International Organization for Standardization.

ISO. (2003). *ISO/IEC 11179: Metadata registries* (all parts). Geneva: International Organization for Standardization and International Electrotechnical Commission.

ISO. (2004). *ISO/IEC TR 20943-3: Procedures for achieving metadata registry content consistency—part 3: Value domains.* Geneva: International Organization for Standardization and International Electrotechnical Commission.

Johanis, P. (2000, November). Statistics Canada's integrated metadatabase: Our experience to date. *Proceedings of the UNECE Workshop on Statistical Metadata,* Washington, DC.

King, W., Marks, P., & McCoy, S. (2002). The most important issues in knowledge management. *Communications of the ACM*, *45*(9), 93-97.

Lakoff, G. (2002). *Women, fire, and dangerous things* (reprint ed.). Chicago: University of Chicago Press.

Oakley, G. (2004, February). *Using ISO/IEC 11179 to help with metadata management problems*. Proceedings of the Joint UNECE, Eurostat, OECD Workshop on Statistical Metadata, Geneva.

Oracle Corp. (n.d.). *Oracle Designer®*. Retrieved July 2004 from http://www.oracle.com

Sager, J. (1990). *A practical course in terminology processing.* Philadelphia: John Benjamins.

Sowa, J. (2000). *Knowledge representation.* Pacific Grove, CA: Brooks/Cole—Thomson Learning

Ullman, J. (1982). *Principles of database systems* (2nd ed). Rockville, MD: Computer Science Press.

Wedberg, A. (1982). *A history of philosophy—volume 1: Antiquity and the Middle Ages.* Oxford: Clarendon Press.

W3C (World Wide Web Consortium). (1997). *HyperText Markup Language.* HTML 4.0 reference specification. Retrieved July 2004, from http://www.w3c.org

W3C. (2004). *Extensible Markup Language*. XML 1.1 Reference Specification. Retrieved July 2004 from http://www.w3c.org

ENDNOTE

1. A partition is a non-empty set of mutually exclusive and exhaustive subsets of some other set. The number of subsets is not necessarily finite.

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Chapter 2.36
Knowledge Management in Supply Chain Networks

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INTRODUCTION

This article reviews current research and practice of knowledge management (KM) and inter-organizational learning in supply chain networks. Knowledge management is the organizational process for acquiring, organizing, and communicating the knowledge of individual employees so that the work of the organization becomes more effective (Alavi & Leidner, 1999). Knowledge management is an increasingly important process in business organizations because "managing human intellect—and converting it into useful products and services—is fast becoming the critical executive skill of the age" (Quinn, Anderson & Finkelstein, 1998). Grover and Davenport (2001) state that KM becomes "an integral business function" when organizations "realize that competitiveness hinges on effective management of intellectual resources." Grover and Davenport also argue that knowledge management works best when it is carried out by all the employees of the organization and not just KM specialists.

Business organizations frequently partner with other firms to complement their core competencies. To collaborate effectively, partner firms have to communicate with each other information about business processes as well as share ideas of how to design or improve business processes. This phenomenon of knowledge sharing across organizational boundaries is called inter-organizational learning (Argote, 1999). Knowledge management, we posit, is necessary to facilitate inter-organizational learning and direct it in a way that supports the organization's overall objectives.

Supply chain systems are an example of business networks. Supply chains involve not only multiple corporate entities but also organizational units within a single organization. We present practices used in business organizations and networks of businesses to manage the information and knowledge sharing processes using the context of supply chain systems.

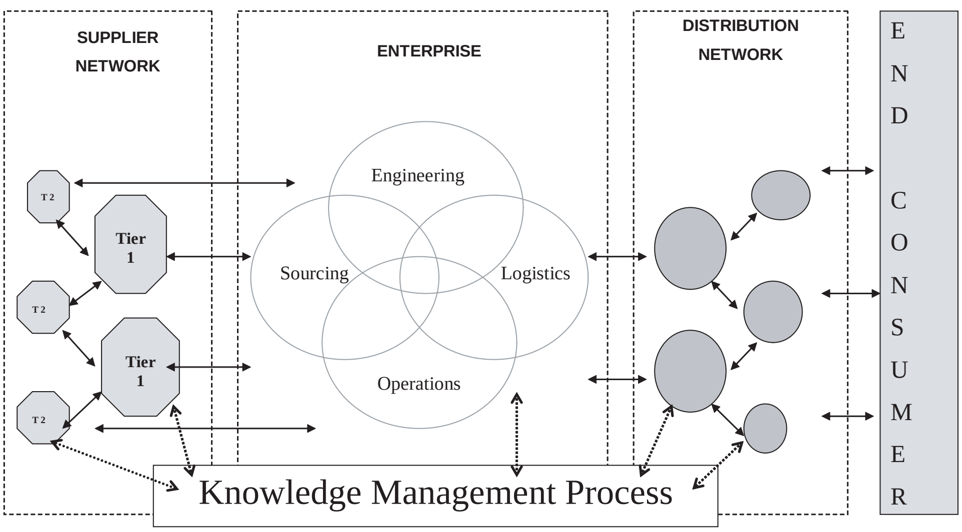
BACKGROUND

A supply chain consists of all parties involved, directly or indirectly, in fulfilling the end consumer's request. Its primary purpose is to satisfy customer needs while maximizing the overall profitability of the chain. A typical supply chain involves a variety of stages that may include customers; a distribution network of retailers, wholesalers, and distributors; manufacturing enterprises; and tiers of suppliers (Figure 1). Information, knowledge, funds, products. and services flow along both directions of the chain, where more than one player is often involved at each stage. The structure of supply chain systems can be described as a business network where inter-organizational learning and information sharing are critical factors in determining the chain's competitiveness.

The performance of a supply chain depends upon how well its processes are managed for the type of product that is associated with the chain. Fisher (1997) classifies products on the basis of their demand patterns, claiming that a product falls into one of two categories, either primarily functional or primarily innovative. Functional products satisfy basic needs and include the staples that people buy in a wide range of retail outlets such as grocery stores and gas stations. These products have stable, predictable demand, and long life cycles. Due to well-developed competition, low profit margins occur, requiring the chain to focus almost exclusively on minimizing physical costs. Companies need to coordinate the ordering, production, and delivery of supplies in order to minimize inventory and maximize production efficiency in order to meet predictable demand at the lowest cost.

Innovative products, such as fashion apparel and technology products including plasma TVs, cellphones, and iPods, are differentiated from competition by their designer options and new features and capabilities. The novelty of these products allow higher profit margins, but also result in more demand uncertainty as it is difficult to predict how the market will respond to

Figure 1. The integrated supply chain



the newest design features and options. The life cycle for innovative products is short as ensuing competition forces companies to introduce newer innovations in order to maintain the higher profit margins. The short life cycles and the great variety typical of these products further increase demand unpredictability. The demand uncertainty from the market environment increases the risk and costs of shortages and excess supplies throughout the chain. To mitigate this risk, it is crucial that information flows not only within the chain but also from the marketplace to the chain. Fisher (1997) describes managers' primary focus in supply chains for innovative products as market mediation, the need to read early sales numbers or other market signals and have the chain respond quickly. The critical decisions to be made are not about minimizing costs but about where in the chain to position inventory and available production capacity in order to hedge against the uncertain demand and be responsive. Supply chain systems reduce the external environmental uncertainty by introducing formal information and knowledge transfer mechanisms between supply chain partners. In supply chains with innovative products, suppliers are evaluated based on their reliability, speed, flexibility, and product development skills as well as for their cost.

Due to the emphasis on market mediation, supply chains for innovative products require more collaboration about product design and improvement of business processes than supply chains for functional products. While information sharing can improve the performance of functional product supply chains, inter-organizational learning is essential to support the overall objectives of the innovative product supply chain.

KNOWLEDGE MANAGEMENT IN SUPPLY CHAINS

As the goal for functional products is to minimize the physical costs associated with the production and delivery of the product, many supply chains have improved their coordination efforts by sharing information. Efficient Consumer Response (ECR) and Quick Response (QR) initiatives are efforts that certain industries have implemented to reengineer the supply channel to make it more responsive to customer demand. Controlling the flow of information and product between different stages within the chain is a major focus of these initiatives as it helps decrease the costs of inventory and shortages. Chains have used technologies such as electronic data interchange (EDI), the Internet, and satellite systems for transmitting point-of-sale data to provide real-time information. Improved coordination is achieved with this information even when the decision-making responsibilities remain decentralized. A $14 billion savings in the food service industry (Troyer, 1996) and $30 billion savings in the groceries industry (Kurt Salmon Associates, 1993) have been documented as a result of implementing these initiatives. Current MS/OR research (e.g., Lee, So & Tang, 2000) studies the value of different types of information that can be shared given the decentralized decision-making framework. For example, Wal-Mart's Retail Link program provides an online summary of point-of-sale data for Johnson & Johnson and Lever Brothers as well as direct satellite transmitted point-of-sale data. Cachon and Fisher (1997) describe the cost savings that Campbell Soup's continuous replenishment program generated for the grocery supply chain. In this instance, retailers transmitted daily inventory information via EDI to Campbell Soup, and the manufacturer assumed responsibility for managing retailer inventories, a process commonly referred to as vendor managed inventory. This particular continuous replenishment program reduced inventories in retailer distribution centers by 50%, while increasing service levels from 98.7% to 99.5%.

Some chains have extended their collaborative efforts to include information about processes as well as more centralized decision making. Aviv (2001) and Raghunathan (1999) describe Collaborative Forecasting and Replenishment (CFAR) as a new inter-organizational system that enables retailers and manufacturers to forecast demand and schedule production jointly. CFAR allows the exchange of complex decision support models and manufacturer/retailer strategies so that the two supply chain parties can reduce demand uncertainty and coordinate their decisions. Wal-Mart and Warner-Lambert embarked on the first successful CFAR pilot, involving Listerine products in 1996. Since then several major manufacturers of functional products, such as Procter and Gamble, have undertaken CFAR projects.

Due to the demand uncertainty and short life cycle, supply chains for innovative products need to develop strategies that will create flexibility and responsiveness within the chain. The exchange of knowledge about processes, innovations, and market interest are vital to the members of the chain as it works to design and distribute the newest product to the market quickly. The Knowledge and Learning in Advance Supply Systems (KLASS) pilot project (Rhodes & Carter, 2003) seeks to develop collaborative learning in networks of suppliers in the automotive and aerospace sectors. Focusing on the tiered supplier network, as illustrated on the left side of Figure 1, KLASS utilized an inter-company, computer-mediated learning network that focused on both immediate performance improvements and longer term objectives. It developed learning and knowledge to advance collaborative functioning and improved performance between the tiered companies linked in the supplier network. Similarly, to manage knowledge across the supplier network and enterprise boundaries, as shown in Figure 1, Chrysler developed a successful supplier-suggestion process to reduce costs and build collaborative relationships with its suppliers (Hartley, Greer & Park, 2002). Both of these are examples of inter-organizational systems.

In another example of an inter-organizational network, Mak and Ramaprasad (2003) introduce the idea of knowledge supply networks, which they define as "integrated sets of manufacturing and distribution competence, engineering and technology deployment competence, and marketing and customer service competence that work together to market, design and deliver end products and services to markets." They outline the nature of the business processes associated with designing and delivering innovative products and describe the need to effectively coordinate the knowledge in the market, design, and supply distribution chains. As costs for product development increase and faster time-to-market is expected, more and more original equipment manufacturers (OEM), such as Motorola and Nokia, are refocusing their competence on marketing, research and design, and critical high level design, and outsourcing everything else to contract manufacturers. This changes the chain structure as outlined in Figure 1 and requires the OEM to create a knowledge management network that will allow them to leverage the supplier and contract manufacturer knowledge, yet still preserve their own knowledge and control.

In order to be competitive, supply chains for innovative products must have processes in place to exchange product and market knowledge. Unlike the chains associated with functional products, innovative chains will not incur much competitive advantage as the result of demand and inventory information sharing. Due to high future demand uncertainty and potentially high profit margins, there is often distrust between the stages of the chain. This distrust can result in parties making uncoordinated decisions that are in their best individual interest (local optimization) and not in the best interest of the supply chain.

For instance, in the PC market, manufacturers suspect their distributors of inflating orders to ensure availability of the product. Dell Corporation removed the distributor stage in its supply chain so that it could improve its market mediation and receive end-consumer information directly. In the automotive and aerospace industry, manufacturers provide suppliers with forecasts that are often wrong, resulting in extreme shortages or excess capacity with no return on investment for the suppliers. Suppliers often make locally optimal decisions as a result. When a supplier could not provide an adequate supply of ashtrays and glove compartment doors, GM lost nearly two months of production of the Buick Roadmaster (Suris & Templin, 1993). In 1999, GM canceled two new models, leaving their suppliers with newly developed capacity and no return for their investment (Pryweller, 1999). In 1997, Boeing could not fill their plane orders largely due to a shortage of 500 different parts from 3,000 part suppliers who did not have enough capacity, resulting in a $1.6 billion charge against Boeing's third-quarter earnings (Cole, 1997).

A survey done by Lee and Whang (2000) identifies that firms are also concerned about the confidentiality of shared information when competition exists, and that it is one of the major hurdles that information sharing in a supply chain must overcome. Besides intentional information leaks, Li (2002) defines the leakage effect as the indirect effect of vertical information sharing that occurs when the shared information becomes known to competition as the result of observing the behavior of the party that receives the information. Li illustrates how competing firms can react to the observed behavior and how this reaction can change the strategic interaction, causing additional gains or losses to the parties between which the information was directly exchanged. Powell, Koput, and Smith-Doerr (1996) point out that firms will continue to work with their partners, once the risks are managed at a "tolerable level."

In addition to trust, several other factors impact the ability of a firm to share information and knowledge productively with other parties in a supply chain. These include the technology infrastructure, application software used to manage the supply chain operations, and the culture of knowledge sharing within a firm as well as within the supply chain.

Scott (2000) studied the process of and reasons for information technology (IT) support for inter-organizational learning. Studying the disk drive industry, Scott identified the need for inter-organizational learning to help "cope with the complexity of new products and the capital intensity" in the industry. She noted that the industry had consolidated with several firms working very closely in a "vertically integrated virtual organization." IT helps the organizations streamline the information flow between them, making it easier to provide feedback between partners and facilitate learning across organizational boundaries. The model developed by Scott helps to explain the role of IT in lower and higher levels of inter-organizational learning. In lower level learning, an organization makes changes to its operations based on feedback from a partner. In higher order learning, partners change operating assumptions and procedures based on a new understanding typically resulting from collaborative work. An important finding from her study was that inter-organizational learning strategies "with customers and suppliers in the disk drive industry were facilitated by IT and constrained by lack of trust."

Kent and Mentzer (2003) conducted a study of the impact of inter-organizational information technology (IOIT) in a retail supply chain. They found that when suppliers invest in IOIT, retailers perceive a commitment to the relationship from the suppliers and are willing to reciprocate. The commitment to the relationship leads to the partners working together to improve logistics efficiency. Therefore, the payoff from the investment in IOIT comes from the reduction of costs in the supply chain as a result of improvements in logistics efficiency. Their findings also support Scott's (2000) observation about the role of trust between partners in a supply chain. In addition to the investment in IOIT, they show that firms must also "demonstrate characteristics of trust such as integrity and faithfulness." Only then will partners perceive the commitment to the relationship. As

Kent and Metzer state, “relationship trust and investment in IOIT can lead to relationship commitment that can lead to logistics efficiency.”

The above examples pertain to inter-organizational systems; however, KM plays an important role even within a single organization. Intra-organizational systems and initiatives are needed to facilitate knowledge sharing across organizational units. Edwards and Kidd (2003) treat knowledge management “as a process rather than as an organizational system” or a piece of technology. In order for this process to work across organizational boundaries, they identify trust, organizational culture, and the “relationship between top down strategy and bottom up organizational learning” as enabling factors. Trust needs to exist between individuals as well as between organizations. There needs to be compatibility between the cultures of organizations for knowledge management processes to work. Aligning the top down strategy with bottom up learning requires the organization to make its strategy for KM clear and create and maintain an atmosphere that supports organization learning. Trust between individuals and organizations can be enhanced by setting up exchange programs and by facilitating voluntary exchange of knowledge.

Another set of factors that Bessant and Kaplinsky (2003) recognize as necessary for learning in supply chain is the “accumulation and development of a core knowledge base,” as well as the “long-term development of a capability for learning and continuous improvement across the whole organization.” In order for each organization in a supply chain to manage how learning takes place, they need to have formal mechanisms and a clear understanding of the value of learning. Only then can long-term efforts be sustained.

This set of factors is based on the concept of absorptive capacity (Cohen & Levinthal, 1990). Cohen and Levinthal describe this as the capacity of an organization to “recognize the value of new, external information, assimilate it, and apply it to commercial ends.” Lane and Lubatkin (1998) suggest that the absorptive capacity of a firm is relative to its partner firms and is dependent on “the similarity of both firms’ knowledge bases, organizational structures and compensation policies,” and one firm’s familiarity with the other firm’s “set of organizational problems.” Szulanski (1996) shows that a unit’s lack of absorptive capacity, a distant relationship with other units and lack of a clear understanding of cause and effect relationships can all become impediments to intra-organizational learning.

In addition to efficiency in logistics is the issue of effectiveness of sourcing in enterprises that have multiple personnel handling the purchasing task. Rozemeijer, Van Weele, and Weggeman (2003) identify three constructs to help corporate purchasing officers create coordinating mechanisms that facilitate purchasing synergies within the corporation. The constructs include purchasing maturity, corporate coherence, and business context. The mechanisms they identified include:

- formal organizational mechanisms such as corporate steering boards or commodity teams;
- informal networking mechanisms such as annual purchasing conferences and job rotation;
- enterprise-wide information and communication systems; and
- advanced management and control systems.

These four mechanisms or systems represent different options for intra-organizational KM. These mechanisms were illustrated for a supply chain with functional products. Rozemeijer et al. (2003) also point out however that purchasing performance depends on increased coordination between multiple purchasing officers and requires constant monitoring to ensure that the purchasing function is aligned with the business context and corporate strategy, which is associated with the type of product and supply chain objectives involved.

CONCLUSION

As the studies cited above show, information technology that supports information sharing is a necessary element for knowledge management processes to work in supply chains. In supply chains for functional products, decentralized decision making can result in good decisions when IT support is effective. However, in innovative supply chains, IT by itself is not sufficient. The other factors are needed as well. Without the other factors, such as trust within and across organizations or an organizational culture that supports learning, the supply chain does not benefit. Even with good IT and information sharing, each company is likely to make decisions that are locally focused, resulting in suboptimal supply chain performance.

Practitioners interested in creating and managing knowledge management efforts in supply chains should consider the following issues carefully:

- The information flow between the tiers in the supply chain and how the systems and organization support information sharing.
- The utilization of information within an organization, especially to support decision making. Decentralized decision making can be beneficial for the supply chain as long as the firms trust each other and want to optimize the performance of the chain. Incentives need to be in place to ensure that each party is motivated to maximize the performance of the chain.
- The organizational culture with respect to learning within each firm and across the tiers in the supply chain. The culture must support learning and facilitate the process of learning.
- Trust between organizations in the supply chain is critical. Unless the firms develop this trust, they will make decisions solely based on their self interest, and that may be detrimental to supply chain performance.
- How the network assimilates the information and how the network changes its actions based on what it has learned is the effect of the knowledge management effort. In the case of functional products, this can be in the form of firms modifying processes to increase efficiency. In the case of innovative products, suppliers may be elevated to status of true partners, taking on more responsibility and risk and sharing in decision making as decisions are made in a more centralized manner.

REFERENCES

Alavi, M., & Leidner, D. E. (1999). Knowledge management systems: Issues, challenges and benefits. *Communications of the AIS, 1,* 1-37.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge.* Norwell, MA: Kluwer.

Aviv, Y. (2001). The effect of collaborative forecasting on supply chain performance. *Management Science, 47*(10), 1326-1343.

Bessant, J., & Kaplinsky, R. (2003). Putting supply chain learning into practice. *International Journal of Operations and Production Management, 23*(2), 167-184.

Cachon, G., & Fisher, M. (1997). Campbell Soup's continuous replenishment program: Evaluation and enhanced inventory decision rules. *Production and Operations Management, 6*(3), 266-276.

Cohen, W. M., & Levinthal, D. A. (1990, March). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Cole, J. (1997, June 26). Boeing, pushing for record production, finds parts shortages, delivery delays. *Wall Street Journal*, p. A4.

Edwards, J. S., & Kidd, J. B. (2003). Knowledge management sans frontiers. *Journal of the Operational Research Society, 54*(2), 130-139.

Fisher, M. (1997). What is the right supply chain for your product? *Harvard Business Review, 75*(2), 105-117.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Hartley, J., Greer, B., & Park, S. (2002). Chrysler leverages its suppliers' improvement suggestions. *Interfaces, 32*(4), 20-27.

Kent, J., & Mentzer, J. (2003). The effect of investment in interorganizational information technology in a retail supply chain. *Journal of Business Logistics, 24*(2), 155-175.

Kurt Salmon Associates Inc. (1993). *Efficient consumer response: Enhancing consumer value in the grocery industry.* Washington, DC: Food Marketing Institute.

Lane, P. J., & Lubatkin, M. (1998, May). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*(5), 461-477.

Lee, H., So, K., & Tang, C. (2000). The value of information sharing in a two-level supply chain. *Management Science, 46*(5), 626-643.

Lee, H., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Technology Management, 20*, 373-387.

Li, L. (2002). Information sharing in a supply chain with horizontal competition. *Management Science, 48*(9), 1196-1212.

Mak, K-T., & Ramaprasad, A. (2003). Knowledge supply network. *Journal of the Operational Research Society, 54*(2), 175-183.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996, March). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 31*(1), 116-145.

Pryweller, J. (1999, June 21). Delays jolt GM suppliers: Some part makers invest millions. *Automotive News*. Retrieved July 6, 2005, from http://www.autonews.com/article.cms?articleId=20471

Quinn, J. B., Anderson, P., & Finkelstein, S. (1998). Managing professional intellect: Making the most of the best. *Harvard Business Review of Knowledge Management*, 181-205.

Raghunathan, S. (1999). Interorganizational collaborative forecasting and replenishment systems and supply chain implications. *Decision Sciences, 30*(4), 1053-1071.

Rhodes, E., & Carter, R. (2003). Collaborative learning in advanced supply systems: The KLASS Pilot Project. *Journal of Workplace Learning, 15*(6), 271-279.

Rozemeijer, F., Van Weele, A., & Weggeman, M. (2003). Creating corporate advantage through purchasing: Toward a contingency model. *Journal of Supply Chain Management, 39*(1), 4-13.

Scott, J. E. (2000). Facilitating interorganizational learning with information technology. *Journal of Management Information Systems, 17*(2), 81-113.

Suris, O., & Templin, N. (1993, October 5). GM production problems hurt '94 model sales. *Wall Street Journal*, pp. A4.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17,* 27-43.

Troyer, C. (1996, May 21-23). EFR: Efficient food service response. *Proceedings of the Conference on Logistics*, Palm Springs, California.

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Chapter 2.37
Frequent Itemset Mining and Association Rules

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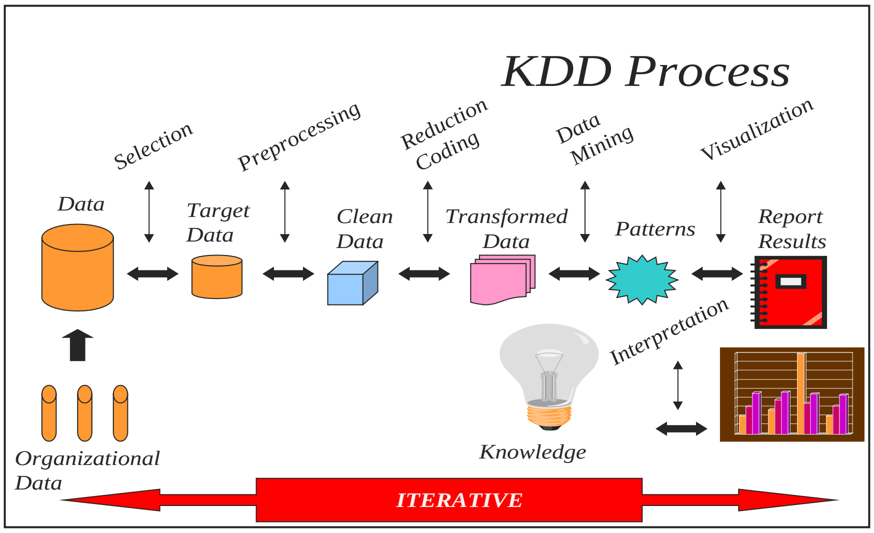
INTRODUCTION

With the advent of mass storage devices, databases have become larger and larger. Point-of-sale data, patient medical data, scientific data, and credit card transactions are just a few sources of the ever-increasing amounts of data. These large datasets provide a rich source of useful information. Knowledge Discovery in Databases (KDD) is a paradigm for the analysis of these large datasets. KDD uses various methods from such diverse fields as machine learning, artificial intelligence, pattern recognition, database management and design, statistics, expert systems, and data visualization.

KDD has been defined as "the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data" (Fayyad, Piaetsky-Shapiro, & Smyth, 1996). The KDD process is diagramed in Figure 1.

First, organizational data is collated into a database. This is sometimes kept in a data warehouse, which acts as a centralized source of data. Data is then selected from the data warehouse to form the target data. Selection is dependent on the domain, the end-user's needs, and the data mining task at hand. The preprocessing step cleans the data. This involves removing noise, handling missing data items, and taking care of outliers. Reduction coding takes the data and makes it usable for data analysis, either by reducing the number of records in the dataset or the number of variables. The transformed data is fed into the data mining step for analysis, to discover knowledge in the form of interesting and unexpected patterns that are presented to the user via some method of visualization. One must not assume that this is a linear process. It is highly iterative with feedback from each step into previous steps. Many different analytical methods are used in the data mining step. These include decision trees, clustering, statistical tests, neural networks, nearest neighbor algorithms, and association rules. Association rules indicate the

Figure 1. The KDD process



co-occurrence of items in market basket data or in other domains. It is the only technique that is endemic to the field of data mining.

Organizations, large or small, need intelligence to survive in the competitive marketplace. Association rule discovery along with other data mining techniques are tools for obtaining this business intelligence. Therefore, association rule discovery techniques are available in toolkits that are components of knowledge management systems. Since knowledge management is a continuous process, we expect that knowledge management techniques will, alternately, be integrated into the KDD process. The focus for the rest of this article will be on the methods used in the discovery of association rules.

BACKGROUND

Association rule algorithms were developed to analyze market basket data. A single market basket contains store items that a customer purchases at a particular time. Hence, most of the terminology associated with association rules stems from this domain. The act of purchasing items in a particular market basket is called a transaction. Market basket data is visualized as Boolean, with the value 1 indicating the presence of a particular item in the market basket, notwithstanding the number of instances of an item; a value of 0 indicates its absence. A set of items is said to satisfy a transaction if each item's value is equal to 1. Itemsets refer to groupings of these items based on their occurrence in the dataset. More formally, given a set $I = \{ i1, i2, i3, \ldots in \}$ of items, any subset of I is called an itemset. A k-itemset contains k items. Let X and Y be subsets of I such that $X \cap Y = \varphi$. An association rule is a probabilistic implication $X \Rightarrow Y$. This means if X occurs, Y also occurs. For example, suppose a store sells, among other items, shampoo (1), body lotion (2), hair spray (3), and beer (4), where the numbers are item numbers. The association rule shampoo, hair spray $\Rightarrow$ beer can be interpreted as, "those who purchase shampoo and hair spray will also tend to purchase beer."

There are two metrics used to find association rules. Given an association rule X ⇒ Y as defined above, the support of the rule is the number of transactions that satisfy X ∪ Y divided by the total number of transactions. Support is an indication of a rule's statistical significance. Interesting association rules have support above a minimum user-defined threshold called minsup. Given the database represented in Figure 2, the support of the association rule shampoo, hair spray ⇒ beer is equal to the number of transactions where shampoo, hairspray, and beer are equal to 1. This is equal to the shaded region and consists of a support of 4 out of 12 transactions, or 33%. Frequently occurring itemsets, called frequent itemsets, indicate groups of items customers tend to purchase in association with each other. These are itemsets that have support above the user-defined threshold, minsup.

Given an association rule X ⇒ Y as defined above, the confidence of a rule is the number of transactions that satisfy X ∪ Y divided by the number of transactions that satisfy X. In Figure 3, the shaded portion indicates the support of Shampoo and Hair Spray. The confidence is then the support of the itemset Shampoo, Hairspray and Beer, divided by the support of Shampoo and Hairspray which equals 4/6 = 66%. It is common practice to define a second threshold based on a user-defined minimum confidence called minconf. A rule that has support above minsup and confidence above minconf is an interesting association rule (Agrawal, Imielinski, Swami, 1993; Agrawal & Srikant, 1994; Agrawal, Mannila, Srikant, Toivonen, & Verkamo, 1996).

Figure 2. Support of shampoo, hair spray ⇒ beer 4/12 or 33%

1. Shampoo	2. Hair Spray	3. Body Lotion	4. Beer
1	0	1	1
1	1	1	0
1	1	1	1
1	0	1	1
0	0	0	1
1	0	1	1
1	1	1	0
1	1	1	1
0	1	0	1
1	1	1	1
1	1	1	1
1	0	0	1

Figure 3. Support of shampoo and hair spray

1. Shampoo	2. Hair Spray	3. Body Lotion	4. Beer
1	0	1	1
1	1	1	0
1	1	1	1
1	0	1	1
0	0	0	1
1	0	1	1
1	1	1	0
1	1	1	1
0	1	0	1
1	1	1	1
1	1	1	1
1	0	0	1

FINDING ASSOCIATION RULES

Finding association rules above minconf, given a frequent itemset, is easily done and linear in complexity. Finding frequent itemsets is exponential in complexity and more difficult, thus necessitating efficient algorithms. A brute force approach would be to list all possible subsets of the set of items I and calculate the support of each. Once an itemset is labeled frequent, partitions of the set's items are used to find rules above minconf. Continuing our example, assume minsup = 65%. Figure 4 lists all the subsets of the set of the items in Figures 2 and 3. The shaded areas indicate the frequent itemsets with support equal to or above

Figure 4. Itemsets and their support

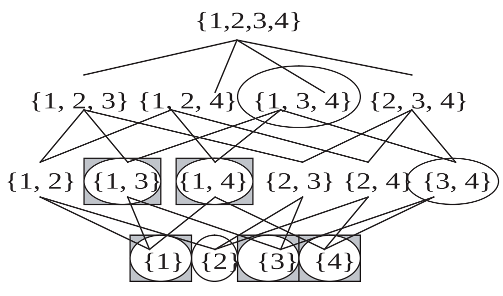
Itemset	Support (in percent)	Itemset	Support (in percent)
{1}	83	{2}	58
{3}	75	{4}	83
{1,2}	50	{1,3}	75
{1,4}	66	{2,3}	50
{2,4}	41	{3,4}	58
{1,2,3}	50	{1,2,4}	33
{1,3,4}	58	{2,3,4}	33
{1,2,3,4}	33		

65%. The set of all itemsets forms a lattice, as seen in Figure 5.

One can see that the brute force method grows exponentially with the number of items in I. In a database containing thousands of items, a brute force approach can become intractable. Algorithms that are exponential relative to the number of variables are said to suffer from "the curse of dimensionality."

If we look at the 1-itemsets in Figure 4, we notice that itemset {2} is below minsup. In fact, all supersets of itemset {2} are below minsup as well. This is illustrative of the upward closure property of support. If an itemset is not frequent, then the itemset's supersets will not be frequent. Many association rule algorithms use this property to prune the search space for frequent itemsets.

Figure 5. Lattice of itemsets



Apriori is one such algorithm (Agrawal et al., 1993; Agrawal & Srikant, 1994; Agrawal et al., 1996).

APRIORI ALGORITHM

Apriori uses the upward closure property of support to move level wise through the lattice. To find frequent itemsets, Apriori first scans the data set for the counts of 1-itemsets, since all 1-itemsets are candidates to be frequent. Those frequent 1-itmesets are used to generate the 2-itemsets that are candidates to be frequent. In general, Apriori generates candidate itemsets at a particular level k from the k-1 itemsets at level k-1. This is done in the algorithm's join step. If two frequent itemsets at level k-1 have the same k-2 items in common, we form the union of these two sets. The resulting set is a candidate k-itemset. Each of these candidate itemsets are checked to see if any of their subsets are not frequent. If so, they are pruned from consideration in the prune step, since if you recall, supersets of itemsets that are not frequent, are themselves not frequent. Candidate itemsets that do not have support equal to or above minsup are also pruned. The algorithm proceeds level wise through the lattice, until there are no more candidate itemsets generated.

Using the data set from Figure 1, in level 1 of Figure 5, the algorithm starts with all the 1-itemsets as candidate itemsets. Candidate itemsets in the figure are circled. Counting the support of each itemset, we see that all but {2} are frequent. A box indicates frequent itemsets. Itemsets {1}, {3}, and {4} combine to form candidate 2-itemsets {1,3}, {1,4}, and {3, 4}. From the data we see that itemsets {1, 3} and {1, 4} are frequent. Since {1, 3} and {1, 4} have k-1 items in common, these itemsets are combined to form the candidate 3-itemset {1, 3, 4}. Itemset {3, 4} is a subset of {1, 3, 4}. Since {3, 4} is not frequent, {1, 3, 4} cannot be frequent. The algorithm stops since we cannot generate any more candidate itemsets.

VARIATIONS ON APRIORI

Researchers have devised improvements to overcome the bottlenecks in the Apriori algorithm. One bottleneck is the time needed to scan the dataset since the dataset is huge, normally terabytes large. Because of this, a lot of the work done by these algorithms is in searching the dataset. The authors of Apriori realized that transactions that do not contain k large itemsets would not contain k+1 large itemsets. Thus avoiding further scans of the dataset (Agrawal et al., 1996). Another improvement was to implement the use of transaction identification lists (TID lists). These are the lists of transactions an itemset is contained in. The dataset is scanned only once to create the TID lists for the 1-itemsets. The TID lists for itemsets on any level k+1 is created by taking the intersection of the TID lists of the itemsets from level k used in their creation. The problem with TID lists is that initially, the size of the list has the potential to be larger than the dataset. In recognition of this, the authors of Apriori developed Apriori Hybrid, which scans the dataset in the beginning levels of the algorithm, and then switches to TID lists.

Other researchers have taken different approaches to the problem of scanning large datasets. In Dynamic Hashing and Pruning (DHP), it was recognized that in level wise algorithms like Apriori, much of the work is done in generating and counting the 2-itemsets (Park, Chen, & Yu, 1995). The approach here was to hash the candidate 2-itemsets. The number of itemsets in each bin is stored. If the total count of the itemsets in a bin is not larger than or equal to minsup, then the itemsets in that bin cannot reach minsup. These itemsets are pruned, and the algorithm proceeds as in Apriori.

Another approach was to break the dataset into n partitions such that each partition fits into main memory (Savasere, Oiecninski, & Navathe 1998). The premise is that any global large itemset must also be one of the local frequent itemsets found in a partition. Once frequent itemsets in local partitions are found, the dataset is scanned to determine which of these is global.

Another approach has been to create a random sample from the dataset large enough to fit into memory (Toivonen, 1996). The sample is then used to find frequent itemsets. In order to increase the probability that those itemsets found in the sample would include all frequent itemsets from the dataset, the sample is scanned with a lower support than that used for the dataset. The transactions of the dataset, not in the sample, are then used to check the support counts of the sample frequent itemsets. Thus only one scan of the dataset is required, but there is no guaranty that all frequent itemsets will be found.

Datasets that are increasing in size pose the problem of how to efficiently mine the new data. One could run an algorithm like Apriori on the "new" larger dataset, but this ignores all previous work done in discovering frequent itemsets. In addition it is costly and inefficient since most of the work done in finding frequent itemsets is in scanning the dataset. To avoid redoing one can take an incremental approach whereby you use the information obtained in previous association rule processing to reduce the amount of dataset scans when new transactions are added (Ayan, Tansel, & Arkun, 1999).

Below, we list the notation used in incremental association rule mining.

- DB is the set of old transactions from the original database.
- db is the set of new incoming transactions (the increment).
- DB+db is the set of old and new incoming transactions (the resulting combined dataset).
- SCDB (X) is the support count of itemset X in DB.
- SCdb (X) is the support count of X in db.
- SCDB + db (X) is the support count of X in DB+ db.

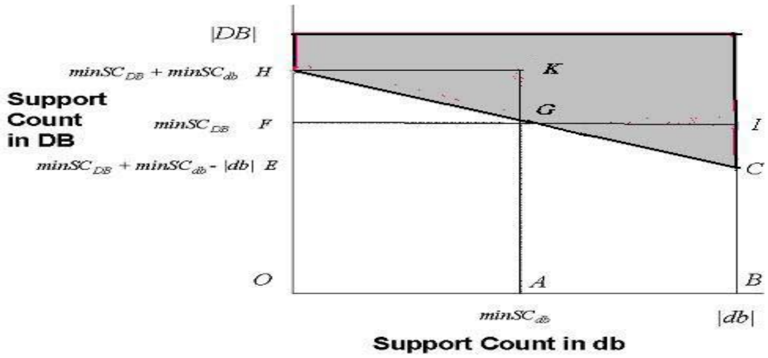
Assume that the size of the increment db is less than the size of the original dataset DB. Define the support count (SC) of an itemset as the number of occurrences of that itemset in the dataset. Figure 6 is an illustration of the incremental approach in terms of the support count of DB (SCDB) plotted against the support count of db (SCdb) (Imberman, Tansel, & Pacuit, 2004). For each point (SCdb, SCDB) in Figure 6, SCdb + SCDB = SCDB+db, which is the support count of the new dataset. Let minSCdb be the minimum number of transactions to be frequent in db and minSCDB be the minimum number of transactions to be frequent in DB. Therefore, for all points G on line HC, SCdb + SCDB = minSCDB+db. Line HC partitions the space of itemsets. All itemsets above and including HC are frequent. All itemsets below HC are not frequent. Triangle HFG represents those itemsets that have become infrequent or have submerged. Triangle GIC represents those itemsets that have become frequent or emerged. The incremental discovery problem can be thought of as efficiently identifying those itemsets in triangles GIC and HFG.

Update With Early Pruning (UWEP; Ayan et al., 1999) has been shown to be an efficient incremental association rule algorithm. Like most incremental algorithms, UWEP uses information found in the increment to prune the search space. First UWEP scans db to find the counts for all the 1-itemsets. In the pruning step, the supersets of the itemsets in DB that are found not frequent in DB + db are pruned from DB + db. The frequent itemsets in DB, whose items are absent in db, are checked to see if SCDB (X) >= SCDB + db (X). Frequent itemsets in db are looked at to see if they are frequent in DB. These are frequent by definition. Lastly, for all itemsets that are frequent in DB or db and have not yet been looked at, they are checked to see if they are frequent in DB + db.

Besides researching new ways for efficiently finding association rules, researchers have looked at the rules themselves, finding new types of association rules. Association rules are Boolean, looking only at the positive associations between items. Some researchers have looked at the negative dependencies as well, calling these rules dependency rules (Silverstein, Brin, & Motwani 1998). A dependency rule can express concepts such as males age 60 or greater = yes and smokes = no ⇒ buy beer = no. Imberman et al. (2002) have shown that dependency rules are more expressive for medical data miming than association rules.

Since most data is not Boolean by nature, how can one show associations with numeric and categorical data? Quantitative association rules

Figure 6. The incremental association rule problem



express associations such as Age: 30 to 39 and Owns car = yes $\Rightarrow$ Median Income = 40,000. One approach was to map each category in a categorical variable, to a Boolean variable and discretize the quantitative variables into intervals (Srikant & Agrawal, 1996). Each interval is mapped onto a Boolean variable. Then any Boolean association rule algorithm can be used to find rules. However, care needs to be exercised in partitioning each variable appropriately. If a quantitative variable is partitioned into too many smaller intervals, minimum support may not be found in any one interval. Therefore some well-supported rules may be missed. Also, confidence can decrease with larger intervals affecting the attainment of minimum confidence. Thus, small intervals might not get minimum support, while large intervals might not get minimum confidence. An approach to solve this problem is to consider all possible continuous ranges (Srikant & Agrawal, 1996). If we were to increase the interval size then we would have no more minsup problem. To take care of this we can combine adjacent intervals. But we may still have minconf problems. We can solve minconf problems by increasing the number of intervals. But doing both leads to two more problems. Given n intervals, there are on average O(n2) possible ranges. There is therefore a blow up in execution time. Given an interval with support, any range containing that interval also has support. This can lead to a blow up in the number of rules known as the many rules problem. Srikant and Agrawal (1996) posed a solution by setting a user-defined maximum on the size of the interval and using an interestingness measure to filter out uninteresting rules.

The ‘many rules problem’ has motivated research into the ‘interestingness’ of rules produced by association rule algorithms. Methods for interestingness involve ordering and grouping association rules in order to facilitate their use and interpretation. Metrics for ordering rules include measures such as confidence, added value, mutual information (Sahar & Mansour, 1999), and conviction measures (Brin, Motwani, Ullman, & Tsur, 1997). Objective interestingness measures seem to cluster into three groups when support and confidence levels are low. Interestingness measures in the same cluster produce similar rule orders. Sahar (1999) along with Mansour (1999) pruned the rule set by discarding ‘uninteresting’ rules. Sahar worked under the premise that simple rules would already be known by the user and can thus be pruned from the rule set. Sahar (2002) used clustering to group similar rules.

FUTURE TRENDS

Association rule discovery algorithms feed their results into organizational knowledge bases. An important issue is the maintenance and update of discovered association rules as new data becomes available. The incremental algorithms we have summarized above are very useful and cost effective for knowledge management. Research into the combination of sound knowledge management techniques and data mining techniques can make significant contributions to the business environment.

Research into the types of rules that can be generated using the techniques outlined in this article is ongoing. Reduced database scanning by improvements on the basic algorithm is another area of research activity. In addition much current research is being concentrated on finding better data structures for more efficient itemset processing (Gosta & Zhu, 2003). Association rule mining is a very active research field.

CONCLUSION

Association rule algorithms show co-occurrence of variables. One of the major problems inherent in Apriori, and algorithms like Apriori, is that there tends to be a large number of rules generated, some of which are commonly known. In addition, attempts to use the rules generated by association rule algorithms has met with mixed results. On the other hand, Apriori has also been shown to find less obvious patterns in the data (Cox, Eick, Wills, & Brachman, 1997), thereby discovering very valuable knowledge.

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REFERENCES

Agrawal, R., Imielinski, T., & Swami, A. (1993). Mining association rules between sets of items in large databases. *Proceedings of ACM SIGMOD* (pp. 207-216).

Agrawal, R., Mannila, H., Srikant, R., Toivonen, H., & Verkamo, A.I. (1996). Fast discovery of association rules. In U. Fayyad, G. PiatetskyShapiro, P. Smyth, & R. Uthurusamy (Eds.), *Advances in knowledge discovery and data mining* (pp. 307-328). Boston: AAAI/MIT Press.

Agrawal, R., & Srikant, R. (1994). *Fast algorithms for mining association rules.* IBM Res. Rep. RJ9839, IBM Almaden.

Aumann, Y., & Lindell, Y. (1999). A statistical theory for quantitative association rules. *Proceedings of the 5th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 261 -270).

Ayan, N.F., Tansel, A.U., & Arkun, E. (1999). An efficient algorithm to update large itemsets with early pruning. *Proceedings of the 5th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 287-291).

Brin, S., Motwani, R. Ullman, J., & Tsur, S. (1997). Dynamic itemset counting and implication rules for market basket data. *Proceedings of ACM SIGMOD* (pp. 255-264).

Cox, K.C., Eick, S.G., Wills, G.J., & Brachman, R.J. (1997). Visual data mining: Recognizing telephone calling fraud. *Data Mining and Knowledge Discovery, 1*(2), 225-231.

Fayyad, U.M., Piaetsky-Shapiro, G., & Smyth, P. (1996). *From data mining to knowledge discovery: An overview. Advances in knowledge discovery and data mining.* Cambridge, MA: AAAI/MIT Press.

Fukada, T., Yasuhiko, M., Sinichi, M., & Tokuyama, T. (1996). Mining optimized association rules for numeric attributes. *Proceedings of the ACM SIGMOD International Conference on Management of Data* (pp. 13-23).

Gosta, G., & Zhu, J. (2003). Efficiently using prefix-trees in mining frequent itemsets. *Proceedings of the IEEE ICDM Workshop on Frequent Itemset Mining Implementations.* Retrieved from http://sunsite.informatik.rwth-aachen.de/Publications/CEUR-WS//Vol-90/

Imberman, S.P., Domanski, B., & Thompson, H.W. (2002). Using dependency/association rules to find indications for computerized tomography in a head trauma dataset. *Artificial Intelligence in Medicine, 26*(1), 55-68.

Imberman, S.P., Tansel, A.U., & Pacuit, E. (2004). An efficient method for finding emerging large itemsets. *Proceedings of the 3rd Workshop on Mining Temporal and Sequential Data, ACM SIGKDD International Conference on Knowledge Discovery and Data Mining.*

Park, J.S., Chen, M.S., & Yu, P.S. (1995). An effective hash based algorithm for mining association rules. *Proceedings of ACM SIGMOD* (pp. 175-186).

Sahar, S. (1999). Interestingness via what is not interesting. *ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 332-336).

Sahar, S., & Mansour, Y. (1999). An empirical evaluation of objective interestingness criteria. *Proceedings of the SPIE Conference on Data Mining and Knowledge Discovery* (pp. 63-74).

Sahar, S. (2002). Exploring interestingness through clustering: A framework. *Proceedings of the IEEE International Conference on Data Mining* (ICDM 2002) (pp. 677-681).

Savasere, A., Omiecinski, E., & Navathe, S. (1998). An efficient algorithm for mining association rules in large databases. *Proceedings of the IEEE International Conference of Data Engineering (ICDE 1998)* (pp. 494-502).

Silverstein, C., Brin, S., & Motwani, R. (1998). Beyond market baskets: Generalizing association rules to dependence rules. *Data Mining and Knowledge Discovery, 2*(1), 39-68.

Srikant, R., & Agrawal, R. (1996). Mining quantitative association rules in large relational tables. *Proceedings of the ACM SIGMOD International Conference on Management of Data* (pp. 1-12).

Toivonen, H. (1996). Sampling large databases for association rules. *Proceedings of the 22nd International Conference on Very Large Databases (VLDB'96)* (pp. 135-145).

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Chapter 2.38
Learning Networks and Service-Oriented Architectures

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INTRODUCTION

The value of knowledge assets in creating competitive advantage and subsequently wealth through innovation has never been greater (Teece, 1998). It is increasingly being acknowledged that the resources and the competencies developed within the organisation as well as the mechanisms for building up and reconfiguring these competencies is the only defence against a fierce competition (Penrose, 1959; Prahalad & Hamel, 1990; Teece, Pisano & Shuen, 1997). However, the nature of knowledge production has changed dramatically over the last years. According to Gibbons et al. (1994), the knowledge production has moved from mode 1 to mode 2. The new mode:

- requires transdisciplinary approaches
- is characterised by heterogeneity of skills
- is context-sensitive involving an intense interaction between producers and users of knowledge

The highly complex and rapidly changing character of contemporary knowledge production makes it almost impossible for single organisations to acquire the full set of required skills. Even large corporations with abundant resources need to turn to other organisations in order to cope with new knowledge requirements. Learning through networking with other firms gives the opportunity not only to share expenses and resources, but more significantly, to listen to new ideas, challenge one's own inherent assumptions, and embrace new perspectives.

The challenge associated with this is to set up an infrastructure to support shared learning and reflection on a regular and sustainable basis. To answer this problem, the mechanism of the so-called learning networks (LN) has been introduced. Learning networks do not refer to networks of organisations where learning simply happens—as is the case with every network—but to interorganisational networks where structures have been established with the primary purpose of increasing the participants' knowledge. These networks:

- involve representatives of different organisations, mainly but not exclusively, private firms
- are formally established with clear and defined boundaries for participation
- have an explicit structure for operation with regular processes that can be mapped to the learning cycle
- have a primary learning target—some specific learning/knowledge which the network is going to enable
- can assess the learning outcomes which feed back to the operation of the network.

The formal character of the network provides an institutionalised organisational platform which represents a permanent structure for identifying knowledge gaps and satisfying knowledge needs, allows evaluation, and accumulates experience regarding the support required by learners. More significantly, the lasting character of membership in learning networks facilitates the development of trust relationships among learners.

Information technology can play a critical role in supporting LNs. Yet, the majority of current KM systems have been designed under the assumption that they will be used within a single organisation or that a single organisation will be responsible for their operation. KM systems appropriate for interorganisational use dictates that several challenges are met. For example, interorganisational information systems must not only provide reliable infrastructures for the organisation itself but also must be capable of sharing resources seamlessly within their network of learning partnerships. These operating conditions demand that such systems are both flexible and operate transparently. Over the past few years, service-oriented architectures have emerged as a framework that addresses this requirement both effectively and efficiently. In this article, we discuss the current use of Web-based service architectures to support LNs and then outline future trends.

BACKGROUND

The new rules of competition (Teece, 1998) have demanded from organisations to build a concrete strategy for learning and continuous change (Argyris & Schon, 1996). Initially, loads of competent tutors and specialised trainers stormed the companies and apparently their resources, delivering high-quality training courses and material. It was only when Orr (1990a, 1990b) observed technicians in Xerox that it was realized that real value learning is intrinsically blended with communities which:

- make their own decisions
- practice the acquired knowledge
- improvise their approaches

In a similar vein, Lave and Wenger (1991) have talked of situated learning—learning that is intrinsically linked to the environment where it is situated—while Cook and Brown (1999) regard organisational learning governed by epistemology of practice rather than epistemology of possession (i.e., knowledge is fundamentally associated with practice and cannot be transferred as a commodity). These contributions have made Stamps (2000) wonder whether "learning is social [and] training is irrelevant" and Wenger (1998, 2000) suggest that real value learning can only happen in "communities of practice." Behind all these approaches, there is the notion that knowledge management cannot be separated from the tacit knowledge (Polanyi, 1966), that is, the knowledge we possess but we cannot tell. Nonaka and Takeuchi (1995) observed the process of knowledge creation within an organisation to conclude that knowledge is generated by regular exchanges between tacit and explicit knowledge. Tsoukas (2002) argues that tacit knowledge cannot be translated or converted into explicit knowledge:

We cannot operationalise tacit knowledge but we can find new ways of talking, fresh forms of interacting and novel ways of distinguishing and connecting…New knowledge comes about…when our skilled performance is punctuated in new ways through social interaction.

Meanwhile, a variety of scholars and policy-makers have noticed the phenomenal success of clusters of different companies. Becattini (1989, 1990) described the Italian experience where networks of small firms and other institutions have helped certain regions to achieve one of the highest rates of economic development and one of the lowest rates of unemployment in Europe. Several case studies point to the same conclusion: Southern Germany, South-West Belgium, Northern Denmark, M4 corridor in UK, Silicon Valley in California (Sengenberger & Pyke, 1990; Saxenian, 1991). Even in less developed economies like Brazil and Pakistan, the collective efficiency developed within clusters has phenomenal results (Bessant & Tsekouras, 2001). It is becoming clear that simple factors such as proximity do not, of themselves, explain the success of clustering. Humphrey and Schmitz identify the importance of developing trust relations, whilst Sengenberger and Pyke (1992) point out the readiness amongst firms for cooperation which help the firms to build shared learning mechanisms.

Building on the understanding developed in the two areas, a new approach has been developed to combine the virtues of both. More specifically, it was realised that significant knowledge benefits can be captured when communities of practice develop across firms boundaries, sharing experiences from their organisations. Using the mechanism of learning networks, practitioners groups are set up to reflect collectively and learn from each other, following a number of principles:

- Firms1, represented by managers, are allocated in small groups with up to 20 members
- All necessary decisions for learning are made by the learners themselves rather than experts and tutors
- Learning is practical and derives from the discussion of the concrete experience of the group members rather than the introduction of abstract concepts
- Part of the participants duties is to go to their own organisations, try out the learned approaches, come back to the group, and report their experience
- The group becomes a forum for sharing concerns, get psychological support, but also receive feedback on their own ideas from other practitioners.
- Experts and tutors may be invited occasionally, only when needed
- Knowledge resources are used but only in conjunction with their practical learning

Of course, knowledge interactions between different firms is not a new phenomenon (Nonaka & Takeuchi, 1995; Von Hippel, 1988). The challenge presented to learning networks was to develop the managerial capabilities required for sustaining and improvising these activities on a long-term basis2. In other words, the challenge for learning networks is to develop the organisational processes and the managerial capabilities which allow the systematic emergence and development of communities of practice between different firms. A critical enabler of this strategy is the appointment of a specially dedicated facilitator to assist the group's practitioners in their structured reflection. The facilitators have gone through special training (e.g., how to enhance group dynamics, how to tackle disagreement between members) and accumulate relevant experience over time. The learning groups receive further support by the network, that is, a wider organisation which includes all group members as well as those which are not in any group at a certain time. The network has its Managing Director, usually called the Network Moderator, who is responsible for providing a common ground for all different groups operating at a time, ensuring the interface between them and the cross-fertilisation of their experience.

The so-called learning networks range from networks focusing on:

- single issues (e.g., the British Quality Foundation)
- particular sectors (e.g., Industry Forum by the Society of Motor Manufacturers and Traders, CIRIA for the construction industry in UK)
- specific regions and particular sectors (e.g., AC Styria for the automotive sector in the Austrian region of Styria)
- specific regions without any sector or topic focus (e.g., Plato network in Ireland)

The benefits of the learning network approach is obvious for SMEs because it gives them a permanent forum for obtaining knowledge in an inexpensive way. Convinced by the advantages of the approach, multinational enterprises have also adopted the concept in three forms:

- internal learning networks between different units or departments of the enterprise, sometimes located in different parts of the world (e.g., Black & Decker)
- joint learning networks among themselves and their suppliers (e.g., the suppliers clubs in TOYOTA / Bessant et al., 2003)
- inter-corporations learning networks among the main players of a sector to share ideas, reflect jointly, and exchange good practices (e.g., SCRIA in the aerospace industry and CRINE in the energy sector in UK)

The potential of KM systems can contribute significantly to the improvement of the learning network processes. On one hand, the innovative scheme of learning networks represents a unique opportunity for KM systems to offer added value to businesses and their managers. Time after time, systems developers discover that successful and cost-effective design of information systems require a combination of theory and practical experience as well as dynamic and proven organisational designs which the information architectures can match.3 A good match between the information systems and the organisational layout can speed up the development process, reduce costs, increase productivity, improve the quality of software, and more significantly increase the relevance of KM systems to users. The next section reviews the value added that KM systems can offer to learning networks and their members.

PORTAL SERVICE ARCHITECTURES FOR LEARNING NETWORKS

Learning networks face the challenge of increasing the level and the knowledge-intensity of interaction among their members while at the same time they want to shorten the cycle of formation, trust development and knowledge sharing within groups. In order to do so, they have to improve their organisational processes that support directly or indirectly the knowledge interactions between the members. These processes include the decision-making, collaborative learning, and dissemination of and harvesting knowledge. Traditionally, all learning network processes were carried out primarily through physical meetings. This imposed significant limitations to the network activities due to severe time and travelling restrictions. For instance, if a manager-member of a group missed a session, he or she could not make up for it while the communication with other group fellows, the group facilitator, or even the network moderator was limited to the times of actual meetings.

The development of Web-based information systems gave the opportunity to learning networks to:

- facilitate planning and management of learning activities, including the decision-making for a number of issues such as the focus of learning, the strategic direction of the network, and so forth
- enhance communication and informal knowledge sharing among the network members
- support organisation of and access to network resources including learning material and "members details and photos" of other network fellows4
- facilitate the knowledge dissemination to the organisations of the firms represented in a group, namely the managers not participating to a group

Most often such activities are supported via a portal operated by the network broker. The network moderator and the group facilitators are ultimately responsible for the content, although virtual interactions such as net meetings and asynchronous communications are encouraged among the network and group members. Needless to say, implementation of a Web-based system does not automatically solve all the problems and the cautious reader should keep in mind the multitude of problems related to the architecture and deployment of IT in any organisational context.

The economics of rolling-out, populating with content, and maintaining such portals are more complex. Three distinguishing strategies have been identified (Tsekouras et al., 2004). Firstly, the liberal approach, where a general support effort is assumed by the broker to "have the ball rolling" in different areas. The broker's effort is rather limited and hopes to see the main initiative—and therefore its cost—undertaken by the network members.

Second is the catalytic intervention strategy, similar to what is called the "Clinton approach" (Greenstein, 2000). This strategy consists of very focused intervention by the broker, who therefore undertakes limited effort to roll out the system. The broker uses its intelligence to identify the critical, for its network, portal areas, and concentrates all its efforts to these areas. This strategy is definitely more intelligent than the liberal approach, but it also carries a significant higher risk since it puts "all its eggs in one basket."

Finally, the heavyweight strategy is where the network moderator is very active in uploading resources, updating the portal with the forthcoming events and learning sessions, filling in the personal details of the network members, and so forth. This incurred the broker a heavy cost in terms of days of work which is undertaken with the hope of high return on investment. This strategy is the most resource-intensive but also the less risky one. However, it requires the broker to be absolutely convinced for the potential benefits.

On the demand side, three generic patterns of usage have been identified regarding the practitioners-members of the network. The first pattern is reading in connection with the networks conventional activities namely physical learning sessions and events. The primary objective of this behaviour is to get prepared for or remembered of the organised sessions of the network, most of which are—at least currently—physical meetings.

The second pattern aims to improve the communication with the network broker in order to exploit his cognitive capability and accumulated experience to direct their own learning. In this pattern, the network members rely on the brokers' capability to direct them to useful news, new learning developments, and new sources of knowledge in order to update their knowledge and their own skills.

The third pattern is the one with the objective of bringing the learners-network members directly in touch with other fellow members or experts in order to learn from them. This virtual and direct transfer of knowledge can happen either in association with an actual meeting or on its own merit—as is the case with the virtual sessions at predefined times.

Despite the significant enhancement of the learning network processes by the LN portal, careful study reveals a broad set of challenges still unresolved by these systems. Although current Web technologies have provided the means for extensive electronic interaction between the network members, the sharing of information and knowledge resources must always go through the central network portal, creating a number of economic or cognitive bottlenecks. Indeed, before a network member can access network information or resources, a person must identify the relevant information or resource, seek the licence from the owner of the relevant information to share it in the network, upload the content in the network portal, and dispatch a notification to network members to alert them to the relevant update.

Carrying out these activities in full requires that considerable resources be consumed. Hence, the most effective strategy for increasing the knowledge-intensive interactions between the members is not necessarily the most efficient one from the resources point of view—what is called the heavyweight approach. Moreover, although individual organisations willingly participate in network exchanges, they remain independent and they want to keep control of their own resources. In other words, organisation's members may accept to share access to part of their own resources with other organisations' members but it is unlikely to consent to pass ownership of these resources to the network broker or other network members.

Third, in distributed computing systems the only trusted party to carry out the required steps is the network brokers, namely the network moderator or the group facilitators. However, the network brokers face significant cognitive limitations. For instance, it is almost impossible for the brokers to be aware of the full set of available knowledge resources existing in different members; even if he or she was, he or she would not be able to review, select, and disseminate all these resources on his or her own.

Finally, as the network grows, the brokers find it increasingly difficult to cope with the escalating responsibilities and demands of their tasks. As a result, the network should move from a "solar configuration" where the broker is the central node of interaction to a "spider web configuration." This configuration presupposes intelligent brokers, concentrating on the most critical aspects of learning networks such as building trust, resolving conflicts, and removing barriers, with the network members turning into active nodes of interaction and learning.

In short, while Web technologies have provided the means for extensive electronic interactions between network members, such interactions are significantly limited by financial and cognitive factors. In consequence, such interactions rarely go beyond the simple exchange of information. In the following section, we discuss how the emerging next generation service architectures can potentially help overcome these restrictions flexibly and transparently.

FUTURE TRENDS

Service-oriented architecture (SOA) (Stojanovic & Dahanayake, 2003) shifts the emphasis of information systems design from particular applications and application development frameworks toward well-defined and self-contained elements of functionality that do not depend on external context or state. Thus, systems are constructed by linking together services as needed so as to achieve specific goals. The value of SOA lies in the fact that it can effectively abstract enterprise architectures using the concept of the so-called

Service Bus, that is, a shared communications medium on which services may connect to and use in a plug-and-play manner.

In particular, in the case of highly decentralized, heterogeneous, and geographically distributed systems, SOA offers distinct advantages. In this context, SOA can help develop systems: that are scalable and can cater to large numbers of ever-changing users; that are trustworthy so as to protect confidential information; and last but not least, that are not constrained in terms of the particular technical choices. In particular, heterogeneity and distribution imply that there are frequent non-trivial issues regarding synchronization and concurrency as well as compatibility. To address these issues, numerous frameworks have been developed over the past decades, which employ middleware services and may rely heavily on reusable code and design patterns. Such frameworks need to address multiple issues including efficient and effective handling of remote processes, data, and input/output; naming; brokering, trading, and leasing resources; multiple levels of software abstractions; multiple attributes; security and trust management; threading and synchronization; and, finally, distributed transaction processing. In this context, SOA provides a novel solution which offers a significant advantage over all other solutions, namely its conceptual simplicity.

In the context of learning networks, SOA fulfils well a number of core requirements:

- Individual organisations can participate in a SOA by offering their resources to other network members without sacrificing control. In fact, they can define their own security policies and trust relationships and enforce them at the service level.
- Brokering and mediation bottlenecks can be readily bypassed, thus removing the information management limitations of the portal approach. In fact, relationships can be developed bilaterally in a peer-to-peer manner.
- Networks become scalable with additional members joining without unbalancing the existing relationships and systems. Moreover, network configurations can evolve in time and change with the topology of partner relationships without disturbing the established relationships of knowledge sharing.
- Different types of resources can be made available under the same service-based interface. For example, structured and unstructured information as well as computational resources can be made readily available under the common interaction paradigm of a service interface.
- Finally, it becomes possible to integrate the resources and process of the learning network to the internal workings of the network members as appropriate. Use of the services is automated and thus less manual effort is required in updating and maintaining resources.

Different technologies can be used to develop SOA. Currently, two candidates seem to attract most interest, namely Web services and the Grid. A Web service is a software system identified by its location on the World Wide Web and whose interface and supported modes of interaction are described using XML. The use of XML-based technologies, including the Universal Description, Discovery and Integration Protocol, and the Web Services Description Language, allow other systems to discover and use the service transparently as well as adapt their operation to meet its requirements. Interaction between systems using the Web service is also carried out using XML messages transferred over the Internet. Web services allow for the loose integration of service components and have the distinct advantage of employing widely available and standardised Web technologies.

Using Web Services, we can develop learning network infrastructures for controlled but open resource sharing especially where we have to deal with well-defined and possibly structured knowledge sources. For example, the case of the spider model architecture can be directly translated into a Web-based distributed and decentralised infrastructure, where network partners are in control of their own resources and are given discretionary access to resources of other members.

Often, the functionality offered by Web services does not fulfil all the requirements of a specific situation. In this case, a set of technologies that have become known as the Grid can be used to provide tighter coupling.

The Grid (Foster & Kesselman, 2003) is an umbrella term used to refer to a selection of technologies, protocols, services, application programming interfaces, software development kits, and turnkey systems to support coordinated resource sharing and problem-solving in dynamic, multi-institutional, virtual organisations. Although the Grid was initially focused primarily on advanced distributed supercomputing applications with emphasis on extreme computational power and data storage, today it commonly includes major technology trends, such as Internet, enterprise, distributed, and peer-to-peer computing to address much more mainstream situations. Indeed, resource sharing supported by the Grid can cater for process building through direct access to computers, software, data, and other resources, as is required by a range of collaborative problem-solving and resource brokering strategies. This type of sharing and collaborative learning is highly controlled, with resource providers and consumers defining clearly and carefully just what is shared, who is allowed to share, and the conditions under which sharing occurs. A set of individuals and/or institutions defined by such sharing rules form what is referred to in Grid parlance as a virtual organisation.

An early example of the use of SOA to support LNs can be observed in the Bloomsbury Bioinformatics Consortium (Orengo, Jones, & Thornton, 2003). This LN brings together researchers and practitioners in institutes located in the Bloomsbury of London with the common aim of developing innovative bioinformatics solutions for the medical industry. Interorganisational learning is assisted by the operation of a network infrastructure developed on the peer-to-peer Grid model, which allows for sophisticated levels of control over shared resources. Moreover, sharing of resources can be carried out in a cost-sensitive manner while embracing issues of quality of service, scheduling, co-allocation, and accounting. Finally, learning resources are annotated following a scheme which is uniform and representative of the particular learning network structure. To this end, the Consortium employs Semantic Web technologies, namely the Resource Description Framework, to describe themes and relationships between the different elements. Development of domain-specific ontologies is seen as a key element for collaborative relationships.

CONCLUSION

The blending of action learning with the network approach has produced a very powerful mechanism for sharing knowledge between different organisations, what has become known more widely as learning networks. This has generated unique results of learning and upgrading not only in terms of the skills of the involved individuals but also in terms of the processes of the relevant organisations. However, physical and practical constraints have limited the amount and the quality of the knowledge interactions among the members of the network. The first generation of Web technologies have enabled virtual and thus more convenient and longer lasting communication with other network partners as well as the network moderator and facilitators. The Web-based information systems also have given network members the opportunity to share resources through a centralised portal. However, these systems request major resource investment from the network brokers, generating a new set of constrains mainly related to the cognitive and practical limitations of the broker. In addition, these systems could not resolve the critical issues of efficient accumulation and ownership of the network resources.

The service-oriented architecture offers the opportunity to tackle these issues in an efficient and transparent way. Sharing of resources is feasible without losing the ownership rights, while the network brokers have to define the rules of sharing rather than collecting and disseminating the resources. The biggest advantage of these solutions is that they enable the transformation of learning networks from a solar broker-critical configuration to a spider web open resource configuration, allowing the flexible development of bipolar knowledge interactions without disturbing the overall balance of the system. Yet, the issues associated with the implementation of these new technologies need to be thoughtfully deliberated and carefully resolved.

REFERENCES

Argyris, C., & Schon, D. (1996). *Organisational learning II* Addison-Wesley.

Beamish, N.G., & Armistead, C.G. (2001). Selected debate from the arena of knowledge management: New endorsements for established organizational practices. *International Journal of Management Reviews, 3*(2), 101-111.

Becattini, G. (1989). Sectors and/or districts: Some remarks on the conceptual foundations of industrial economics. In E. Goodman & J. Bamford (Eds.), *Small firms and industrial districts in Italy.* London: Routledge.

Becattini, G. (1990). The Marshallian industrial district as a socio-economic notion. In F. Pyke, G. Becattini & W. Sengenberger (Eds.), *Industrial districts and inter-firm cooperation in Italy.* International Institute for Labour Studies, Geneva.

Bessant, J., Kaplinsky, R., & Lamming, K. (2003). Putting supply chain learning into practice. *International Journal of Operations & Production Management, 23*(2), 167-184.

Bessant, J., & Rush, H. (1995). Building bridges for innovation: The role of consultants in technology transfer. *Research Policy, 24*, 97-114.

Bessant, J., & Tsekouras G. (2001). Developing learning networks. *A.I. & Society, Special Issue on Networking, 15*, 82-98.

Best, M. (1990). *The new competition.* Oxford, UK: Polity Press.

Buchel, B., & Raub S., (2002). Building knowledge-creating value networks. *European Management Journal, 20* (6), 587-596.

Burner, M. (2003). The deliberate revolution: Transforming integration with XML Web services. *ACM Queue, 1*(1), 12-20.

Cook , S.D., & Brown, J.S (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 10*(4), July-August, 381-400.

Foster, I., & Kesselman, C. (2003). *The grid: Blueprint for a new computing infrastructure.* Morgan Kaufmann.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994) *The new production of knowledge: Science and research in contemporary societies.* London: Sage.

Greenstein, F. (2000). *The presidential difference: Leadership style from Roosevelt to Clinton.* Martin Kessier books, Free Press.

Humphrey, J., & Schmitz, H. (1996). The triple C approach to local industrial policy. *World Development, 24*(12), 1859-1872.

Lave J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Leonard-Barton, D. (1995). *Wellsprings of knowledge.* Boston: Harvard Business School Press.

McDermott, R. (1999). Why information technology inspired but cannot deliver knowledge management. *California Management Review, 41*(4), 103-117.

Monday, P.B. (2003). *Web services patterns: Java Edition.* New York: Academic Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company.* New York: Oxford University Press.

Orengo, C.A., Jones, D.T., & Thornton, J.M. (2003). *Genes, proteins and computers.* BIOS Scientific Publishers.

Orr, J. (1990a). *Talking about machines: An ethnography of a modern job.* Doctoral thesis, Cornell University.

Orr, J. (1990b). Sharing knowledge, celebrating identity: War stories and community memory in a service culture. In D.S. Middleton & D. Edwards (Eds.)*, Collective remembering: Memory in society.* Beverly Hills, CA: Sage Publications.

Penrose, E. (1959). *Theory of the growth of the firm.* New York: John Wiley & Sons.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Keegan Paul.

Prahalad, C., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review,* May-June, 79-91.

Saxenian, A. (1991). The origins and dynamics of production networks in Silicon Valley. *Research Policy, 20.*

Schmitz, H., (1995). Collective efficiency: Growth path for small-scale industry. *Journal of Development Studies, 31*(4), 529-566.

Sengenberger, W., & Pyke, F. (1992). Industrial districts and local economic regeneration: research and policy issues. In F. Pyke & W. Sengenberger (Eds.), *Industrial districts and local economic regeneration* (pp. 1-30). International Institute for Labour Studies, Geneva.

Stamps, D. (2000). Communities of practice: Learning is social. Training is irrelevant. In E. Lesser, M. Fontaine, J. Slusher, (Eds.), *Knowledge and communities* (pp. 53-64). Butterworth-Heinemann.

Stojanovic, Z., & Dahanayake, A. (2004). *Service-oriented software system engineering: Challenges and practices.* Hershey, PA: Idea Group Publishing.

Teece, D. (1998). Capturing value for knowledge assets: The new economy, markets for know-how, and intagible know-how and intangible assets. *California Management Review, 40*(3), Spring, 55-79.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18,* 509-33.

Tsekouras, G., Swift, G., Coughlan, C., Berry, M., Steiner, G., & Sochos, A. (2004). *Final evaluation report.* Knowlaboration Project, IST-2001-32505, EU, Luxembourg.

Tsoukas, H. (2002). Do we really understand tacit knowledge? In M. Easterby-Smith & M.A. Lyles (Eds.), *Handbook of organizational learning and knowledge.* Blackwell.

Von Hippel, E. (1988). *The sources of innovation.* Oxford: Oxford University Press.

Wenger, E. (1998). Communities of practice: The key to knowledge strategy. In E. Lesser, M. Fontaine, & J. Slusher (Eds.), *Knowledge and communities* (pp. 3-20). Butterworth-Heinemann.

Wenger E., & Snyder W. (2000). Communities of practice: The organisational frontier. *Harvard Business Review,* Jan-Feb, 139-145.

ENDNOTES

1. These firms can be even in the same sector, but they should not be direct competitors in the sense of targeting the same market niche.
2. The effectiveness of communities-based learning has been a concern for managers in intraorganisational context (Buchel & Raub, 2002).
3. The failure of developers to take sufficiently into account these issues have led to a significant amount of criticism against KM systems (McDermott, 1999; Beamish & Armistead, 2001).
4. The access to contact information of other network fellows has been acknowledged as a very important contribution by the network members "as we only meet monthly [and] it's handy to refresh memory (face to name)" (Tsekouras et al., 2004).

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Chapter 2.39
Distributed Learning Objects: An Open Knowledge Management Model

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ABSTRACT

This chapter analyzes the emergence of learning objects as a dynamic and interactive relationship between technology and the organization. We examine the way that organizational objectives are embedded within selected technologies. In other words, how is the selected technology addressing the organization's needs? Further, we argue for a socially-constructed model of knowledge management. Specifically, we utilize Demarest's (1997) four-step process of the construction of a knowledge economy. From these processes, via a constructed technological system, a learning object economy emerges, which includes various constituents: the 21st century learner, the subject matter expert (university professor), vendors who support or enable knowledge management, and populaces that harvest and benefit from the collection of knowledge.

INTRODUCTION

As state and federal funds diminish and as higher education resources and university budgets become more restricted, postsecondary institutions are becoming increasingly entrepreneurial in pursuing and developing technological solutions. Meyer (2002) describes a changing marketplace, increasingly global in orientation, where technology enables the provision of adult education, executive training/retraining, competency-based programs, and education to remote geographical areas. Knowledge management,1 in higher education, is a way to retain and manage knowledge products. As higher education organizations increasingly interact with other organizational types, such as corporations, consortia, and other educational institutions, knowledge products become critical in the exchange process. Technological systems are designed to manage knowledge and are situated in social systems with corresponding cultures, values, and beliefs. As such, higher education, as an organizational structure and a social system, must consider processes, policies, and embedded assumptions about technology, teaching, and learning, not only within their own institution, but also across those with which they interact.

The trend toward knowledge management is evidenced in the myriad of technological artifacts that have emerged to capture, categorize, and manage learning objects. During their evolution, learning objects have come to be defined in a number of ways, depending on the context and culture from which they emerge, for example, computer science, education, instructional technology, and so on. For our purposes, we define a learning object as any digital asset that is intended to be used to achieve a learning objective and can be re-used in different contexts. Learning objects may be data or data sets, texts, images or image collections, audio or video materials, executable programs, courses offered through Learning/Course Management Systems (L/CMS), or other resources that can be delivered electronically. Learning objects should be re-useable and re-purposeable over time and location and interoperable across systems and software (see Downes, 2002; Robson, 2001; Wiley, 2000). Additionally, learning objects can be combined or aggregated in different ways providing the potential for individualized learning experiences for specific learners in which their learning styles, prior knowledge, and specific learning needs are accounted for. They may also offer great value in terms of saving time and money in course development, increasing the reusability of content, enhancing students' learning environment, sharing knowledge within and across disciplines, and engaging faculty members in a dynamic community of practice (Bennett & Metros, 2001). Learning objects may be created by individuals or institutions and therefore require consideration of digital rights as well as storage and distribution.

How learning objects are stored and subsequently accessed has been primarily addressed through technology systems known as digital learning object repositories. Thomas and Home (2004) have identified four rationales, not only for the development of learning objects, but also for their storage in these digital containers.

1. The Efficiency Route: The more institutions work together, the less likely replication of efforts and therefore reduced costs based on the idea that learning objects "deliver industrial economies of scale" (p. 12).
2. The Teacher-Centered Route: The more that educators share resources and best practices, the more likely teaching will improve. In this manner learning object "creation [is] co-production" (p. 12).
3. The Pupil-Centered Route: Learners who have access to a variety of objects designed with different learning needs in mind, can be better supported. In this sense, learning objects become "scalable and networked" (p. 13).
4. The Freedom Argument: Educators should take ownership and be able to disseminate freely to the larger educational community without struggling with or against issues of institutional ownership, intellectual property or even censorship.

These rationales serve to illustrate the value structures within organizational cultures that determine how technology is used to make knowledge accessible and the reasons for doing so. Such positions are reflected in organizational policies and are particularly critical within cross-institutional interactions.

This chapter analyzes the emergence of learning objects as a dynamic and interactive relationship between technology and the organization. We examine the way that organizational objectives are embedded within selected technologies. In other words, how is the selected technology addressing the organization's needs? Further, we argue for a socially-constructed model of knowledge management. Specifically, we utilize Demarest's (1997) four-step process of the construction of a knowledge economy. Next, we examine the way that knowledge is transmitted through a selected technological system. From these processes, via a constructed technological system, a learning object economy2 emerges, which includes various constituents: the 21st century learner, the subject matter expert (university professor), vendors who support or enable knowledge management, and populaces that harvest and benefit from the collection of knowledge. We discuss four current models of knowledge management found in higher education: the traditional model, the intellectual capital/appropriative model, the sharing/reciprocal model, and the contribution pedagogy model. We propose a new, relativist model of knowledge management for higher education that accommodates cross-institutional cultures and beliefs about learning technologies, construction of knowledge across systems and institutions, as well as the trend toward learner-centered, disaggregated, and re-aggregated learning objects, and negotiated intellectual property rights.

A STARTING POINT: THOMAS'S THEORY OF ORGANIZATIONAL TECHNOLOGY

Thomas (1994) argues that a technical system utilized within an organization can be objective, but also infused with objectives, reflective of the interests or goals of particular groups within the social system. A technological system, he contends, has the ability to define and redefine tasks, responsibilities, and relationships or to evoke or reinforce change. Further, the eventual selection of a specific technology reflects the interests and ideologies of the organizational structure. Organizations are composed of interdependent social and technological systems where changes in one usually occasion adaptation in the other (e.g., a course management system many interact with a registration system). However, the relationship between technology and the organization is dynamic and interactive, that is, technology may cause organizational change and organizational objectives may produce a change in the technological system. Thomas explains that in order for the technology to be incorporated into organizational life, it must be transformed from a physical object into a social one. In other words, organizational members must recognize that the technology exists and then negotiate a set of understandings about what it is, what it means, and how it defines and redefines tasks, responsibilities, and relationships. Thomas proposes a model of organizational technology whose adoption and use is shaped or determined, to some extent, by the organization that selects it. While he acknowledges that the technological system interacts with the organization and its objectives and vice versa, this model is limited to some extent by those very things: the organization and its objectives.

Current knowledge management models are organizationally-centered and are thus limited by the values and interests of their constituents. However, others are arguing for a transformation of the knowledge economy from one that is proprietary to a freestanding, shared knowledge community (Norris, Mason, & Lefrere, 2003). Norris et al. point to eight external and internal forces that are producing this shift: (1) Investments in infrastructure and best practices by "early adopters" of e-knowledge (e.g., associations, governmental agencies, corporations, universities) deliver results that encourage wider adoption, and also facilitate new generations of enterprise applications; (2) Global enterprises that increase competitiveness by developing faster ways to manage their knowledge and strategic learning by creating tools that non-experts can use; (3) Growth in expert networks and easier, more productive participation in communities of practice that push e-knowledge practices and competencies; (4) Increasing sophistication by users, who develop an appetite for services that provide significant gains in their capacity to access and assimilate knowledge; (5) Advances in Internet and intranet-based capabilities that enable jump shifts in creating and accessing knowledge stores; (6) Innovations in mobile communications that provide ubiquitous access to perpetual learning solutions, as well as new ways to meet demands for e-commerce in any place or time; (7) Insight into new and more effective ways of experiencing how knowledge drives innovation; and (8) Increased understanding about how to deploy international standards in ways that ensure useful return on investments (e.g., through interoperability) that stimulates continued investment. We believe that these are just some of the local and global changes occurring that are motivating higher education to explore a system of knowledge management that is socially-constructed rather than organizationally-determined. As this trend unfolds, there is an increasing demand for collaborative discourse and negotiation, not just about what technology means, but also how it is designed and how artifacts such as learning objects are shared. This trend is evidenced by such efforts as the IMS Global Learning Consortium, Inc., in which members from around the world work together to develop specifications for e-learning technologies.

SOCIAL CONSTRUCTION OF KNOWLEDGE AND LEARNING OBJECTS

The global nature of education within a distributed learning context requires that higher education, particularly considering learning objects as a valuable commodity that can be traded and exchanged, is part of an evolving knowledge economy. Texts, videos, and other materials have proven the value of institutionally-generated knowledge, but traditionally these products have produced revenue for an individual with value capital for the institution. Learning objects are forcing institutions to examine the economic exchange of the knowledge capital they are generating as they search for strategies to manage and negotiate value.

Following Thomas's theory of the social or organizational construction of technological systems and drawing from an economic business perspective, Demarest (1997) postulates that organizations value knowledge based on "what works." Business uses resource capital in order to develop processes and structures that result in increased sales and revenue. Davenport, DeLong, and Beers (1998) found four distinct types of knowledge management initiatives in corporations that were intended to:

1. Provide repositories for internally generated policy and informational knowledge;
2. Provide access to knowledge or transfer among individuals;
3. Facilitate the generation and use of knowledge; and
4. Manage knowledge assets in such a way that value is apparent.

Corporate knowledge management comes from an economic model that is based on a knowledgeable workforce that increases the organization's return on investment. Davenport, et al. believe an economic model is appropriate for learning objects in higher education in that they are, by definition, designed to be re-used and shared. Whether or not they have a monetary value assigned to them is incidental, it is the investment of development and dissemination that belies their institutional value. In higher education, "what works" is similar to that of business, but involves "human capital," which may result in increased enrollments, higher post-graduation employment rates, and academic recognition and prestige for the knowledge generated and disseminated. It is the latter that applies most directly to learning objects in that academic recognition comes from the intellectual production of knowledge that is to be disseminated across institutions, and to a large extent contributes to the knowledge base of those institutions.

Higher education values philosophical and scientific knowledge that is generated by the scholarship of its members. Such knowledge has traditionally driven innovation and production (Lyotard, 1984). The commodification of knowledge through information distributed through technologies such as the Internet has expanded the power of university-generated knowledge that can reach beyond business and government to everyone with access to the Internet. However, the value of philosophical and scientific knowledge may be confused with knowledge that keeps the organization performing. For Demarest (1997) this includes:

- A shared understanding of how value is determined, assigned, maintained, and communicated throughout the organization and with external groups or individuals with whom the organization interacts.
- A set of processes and systems—technical or human—that support and help channel the [organization's] value-creating activities (p. 1).
- A set of indicators that associate the value-creation process with the measures of the organization's success.
- A set of systems that as a part of the "knowledge management infrastructure that monitor the efficiency and effectiveness of that value creation process, indicate opportunities for performance improvement and generally signal the relative rise or decline in value creation" (p. 1).

Higher education has parallel types of performance knowledge manifested in standards for knowledge acquisition by the learner (program requirements, degree audits, grades), standards of academic knowledge (criteria for merit and tenure, peer review of intellectual property), structures and processes for control of organizational knowledge (publications, events, training), and standards for institutional knowledge (internal reviews, accreditation). The sum total of these types of knowledge and the mechanisms through which their value is determined and tied to performance is what allows the institution to function and yet varies among institutions, challenging the cross-fertilization and reciprocation that goes hand-in-hand with exchange of resources. Demarest believes organizational knowledge is socially constructed, and shared. This occurs through four processes: construction, embodiment, dissemination, and use.

Construction is "the process of discovering or structuring a kind of knowledge" (p.6). Organizations that are learning-focused (i.e., K-12, higher education, and workplace professional development departments) utilize specific processes of identifying valued knowledge. Value propositions in such organizations, and to a certain extent in industry where learning is seen as training, may come from external events or forces (community needs, governmental mandates, etc.) or from experience through interaction with client populations (focus sessions, course or training evaluations, documented complaints, etc.). Valued knowledge emerges through an iterative process of examining and implementing the governing body's mandates (government, professional organization, and certifying agencies), determining community- or client-based values and needs, and identifying best practices and policies that support the identified organizational outcomes.

Embodiment is "the process of choosing a container for knowledge once it is constructed" (p. 6). The container may take a variety of forms, most typically a document: manual, memoranda, report, tutorial, or speech. In higher education, such embodiments may be captured as learning objects and stored in a repository or learning content management system (L/CMS). How the embodiment is conceptualized may reflect the organizational cultural beliefs about the social relationships, communication processes, and the structures of authority. For example, L/CMSs that are course-based and only accessible to registered members of the course may indicate intellectual property controls or return on investment as indicated by course registration.

Dissemination "refers to the human processes and technical infrastructure that make embodied knowledge, such as documents, available to the people that use the documents and the bodies of knowledge" (p.6) that serve a function to achieve the organizational goals. Such knowledge dissemination is increasingly digital, although issues of access through systems and (perhaps) limitations of user's technical skills may be why some educational organizations rely on printed media. Digitization has enabled knowledge updates, re-organization, and re-purposing to be quickly and easily possible. Communication about such changes however must be made to the population who uses the knowledge.

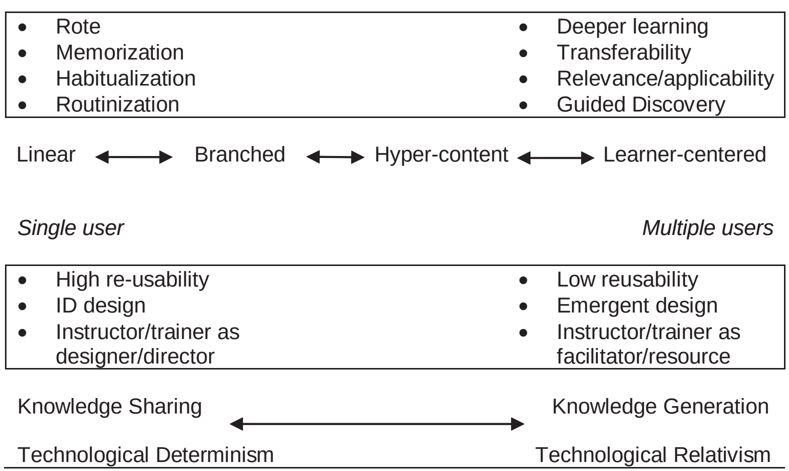
Use refers to the ultimate objective of any knowledge management system: the "production" (p. 6) of value. At this point, Thomas's value proposition is most evident. Organizational knowledge may be constructed, embodied, and disseminated but until it is used, its value is only a construct. Use, it can be argued, is what determines the value of any knowledge. Learning objects stored in repositories or located by "Googling," but finding out by whom, when, or for what reason (much less for what outcome) is marginally addressed through metadata, but more directly addressed through strategies such as Digital Rights Management (DRM). DRM identifies the rights of holders, permissions, and tracks usage. The Digital Object Identifier (DOI®) system identifies and tracks use of digital objects, primarily to protect and document how intellectual property is being used, but not to discover the knowledge value of an object. As tracking strategies become adopted and uniformly used, we suspect value will be determined more by frequency of use than by other indicators, such as return on investment (ROI), or by the knowledge value to the user. Most importantly, the social construction of organizational knowledge does not address knowledge acquisition, which is a primary function of higher education.

TECHNOLOGY-SUPPORTED KNOWLEDGE ACQUISITION AND CONSTRUCTION IN HIGHER EDUCATION

The US history of funding technology as a strategy for reform illustrates the theory of technological determinism3, but belies the reality of the application and adoption of technology and the difficulty, if not impossibility of its predictability and control (Hughes, 2001). Technological relativism4 embraces this ambiguity and better reflects what actually occurs in the post-structuralist learning environment where faculty conduct scholarship and the learner engages in social learning through a variety of technologies, in a variety of ways, in different contexts that support the institutional goals and philosophy. Sørensen (1996) discusses the prevailing discourse about learning through doing, using, and interacting by which a learning economy is produced, based on the notion that learner actions involve production that is supported by various technological systems. As learners increasingly access objects within structured learning experiences they are also generating objects that document, describe, illustrate, or share their own knowledge acquisition. This process reflects Demarest's focus on performance enacted through his social model of knowledge management. In higher education, performance outside of pedagogically-driven environments is less valued because it occurs outside of the economy. The organization assigns value based on the source of the knowledge. Because the learner can access knowledge anywhere or anytime, value propositions erode and are relative, at least for the learner.

The nature of learning object construction and re-use as disaggregated5 course content that may be re-aggregated in different ways reflects current thinking about the social construction of knowledge espoused in pedagogical models of online learning (Simonson, Smaldino, Albright, & Zvacek, 2003), the commodification of the course (Diaz, 2004), and the instructional use of learning objects (Higgs, Meredith, & Hand, 2003). Figure 1 below illustrates learning designs in distributed learning systems. Linear learning designs are more content-driven with little deviation from the instructional path and low interactivity with others or the content that is predetermined and a strategy for sharing knowledge. Such designs are highly re-usable and functional when concept, principle, and procedural knowledge are the goal. As the learner moves to the right of the continuum they are afforded more choices about the path of instruction, information formats, and sources, and how they will demonstrate and document their knowledge acquisition. The learner becomes, to a degree, a designer of their own instruction and a generator of knowledge. Difficult to replicate and re-use, this design holds more promise for transfer of knowledge to other contexts and deeper learning (Carmean, 2002). The generation of knowledge and eventual dissemination via learning objects represents a shift, not only in who generates and how generation occurs, but also in how constituencies receive the knowledge. Didactic instruction is a universally used approach to teaching in classroom settings. The traditional approach to instruction in higher education is instructor-dependent, content-driven, and situated in knowledge transfer (Gibbons & Wentworth, 2001). This is at odds with what is known about adult learning in college and the workplace (Mentkowski, 2000) and in research indicating that as educators use technology in general, their role as subject matter expert shifts to that of guide and facilitator, reflecting an epistemological shift with a variety of associated outcomes (Reeves, 2002). A learning object pedagogy, unlike the traditional model, is one in which the learner makes decisions and choices about a task or problem as they locate relevant information, and construct and generate knowledge eventually embodied in a learning object. The instructor and LCMSs, serve as guide and facilitator.

Figure 1. Learning designs in distributed learning systems



Objects that are used within larger pedagogical frameworks, classrooms, L/CMSs, or blended learning environments, have embedded systems which determine or sanction the function of the object and which operate within the instructional designer's pedagogical determinism. Although objects that are learner-centered achieve multiple objectives and are more likely to be generative, they are also confined to some degree by the system, process, and technology within which they operate. The disaggregation of the course has provided a natural opportunity for the learner to modify existing objects or create new ones that become a part of the knowledge used by others to learn (Collis & Stijker, 2003). It is the opportunity for knowledge generation that informs the social model of knowledge management through knowledge management learning designs that operate across institutions, through cross-fertilization, be it intentional (determinist) or selected (relativist).

TRANSMISSION OF KNOWLEDGE ACROSS, THROUGH, AND IN SPITE OF ORGANIZATIONS

The challenge of any institutionalized knowledge base and system of transmission, transferal, or adoption is that no learner remains within the organizational context throughout their day-to-day life, and they move between contexts across their learning and working life. As workers who are engaged in continual learning, we move between and among organizations that use technologies, the use of which, for the most part, is defined for us by the organizations in which we are situated. Learning environments, rules, procedures, and intended outcomes change as we move from school to work to training. Thus within an institution, the individual acts and interacts from a personal point of view.

In post-secondary education, technology is used to support learning, primarily as an Information Communication Technology (ICT) through which knowledge is constructed, learning is managed, or learning objects are disseminated. E-learning has become standard in higher education, as evidenced by the burgeoning and robust market for course management systems, Web-based tutorials and simulations, and mobile computing. Of course, learners in formal educational environments also acquire knowledge from family, social groups, and other social, religious, or civic organizations (Bransford, Brown, & Cocking, 2000). Social learning is ill-structured and not necessarily outcome-driven, while learning that is not situated in work or education is typically uniquely structured and without conditional assessment measures. For most of us, our preparation to learn strategically in formal and organized settings begins at an early age in traditional educational institutions. The nature of this type of learning is so institutionalized that it crosses most cultures, economic groups, and generations. Yet when we leave an educational setting and are required to learn in workplace environments, the nature of learning shifts.

In the workplace, technology is also used as an ICT although the focus is more on job skills training for just-in-time, just-in-need, or just-in-case learning that relates to job tasks, seen as performance support. Designs for workplace knowledge management systems are equally recommended to be learner-oriented in interface and content as well as management design (Raybould, 2002). Over the developmental life of the learner, then, the organizational uses and expectations of technology shifts at the macro level as well as the micro level as discussed by Thomas (1994).

An often-missing component from the decision to implement a technology-mediated learning strategy is evaluation or effectiveness studies to determine if the selected technology has the ability to address institutional goals and concerns. The literature in this area looks at "satisfaction" in a way that does not always address actual learning outcomes and overall, there exists a lack of empirical studies showing that the use of instructional technology actually improves learning regardless of the context (Arbaugh, 2002; Buckley, 2002; McClelland, 2001; McGorry, 2003; Neal, 1998). Studies conclude that the full potential of instructional technology is reached only by a full transformation of the learning process, faculty development, and institutional systems (Buckley, 2002; Jamieson, Fisher, Gilding, Taylor, & Trevitt, 2000; Moore, 2002). The research on the effectiveness of distance education or online learning programs shows difficulty with student-instructor communication, lack of socialization both with the instructor and other students, student engagement and interaction, innovation in teaching, and technical difficulties or support (McGorry, 2003; Salisbury, Pearson, Miller, & Marett, 2002). Finally, the instructor's actual technological expertise (Lea, Clayton, Draude, & Barlow, 2001; Webster & Hackley, 1997) along with their ability to overcome interaction problems (Berger, 1999) has been found to be important both in faculty member's decisions to adopt instructional technology and in students' satisfaction and learning outcomes. These findings are at odds with return on investment (ROI) arguments that distributed education can serve large populations without denigrating effectiveness, a trend seen in higher education.

Technology has shifted the nature of traditional learning and training by removing the learner from contexts, such as school and workplace. Taylor (2001) has developed a model that describes the shift in distributed learning from linear and print-based to flexible and modular/digital based:

- The "correspondence model" relies on print-based resources.
- The "multimedia model" provides learning resources through a variety of media including print.
- The "tele-learning model" incorporates modes of presentation of materials to include audio or video-conferencing and broadcast TV or radio.
- The "flexible learning model" requires that students engage in interactive, online computer-mediated resources and activities.
- The "intelligent flexible learning model" is the next generation model in which the learner accesses learning processes and resources through portals.

Learning through and with learning objects enables the learner to self-direct their experiences and engage with others for purposes that best support their learning, while utilizing objects that best match their needs. Diaz (2004) notes that the more complex and autonomous the system, the more it allows the learner to manage their own learning, but the higher the degree of technical skills necessary, and the larger the institutional investment. Conversely (or perversely), the more the learner is engaged in making choices and directing learning experiences, the greater the likelihood they will generate knowledge. Personally constructed knowledge is then influenced by the organizational knowledge that shapes our behaviors, values, and norms that we bring to learning or working context. The process of knowledge construction is reflected in the way organizations approach knowledge management. Learner- or worker-generated knowledge is not without limitations and barriers within certain models of knowledge management.

FOUR MODELS OF KNOWLEDGE MANAGEMENT

Existing models of knowledge management have emerged from policy and practice. Although the tradition of distributed instructional materials is not new for higher education, the shift toward digitalization has affected the nature of distribution, as well as policy decisions. Learning objects are a relatively new concept with regard to knowledge management, and the idea of re-use and re-purposing has necessitated specific management and ownership considerations. Typically, learning objects originate with ideas generated by faculty members and are created with supports from the university, then distributed through a local or external repository. Rights of ownership and attribution are critical as are permissions to re-use, revise, and maintain the objects. Pre-learning object policy has not fully accounted for the unique provisions of reuse. In this evolving context of learning objects, we have identified four models that address control and ownership in varying ways: traditional pre-digital, intellectual capital/appropriative, sharing/reciprocal, and contribution-pedagogy.

Traditional Pre-Digital Model

The traditional model of ownership in the area of copyright predates technology. Up until the passing of the Digital Millennium Copyright Act of 1998 (DMCA), and perhaps after, long established legal principles grant to employees, such as faculty members, the inherent right of ownership to their inventions (Chew, 1992). Intellectual property policy language, especially in the area of digital works such as learning objects, can sometimes be ambiguous. McMillen (2001) finds that academic custom, the informal principles of university practice, impact copyright ownership in two ways. First, if there is ambiguity in a faculty member's contract or other written document that expressly assigns copyright ownership, courts may look at custom and usage to determine the university and professor's intent regarding ownership. In other words, courts could decide to take into account an institution's established practices in deciding who should retain property rights. Second, if no contract, policy, or written document regarding copyright ownership exists, courts are permitted to use the academic custom and usage within or outside the institution to determine what the parties would have agreed to had they addressed copyright ownership.

In Rhoades (1998) examination of the actual ownership of faculty products, he found that, of the contracts analyzed, a majority of them had extensive provision for faculty ownership; in fact, the institution does not always claim ownership, even when it is a "work for hire." The "conditions" of production or use of resources are pivotal in determining ownership and assigning profits. In her analysis of intellectual property ownership in the institution of higher education in the United States, Chew (1992) reexamines ownership via social tradition and case law. Surprisingly, her findings reveal that, despite common assumptions, long established legal principles grant to employees, such as faculty, the inherent right of ownership to their inventions. Faculty members' claims on their inventions and the enforceability of university policies are unclear. However, as distributed learning technology evolves and requires greater use and infusion of institutional resources, ownership, and control may begin to away from individual creators and contributors and toward resource providers. Further adding to the ownership ambiguity is the vast array of digital products that are being produced within commercial and non-commercial collaborations and partnerships.

Intellectual Capital/Appropriative Model

The intellectual capital or appropriative model holds that ownership, control, and maintenance of intellectual property, especially in the area of distributed learning, is important. Under this model, institutional resources expended are carefully monitored and among other factors, become the criteria for ownership and control. Further, the vast majority of higher education institutions' intellectual property policies are increasingly based on this model (Diaz, 2004). The arrival of technology into the area of copyright has created a new market for products that previously had little or no commercial value. In fact, many copyright sections of intellectual property policies differentiate between digital and non-digital property and contain specific and substantial rights over these economically viable products. The intersection of intellectual property rights, specifically in the area of copyright, and technology in higher education is the realm of distributed learning, including distance education, learning objects, digital repositories, and electronic courseware products.

Consistent with previous studies in the area of intellectual property copyright policy transformation and the corresponding commodification of educational products (Chew, 1992; Lape, 1992; Packard, 2002; Slaughter & Rhoades, 2004), Diaz (2004) finds that policies are evolving to further address distributed learning products in a variety of ways. Findings indicate that institutions are revising policies to further deal with and capture instructional products. Policies are aligned with the organizational change that is occurring in higher education within a larger context of an information-based economy (Castells, 2000). Additionally, the new instructional model is heavily dependent on information technology in the form of network connectivity, infrastructure and support staff, thus making it resource intensive. Policies reflect this change by mimicking the shift in ownership conditions away from those required in a traditional setting to those required in a high technology setting. Use of institutional resources in the instructional process has been nominal (i.e., secretarial support, libraries), compared to those required now: media specialists, instructional designers, and so on. Ownership terms changed to address the new instructional model, but claims on instructional products have appeared where there were previously none.

Institutions are asserting ownership where they previously had not because online courses and course materials present a potential source of revenue from which the institution could benefit. Several explanations exist for this increasingly appropriative behavior. Faculty-developed electronic content and courseware materials (especially in specialized academic areas where the market is deficient) present a potential source of revenue and savings, as the institution will not have to pay costly licensing fees to purchase or utilize externally developed products. Increasing “contracted” education serves the dual purpose of producing salary savings while providing one-on-one attention to students and improving their performance (Twigg, 2000). The appropriation of digital knowledge may also be a preemptive move on behalf of universities that fear faculty members will package their courses and make them available to multiple markets (while employed at the present institution or after they have left), perhaps in competition with the college or university that employs them.

Sharing/Reciprocal Model

The sharing reciprocal model is based on shared value and the exchange of learning objects and other digital materials across organizations and institutions (Diaz & McGee, 2004). The focus here is on the support of learning activities. Individual institutions support the assembly of learning objects, which may be shared across departments but, more commonly, objects are imported from many other places. Table 1 illustrates the many partners that may be involved in these consortia. Organizational support mechanisms and systems moderate costs. Many institutions join consortium in order to create a system for storing and distributing objects in what becomes a mutually beneficial learning object economy (Learning Content eXchange, 2003). Consortia often articulate content and evaluation standardization as a strategy to increase the market value of an object. DRM, Royalty Rights Management (RRM), index, and search functions as well as supporting technologies are collectively addressed and operated through a well-organized consortia

Table 1. eLearning partnerships

Organizational Partnership	Partners
EDUCAUSE Corporate Partner Program (http://www.educause.edu/partners/about.html)	• IT professionals (public/private) • Technologists • Managers • Higher education executives
Massachusetts Institute of Technology DSpace Federation (http://dspace.org)	• Columbia University, Cornell University, Ohio State University, and the Universities of Rochester, Toronto, and Washington • Hewlett-Packard • MIT Libraries
The Fedora Project (http://www.fedora.info/)	• University of Virginia • Andrew W. Mellon Foundation • Cornell University

initiative. Such collaboration allows members to establish pre-determined policies and procedures that articulate a negotiated value and standard of quality for the objects that are shared.

Learning object registries can provide standards and access for institutions that may not be interested in partnerships. One example is the Learning Object Network (LON) (http://www.learningobjectsnetwork.com) that uses Digital Object Identifier (DOI) as the identifier mechanism and collects object metadata and location information so they can direct potential users to the source. Institutions or consortia must determine the degree of access and set policy that sets the rights of the owner of the object. One approach to DRM is the Creative Commons Project6 that provides no-cost licenses so that copyright holders can inform potential users about copyright restrictions. Knowledge management systems that can serve consortia provide customizable interfaces that can meet the unique needs and preferences of a group regardless of their funding level or size. For example, EZ Reusable Objects (EZRO) is an open source, free Web application that requires little to no technical expertise to configure and operates to manage learning objects. EZRO is scalable and responds to the specific needs of consortia driven by a variety of goals and directed by institutional policy.

The first three models discussed above fail to address the value of knowledge acquisition acquired through learner-object interaction, which should be an expectation and criteria in the learning object economy. Instead, they focus specifically on the exchange of goods in terms of the agreed-upon market value rather than the knowledge value that informs the "buyer" of whether or not, as Demarest would argue, the product "works." For higher education the value should reside in the object's actual knowledge value.

Contribution Pedagogy Model

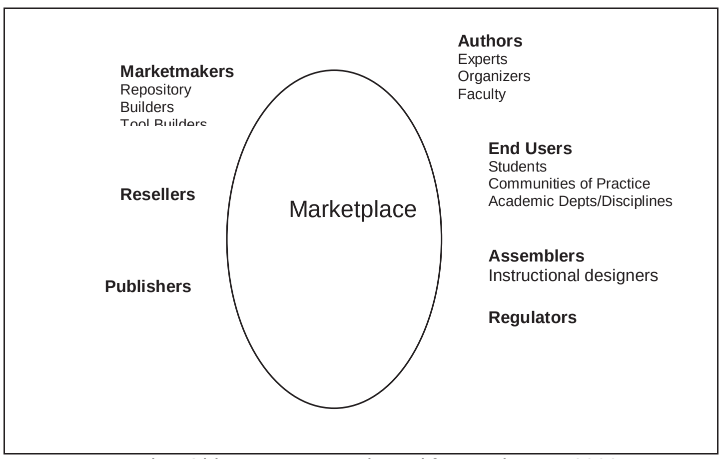
The focus of the contribution-pedagogy model is that learners contribute to object development or generate objects themselves, thereby contributing to the knowledge base of the institution. This reflects the shift toward a learning object pedagogy in which learners, not only learn from experience by participating in the generation of the object, but by contributing to the learning of others through object development and re-use. Collis and Striker (2003) suggest that by having learners generate learning objects, and contribute to a course repository that grows with each offering of the course, the burden of producing objects is shifted away from the institution and the instructional process. This results in a variety of benefits: time is saved for the instructor or content-generator, resources are designed by the population for which they are intended by providing a locally better "fit" with the intended audience, learners can contribute and revise objects over time by updating content or presentation, and the tacit knowledge of the learner is transparent and can be shared or studied by the institution (Collis & Winnips, 2002).

Laurillard and McAndrew (2003) illustrate the contribution-pedagogy model in their design of generic learning activities that shift teaching from a transmission model to a construction model. A design of generic learning activities shifts teaching from a transmission model to a construction model as illustrated by Laurillard's "Conversational Framework" for learning. This iterative process requires the learner to engage, act, and reflect upon what they know and how they come to learn. An analysis of scalable (individuals or groups) and sustainable (efficient and economic) learning designs address how to design for diversity of learner experiences, goal-based learning, re-use of objects, use of online learning tools for learning outcomes, clear and succinct instructions, and dynamic technology function. Specific recommendations are made for the design of objects to be used in multiple courses. When multiple applications are considered at the design stage, there is an increased likelihood of increased re-use across disciplines. Additionally, objects can be easily re-versioned depending on the needs of new or revised courses and pedagogy is wrapped around objects, activities, and supports. The Sharing/Reciprocal and Contribution-Pedagogy models impact how value is attributed, estimated, and assigned to learning objects and reflect Thomas and Home's (2003) Student-centered Route and Freedom Argument for the distribution and access of learning objects that suggests a new economy.

Learning Object Economy

Higher education's new approach to its knowledge products has led to the emergence of a learning object economy. Johnson (2003) notes that the learning object economy has at least five markets of exchange: proprietary, commercial, free, shared, and peer-to-peer. Each of these "markets" has a corresponding culture and has been met with varying degrees of success. He argues that a fully functioning learning object economy would satisfy the needs and requirements of its constituents: market-makers (repository builders), instructors, end users, assemblers, regulators, publishers, resellers, and authors. Figure 2 illustrates the way that various constituents intersect and exchange in this new economy (Johnson, 2003).

Figure 2. Learning object economy (Learning Object Economy adapted from Johnson, 2003)



Learning Object Economy adapted from Johnson, 2003.

Technologies, if they resonate and are adopted, can generate an economy that is derived from the value placed on them by a social group. Groups may have different interpretations of the basis of the value. Since learning objects require group collaboration, represent knowledge construction, and are disseminated across populations, there is a high level of mediating variables and processes.

Technological systems, if they resonate with the organization and are adopted, can generate an economy that is derived from the value placed on them by a social group. Groups may have different interpretations of value, and since learning objects require group collaboration, represent knowledge construction, and are disseminated across varied populations, a high level of mediating variables and processes exist. Johnson (2003) describes five markets, each with a different exchange approach, in which learning objects operate. These markets—proprietary, commercial, free, shared, and peer-to-peer—are described in Table 2.

Each of the aforementioned four knowledge management models (traditional-pre digital, intellectual capital/appropriative, sharing/reciprocal, and contribution pedagogy) intersects with one or more of Johnson's learning object economy markets. For instance, the traditional-pre digital, intellectual capital/appropriative models exist within the value system of the proprietary and commercial markets. The last three markets, free, shared, and peer-to-peer, also exist in higher education settings. It is possible for appropriative and non-appropriative models to coexist, for instance within a college or department. Each market satisfies those constituents' needs and is aligned with a set of culture-specific values. Implicit needs must also be met in order for exchange to flourish. For instance, learning objects must be credible or carry some quality assurance regardless of the system within which they operate.

Although the literature (Hart, 2004; Kidwell, Vander Linde, & Johnson, 2000; Norris et al., 2003) suggests a maturing of knowledge management practices that have resulted in a myriad of systems, the learning object economy in all markets is still weak at best. As Johnson (2003) points out, the current level of activity has not yet reached a "tipping point." The solution, he postulates, is an "economy of content in which individuals and organizations can acquire, adapt, and repurpose content" (p.7). Table 3 presents a summary of Johnson's drivers, enablers, and mediators to a thriving learning object economy.

Several of these drivers, enablers, and mediators are present in the models discussed earlier and suggest some explanation for the under use of learning objects. For instance, higher education intellectual property policies governing the control and ownership of digital instructional products or learning objects are often structured in such a way as to inhibit development and sharing outside of the originating institution (Diaz, 2004). This type

Table 2. Learning object economy and the five markets

Market	Product Example
Proprietary	Private company training repository
Commercial	E-learning companies selling learning objects
Free	MERLOT or the Educational Learning Object Exchange
Shared	Higher education LO consortia
Peer-to-peer	Sharing systems between higher education institutions

Table 3. The learning object economy: Drivers, enablers, and mediators (Adapted from Johnson, 2003)

	Definition	Higher Education Example
Drivers	Knowledge, productivity, competition, readiness, infrastructure	Faculty-, student-, staff-produced knowledge; L/CMSs; wireless learning environments.
Enablers	Learning technologies, learning design, standards	A menu of learning technologies available to educators; learning technologists as support staff to enhance learning and teaching functions.
Mediators	Resources, policies, perceived value	Learning technologies centers; flexible and adaptable intellectual property policies.

of behavior, evident in the Intellectual Capital/Appropriative Model, also prohibits the sharing of resources and distribution of costs: mediators in the economy. The Appropriative Model and other models discussed are limited, to some extent, by their social context. Each is operating within the boundaries of their organizational context and corresponding values and is thus limited by those constraints. In response to these limitations, we propose a new relativist model. We argue that in order for a learning object economy to succeed, it must be able to take advantage of and utilize its drivers, enablers, and mediators independently of a social or organizational context.

Open Knowledge Model

Knowledge sharing and re-construction with intellectual property rights attribution and learner-owner intellectual property rights are necessary in an increasingly globalized and distributed learning ecosystem.7 The Open Knowledge Model embodies trends in a variety of disciplines: computer science (see OKI and OSPI), education (see McGee & Robinson, 2004), science (see Cottey, 2003), and social justice (see Open Knowledge Network) in that it utilizes a relativist construction and accommodates cross-institutional cultures and beliefs about learning technologies, the construction of knowledge across systems and institutions, as well as the trend toward learner-centered e-learning, disaggregated and re-aggregated learning objects, and negotiated intellectual property rights.

We build on Thomas' and Demarest's conceptual frameworks in an attempt to address the emergent model of knowledge management in higher education that reflects current beliefs about the learner, the function of the institution, the trend toward knowledge generation, and the evolution of existing models. In that the function, definition, and value of technology are relative to organizational culture and values, we assert that no organizational position is more or less valid than another (Wescott, 2001). The Open Knowledge Model provides for this caveat. This is not to say that value is not shared across higher education systems, but rather that individual organizations and their members have come to contribute to the value given to the knowledge that is generated within them.

The first component of the Open Knowledge Model addresses how the culture and actions of higher education tacitly and explicitly determine the value, purpose, and role of knowledge for the institution at large. The culture of each higher education institution determines the value and use of knowledge, rather than the technology. This is clearly reflected in institutional efforts such at MIT's OpenCourseWare project in which course syllabi and materials are accessible to all in an effort to support their "mission to advance knowledge and education, and serve the world in the 21st century. It is true to MIT's values of excellence, innovation, and leadership" (MIT, 2004). MIT has chosen to share intellectual property that represents the values, norms, and standards of learning of their unique and specific mission. We see such efforts as supporting the inherent purpose of higher education: as a primarily generator of bodies of knowledge that should be made freely available to the public. Traditional models of knowledge dissemination that are tied to processes of tenure and promotion (peer-referred journals with limited circulation) restrict knowledge access. In the Open Knowledge Model, intellectual property is digitized and distributed with rigorous standards of review, but made available to anyone who is interested, rather than a privileged few through repositories (Crow, 2002).

Traditionally, intellectual property rights policy has indicated the market value higher education has placed on learning objects, however, documented knowledge acquisition (through learner generation) and use of learning objects (through tracking) is a more authentic indicator of value. In the Open Knowledge Model, intellectual property rights are determined by the generator and negotiated by the end user who may choose to re-purpose the content through licenses allowed through systems. The growing number of

Table 4. Stages of organizational learning

ß	• Proliferation of information technology (IT) in higher education (HED) • Increased entrepreneurial behavior in HED • Increased competition or economic pressure
Learning Stage I	• Emerging HED IT profession • Established HED entrepreneurial behavior (patents) • Collaborative HED/IT professional organizations (EDUCAUSE) • Elite organizational behavior (MIT's OKI, DSpace)
Learning Stage II	• higher education develops L/CMSs • Current technology is expensive and insufficient • Organizations seek to "retain" knowledge
Diffusion	• Social consensus via organizational leaders (in process) • Lower level orgs mimic behavior
Institutional Copyright Policy Transformation	• Whole policy revisions • Addendums to existing policies • Instructional technology/software clauses

repositories and referatories indicates that learning objects are a valid and valued knowledge source both within and outside of any one institution. Additionally, we propose that knowledge value is reflected in use and re-use of learning objects.

The second area of focus deals with the ways in which knowledge is created, embodied, disseminated, and used in higher education; the relationship between knowledge and technological innovations; and the relationship between knowledge, innovations, and performance standards that higher education requires in order to meet its strategic objectives. Higher education, as an institution, embodies cultures that are both shared and not shared. For instance, sharing and collaboration in a learning object economy can occur within and across disciplines, departments, and the institution as a whole. In this sense, the academic setting is unique in that cross-cultural/organizational generation, sharing, and re-purposing, is possible and brings the added benefit of greater innovation and diffusion of knowledge. Further, repositories and referatories, as technological systems, make this possible as learning objects grow and become more meaningful with use and reuse. With successful cross-pollination comes increased funding; consortia and leveraged resources and capital, standardization by industry in accordance with established values to support reuse.

The third area of focus deals with the strategic and material commercial benefits that higher education expects to gain from more effective knowledge management practices and performances. These may include increased revenue, prestige, partnerships, cross-organizational fertilization, and higher skilled faculty and graduates. Several factors have contributed to the development of knowledge management. The literature in the area of globalization in higher education points to information technology, organizational change, and productivity growth (Castells, 1997, 2000; Tiffin & Rajasingham, 2003). The development of new intellectual property policies, and the extensive revision of existing ones (Olivas, 1994), is one signal of the organizational transformation and the effort to harness productivity to the benefit of the institution. Globalization, increased competition among non-profit and for-profit educational entities, and changes in funding structures has all contributed to changes in the way higher education institutions deliver services and leverage their instructional products.

The utilization of distributed learning technologies and systems has several benefits for the academy: increased research productivity, generation of tuition revenue via increased access, institutional acquisition of instructional products, and improved learning. While some of these outcomes are yet unproven, they are well documented in the language that surrounds policy. Several studies have suggested higher education's move toward commercializing instructional products (Anderson, 2001; Slaughter & Rhoades, 2004; Welsh, 2000). One can speculate on what has prompted such activity in this area. Organizational learning theory tells us that a number of precipitating jolts, both external and internal to the organization, can prompt such changes (see Table 4). Such jolts can come from the changing economy, changing technology, and pressure to improve learning outcomes (Castells, 2000).

The Open Knowledge Model represents the drivers of knowledge management: the methods for management and the conceptual framework that guides processes of knowledge generation. It supports a new economy based on authentic knowledge value in which human capital is embraced and recognized as the core of educational institutions and that which higher education can best support and sustain.

REFERENCES

Anderson, M. (2001). The complex relations between the academy and industry: Views from the literature. *The Journal of Higher Education, 72*(2), 226-246.

Arbaugh, J. (2002). Managing the online classroom: A study of technological and behavioral characteristics of Web-based MBA courses. *Journal of High Technology Management Research, 13*(2), 203-223.

Becker, H. (2001). *How are teachers using computers in instruction?* The Center for Research on Information Technology and Organizations. Retrieved February 12, 2004, from http://www.crito.uci.edu/2/pubdetails.asp?id=292

Bennett, K. & Metros, S. (2001). *The promise and pitfalls of learning objects: Current status of digital repositories.* Retrieved from http://itc.utk.edu/educause2001

Berger, N. (1999). Pioneering experiences in distance learning: Lessons learned. *Journal of Management Education, 23*(6), 684-690.

Bransford, J., Brown, A., & Cocking, R. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

Buckley, D. (2002). In pursuit of the learning paradigm. *Educause Review,* January/February.

Carmean, C. (2002). *Learner-centered principles.* Retrieved on March 11, 2004, from http://educause.edu/nlii/keythemes/lcp/

Castells, M. (1997). *The power of identity.* Oxford: Blackwell Publishers.

Castells, M. (2000). *The rise of the network society* (2nd ed.). Oxford: Blackwell Publishers.

Cavanaugh, C. (2001). The effectiveness of interactive distance education technologies in K-12 learning: A meta-analysis. *International Journal of Educational Telecommunications, 7*(1), 73-88. Retrieved June 15, 2004, from http://www.unf.edu/~ccavanau/CavanaughIJET01.pdf

Chandler, D. (1996). Shaping and being shaped: Engaging with media. *CMC Magazine,* (3), 2. Retrieved June 15, 2004, from http://www.december.com/cmc/mag/1996/feb/toc.html

Chew, P. (1992). Faculty generated inventions: Who owns the golden egg? *Wisconsin Law Review, 2*, 259-314.

Clark, T. (2001). *Virtual schools: Trends and issues*. Distance Learning Resource Network and WestEd. Retrieved on March 14, 2004, from http://www.wested.org/online_pubs/virtualschools.pdf

Collis, B. & Striker, A. (2003). Re-useable learning objects in context. *International Journal of E-learning, 4*(2), 5-16. Retrieved October 13, 2004, from http://dl.aace.org/14190/

Collis, B. & Winnips, K. (2002). Two scenarios for productive learning environments in the workplace. *British Journal of Educational Technology, 33*(2), 133-148.

Cook, J. & Cook, L. (1998). How technology enables the quality of student-centered learning. *Quality Progress,* July, 59-63.

Cottey, A. (2003). Open Knowledge: A proposed adaptation of Open Science, focusing on guidelines for knowledge claims. *SGR Newsletter, 26,* 17-8.

Creative Commons (2004). *"Some rights reserved": Building a layer of reasonable copyright.* Retrieved April 15, 2004 from http://creativecommons.org/learn/aboutus/

Crow, R. (2002). *The case for institutional repositories: A SPARC position paper.* Washington, DC: The Scholarly Publishing and Academic Resources Coalition.

Curren, L. (2004). *MIT's Double-Secret Hidden Agenda. eLearn.* Retrieved June 15, 2004, from http://www.eLearnMag.org/subpage/sub_page.

cfm?ar ticle_pk=11125&p age_number_nb=2&title=FEA TURE%20STORY

Davenport, T., DeLong, D., & Beers, M. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 374-84.

Demarest, M. (1997). *Knowledge management: An introduction*. Retrieved March 1, 2004, from www.noumenal.com/marc/km1.pdf

Demarest, M. (1997). Understanding knowledge management. *Long Range Planning, 30*(3), 374-384.

Diaz, V. (2004). *The digitization and control of intellectual property: Institutional patterns of distributed learning behavior and the organizational policy response.* Unpublished doctoral dissertation, University of Arizona.

Diaz, V. & McGee, P. (2004). *Policies for success on the new learning object frontier.* Presentation at the National Learning Infrastructure Annual Meeting. San Diego, CA.

Downes, S. (2002). *Design and reusability of learning objects in an academic context: A new economy of education?* Retrieved June 15, 2004, from http://www.usdla.org/html/journal/JAN03_Issue/article01.html

EZRO (2004). Retrieved June 15, 2004, from http://ezro.devis.com/

Gibbons, H. & Wentworth, G. (2001). *Andragogical and pedagogical training differences for online instructors*. Paper presented at DLA 2001, Callaway, Georgia. Retrieved March 9, 2004, from http://www.westga.edu/~distance/ojdla/fall43/gibbons_wentworth43.html

Higgs, P., Meredith, S., & Hand, T. (2003). *Technology for Sharing: Researching learning objects and digital rights management.* Flexible Leader 2002 Report. Retrieved January 10, 2003, from http://www.flexiblelearning.net.au/leaders/fl_leaders/fll02/finalreport/final_hand_higgs_meredith.pdf

Hughes, T. (2001). Through a glass darkly: The future of technology-enable education. *EDUCAUSE Review*. Retrieved April 13, 2004, from http://www.educause.edu/ir/library/pdf/ffp0111s.pdf

Jamieson, P., Fisher, K., Gilding, T., Taylor, P., & Trevitt, C. (2000). Place and space in the design of new learning environments. *Higher Education Research and Development, 19*(2), 221-237. Retrieved June 17, 2004, from http://www.oecd.org/els/pdfs/EDSPEBDOCA027.pdf

Johnson, L. (2003). *Challenges impeding the learning object economy.* Macromedia White Paper. Retrieved June 15, 2004, from http://download.macromedia.com/pub/solutions/downloads/elearning/elusive_vision.pdf

Joy, L. (2004). *Training versus learning.* Retrieved on March 18, 2004, from http://www.structured-training.com/asp/trainingvlearning.asp

Kidwell, J., Vander Linde, K., & Johnson, S. (2000). *Applying corporate in higher education.* EDUCAUSE Quarterly. Retrieved June 17, 2004, from http://www.educause.edu/ir/library/pdf/EQM0044.pdf

Lape, L. (1992). Ownership of copyrightable works of university professors: The interplay between the copyright act and university copyright policies. *Villanova Law Review, 37,* 223-269.

Laurillard, D. & McAndrew, P. (2003). Reusable educational software: A basis for generic e-learning tasks. In A. Littlejohn (Ed.). *Resources for networked learning.* UK: Kogan-Page.

Lea, L., Clayton, M., Draude, B., & Barlow, S. (2001). The impact of technology on teaching and learning. *EDUCAUSE Quarterly, 24*(2).

Learning Content eXchange. (2003). A new industry model for the e-learning market. Retrieved

June 17, 2004, from http://www.learningcontent-exchange.com/LearningObjectEconomy.pdf

Lyotard, J. (1984). *The postmodern condition: A report on knowledge.* (Trans. G. Bennington and B. Massumi). Minneapolis: University of Minnesota Press.

McClelland, B. (2001). Digital learning and teaching: Evaluation of developments for students in higher education. *European Journal of Engineering Education, 26*(2), 107-115.

McGee, P. & Robinson, J. (2004). The digital divide: Making a case for open source. Paper published in the *Proceedings of the Education and Information Systems: Technologies and Applications (EISTA) Conference*, Orlando, Florida.

McGorry, S.Y. (2003). Measuring quality in online programs. *The Internet and Higher Education, 6*(2), 159-177.

McMillen, J. (2001). *Intellectual property: Copyright ownership in higher education, university, faculty, & student rights.* Asheville, NC: College Administration Publications, Inc.

Mentkowski, M. & Associates. (2000). *Learning that lasts: Integrating learning, development, and performance in college and beyond*. San Francisco: Jossey-Bass.

Meyer, K. (2002). Quality in distance learning. *ASHE-ERIC Higher Education Report, 29*(4), 1-121.

MIT (2004). *OpenCourseWare*. Retrieved from http://ocw.mit.edu/index.html

Moore, M. & Kearsley, G. (1996). *Distance education: A systems view.* Wadsworth Publishing.

Neal, E. (1998). Using technology in teaching: We need to exercise healthy skepticism. *The Chronicle of Higher Education, B4.*

Nichols, R. (1996). The value of education and training. *Discourse, 2*(1), 13.

Norris, D., Mason, J., & Lefrere, P. (2003). *A revolution in the sharing of knowledge: Transforming e-Knowledge.* Ann Arbor: Society for College and University Planning.

Olivas, M. (1992). The political economy of immigration, intellectual property, and racial harassment: Case studies of the implementation of legal changes on campus. *Journal of Higher Education, 63,* 570-598.

Open Knowledge Initiative (OKI) (2004). http://web.mit.edu/oki/index.html

Open Knowledge Network (OKN) (2004). http://www.openknowledge.net/

Open Source Portfolio Initiative (OSPI) (2004). http://www.theospi.org/

Packard, A. (2002). Copyright or copy wrong: An analysis of university claims to faculty work. *Communication Law and Policy, 7,* 275-315.

Perdue, P. (1994). Technological determinism in agrarian societies. In M.R. Smith & L. Marx, (Eds.), *Does technology drive history? The dilemma of technological determinism.* Cambridge, MA: MIT Press.

Por, G. (1997). *Designing knowledge ecosystems for communities of practice.* Paper presented at the Advancing Organizational Capability via Knowledge Management Conference, Los Angeles, California. Retrieved February 10, 2004, from http://www.co-i-l.com/coil/knowledge-garden/dkescop/index.shtml

Raybould, B. (2002). Building performance-centered Web-based systems, information systems, and knowledge management systems in the 21st century. In A. Rossett (Ed.), *The ASTD e-learning handbook* (pp. 338-353). New York: McGraw-Hill.

Reeves, T. (2002). *Evaluating what really matters in computer-based education.* Retrieved June 15, 2004, from http://www.educat io nau.ed u.au/archives/cp/reeves.htm

Rhoades, G. (1998). *Managed professionals: Unionized faculty and restructuring academic labor.* Albany: State University of New York Press.

Robson, R. (2001). *All about learning objects*. Retrieved June 15, 2004, from http://www.eduworks.com/LOTT/tutorial/learningobjects.html

Rossett, A. & Donello, J. (1999). *Knowledge management for training professionals.* Retrieved February 3, 2004, from http://defcon.sdsu.edu/1/objects/km/map/index.htm

Rossett, A. & Marshall, J. (1999). Signposts on the road to knowledge management. In K.P. Kuchinke (Ed.)*, Proceedings of the 1999 AHRD conference: Vol. 1* (pp. 496-503). Baton Rouge, LA: Academy of Human Resource Development.

Salisbury, W., Pearson, R., Miller, D., & Marett, L. (2002). The limits of information: A cautionary tale about one course delivery experience in the distance education environment, *e-Service Journal, 1*(2).

Sieczka, K. (n.d.). *Workplace training versus traditional classroom training.* Retrieved February 16, 2004, from http://www.ideamar keters.com/library/article.cfm?articleid=25789

Simonson, M., Smaldino, S., Albright, M., & Zvacek, S. (2003). *Teaching and learning at a distance: Foundations of distance learning* (2nd ed.). Upper Saddle, NJ: Pearson Education, Inc.

Slaughter, S. & Rhoades, G. (2004). *Academic capitalism in the new economy.* Baltimore: Johns Hopkins Press.

Smith, M. & Marx, L. (Eds.) (1994). *Does technology drive history: The dilemma of technological determinism*. Cambridge, MA: MIT Press.

Solmon, L. & Wiederhorn, J. (2000). Progress of technology in the schools 1999: Report on 27 states. Milken Foundation. Retrieved February 12, 2004, from http://www.mff.org/publications/publications.taf?p age=277

Sørensen, K. (1996). *Learning technology, constructing culture: Socio-technical change as social learning.* STS working paper no 18/96, University of Trondheim: Centre for technology and society. Retrieved June 15, 2004, from http://www.rcss.ed.ac.uk/SLIM/public/phase1/knut.html

Taylor, J. (2001). Fifth generation distance education. *Higher Education Series, 40.* Retrieved June 15, 2004, from http:// www.dest.gov.au/highered/hes/hes40/hes40.pdf

Thomas, G. & Home, T. (2004). *Using ICT to share the tools of the teaching trade: A report on open source teaching.* Becta ICT Research. Retrieved April 9, 2004, from http://www.see veaz.myschools.net/Bestpractice/OSDDB6.pdf

Thomas, R. (1994). *What machines can't do: Politics and technology in the industrial enterprise.* Berkeley: University of California Press.

Tiffin, L. & Rajasingham, L. (2003). *Global virtual university.* London; New York; Canada: Routledge.

Twigg, C. (2000). *Who owns online courses and course materials: Intellectual property policies for a new learning environment.* The Pew Learning and Technology Program, Center for Academic Transformation at Renssalaer Polytechnic Institute.

Webster, J. & Hackley, P. (1997). Teaching effectiveness in technology-mediated distance learning. *Academy of Management Journal, 40,* 1282-1309.

Welsh, J. (2000). Course ownership in a new technological context: The dynamics of problem definition. *The Journal of Higher Education, 71*(6), 668-699.

Wescott, E. (2001). *The Internet encyclopedia of Philosophy.* Retrieved March 18, 2004, from http://www.iep.utm.edu/r/relativi.htm

Wiley, D. (2000). *Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy.* The instructional use of learning objects: Online version. Retrieved June 15, 2004, from http://www.reusability.org/read/

Wiley, D. (2003). *Learning objects: Difficulties and opportunities.* Retrieved June 15, 2004, from http://wiley.ed.usu.edu/docs/lo_do.pdf

Winner, L. (1977). *Autonomous technology: Technics-out-of-control as a theme in political thought.* Cambridge, MA: MIT Press.

ENDNOTES

1. "Knowledge management involves recognizing, documenting, and distributing the explicit and tacit knowledge resident in an organization" (Rossett & Marshall, 1999).
2. A learning object economy requires that individual objects are created and shared across institutions (Johnson, 2003).
3. Technology drives change and events. In teaching and learner this means that pedagogy and learner's actions are determined by technology and indeed effect changes in practice. The authors see this more as a result of technological drift (Winner, 1997) through which organizations have been inattentive to the determinism that has become enculturated (see Perdue, 1994).
4. In our view, technological relativism means that the function, definition, and value of technology are relative to the organizational culture and values and the beliefs about the value within the higher education community. Additionally, we assert that no organizational position is more or less valid than another (Wescott, 2001), but equal consideration must be given to each value position. Additionally, individuals choose what and how they use and adapt technologies to their own purposes (Chandler, 1996).
5. Learning objects typically are parts of a larger course or unit of study. Aggregation involves combining objects to create a scope of learning content.
6. Creative Commons (2004) is a free licensing service that "uses private rights to create public goods: creative works set free for certain uses. Like the free software and open-source movements, our ends are cooperative and community-minded, but our means are voluntary and libertarian. We work to offer creators a best-of-both-worlds way to protect their works while encouraging certain uses of them—to declare "some rights reserved."
7. An ecosystem is a combination of systems that interact to support the survival and generation of organisms that exist within it. The authors see the tools, resources, people, and experiences accessible to the higher education student as constituting a digital learning ecosystem that contributes to a digital knowledge ecosystem (Por, 1997).

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Chapter 2.40
Conceptual Framework and Architecture for Agent-Oriented Knowledge Management Supported E-Learning Systems

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ABSTRACT

In this era of information, traditional practices, technologies, skills, and knowledge are becoming obsolete at a much faster pace than ever before. This makes lifelong learning a necessity for everyone. An e-learning system is a promising solution to the demand for a flexible means of delivering knowledge to educate a large number of people over a vast area. Knowledge management systems (KMSs) are a fast growing area of research on the creation and sharing of knowledge. Agent-oriented software engineering is opening up a new horizon for the analysis and development of systems in an open, complex, and distributed environment. This article proposes a conceptual framework and architecture for the development of an agent-oriented e-learning system supported by knowledge management to provide a flexible, self-paced, and collaborative learning environment with the least constraints. The framework is based on the technologies of e-learning systems, multi-agent systems (MASs), and KMSs. The proposed system architecture consists of three levels: user level, domain level, and Web level. The system will provide all of the basic teaching- and learning-related support facilities, plus some enhanced features that are provided by the agents

within the system. The system will also provide the facilities for capturing and sharing the knowledge created during utilization of the system. Finally, conclusions and the potential theoretical and practical implications of the proposed system are presented.

INTRODUCTION

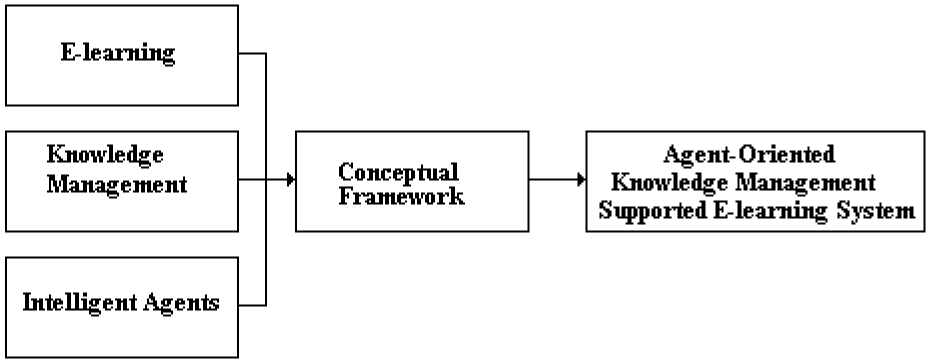
There is no universal definition of e-learning. Broadly speaking, e-learning can be defined as learning activities performed over electronic device(s). Terms such as technology-based learning, computer-based learning, computer-based education, and Web-based training can be classified under the banner of e-learning. E-learning systems embrace a wide collection of applications and processes such as Web-based, computer-based, or digital collaboration. E-learning and distance learning are commonly considered interchangeable (Usnews, 2003). In this study, we define e-learning as credit-granting education or training courses delivered to remote (off-campus) location(s) via audio, video, or computer technologies such as the Internet, including both synchronous and asynchronous instruction (Ozdemir et al., 2000). An e-learning system is well suited for mass education and training. The cost and difficulty of accessing information on the Web are continuously decreasing, given the support of an increasing plethora of portable or hand-held computing devices such as sub-notebooks, palm devices, pocket computers, and WAP phones. E-learning has the potential to become a cost-effective tool for mass education, one of the key applications in e-commerce and the largest information industry in the near future (Cisco, 2004; White, 2003).

Multi-agent systems (MASs) have been given a more general meaning. The term is now used to refer to all types of systems composed of multiple autonomous components that behave like agents (Flores-Mendez, 2001). Wooldridge (1997) stated that the technologies of agents and MASs have brought a new way of visualizing and implementing open, complex, and distributed systems. Different kinds of agents are applied in a wide variety of disciplines (Giraffa et al., 1998; Jennings et al., 1998; Nwana, 1996). With the gradual maturity of agent-developing techniques, people are beginning to apply them in fields other than e-commerce (Guttman et al., 1988; Liang et al., 2000), manufacturing (Lee et al., 1999; Zhang et al., 1995), or multiple-scheduling under a distributed environment (Glezer et al., 1999; Sen, 1997).

Applying agents to increase or enhance the system's features is not new. Researchers or developers have always named their agents in line with the nature of the job or the applied areas of the agents, or even according to the name of the research project. Some typical examples within the field of education are pedagogical agent, tutor, mentor, and assistance (Giraffa et al., 1998). Examples in other fields are information agents, webot, softbot (BotSpot, 2003), personal agents, digital butlers, and virtual secretaries (Vise, 2004). The redesign and modification of the e-learning system utilizing the techniques of agents likely will introduce extra helpful features and can improve the efficiency of the e-learning system. Ritter (1997) highlighted the use of different tools to communicate with an agent tutor in a target learning environment. Lester et al. (1997) reported a simple constraint agent that could enhance learning. Ganeshan et al. (2000) reported the use of pedagogical agents in tutoring on the subject of medical diagnosis.

Knowledge is a justified belief that can increase an entity's capacity for effective action (Huber, 1991; Nokaka, 1994). Commercial KMSs are gaining the attention of users due to their ease of use, functional diversity, and wide availability. They provide functions that support the repository of knowledge — something current e-learning systems lack (Serban et al., 2002). We believe that our proposed framework essentially integrates

Figure 1. The research approach



KMSs and that e-learning systems will post a new challenge to the designing of e-learning systems to share and contribute knowledge.

This chapter is organized as follows. In the background section, a brief review of the literature on KMSs and agent-oriented e-learning systems is presented. The following section presents the foundation of the conceptual framework for the development of an agent-oriented e-learning system supported by knowledge management. The next section describes the construction of the three-level system architecture; namely, the user level, domain level, and Web level. The final section concludes with an overall summary and discussion of the theoretical and practical implications of the proposed system.

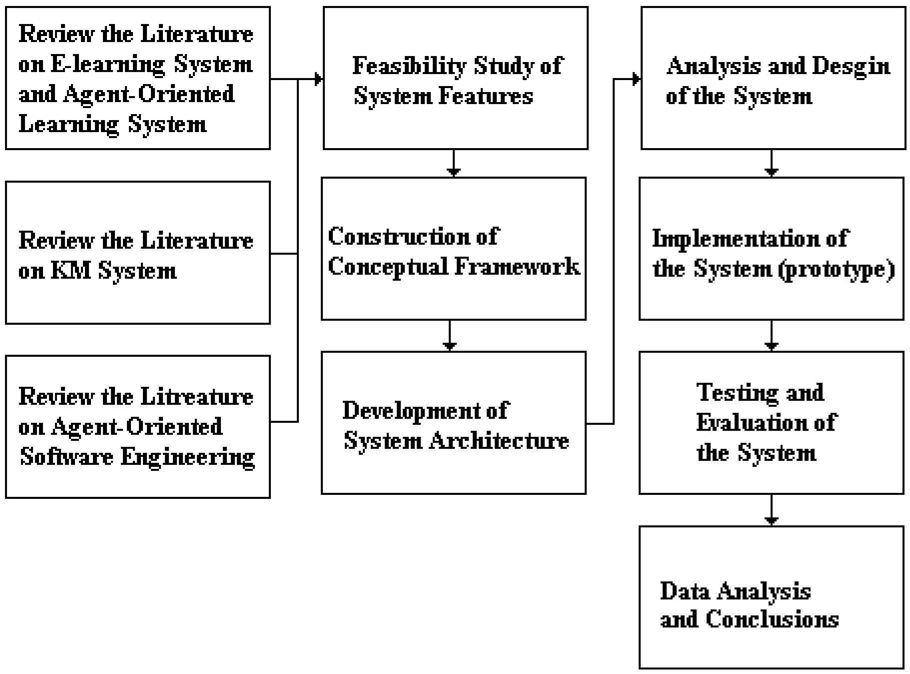
Figure 1 depicts the research path of this study. It begins with a review of the latest concepts, models, and technologies from the three different pertinent areas of e-learning, knowledge management, and intelligent agents. A conceptual framework is constructed and based on the literature review. The next stage is the development of an agent-oriented, e-learning system supported by knowledge management. The system architecture and the prototype are built using the latest computing technologies. Finally, the system is evaluated and validated.

RESEARCH METHODOLOGY

Figure 2 depicts the research methodology of this study. The following research issues are addressed in each phase of the research.

- Literature review of e-learning systems and agent-oriented learning systems, KM systems, and agent-oriented software engineering: Relevant literature related to e-learning systems and agent-oriented systems, KM systems, and agent-oriented software engineering will be studied. Based on an in-depth review of the literature, we propose the use of a conceptual framework that provides a template and gives us a mechanism for understanding the research issues and developing an agent-oriented e-learning system supported by knowledge management.
- Feasibility study of system features: This provides a clear picture of what features the future system should have. Based on available technologies and resources, the careful selection and aggregation of the features that had previously been identified from the literature review enables a logical view of a concrete and developable model.

Figure 2. The research methodology



- Construction of a conceptual framework: The proposed framework will be constructed. Different kinds of agents, KM, and e-learning components will be mapped into the framework to demonstrate how the system will function and to support the system's conceptual objectives.
- Development of the system architecture: A good system architecture provides a solid foundation for the development of the system. A conceptual map consisting of different components of the system with different functionalities is developed. It investigates how the components interact with each other. It maps the relationship of the system components to the required objectives and reduces the risk of missing, redundant, and coupled system functionalities.
- Analysis and design of the system: This is an important step in the development of the system. We need a clear understanding of the domain(s) on which the system rests. Here, different solutions are formulated and selected to meet the objectives and goals of the system.
- Implementation of the system: In this phase, we build the prototype through which the various issues arising in the early stages can be addressed and clarified. The prototype will provide a means by which the designer will attempt to clear up uncertainties or questions about concepts, frameworks, designs, and technical issues.
- Testing and evaluating the system: This is the phase in which the correctness and usability of the system are verified. The actual

expected functionalities of the system are compared for possible modification of the system. When adopting the system, the designer can gain insights into the level of application and look into the users' workload and problems.

- Data analysis and conclusion: Once the system has been developed and tested, the users' attributes, observations, and feedback from previous tests and surveys are examined in detail. Researchers can capture information on the users' acceptance of the system and determine further directions for improvement.

THEORETICAL UNDERPINNINGS OF AGENT-BASED E-LEARNING

This section introduces the background of our study. The discussion of relevant literature in three pillars provides a thorough understanding of the scope and the objectives of our research.

Agent-Based E-Learning Systems

In the past few years, many papers on agent-oriented e-learning systems have been published. Cristea et al. (2000) carried out a study on a Web-based, agent-oriented, long-distance teaching environment for teaching academic English. Thibodeau et al. (2000) developed the White Rabbit, a system to enhance cooperation among a group of people using intelligent agents to analyze their conversations. The aim of the Toolkit for the Management of Learning project led by Liber et al. (2000) was to develop tools to help teachers and students manage learning resources, negotiate learning programs, and develop learning profiles. A project exploring the role of agents as learning companions for humans was carried out by Uresti (2000). Nobe et al. (1997) conducted a pilot study

Table 1. A summary of different applications of agents in education

Nature	References	Areas of Application
Pedagogical agent – is directly involved in the transfer of knowledge	Acros et al. 2000	Agent capacity added to a virtual reality simulator as a demonstrator to teach Laparoscopy and Hystreoscopy surgery.
	Cristea et al. 2000	Using an agent in a web-based system to teach English in an academic environment.
	Ganeshan et al. 2000	Developing an animated agent used to tutor in medical diagnosis for a pedagogical purpose.
	Lester et al. 1997	Applying a simple constrained agent to enhance the effect of learning.
Supportive agent –reduces workloads from supportive activities in related teaching.	Liber et al. 2000	Utilizing an agent to manage learning resources, negotiate learning programs, and develop learning profiles.
	Nobe et al. 1997	Developing an agent with anthropomorphic ability to enhance the effects of learning.
	Ritter 1997	Having the agent act as a tutor to enhance communication between learners and the learning system.
	Thibodeau et al. 2000	Using an agent to analyze the conversation of users to enhance group cooperation online.
Guardian agent – works with the learner in a peer-to-peer manner to assist and reduce the user's workload	Liber et al. 2000	Using agents to manage the learning resources, negotiate learning programs, and develop learning profiles.
	Uresti 2000	Have agents act as learning companions.

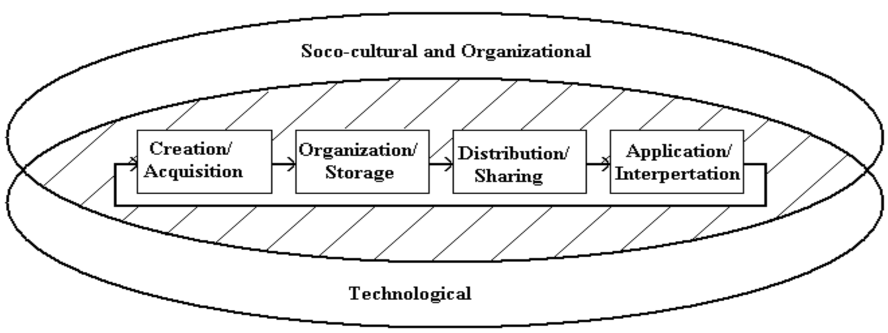
on a gaze-tracking method to access relevant aspects of an anthropomorphic agent's hand gestures in a real-time setting. A study of Adele, an animated pedagogical agent used in tutoring the subject of medical diagnosis, was presented by Ganeshan et al. (2000). The LAHYSTOTRAIN demonstrator, a training system that is combined with a virtual reality simulator and used for training in laparoscopy and hystreoscopy surgery, was developed by Acros et al. (2000). Miller et al. (2000) implemented an intelligent team-training system using an agent-oriented approach. Following this trend of development, an agent-oriented e-learning system for mass education should be in the horizon. The different applications for agents in education are summarized in Table 1.

Knowledge Management Systems

Broderick (2003) pointed out that learning occurs through personal experience or by sharing and repeating the experiences of others. The transfer of knowledge is a form of interaction between people. The knowledge management (KM) processing cycle may include steps such as the creation, capture, organization, accessing, and application of knowledge (Hayward 2000). It is people within the organization that create explicit knowledge or convert implicit knowledge to explicit knowledge. When learning and teaching experiences are documented and processed, they become knowledge. KM helps people to organize, store, distribute, and share knowledge. Procedures to capture and share pedagogical knowledge are equally important to the role of knowledge management within a successful organization. Daveport et al. (1998) stated that between data, information, and knowledge, organizational success and failure often depends on what you need, what you have, and what you do with each. Figure 3 shows the iterative perspective of the KM process (Rhsmith, 2003).

Garrison et al. (2003) pointed out that the latest direction in the development and research of Web-based learning systems (Web base) is to work with the artificial intelligence and introduce the semantic structure. Such new systems will be navigated and processed smoothly by both human and intelligent agents. Lytras et al. (2003) discussed the establishment of knowledge networks for e-learning enhancement through peer-to-peer technology. Kidwell et al. (2000) conceptualized the potential applications and benefits of knowledge management for higher education. In his thesis, Putzhuber (2003) provided a detailed study of the differences and similarities between e-learning and KM, and highlighted the benefits and possibilities of combining the two by building a prototype model.

Figure 3. The process of knowledge management (Rhsmith, 2003)

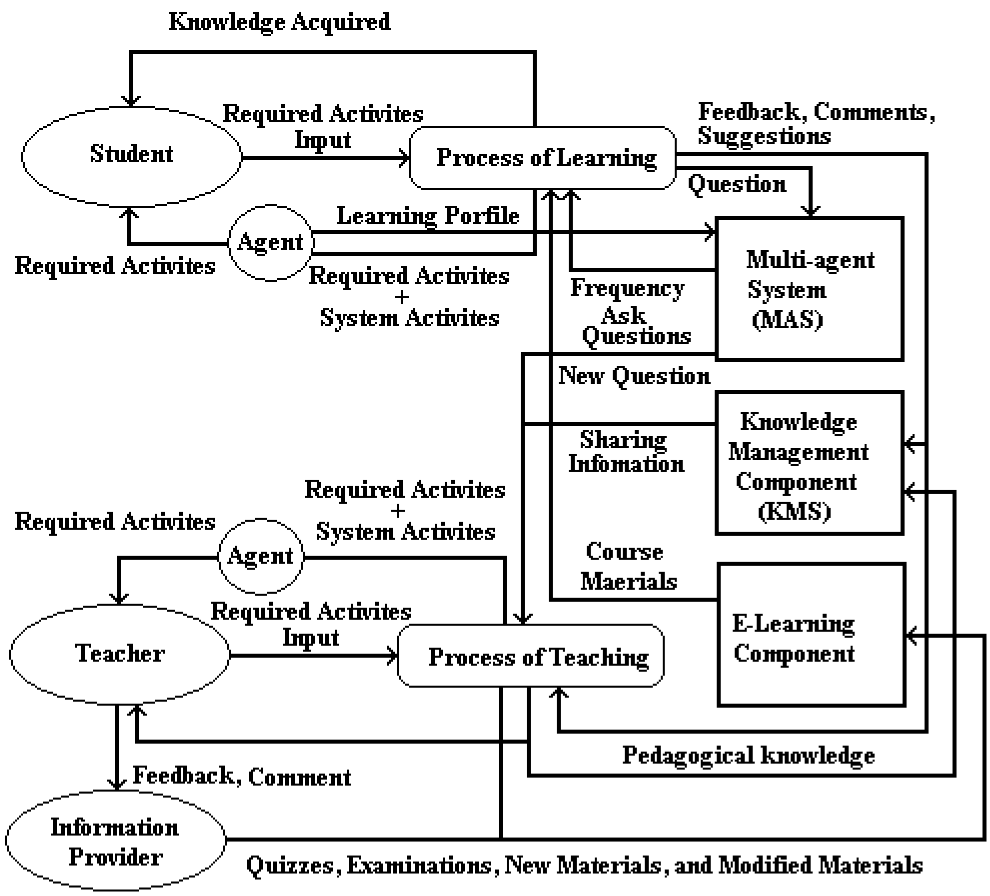


Commercial portals take up many features of KM and combine them with powerful search engines and intuitive and customizable Web interfaces. Strauss (2000) held the view that it should be possible to customize and personalize a portal, and that a portal should be desktop-oriented and adaptive. From a user's point of view, a KMS is a personalized collection of services and information, possibly a single point of access, where searching can be carried out across one or more resources. A KMS provides a tailored view of the aggregated information set, ease for aggregated cross searching, streamlined authentication, and user profiling. All of these features are rarely found in existing e-learning systems.

TOWARD DEVELOPMENT OF A CONCEPTUAL FRAMEWORK FOR AN AGENT-ORIENTED KM SUPPORTED E-LEARNING SYSTEM

A conceptual framework of an agent-oriented knowledge management supported e-learning system is shown in Figure 4. Within the conceptual framework, the student, the teacher, and the

Figure 4. The conceptual framework for the development of an agent-oriented e-learning system supported by knowledge management



information provider are the major users. The two agents as personal assistants of the two users (i.e., the student and teacher) form the basic part of the conceptual framework, together with the process of learning and teaching. For completeness, three major building blocks (i.e., the MAS, KMS, and e-learning system) are added to provide the services needed to support teaching or learning sessions on the Web. Two important features provided by the conceptual framework are illustrated in Figure 4. They include (1) using agents to reduce the workload of the users, and (2) capturing and sharing educational knowledge. Their detailed descriptions are given in the following sections.

In Figure 4, one can see that the student starts the learning process with the corresponding components responding by delivering all of the required materials, learning activities, and support and system activities to the student through the learning process. System activities are not part of the learning activities, but the system needs them to run smoothly. One example is the updating of the user's profile; another is the verification of the user's identity. An agent between the student and the process of learning can help filter out unnecessary information and handle all of the system activities, thus reducing the workload of the student. For the teacher who is involved in the process of teaching and disseminating pedagogical knowledge, the role of the agent is different. A question raised by the student will be sent to the MAS to answer. If the MAS fails to answer, it will pass the question to the teacher. The feedback, comments, and suggestions of the student and the pedagogical knowledge from the teacher will be captured and documented with the aid of the KMS component. After this information is filtered and processed, it may become knowledge that can increase the effectiveness of the system.

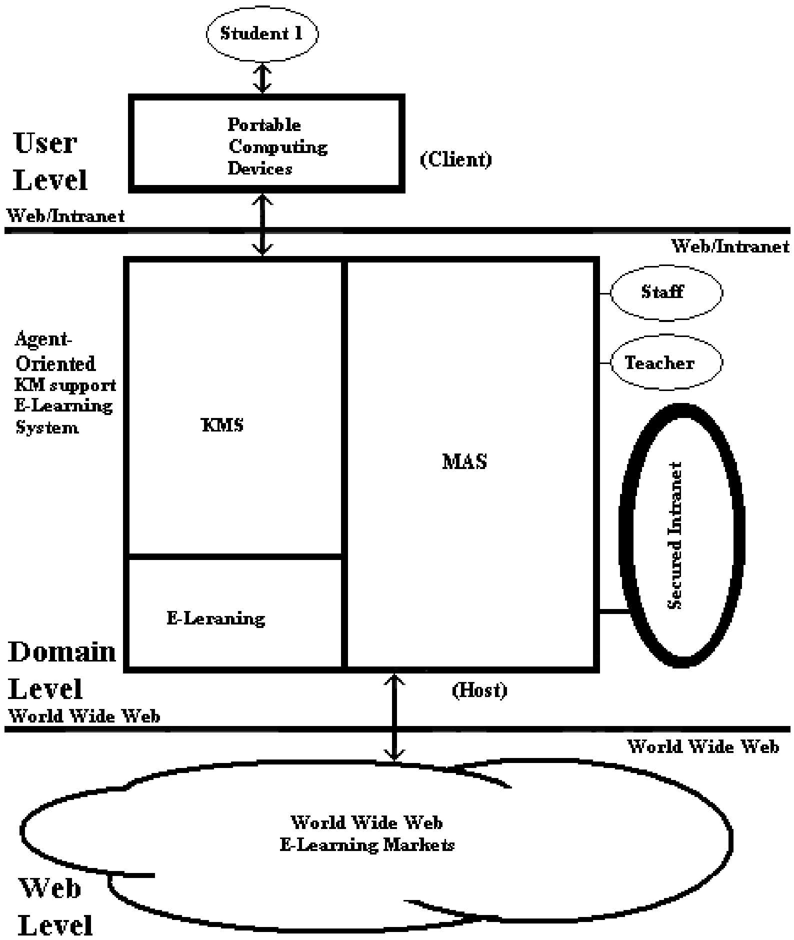
Intelligent agents working in KMS are not rare (Baek et al., 2004; Staniszkis et al., 2004). An online intelligent agent can keep track of the learning sessions. By observing the learner's behavior, the agent can follow the learning strategies or behavior of the learner (patterns, study times, and learning sequences). An agent can also record the learner's sources and methods of accessing supplementary materials that are not found in the teaching materials. The collection of this type of information may produce new knowledge or teaching materials after refinement by teachers or educators. In our framework, the agents take up most of the low-level jobs and indirectly monitor the learner's behavior by streamlining the process of creating, storing, and sharing of knowledge, which is a vital part of a successful KMS.

An agent is defined as a program that works automatically on routine tasks specified by a single user. It seems natural to determine the number of required agents based on different users. Adopting object-oriented analysis (Larman, 2001) and employing techniques such as scenario building, use-case analysis, and object generalization, we identify the following four major groups of users (actors) in an e-learning system: the learning, teaching, supporting, and information provider groups. The last group does not have a significant role to play here. The three-level conceptual model, corresponding to the four identified major groups of users, is shown in Figure 5.

The conceptual model consists of three levels:

- User level: At the user level, the student uses a client machine to access the system through an intranet or the Web. The client machine can be a desktop personal computer or any portable computing device.
- Domain level: At the domain level, a host machine is used to provide the working environment for the MAS, the e-learning system, and the KMS. The host machine(s) can be a single server or a cluster of servers in an intranet form. The duties of the host machine(s) include system security; information storage, update, and access; and learning- and teaching-related activities

Figure 5. Three-level conceptual model



supporting the four major groups of users. The teacher and support staff will access the system through the intranet at the domain level and the Web level.

- Web Level: The third level is the Web level, which is an aggregation of suppliers of the e-learning market. A market consists of exchangeable and reusable information resources, which spans different platforms and is well supported by the current e-learning services providers.

The three-level conceptual model is constructed on the popular client server structure when joined with the Web. Each level is independent of the others, with high-level communication carried out through the agents. Any modification at one level may not cause significant changes at another level, thus reducing the impact of the rapid growth of new technologies that may cause necessary changes at any level. The user level can be any computing device ranging from desktop to hand-held computers. The smaller the size of the learning device, the greater the learning mobility of the users will be. Also, different learners can use different devices to access the system. Finally, the Web level acts as an open architecture for other providers of e-learning services to join in, as long as agent communication is enabled for both parties.

In the next section we will provide a more detailed presentation of our conceptual model. Through this discussion, several critical issues related to e-learning effectiveness will be pointed out.

User Level

Agent at the Client Machine

The client machine is used to support the student's learning, the presentation of course materials, performance evaluations, and monitoring. A Guardian Agent (GA) with certain features similar to the Personal Guardian (Ozdemir et al., 2000) is used here. The GA will filter all messages, materials, and requests from the host, other students, or the Web. Only learning-related activities or requests the agent is unable to handle will be passed to the user.

When a user starts the learning session, the GA can obtain the login information from the user profile and automate the login process. The GA then sets up the environment and sends the user preferences and progress to the Presentation Agent to get the required materials. During the learning session, the GA can filter the incoming mail and messages and reduce the distraction to the user caused by unnecessary conversation. From the progress log, the GA can give reasonable and appropriate advice and reminders about appointments and assignments at the right time. When the user needs to search or get extra information during the learning process, the GA can try to estimate the quickest way and then get the required materials based on the user's past experiences. All the way, the agent can monitor and keep track of the user and collect valuable information online until the session ends. From this scenario, a brief description of the components in the client machine is given as follows:

1. The user interface is a general interface that provides communication between the client machine and the user.
2. The personal profile will provide the user's personal information, preferences, and academic records to the GA.
3. The progress log is the place where the GA stores the information about the learning progress, such as project due dates, appointments, meetings, and so forth.
4. The GA to store performance-related information uses the user library. Such information is needed for the analyses of learning patterns or for the creation of study plans.
5. The personal library is where the locations and passwords for all accessible resources are stored. The GA uses this information to automate the retrieval of information.
6. Correspondence information stores personal information and preferences about the user needed by the GA to communicate or filter information.
7. Working space is simply a place used by the GA to temporarily store information. The objective of the GA is to enable the learner to have more time for core learning activities such as studying lecture notes, practicing quizzes, revising for examinations, doing assignments, attending tutorials, and participating in group projects or discussions. In the next section, a brief tour of the MAS is given.

Domain Level

MAS Module of the Host Machine

The MAS module contains the pedagogical agent, facility agent, presentation agent, help agent, domain agent, search agent, and administrative agent.

1. The pedagogical agent works on behalf of the teacher. It can take over from the teacher any non-teaching related duties and simple routine jobs. Providing help, guidelines, or assistance online, or answering the frequently asked subject questions are good examples of the pedagogical agent's duties.
2. The facility agent works on behalf of the support staff. It can take over from the staff all routine jobs and administrative and support duties that require no decision-making. Examples of such activities are the drawing up of timetables, registration of classes, collection of assignments, and so forth.
3. The presentation agent handles the requests for materials from the students and redirects all of the requests to the appropriate system agents to process. It also acts as the coordinator and makes sure that the correct answer goes to the right person or agent.
4. The help agent handles questions from the students and looks for an answer from the frequently asked questions pool. If the help agent fails to find an answer, the question will be passed to the pedagogical agent and then to the teacher to answer.
5. The domain agent handles all of the communications from the Web between the host and the suppliers of the e-learning markets.
6. The search agent specializes in search for information. It will search the electronic library first, the knowledge base next, and the Web last.
7. The administrative agent is responsible for verifying the user's and GA's identity and authorization of access resources. Any agent accessing the system will have its current status posted on the agent bulletin board when in contact with other online agents.

A brief but complete view of the MAS is presented here. Table 2 summaries the relationships between the actors, the agents, and the levels where the intelligent agents are serving.

Different agents with different goals are grouped together to form the MAS. Together, they reduce the workload and increase the functionality and efficiency of the system. Table 3 gives a brief summary of the relationships between the constructed agents and their boundaries of services.

E-Learning Module of Host Machine

It is a unique challenge for educators to create a cohesive community of inquiry in a medium that

Table 2. The major actor and its related agent with location level

Actor	**Agents**	**Levels**
Student	Guardian Agent	User
System - Information Search	Search Agent	User/Domain
Teacher (teaching staff)	Pedagogical Agent	Domain
Staff (support staff)	Facility Agent	Domain
System - Course Offerings	Presentation Agent	Domain
System - Security Control	Administration Agent	Domain
System - General Support	Administration Agent	Domain
E-Learning Markets	Domain Agent	Domain/Web

Table 3. Agents and boundaries of services

Agents	Boundaries of serving
Guardian Agent	Activities related to supporting studying by learners.
Pedagogical Agent	Activities related to teaching, consultation, and tutoring.
Presentation Agent	Activities related to user and agent authorization, and allocation of system resources to agents.
Admin Agent	Activities related to user and agent authorization, and allocation of system resources to agents.
Facility Agent	Activities related to recording, verification, and administration.
Search Agent	Activities related to searching for information, and acquiring extra materials over WWW.
Help Agent	Questions frequency asked by users.
Domain Agent	Information exchanged by third parties over the WWW.

provides no real human-to-human contact. There are systems that provide many administrative functions for the student and more system support tools than a normal e-learning system provides, such as WebCT (Webct, 2003) and Elearning Software Solutions (Elearningsoftware, 2003). However, these learning management systems are only enhanced and expensive versions of the ordinary e-learning system.

To differentiate the agent-oriented component from the non-agent component, we label all non-agent components as managers. Different managers that provide different features are found in the e-learning component.

1. The material manager controls the accessing and updating of the course materials database.
2. The examination manager controls the accessing and updating of the evaluation and quiz database. The examination manager is also responsible for conducting and marking online examinations or quizzes.
3. The administration manager controls the accessing and updating of the student records database.
4. The library manager controls the accessing and updating of the electronic library database.

Together, they provide the core functions needed to support teaching and learning. Table 4 summarizes the relationships between the e-learning components and the boundaries of their services.

Table 4. E-learning module components and boundaries of services

Components	Boundaries of services
Material Manager	Controls the creating and updating of the course.
Administration Manager	Controls the flow of documents and information, reviewing, and publishing.
Examination Manager	Stores information by categories, meta searching across internet by key words.
Library Manager	Controls activities related to recording, verifying, and offering materials.

KMS Module of Host Machine

The KMS provides some features that most existing e-learning systems lack and that are useful in sustaining a collaborative learning environment. It offers a centralized point of access for finding and managing information. By using a browser to view the dashboard site, the user can perform document management tasks and find information. A KMS with portal features can help both teachers and students to effectively capture and share educational experiences and knowledge. Embedding the KMS in an e-learning system, we make available the following benefits: (1) The portal manager allows the presentation of course materials in the way the user wants and keeps the user's preferences in the user profile database. (2) The workflow manager supports document management. Through it, the user can check documents in and out, review a document's history, apply controls over publishing, and automatically route the documents to reviewers. (3) The content manager controls access to the documents and information for building the personal portal with contents from the knowledge base database, multimedia database, and course materials database. (4) The subscription manager provides functions for use in subscribing to new or changing information. (5) The Web claw manager with the index search workspace database enables information to be browsed through categories, searches using keywords, and searches across trusted intranets

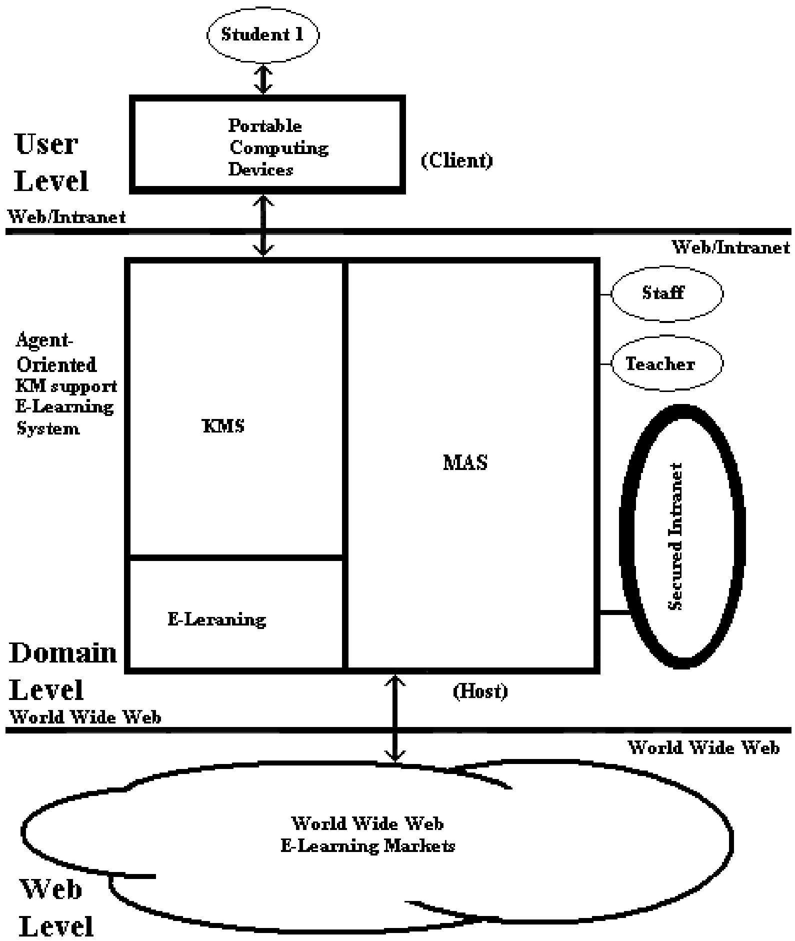
Table 5. Components of the KMS module and boundaries of services

Components	**Boundaries of activities**
Portal Manager	Creates and maintains the learner's personal portal.
Work Flow Manager	Controls the flow of documents and information, reviewing, and publishing.
Content Manager	Controls access to the contents of the course and supplementary knowledge.
Subscription Manager	Controls subscriptions to new or changing information and notifies the users.
Web Claw Manager	Gathers web information from an entrusted intranet. Supports information by categories, key words, or meta searching across the internet.
Dispatcher	Filters all incoming requests and dispatches the requests to the appropriate receiver.

Table 6. Databases and stored related information

Database	**Nature of the Information**
User Profiles	The preferences of each user for use in building the personal portal.
Index Search Workspace	Supports the different modes of searching with the system or the entrusted intranet with help from the Web Claw Manage.
Knowledge Base	The main base for the storing and sharing all knowledge other than the fixed teaching materials.
Multimedia	Is the storage for all information that not in a textual format.
Course Materials	The place for storing all of the course materials.
Student Records	The place where the student's academic records are stored.
Evaluation and Quiz	The place where all the tests and examination papers are stored.
Electronic Library	The place to look for frequently asked questions and answers. Supplemental materials and help files are also found here.

Figure 6. System architecture for the development of an agent-oriented e-learning system supported by knowledge management



in a transparent manner. (6) The dispatcher filters all incoming requests and dispatches the requests to the legitimate owners or handlers.

Table 5 summarizes the relationships between the portal components and their boundaries of activities.

The system architecture of an agent-oriented e-learning supported by knowledge management is shown in Figure 6. Multiple concurrent users from different levels, the managers of the e-learning and KMS module, and the agents from the MAS module are all constituent parts of the architecture. There are eight databases in the host machine to store different types of information at different levels of security. Table 6 summaries the relationships between the databases and the nature of the information stored in them.

Trusted Web servers, database servers, e-mail servers, or communication servers can join the intranet to share their information or services with the system and users. On the client machine, more than one set of personal information and utilities are found so that the student can select different settings when he or she uses a different machine to login or work with another agent-oriented e-learning system.

Web Level

E-Learning Resources at Web Level

The domain agent at the host machine handles all communications between the Web and the system. This communication channel acts as an aggregate of different supporting e-learning resources. The e-learning resources consist of exchangeable and reusable information resources that span different platforms. The members of the e-learning resources include education brokers, global education brokers, online consultants, digital libraries, and information providers. The education brokers from local or global sources can provide new teaching materials, training courses, and other support services. Digital libraries can provide information or resources in both the kind of quantity and quality that no single, privately owned library could offer. Information providers can supply new and updated information in a cost-effective and timely manner. Online consultants can provide services that are not available internally in the system.

A Validation Strategy

The final goal of this research is to validate the model in a real-world setting. More specifically, through an exploratory study, the research is to investigate the learning result of KM activities during the learning process. First, the system will be evaluated with a larger scale test of multiple users in a real environment. The feedback from different users and the performance of the agents will be examined in great detail to see how well agents can fit into the model. Second, a model for evaluation will be developed and used to investigate the impact on the learning of students of the agent-oriented e-leaning system supported by knowledge management. Students of the Hong Kong Polytechnic University and other tertiary institutions will be invited to take part in the evaluation exercises. A control group of students will be set up. Both qualitative and quantitative methods will be used to compare the differences between the two approaches.

CONCLUSION

The study was motivated by the need to design a flexible, self-paced e-learning system with the least constraints for lifelong learners, given that both people and organizations need to remain competitive in this era of information. A solution that would answer the challenge of providing a flexible, continuous education is to enhance the knowledge capacity of agent-oriented e-learning systems. A conceptual framework and the corresponding system architecture for the development of an agent-oriented, knowledge-supported e-learning system are described in this chapter. We present a viable approach by integrating e-learning, KM, and agent techniques to enhance the quality of the support function for lifelong learners. Some of the benefits of integrating e-learning and KMS with an agent-oriented approach include: (1) supporting KM functions such as notifications of subscriptions, workflow control, and aggregation of information over various sources, (2) enhancing the quality of the support provided to students in the spirit of collaborative teamwork learning, (3) facilitating the creation of knowledge for the student and the teacher, and (4) offering a means for the systematic self-adaptive improvement of the system.

As for future research, we are interested in a number of issues. We are interested in applying data mining techniques to look for any interesting patterns or relationships in data collected by an online agent about the activities of learners and the profiles of users. Other research areas that might be interesting to explore are effective learning patterns, the sequence of the presentation of materials in successful learning, or any early observable behavior that indicates poor learning results within the e-learning system.

Another interesting issue relates to the relationship between ontology and e-learning agents. Integration with ontology enables agents to communicate and share different views of the world (i.e., the environment of one agent with one another). Lytras et al. (2003a) pointed out that the construction of an e-learning platform entitled "Semantic for E-Learning" by merging e-learning, KM, and ontology could be one way in which research in this area could be extended.

The mobility of agents is also an exciting area for further research. Mobile agents that travel from one machine to another (e.g., from a desk top to a palm top) enables the learner to take lessons even in a more convenient way but creates the problem of resource availability; namely, the size of the memory which is commonly true for wireless connection handheld devices.

Enhancing e-learning with a KM-oriented metadata schema (Lytras et al., 2002) or with semantic Webs that greatly increase the automatic transferability of knowledge from systems to users or peer-to-peer with other e-learning systems is another direction that we are going to investigate after completing the development of an agent-oriented, knowledge management supported e-learning system.

THEORETICAL AND PRACTICAL IMPLICATIONS

The approach, conceptual framework, and architecture proposed in this paper require a significant amount of integration of research from different fields such agents, MAS, software engineering, pedagogical agents, KMS, e-learning, and agent-oriented software engineering. Some of the challenges in this integration include sorting out the following roles for the different actors: (1) the student's role in effective learning, (2) the reduction of the workload of the user by agents, (3) the role of the central repository in effective learning, and (4) the role of agents in an e-learning system, especially in a cooperative and interactive system.

E-learning, KMS, and agents are still under development, and many areas have not been fully exploited yet. The approach presented in this chapter illustrates the process of starting from the modeling of a conceptual framework to the construction of a system architecture using a system development perspective. Employing such an approach, it is possible to create an agent-oriented e-learning system supported by knowledge management with better overall performance than any specially tuned e-learning system with some enhanced features. This approach poses challenges in the merging of different systems and technologies. It helps the designer minimize the time and effort required to develop the next generation of e-learning systems. From a teaching viewpoint, there is no better instructional system than a cooperative and interactive system. The proposed architecture provides a channel for teachers and students to capture and share experiences, thus providing a better cooperative, interactive learning environment. A companion acts as a personal assistant that can learn the user's habits and preferences and can modify itself with a minimum amount of intervention from the user.

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REFERENCES

Acros, J., et al. (2000). *LAHYSTOTRAIN: Integration of virtual environments and ITS for surgery training.* Intelligent Tutoring System 5th International Conference ITS 2000.

Baek, S.K., Liebowitz, J., Prasad, S.Y., & Granger, M.J. (2004). *The intelligent agent-based knowledge management system for supporting multimedia systems design on the Web.* Retrieved from http://hsb.baylor.edu/ramsower/ais.ac.97/papers/sbaek.htm

Broderick (2003). Retrieved from www.geocities.com/ok_bcurt/Learningfrom.doc

Cisco (2004). E-learning. Retrieved from http://www.cisco.com/gov/people/e_learning.html

Cristea, A., & Okamoto, T. (2000). Knowledge computing method for enhancing the effectiveness of a WWW distance education system. *Springer LINK: Lecture Notes in Computer Sciences, 1892*, 289-292.

Davenport, T.H., & Prusak, L. (1998) *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Elearningsoftware (2003). Retrieved from http://www.elearningsoftware.co.uk/

Flores-Mendez, R.A. (2001). Towards a standardization of multi-agent system frameworks. *ACM Crossroads Student Magazine.* Retrieved from http://www.acm.org/crossroads/xrds5-4/multiagent.html

Ganeshan, R., Johnson, W.L., Shaw, E., & Wood, B.P. (2000). *Tutoring diagnostic problem solving.* Intelligent Tutoring System 5th International Conference ITS 2000.

Garrison, D.R., & Andreson, T. (2003). *E-learning in the 21st century: A framework for research and practices.* New York: RoutledgeFalmer.

Giraffa, L.M.M., & Viccari, R.M. (1998). The use of agents techniques on intelligent tutoring system. *Computer Science SCCC '98. XVIII International Conference of the Chilean Society of 1998*.

Glezer, C., & Yadav, S.B. (1999). Conceptual model of an intelligent meeting-scheduler. *Journal of Organizational Computing and Electronic Commerce, 19*(4), 233-251.

Guttman, R.H., Moukas, G.A., & Maes, P. (1988). Agent-mediated electronic commerce: A survey. *The Knowledge Engineering Review, 13*(2), 147-159.

Hayward, S. (2000). *Choosing wisely: Technologies for knowledge management.* Gartner Symposium ITXPO, Fla.

Huber, G. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Jennings, N.R., Sycara, K., & Wooldridge, M. (1998). A roadmap of agent research and development. *Autonomous Agents and Multi-Agents Systems, 1,* 7-38.

Kidwell, J.J., Vander-Linde, K.M., & Johnson, S.L. (2000). Applying corporate knowledge management practices in higher education. *EDUCAUSE Quarterly, 4,* 28-33.

Larman, C. (2001). *Apply UML and patterns: An introduction to object-oriented analysis and design and the unified process* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Luan, J. (2001). *Learner relationship management: signs of things to come.* Annual Conference of the Community College League of California, Riverside, CA.

Lee, W.B., & Lau, H.C.W (1999). Multi-agent modelling of dispersed manufacturing networks. *Expert System with Applications, 16*, 297-306.

Lester, J.C. et al. (1997). The persona effect: Affective impact of animated pedagogical agents.

Conference Proceedings on Human Factors in Computing Systems ACM.

Liang, T.P., & Huang, J.S. (2000). A framework for applying intelligent agents to support electronic trading. *Decision Support System, 28,* 305-317.

Liber, O., Oliver, B., & Britain, S. (2000). The TOOMOOL project: Supporting a personalized and conversational approach to learning. *Computer and Education, 34*, 327-333.

Lytras, M.D., Poulodui, A., & Poulymenakou, A. (2002). Dynamic e-learning setting through advanced semantics: The value justification of a knowledge management oriented metadata schema. *International Journal on E-Leaning, Oct-Dec*, 49-61.

Lytras, M.D., Tsilira, A.A., & Themistocleous, M.G. (2003). *Peer-to-peer knowledge networks and e-learning clusters of application: A conceptual and technological spproach of potential business value.* Ninth Americas Conference on Information Systems.

Lytras, M.D., Poulodui, A., & Themistocleous, M.G. (2003a). *Towards the semantic e-learning: An ontology oriented discussion of the new research agenda in e-learning.* Ninth Americas Conference on Information System.

Miller, M.S., Yin, J., Volz, R.A., Ioerger, T.R., & Yen, J. (2000). *Training teams with collaborative agents.* Intelligent Tutoring System 5th International Conference ITS 2000.

Nobe, S., Hayamizu, S., Hasgawa, O., & Takahashi, H. (1997). Are listeners paying attention to the hand gestures of an anthropomorphic agent? An evaluation using a gaze tracking method. *Springer LINK: Lecture Notes in Computer Sciences 1371,* 49-58.

Nokaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nwana, H. (1996). Software agents: An overview. *Knowledge and Engineering Review, 11*(3), 1-42.

Ozdemir, B., & Alpaslan, F.N. (2000). An intelligent tutoring system for student guidance in Web-based Courses. *Knowledge-Based Intelligent Engineering Systems and 25Allied Technologies, 2000 Proceedings Fourth International Conference.*

Putzhuber, W. (2003). *From elearning to knowledge management—Bridging the gap.* Master Thesis. Graz Unicverity of Technology.

Rhsmith (2003). Retrieved from http://www.rhsmith.umd.edu/is/malavi/icis-97-KMS/index.htm

Ritter, S. (1997). *Tool/agent communication: Base document.* Retrieved from http://grouper.ieee.org/P1484/doc/wg7/tooltutorspec.html

Sen, S. (1997, Jul/Aug). Developing an automated distributed meeting scheduler. *IEEE Expert, 12*(4), 41-45.

Serban, A.M., & Laun, J. (2002). *Knowledge management: Building a competitive advantage in higher education.* San Francisco: Jossey-Bass.

Staniszkis, W., & Staniszkis, E. (2004). *Intelligent sgent-based rxpert interactions in a knowledge management portal.* Retrieved from www.icons.rodan.pl/articles/SS03.pdf

Strauss, H. (2000). A home page foth not a portal make. Converge 2000 Portal Technology Symposium, San Diego, CA. Retrieved from http://www.princeton.edu/%7Ehoward/slides/portals_files/fram

Thibodeau, M., Belanger, S., & Frasson, C. (2000). WHITE RABBIT - Matchmaking of user profiles based on discussion analysis using intelligent agents. *Springer LINK: Lecture Notes in Computer Sciences, 1839,* 113-122.

Uresti, J.A.R. (2000). *Should I teach my computer peer? Some issues in teaching a learning companion*. Intelligent Tutoring System 5th International Conference ITS 2000.

Usnews (2003). Retrieved from http://www.usnews.com/usnews/edu/elearning/articles/el-students.htm

Vise (2004). Retrieved from http://www.vise.cs.uit.no/vise/schedule.htm

Webct (2003). Retrieved from http://www.webct.com/

White, G. (2003). *The changing landscape: E-learning in schools*. Retrieved from http://www.educationau.edu.au/papers/changing_landscape_gw.pdf

Wooldridge, M. (1997). Agent-based software engineering. *IEE Proceedings on Software Engineering*, *144*(1), 26-37.

Zhang, H.C., & Zhang, D. (1995). Concurrent engineering: An overview from manufacturing engineering perspective. *Concurrent Engineering: Research and Application, 3*(3), 221-237.

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Chapter 2.41
Knowledge Management Agents

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APPLYING AGENTS WITHIN KNOWLEDGE MANAGEMENT

The agent has existed as a concept for thousands of years. In the human context, an agent is a person that performs some task on your behalf, for example, a travel agent planning flights and accommodation for your holiday, or a real-estate agent helping you buy or sell a house, or someone arranging marriages. Some Biblical laws specifically refer to agents.

In the much more recent software context, an agent is loosely a program that performs a task on your behalf. Agents have grown in popularity since the introduction of the PC (personal computer) as the target environment for application software has increased in complexity. Software systems must now operate robustly in a networked, global environment comprised of diverse, distributed technologies. Furthermore, the environment is dynamic, and frequent change is inevitable. Having automated help is almost a necessity.

Despite many attempts, there is no universally agreed technical definition of agents. An oft-cited reference by Franklin and Graeser (1996) gives almost a dozen different definitions. Let us consider a textbook definition given by Wooldridge (2002, p. 15). An agent is "an encapsulated computer system, situated in some environment, and capable of flexible autonomous action in that environment in order to meet its design objectives."

Essential characteristics of the agent paradigm that can be elicited from this definition are:

- The autonomy of individual agents, or their ability to act for themselves and to achieve goals
- The reactivity of individual agents in response to changes in the environment
- The modularity of individual agents and classes to allow the easy development of complex systems
- The ability of agents to communicate effectively and interact with legacy systems

Optional characteristics of the agent paradigm, which emerge from broader considerations of agents than the above definition, include mobility in moving around a network and the ability to reason.

This article rests on the metaphoric view of agents as entities performing tasks on one's behalf. Agents are presumed useful for building software to interact with complex environments such as the Internet or within complex organizations such as universities and multinational corporations. Expected of a program being viewed as an agent is an ability to sense and be aware of the environment in which it is situated, an ability to communicate with other agents, and an ability to take action in its situated environment. According to these three expectations, sophisticated e-mail programs such as Microsoft's Outlook and Qualcomm's Eudora can be viewed as agents. They are situated on the Internet and sense various aspects of the Internet, including when Internet connections are live and when new mail arrives. They communicate with other e-mail clients by sending and receiving messages. They take actions such as raising alerts when mail has arrived, sending mail that has been queued once an Internet connection is restored, or filtering messages according to rules.

We now connect with knowledge. Organizations operating in today's software environment need to represent, interact with, and above all, maintain a large collection of knowledge, including, for example, business practices, trade secrets, intellectual property, organizational hierarchies, promotional organizational descriptions, and knowledge of both its own policies and policies of relevant, external regulatory bodies. There is out of necessity great diversity in the form, content, and context of the knowledge. Most of this knowledge is in unstructured or semistructured form. The problem of the representation and maintenance of such knowledge within an organization can be loosely called the knowledge management problem.

For the purposes of this article, there is no need to define the knowledge management problem or knowledge management, for that matter, more precisely. However, we note that the term knowledge management subsumes the term content management. Referring to knowledge rather than content suggests some concern with formalizing knowledge explicitly.

How might agents be applicable to the knowledge management problem? As a running, concrete example, consider knowledge management issues related to the responsibilities of a university lecturer in charge of a subject1. She or he must prepare, deliver, and maintain content in a variety of forms, possibly including lecture notes, papers, and media presentations. Let us particularly focus on one component of the task, namely, maintaining a Web site for the subject.

Several possibilities exist for enlisting the help of agents. An obvious first task for agents is to help with the acquisition of knowledge, which is obtaining content and placing it on the Web site.

What type of software agent might be useful for the acquisition of knowledge? It is natural to envisage a custom Web crawler (http://en.wikipedia.org/wiki/Web_crawler), Programs that trawled specified Web sites looking for content were early applications built to exploit the World Wide Web. Building a Web-crawling agent immediately raises important considerations. The agent should be aware of important regulatory issues such as the fact that downloading mp3 files is illegal in some countries without the authorised permission of the copyright holder. The agent should also be aware of conventions such as the robots.txt protocol (http://en.wikipedia.org/wiki/Robots.txt_protocol) in which guidelines are given about parts of a file hierarchy that should be ignored by well-behaved agents. There are many similar policies of which a knowledge-acquiring agent would need to be aware. These policies demonstrate some of the complexities that need to be taken into account in building agents.

Search engines are based on exhaustive trawls and efficient indexing of files using techniques from information retrieval. Agents can also be constructed using techniques derived from experience in building knowledge-based expert systems. Consider the task of tracking down a particular paper by a particular author. One may have been referred to the paper by word of mouth or by the need to cite a final version of the paper for which you only had a preliminary version. A prototype citation-finding agent, CiFi (Loke, Davison, & Sterling, 1996), was built for this task. CiFi used the following three strategies for finding papers. First, CiFi tried to find a link from the author's home page2 using heuristics about possible keywords such as research and publications. Then CiFi looked for a link from a page of publications or technical reports linked from the author's department. Finally, CiFi sent an e-mail to the author asking for the file or citation.

A challenge in building CiFi was making it work on a variety of Web sites. Ideally, a single agent is desirable that can operate successfully over a range of Web sites. CiFi was not particularly intelligent or effective. It clearly reflected a bias to papers written by researchers within universities. It failed, for example, to find white papers written by companies. It would have had difficulty adapting to current spam filters if its e-mail message was blocked. Having agents adapt to changing circumstances is a desirable property. However, CiFi is indicative of an agent that might be applied to a knowledge management task.

Another task that might be assigned to an agent is to look for new articles by particular authors. Suppose you respect the work of a particular researcher and want to be notified of any of his or her new publications. It is possible for an agent to look for changes on a Web site and alert you that a new publication may be present3. In general, reporting changes or the presence or absence of documents is a task that the reader should have no difficulty in identifying as being potentially useful within his or her own organization. Providing new information or reminding participants that the next step in a work flow needs to happen can be helpful. Such an agent can be viewed as being a facilitator. Facilitation was espoused by Winograd and Flores (1987) as an alternative model for agents rather than artificial intelligence.

Let us return to specific tasks within Web-site management. Content on a Web page may be made available through links to other resources. However, it is frustrating when browsing to find outdated links on Web pages. An agent could check periodically whether links are still live. It would need to sense the result of its search and update the links on the page.

Here is another task for an agent. Some of the knowledge on a Web site can be usefully cross-linked. For example, an online quiz would be enhanced for self-study by having links from questions to material where the correct answer can be found. These links may be provided once the student has attempted the quiz. An agent could construct these links automatically. Of course, any changes to content would mean that the cross-links would need to be checked. A prototype agent called QuizHelper that can perform this task has been described in Chan and Sterling (2003).

Several of the above suggestions for agents address the performance of maintenance activities. Maintenance is key for knowledge management. The reader can doubtless imagine maintenance activities in his or her own environment that might be performed by an agent. Some maintenance activities are already happening automatically, for example, through alerts about software updates or the downloading of security patches.

A different type of task that an agent can perform is monitoring the use of a program.

For a program developed to help students learn material, an educator may want an agent to assess if the program is being used properly by the students. The assessment may be used to give feedback to the software developers or to try to ascertain whether the student is meeting learning objectives. The conceiving of agents to monitor student interaction with a program suggests good design questions. How is the agent going to sense what the student is doing? How are student actions going to be interpreted? How can student activities be matched to learning objectives?

Now imagine a system consisting of several of these agents working together performing tasks in a domain. A system consisting of multiple cooperating agents is known as a multiagent system. The conceiving of separate tasks being performed by separate agents simplifies the conceptualisation of how the system may be built. We discuss the building of multiagent systems later.

Agents need to be aware of the environmental context, and there is growing work on the representation of the context and the environment. Explicit models of the environment and context are examples of models of knowledge, our next topic. It is a challenge to handle the knowledge of different agents in a multiagent system, and this leads us to the important but difficult and conceptually rich area of agent ontology.

While ontology is discussed in other articles in this volume, we address it briefly as ontology is an important topic for agents and one that is underestimated by agent researchers. The most common definition of an ontology is "an explicit specification of a conceptualisation."4 In practice, an ontology is an explicit, formal knowledge-representation scheme.

As stated previously, an ability to communicate is intrinsic to an agent. In order for meaningful communication to occur between agents, they must understand what each other's terms mean. Clearly, knowledge management tasks are easier if all agents involved, including humans and software agents, agree on the vocabulary they are using.

Agent developers until now have assumed that each application would have a suitable ontology. Explicit languages have been developed for agent communication, notably KQML as discussed by Finin, Labrou, and Mayfield (1997), and the more recent standard, ACL, being developed by FIPA (Foundation for Intelligent Physical Agent; http://www.fipa.org). Both KQML and ACL are based on the speech-act theory originally espoused by Searle (1969). Communication by an agent using KQML has a field for an ontology. It is presumed that by knowing what ontology an agent uses, correct meaning will be applied. ACL is more sophisticated and even provides a specification for an ontology agent "for registering and serving ontologies to agents" (http://www.fipa.org/specs/fipa00086/).

There are several dimensions to consider with respect to an ontology. Is it general purpose or domain specific? Is it maintained centrally, or distributed among several agents? Do all agents use the same ontology or is meaning negotiated between different ontologies? Does each task have its own ontology? Where should the ontology come from? One possibility is that an organization maintains its own ontology that constitutes its single organizational view of the world. An alternative possibility has been that someone develops a single ontology to which developers refer. The prototypical example of a single ontology is Cyc, which has been under development for 20 years. An open-source version of Cyc is available at http://www.opencyc.org. A recent development with regard to Cyc is the use of contexts to represent local knowledge.

Knowledge depends on context. Different cultures do things differently, and the behaviour of an agent needs to be culturally appropriate. An increasingly common view is that agents should be allowed to have diverse views. Cultural issues should not be underestimated. Even within organizations, there is a need to interact with outside organizations, be they commercial, regulatory, or cooperative. Outside organizations will have a different view of the world and hence a different ontology. When agents communicate or cooperate in tasks, their knowledge may need to be matched, a process we call knowledge mediation.

An approach to achieving knowledge mediation is by viewing tasks as context, as advocated in Lister and Sterling (2003). Agents only need to be able to match up sufficient knowledge to perform a task rather than to match a complete ontology. While partial matching may lead to difficult maintenance issues should a task be repeated, it seems more realistic and akin to how people interact despite clearly different views of the world. This raises the issue of modeling tasks for agents. The knowledge of a domain is usually separate from the knowledge of performing tasks in the domain. In building an agent application, this needs to be taken into consideration.

The next topic to be considered is the practice of building multiagent systems. How should multiagent systems be built for knowledge management applications? Today's dynamic, distributed, heterogeneous environment presents a problem for software developers. Traditional software engineering has demanded the complete specification of a software application before issuing assurances that the application will work correctly. Producing a complete specification of requirements is not realistic and almost certainly impossible given the inevitable changes. It is questionable whether current software-development techniques are adequate5. The relatively new paradigm of agent-oriented programming (Wooldridge, 2002) has emerged as a potential successor to object-oriented programming, and in principle is better able to address the new demands on software.

While substantial experience has been accumulated in building individual agents, building a multiagent system remains a challenge. The first complete methodology proposed to guide the process of developing a multiagent system was Gaia (Wooldridge, Jennings, & Kinny, 2000). According to Gaia, a multiagent system is conceived as a computational organization of agents, with each agent playing a specific role, or several roles, within the organization and cooperating with other agents toward the achievement of a common application (i.e., organizational) goal. The field of agent-oriented software engineering has blossomed since 2001 to address the question of how to develop agents systematically. No single methodology has emerged as the best choice for developers.

A good overview of the range of methodologies for building multiagent systems can be found in Bergenti et al. (2004). Almost all methodologies highlight roles, goals, and agents as important new concepts for building multiagent systems rather than object-oriented systems. However, just as there is no agreed-on definition for agents, there is no agreed-on definition for roles and goals. Let us consider them briefly.

Roles are abstractions of agents, and they specify high-level aspects of an agent such as responsibilities, constraints, and permissions. It is useful to clarify in what role an action to be undertaken by an agent is to be performed. Goals are high-level representations of the purpose of a system. They specify what is to be achieved, the aspect of system analysis, rather than how something is to be achieved, which is system design and implementation. Eliciting system requirements in terms of roles and goals can be intuitive and different than the established object-oriented practice of using cases.

For many applications, we will want to consider a system as consisting of both humans and software agents. Knowledge management certainly involves people. A distinct advantage of the agent paradigm is that it facilitates thinking in terms of systems consisting of both humans and software agents. Thinking of a system in terms of roles and goals blurs the difference between human agents and software agents, which from experience is useful during elicitation.

Design proceeds once roles and goals have been elicited. Agents are chosen to fulfill one or many roles. The agents will perform tasks and activities to achieve goals and follow protocols. There is a growing body of literature on appropriate protocols for multiagent systems. The use of agents can help to abstract interface issues. Agents can serve as a wrapper around legacy systems. The interacting agents are designed to communicate correctly. How an agent communicates with the legacy program becomes an internal matter that does not need to be addressed by the system as a whole. Agents can also be designed to consume services, a view consistent with the current vision of Web services.

This article has been concerned with relating two topics: knowledge management and multiagent systems. We have considered how agents might be applied to knowledge management by identifying some knowledge management tasks that might usefully be performed by agents. We discussed how agents might be developed to perform the tasks, highlighting the extra concepts of goals and roles that are useful for the development of agents. In conclusion, knowledge management can be viewed as a system where humans and software agents cooperate. Research has been performed that indicates that building agents to perform knowledge management tasks is promising.

REFERENCES

Bergenti, F., Gleizes, M. P., & Zambonelli, F. (2004). *Methodologies and software engineering for agent systems: The agent-oriented software engineering handbook.* Norwell, MA: Kluwer.

Chan, K., & Sterling, L. (2003). Light-weight agents for e-learning environments. *Foundations of Intelligent Systems: Proceedings of the 14th International Symposium, ISMIS 2003* (pp. 197-205).

Finin, T., Labrou, Y., & Mayfield, J. (1997). KQML as an agent communication language. In J. Bradshaw (Ed.), *Software agents.* Cambridge, MA: MIT Press.

Franklin, S. P., & Graeser, A. G. (1996). Is it an agent, or just a program? A taxonomy for autonomous agents. In J. P. Muller, M. J. Wooldridge, & N. R. Jennings (Eds.), *Intelligent agents III.* Berlin: Springer-Verlag.

Gómez-Pérez, A., Fernández-López, M., & Corcho, O. (2004). *Ontological engineering.* London: Springer-Verlag.

Lister, K., & Sterling, L. (2003). Tasks as context for intelligent agents. In J. Liu, B. Faltings, N. Zhong, R. Lu, & T. Nishida (Eds.), *Proceedings of the 2003 IEEE/WIC International Conference on Intelligent Agent Technology* (pp. 154-160). IEEE Computer Society.

Loke, S. W., Davison, A., & Sterling, L. S. (1996). CiFi: An intelligent agent for citation finding on the World-Wide Web. In Springer lecture notes in artificial intelligence: Vol. 1114. *Proceedings of the 4th Pacific Rim International Conference on Artificial Intelligence (PRICAI-96)* (pp. 580-592).

Searle, J. R. (1969). *Speech acts: An essay in the philosophy of language.* Cambridge, MA: Cambridge University Press.

Shakes, J., Langheinrich, M., & Etzioni, O. (1997). Dynamic reference sifting: A case study in the homepage domain. *Proceedings of the 6th International World Wide Web Conference* (pp. 189-200).

Winograd, T., & Flores, F. (1987). *Understanding computers and cognition: A new foundation for design.* Reading, MA: Addison Wesley Publishing Inc.

Wooldridge, M. J. (2002). *An introduction to multiagent systems.* Chinchester, UK: John Wiley.

Wooldridge, M. J., Jennings, N. R., & Kinny, D. (2000). The Gaia methodology for agent-oriented analysis and design. *International Journal of Autonomous Agents and Multi Agent Systems, 3*(3), 285-312.

ENDNOTES

1. In the United States, a subject is called a course, a fact that illustrates the ontology problem discussed later in the article.
2. Finding an author's home page is an interesting task in and of itself, and agents have been developed to accomplish the task. The best known is Ahoy!, which was retired in 2000. More information can be found in Shakes, Langheinrich, and Etzioni (1997). Note that the need for such an agent has been essentially obviated by Google.
3. A free Web service was developed to notify users of Web-site changes several years ago. It is worth commenting that some people view the task an agent performs as a service, and the metaphor of intelligent services is used to describe similar concepts being discussed in this article. This is not the place to debate the relative merits of the agent metaphor vs. the services metaphor.
4. This definition of ontology is given by Gruber, and it is discussed at length in Gómez-Pérez, Fernández-López, and Corcho (2004).
5. It is a belief underlying the article that current software-development methods are inadequate, but the argument is beyond the scope of this article.

Chapter 2.42
Intelligent Agents for Knowledge Management in E-Commerce:
Opportunities and Challenges

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ABSTRACT

E-commerce has become a key aspect of the global business environment, causing fundamental changes in markets and organisational structures. This chapter considers how knowledge management, the latest management approach aimed at improving business performance, can create new business opportunities in the new business environment that is defined by electronic commerce. Knowledge management deals with the systematic generation, codification and transfer of knowledge and can be supported by a number of technologies, known as knowledge management tools. It has been argued that intelligent systems can offer additional capabilities and advantages in comparison with more traditional information technologies. This chapter investigates the potential of intelligent agent-based software for more effective knowledge management in the context of e-commerce, adopting the perspective of an SME involved in development of intelligent agents-based knowledge management software. The chapter concludes with a research agenda for knowledge management research in e-commerce.

INTRODUCTION

The importance of knowledge management (KM) as a competitive differentiator is increasingly recognised by both 'traditional' and 'virtual' organisations. A recent OECD report claims that industrial countries are spending as much on intangible knowledge-based investments as on physical equipment (OECD, 1999). There is an expectation that the technical exploitation of knowledge data will improve substantially with the use of intelligent tools that have several additional capabilities in comparison to traditional knowledge management tools, as discussed in this chapter. With improvements in IT-based systems for handling knowledge, knowledge management is becoming an essential theme of research into business success. Yet, it has been argued (e.g., Hlupic et al., 2001; Myers, 1996; Snowden, 1998) that the effective management of knowledge involves more than simply exploiting the data held on information systems. It also requires attention to the 'softer' parts of the corporate knowledge base, as found in the human and cultural aspects of businesses, particularly the experiences and tacit knowledge of employees. There is a growing emphasis on innovation through 'knowledge work' and 'knowledge workers' and on leveraging 'knowledge assets' (Swan et al., 1999).

While some research also makes reference to the organisational context within which the technology will be used (e.g., Delesie and Croes, 2000; Edwards and Gibson, 2000), there is little evidence of whether or how the organisational and technical dimensions have been integrated. The challenges, both technical and contextual, presented in this chapter indicate that electronic commerce creates a new context for knowledge management, not just in terms of the cultural and business environment created, but also in terms of the actual knowledge that is captured, exchanged and exploited. To deal successfully with the latter, it has been suggested that artificial intelligence, and intelligent agents in particular, have a key role to play (Smith and Farquhar, 2000). This chapter will consider how this new technology can be applied in practice. Typically, research in knowledge management would consider the view of the 'client', i.e., how a particular organisation improves its knowledge management practices. Our chapter focuses instead on the ways in which the new context of electronic commerce creates business opportunities for the provider of intelligent technology to support knowledge management. This party, the 'supplier', needs to have a broader view of the new technological and cultural landscape. We access this perspective by researching the case of an internationally oriented SME involved in multi-agent software development used for knowledge management in electronic commerce.

The chapter is structured as follows. The next section presents some of the key organisational and technical challenges for knowledge management, with emphasis on the role intelligent multi-agents and the challenges that electronic commerce presents for knowledge management. Section three introduces the case of an SME involved in development of intelligent agents-based KM software. A research agenda for KM research in e-commerce is then proposed, and conclusions are drawn.

KEY CHALLENGES IN KNOWLEDGE MANAGEMENT

The literature has been unable to agree on a definition for the term 'knowledge management' (Brooking, 1999; Hlupic et al., 2002; Malhotra, 1997; Trauth, 1999). One reason is that discussions of, and approaches to, the subject are rooted in different academic disciplines and areas of professional expertise. From the information systems perspective, for example, KM is often looked upon as synonymous with new forms of 'data mining' and 'warehousing' — the 'hard' tools that allow for sophisticated pattern searches of raw data (Trauth, 1999). From the innovation management perspective, a 'cognitive' approach is adopted, which looks at the transfer of explicit and tacit knowledge through product development and organisational change procedures (Kuhn and Abecker, 1997; Leonard-Barton, 1995; Nonaka and Takeuchi, 1995). The management literature places particular emphasis on issues of 'organisational learning', especially structures which encourage creativity and knowledge sharing (Ruggles, 1997). It is increasingly evident that these definitions do not adopt a multi-disciplinary approach, despite the multi-disciplinary interest in KM (McAdam and McCreedy, 1999; Phillips and Patrick, 2000). Instead, a managerial perspective is often predominant that does not necessarily accommodate the capabilities of information systems. The reverse is also common in research that is intended for a technical audience. We argue that KM must move towards a more holistic approach to nurturing and exploitation knowledge assets in both 'traditional' and 'virtual' business environments. In the chapter we demonstrate this in two ways. First, in this section, we give as much attention to the capabilities of intelligent technology as to the context of electronic commerce applications. Second, in the following sections, we demonstrate how technology and context become intertwined in the empirical evidence that our case study provides. Starting with knowledge management tools, this section presents a technological followed by an organisational perspective on knowledge management.

Knowledge Management Tools

Knowledge management tools, as all tools, aim to assist in the completion of a task with ease and efficiency. Ruggles (1997) suggests that KM tools can be divided into three categories, which are believed to represent the primary knowledge activities of most organisations:

- Knowledge Generation — the creation of new ideas, recognition of new patterns, the synthesis of separate disciplines and the development of new processes.
- Knowledge Codification — the auditing and categorisation of knowledge.
- Knowledge Transfer — the exchange of knowledge between individuals, groups and organisations.

The majority of KM tools are designed to deal with structured data, where information is directly entered into fields or can be categorised in some manner. Each of these stages presents technical challenges. One important issue is indexing, in other words, the appropriate structuring of data or information to facilitate or lead to knowledge discovery (Delesie and Croes, 2000). Knowledge acquisition and representation can also be difficult to address in KM systems, as they are for knowledge-based systems; they are issues that have been recorded extensively in the expert systems literature (e.g., Doukidis & Whitley, 1988; Firlej & Hellens, 1991; Hart, 1986). With KM systems, the key issue is probably the need to move beyond simple structured data mining towards the capture, mining and manipulation of tacit or unstructured data. Practitioners and researchers alike have identified tacit data as a, if not the, corporate resource to be managed and exploited for competitive advantage in the information-intensive economy. In other words, an additional technical challenge for knowledge management is the management of tacit knowledge, which is normally stored and exchanged using unstructured data. Takeuchi (2001) argues that organisational knowledge is created precisely during the time that tacit knowledge is converted to explicit (p. 321). Therefore, a key challenge for the design of KM technology is the identification of patterns (Brash, 2000) in unstructured data that enables reuse of the technology and contributes to system flexibility (Selvin and Buckingham Shum, 2000). There is an expectation that the new generation of KM tools will address this challenge using artificial intelligence (AI) techniques such as case-based reasoning, neural networks and intelligent agents. This chapter focuses on the role of the latter.

Intelligent agents are software objects (special types of computer programs) capable of communicating with each other and reasoning about information contained in messages that pass among them. To justify the adjective intelligent, agents must be able to make decisions under conditions of uncertainty, to act upon incomplete information, albeit in a narrow knowledge domain. Key elements of an intelligent agent, which enable it to achieve a limited-scale perception, cognition and execution, are knowledge bases with domain heuristics, simulated simple values and attitudes, and algorithms for reasoning, learning and pattern recognition. Advanced versions of agents can learn from experience and may even have distinguishing personality traits. Standard artificial intelligence techniques may be used for constructing agents, e.g., predicate calculus, genetic algorithms, fuzzy logic and neural networks. However, the experience indicates that the best results are achieved if a very large number of very simple agents is allowed to cooperate and compete among themselves and thus generate "Emergent Intelligence." Agents could be designed to have a particular attitude towards taking risks under conditions of uncertainty. Thus, a team of agents with different risk-taking characteristics emulates a crew of operators with a variety of attitudes to decision making.

Multi-agent systems use multiple intelligent agents and are characterised by distributed problem solving. They contain software objects (agents) capable of exchanging messages among themselves and their users, interpreting the meaning of messages and negotiating decisions. An interesting development in multi-agent systems is an attempt to provide agents with a mechanism for modifying protocols that regulate negotiations, which they conduct among themselves (e.g., Muller et al., 1996). This capability enables agents to incrementally improve their decision-making performance. These capabilities are particularly useful in electronic commerce (as discussed further on in this chapter) where intelligent agents have been taken up. The concept of multi-agent design and control is well developed, although not necessarily articulated in the context of knowledge management. It has been argued that, in this context, the role of artificial intelligence is "giving powerful assistance to people as they solve problems" (Smith and Farquhar, 2000, p.22). This quotation points to the interdependence of technology and the context of use, and supports the idea that the technological challenges mentioned here are witnessed and can only be addressed within a particular organisational and cultural context.

The Knowledge Management Context: Challenges For E-Commerce

Knowledge management, while supported by technology, remains a complex management practice for all organisations — tools will not work unless they can be integrated in the organisational and cultural context. The following paragraphs consider the reasons why this may be the case at four separate but interconnected levels, where KM benefits are realised: the individual, organisational, interorganisational and international levels. Particular emphasis is given to the additional challenges that are present in an electronic commerce context.

At an individual level, KM provides organisational members with opportunities and tools to operate, and where possible flourish, in an environment of continuous change. Attention to the individual level signifies acceptance of idiosyncratic knowledge, recognising that personality plays a critical role in the way that people acquire, perceive, value and use knowledge as well as that the creation of knowledge is affected by the world view of the individual (Guns and Välikangas, 1998). This is particularly relevant for the e-commerce context. Specifically, in business-to-consumer e-commerce relations, in contrast to traditional commerce, the customer is not visible and typically not known. The technological awareness of individuals also varies. The potential customer population is large (possibly global) and the 'customer' could have any background (cultural, financial or educational). In knowledge management terms, this presents a business opportunity: customer behaviour can be electronically recorded, therefore can be manipulated and exploited for competitive advantage. Some mechanisms, like cookies, try to contribute to 'learning' more about the customer profile and preferences, although in essence there are several limitations related to the authenticity and interpretation of the data they record. Furthermore, given the technical challenges reviewed previously, it is not clear how organisations can manipulate the vast amounts of data and extract meaningful patterns that could be used for 'mass customisation' or differentiating their products in a global market where first mover advantage is visible and can easily be imitated. Intelligent agents can play a key role here by providing personal attention to the customer, learning and remembering individual preferences, which can be communicated or negotiated as needed. The business implication for the company using the technology is dual: customer service can improve as individual traits are catered for and the company gains knowledge about trends and patterns that can be unveiled from customer choice.

At an organisational level, KM supports the streamlining of activities and facilitates improved organisational response to internal and external changes. This often places attention on organisational processes and presents several challenges, not least the difficulty of identifying processes (Nickols, 1998). Huysman and de Wit (2000) have identified several 'traps' that relate to KM at this level:

- An opportunity trap — KM will be more effective if it is problem-driven, i.e., if it responds to concerns that are relevant in the particular organisational context, rather than if it is technology-driven or attempting to imitate other businesses, as is often the case.
- A codified knowledge trap — It is difficult to record previous knowledge for others to access, especially as new knowledge keeps being created and human actors are busy making sense of the new knowledge and conditions.
- A management trap — KM is dominated by management initiatives, but it is unlikely to be effective unless knowledge workers willingly take part in it.
- The operational level trap — KM should not be limited to the operational level, in the same way that knowledge exchange processes cannot be limited to this level.

In organisations that use electronic commerce, either partially or fully (virtual organisations), the notion of business processes maybe entirely different, as these companies are based on different business models (Tapscott et al., 2000). This complicates the significance of these 'traps' for the networked enterprise and its stakeholders. On the one hand, as business processes are predominantly electronic, they should be more transparent and traceable than in traditional business — thus, information about business transactions is structured and explicit, and this should facilitate knowledge management. For example, it should be easier to create an organisational memory about business transactions and make this readily accessible to knowledge workers. On the other hand, several business processes transcend the boundaries of the organisation, as electronic links to customers, suppliers and other stakeholders make the organisation an extended, networked enterprise. This makes it harder to convert information into knowledge: different organisational settings and therefore different cultural environments, with different sets of tacit knowledge, interact. A related difficulty at this level, which also applies to traditional companies, is that the available data about processes, procedures and resources may be incomplete. This makes it harder to uncover patterns that can lead to knowledge codification and possibly the generation of new knowledge. The use of intelligent agents can be helpful in this respect. Specifically, intelligent agents that are characterised by autonomous learning can use previous history, and learn from it even if the way in which it is interpreted changes at a very fast rate.

Interorganisational and international levels (in many cases, these can be used interchangeably in e-commerce) are therefore more relevant in considering the challenges of the knowledge management context in electronic commerce. At the moment, little is known about the transfer of knowledge at an interorganisational level. Arguably, one of the advantages of KM is that it enables organisations, regardless of size and resources, to compete globally against larger regional trading blocs, tending to reduce economy of scale differences. The problem at this level is that different cultures have different mental models of collaboration or trust (Kidd, 2000). Electronic commerce research acknowledges the importance of trust between trading partners (e.g., Hart and Saunders, 1997; Miles and Snow, 1992; Ratnasingham, 1998; Wilson, 1997) but does not consider how this may relate to knowledge creation and transfer in-between different stakeholders. In more mature and structured interorganisational relations, such as outsourcing, KM has yet to receive appropriate attention (Currie and Pouloudi, 2000). The potential role of multi-agents, at this interorganisational level, is in their ability to represent business partners in the networked enterprise and conduct negotiations on their behalf. They can be also utilised for business-to-business types of transactions, operating, for example, in the context of supply chain dealings. Both roles entail technical and organisational issues. From a technical perspective, the use of multi-agent systems eliminates the need for the selection and implementation of optimal algorithms, which is a complex endeavour. Agents will negotiate what to do next in every particular situation, based on local information and a set of general rules, without any need for optimisation algorithms to be programmed into the system in advance.

From a business perspective, the situation is rather complex because it is at present not clear which rules, roles and responsibilities apply in a legal context that is not well defined. Despite the progress in electronic commerce legislature, several issues remain to be resolved at a global scale for transactions occurring entirely in electronic format or crossing national boundaries (see for example Timmers, 1999, pp.171-174, for an overview of key legal and regulatory issues in the European Union and the USA).

Electronic commerce, by its very nature, combines a business with a technological environment, as transactions occur electronically. It is obvious from the discussion in this section that it offers a good opportunity to illustrate the interdependence of technical and organisational (often inter-organisational) factors in knowledge management. In the next section we consider the technical and business environment of a recently established company that develops, supplies and supports multi-agent software, and serves as a case study for considering the potential of intelligent agents for knowledge management in e-commerce.

EMPIRICAL INSIGHTS FROM THE USE OF MULTI-AGENTS FOR KM IN E-COMMERCE

Following from the previous discussion on the interrelations of technical and organisational factors related to knowledge management in electronic commerce, this section presents how these are witnessed in practice. For our description we adopt the perspective of a small enterprise that has strong links with Brunel University. This allows an 'insider view' to the opportunities and challenges it faces in providing multi-agent support for knowledge management in electronic commerce. Starting with a description of the company and its multi-agent software, the section leads on to a discussion of the role of intelligent agents in knowledge management, which serves as a guide for proposing a broader agenda for research in this area.

The Company

The company was established in October 1999 to exploit multi-agent research but it has a long history of informal existence marked by previous international collaboration among its founders. Although its physical premises are in the UK, it is largely a virtual corporation with researchers, system designers and programmers collaborating over intranets and the Internet. For example, the main activities related to software development are carried out in Russia. The company aims to become "virtual" and to sell its products and services mainly though the Internet. In doing so, it would become an e-commerce-based organisation selling products and services that support e-commerce. In practical terms, this means that the company has the advantage that it understands from its own experience the challenges of integrating work processes across different cultural settings, hence it is able to exploit this knowledge for providing better products and support to its customers as well.

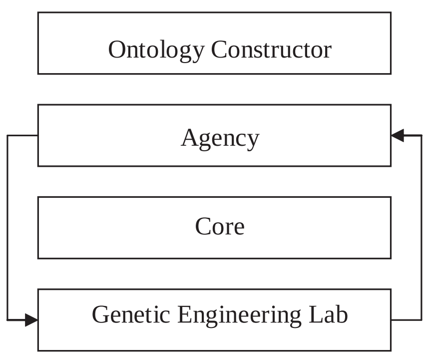
The corporation has a flat structure, where, as described on the company's web site, "teamwork dominates every aspect of corporate life." Also, the corporation considers intellectual capital to be its key asset. Consequently, knowledge management is important for the company not just as a product but as a competitive differentiator: the company is its own customer. For example, organisational memory is facilitated by the company's own knowledge management software. Similarly, the company culture is maintained through an extensive electronic network. The company is currently in the process of extending the functionality of its web site for procurement and selling its product and services. Plans for e-commerce include using the company's web site for selling, in large volumes, scaled down multi-agent tools and shells to small-to-medium software developers around the world.

Capabilities of Multi-Agent Software

Agents are trained (have access to knowledge) rather than programmed to do a particular job. Advanced versions of agents can learn from experience and have distinguishing personality traits. They can be, for example, risk-averse and this will influence their negotiating behaviour. The principal element of multi-agent systems, which enables them to achieve a limited-scale perception, cognition and execution, is an Ontology, which contains knowledge about the domain in which the system operates. To keep the Ontology simple, the domain of agent activity has to be reasonably narrow. The second component of the system is the Engine, shown in Figure 1.

A key advantage of this architecture is that modifications are easy because the agent code is reusable, multi-agent engines are expandable and the Ontology can be updated by operators without any knowledge of computer programming using

Figure 1. The engine of a multi-agent system



a visual tool called Ontology Constructor. The Agency in the above diagram is the space where agents are created and where they work (negotiate), the Core is a set of run-time algorithms enabling parallel work of a very large number of agents and the Genetic Engineering Lab is a place where the performance of agents is monitored and modifications are made to their "genetic code" to improve their performance (e.g., to negotiate more aggressively, or more carefully).

Multi-agent systems are perceived to be cost-effective; each agent has a limited intelligence yet the overall intelligence of a "swarm" of agents is quite impressive. This is because agents cooperate with each other and make decisions through negotiations. Agents act upon locally available information with great speed, but always respect general policies and rules. They consult each other and they bargain with a view to maximising the overall value of the process they are controlling, rather than furthering their own individual interests. In other words, multi-agent systems behave as an effective team, and the effective teamwork results in an emergent performance, a performance that far exceeds the sum of performances of individual team members. The inherent advantage of multi-agent systems is that they work on the principle of a free market. Agents match supply to demand, and if the perfect match is not possible, they negotiate special deals to achieve partial matching.

Supporting Knowledge Management for E-Commerce

In the context of electronic commerce, agents improve the performance of portals and web sites by providing visitors with an intelligent, personalised, one-to-one service. In particular, they communicate with each visitor as an individual, recognising specific needs and expectations. They also recognise visitors when they return to the site. In addition to this customer relationship management role, multi-agents match portal offerings to visitors' demands rapidly and effectively, and negotiate discounts and special deals on behalf of their clients. From a knowledge management perspective, they continuously analyse available data in the background, with a view to discovering, preserving, maintaining and updating knowledge about each visitor. Discovering and managing knowledge through the use of agents can be directed both to the business environment (customers, competitors, investors, administrative and legal factors, new technologies, etc.) but also to the client's own business processes (cost-effectiveness of human and technological resources, organisational structures, business culture, geographical locations, etc.).

The competitive differentiator of a Multi-Agent Knowledge Management System is based on effective clustering algorithms that enable rapid discovery of knowledge, which as discussed in previous sections can be 'buried' in unstructured data. The key to the effectiveness is the use of multi-agent technology, which provides distributed intelligence to help the process of clustering. Principles and rules of clustering, which are obeyed by agents, are in the first instance entered into the system ontology by knowledge management experts. The system is designed to enable operators without knowledge of computer programming to modify and update clustering principles and rules and thus influence the system performance. The company's selling point is that this system is much less expensive than a typical data mining system and far more effective (e.g., as it enables knowledge exploitation of unstructured data) and user friendly. A unique aspect of the system's user friendliness is the capability to provide the user with a graphical representation of clustering results so that stronger links between data elements appear clearly.

It is worth noting that clustering becomes a self-organising process. As new data become available to the system, the clusters of knowledge are re-evaluated and reconfigured, allowing for a dynamic interpretation of business results. Furthermore, the system can provide patterns without 'knowing' much about the data. This means, on the one hand, that the system may highlight relationships between data that is not obvious, even to the knowledgeable human agent, thus unveiling real competitive edge issues for their clients. On the other hand, the clustering process becomes faster if human agents define restrictions for the clustering processes, based on their capability to interpret meaningful associations among data elements. This dilemma between speed and scope of data analysis illustrates the interplay of technical capabilities and organisational priorities. The human agent can improve the efficiency of the technology by a good understanding of the context, which can lead to a better definition of Ontology as well as a more insightful interpretation of the data analysis results. Obviously, the responsibility for the translation of results in appropriate business policies lies also with the human agent.

DISCUSSION AND IMPLICATIONS FOR RESEARCH IN KNOWLEDGE MANAGEMENT FOR E-COMMERCE

The interactive character of electronic commerce enables information (and, hence, knowledge) sharing across organisational entities or individuals, often across national boundaries. Through their electronic commerce interactions and transactions, companies acquire much information that can easily be stored and exploited (as the data is usually in electronic form). However, few users of electronic commerce have considered using this information as a basis for understanding and managing their organisational knowledge better. The potential benefits of more effective knowledge management in the context of e-commerce are apparent for both organisational processes and interorganisational relations, and we argue that multi-agent technology has an important role to play in this area. In the previous section we saw how a software house exploited their multi-agent software for knowledge management in electronic commerce for the company and the company's clients.

Electronic commerce is a unique environment for knowledge management, not only because it uses the Internet as a platform but also because the data available to users of e-commerce become dated very quickly as the electronic market changes at a rapid pace. Therefore 'traditional' information technologies cannot deduce knowledge for the future exclusively from past data because of dynamic changes in the turbulent global economy. Companies that aim to support knowledge management in electronic commerce environments have to investigate novel ways of managing and exploiting the individual, organisational and interorganisational knowledge. Intelligent multi-agent technologies can provide a technological solution for dealing with the uncertain conditions of this context, manipulating incomplete or ill-structured historical data.

At the moment, both research and practice of knowledge management in e-commerce are in their infancy. For example, there are a number of problems that we have identified in current practice as well as in the theoretical understanding of KM, namely:

- the variety of theoretical approaches to KM and the lack of consensus in the literature about what constitutes KM and how effective KM can be achieved;
- the limited availability of empirical reports to support these approaches and provide guidance for further improvements in KM practice;
- the lack of KM tools and the differences in the support that existing tools provide to user organisations;
- the lack of awareness about KM opportunities for both traditional and virtual organisations, either because of technical limitations of the available tools or because user organisations are unable to identify or

communicate their needs for more effective KM and the organisational structures that will support them; and
- the lack of substantial research effort to investigate technical and social aspects of KM in e-commerce environments.

As a result of these problems, it is not surprising that the appreciation of the challenges and necessity to integrate technical and organisational aspects of KM, which we believe is critical for more effective KM, is at best incomplete. As yet, there is no generic model of KM grounded in empirical research, which companies or industrial sectors can use as a basis for organising and managing their information resources. Such a model could allow organisations to leverage their core competencies and key skills. Both organisational and technical issues of KM raise significant challenges. However, it is also evident that, even though they are often separated in the literature, in a practical context they are inseparable as they inform and influence each other. We argue that research in KM should reflect this synergy of organisational and technical issues. Research needs to be directed towards understanding how these areas limit or enhance the competitive benefits of KM theories and models — what this new way of working entails with regard to skills, organisational structures and operations.

In other words, the implementation of a KM tool will not result in a 'knowledge environment' if other knowledge activities are not supported. For instance, knowledge transfer is unlikely to occur if the organisational culture was one of hoarding information (Clegg and Palmer, 1996; Irani and Sharp, 1997; Walsham, 1995). Moreover, in order to combine the expertise of key stakeholders, new forms of working — such as 'cross-functional teams' — may be needed (these may include, for instance, consumer behaviour experts, database marketers and IT experts). These issues have been recognised for some time in the innovation literature (Madhaven and Grover, 1998), although this has not been investigated in the context of e-commerce.

In addition, there is a lack of published empirical work in this area and there is a lack of tools that organisations can utilise and adapt for KM activities in both traditional and virtual business environments. Similarly, evaluation measures for any available tools are lacking. The investigation of the product and approach followed by the case company considered in this chapter provides some insight in the potential of intelligent agents for KM in electronic commerce but clearly presents a specific, sole experience of a recently established company. More research is needed to provided a more in-depth understanding of the way in which companies respond to knowledge management, and in particular to the use of KM technologies to exploit and enhance their electronic commerce activities. We argue that important areas for further research in this area include the following aspects.

First, in order to inform technological improvements, it is necessary to investigate and evaluate knowledge management tools (including multi-agent-based tools) in real e-commerce environments. This should result in a better understanding of the potential and current limitations of such tools, leading, in turn, to specification of requirements for further development of such tools. Second, in order to improve knowledge management at the strategic level in the use of electronic commerce, it is necessary to identify main barriers and driving forces for knowledge management in e-commerce. This involves defining what knowledge is relevant in the context of e-commerce and how it can be captured, stored, refined and applied. A related aspect is the identification of critical success factors for effective knowledge management in e-commerce-based environments, including research on organisational structures that support knowledge management in e-commerce. Third, knowledge management provides an opportunity to improve organisational practices and processes. Therefore, future research should investigate issues related to teamwork, leadership, culture, incentives and motivation for knowledge management, identifying ways for integrating knowledge management into the daily workflow and particularly the types of reward structures to support knowledge sharing and collaboration. An important dimension of this research is exploring how knowledge management can lead to individual and organisational learning as this will lead to sustainable competitive advantage.

CONCLUSIONS

This chapter has discussed the potential of intelligent agents for knowledge management in e-commerce, using insights from an SME providing such knowledge management tools. The chapter emphasised that technical, organisational and interorganisational aspects need to be considered in parallel for providing useful solutions for organisations doing business electronically. The research setting described in this chapter could stimulate interest for identifying opportunities for competitive advantage for e-commerce user organisations from better KM and threats from KM practices in a business context. A number of future directions of research in this area have been identified on that basis. Our main recommendation is for considering the future of technology within the context in which it will be applied.

REFERENCES

Brash, D. (2000). Developing and validating generic knowledge: An initial experience report. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 170-177).

Brooking, A. (1999). *Corporate memory–Strategies for knowledge management.* UK: International Thomson Business Press.

Clegg, S. R., & Palmer, G. (1996). *The politics of management knowledge.* London: Sage Publications.

Currie, W. L., & Pouloudi, A. (2000). Evaluating the relationship between IT outsourcing and knowledge management. *Journal of Change Management, 1*(2), 149-163.

Delesie, L, & Croes, L. (2000, July 17-18). Managing the variability of medical care: Fostering consensus, benchmarking and feedback. The case of drug prescription patterns among Belgian home practitioners. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 80-87).

Doukidis, G., & Whitley, E. A. (1988). *Developing expert systems.* Lund: Chartwell-Bratt.

Edwards, J., & Gibson, P. R. (2000). Knowledge management using CSCW in global strategic alliances and joint ventures via the Internet. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 376-384).

Firlej, M, & Hellens, D. (1991). *Knowledge elicitation: A practical handbook.* New York: Prentice Hall.

Guns, W. D., & Välikangas, L. (1998). Rethinking knowledge work: Creating value through idiosyncratic knowledge. *Journal of Knowledge Management, 1*(4), 287-293.

Hart, A. (1986). *Knowledge acquisition for expert systems.* London: Kogan Page.

Hart, P., & Saunders, C. (1997). Power and trust critical factors in the adoption and use of electronic data interchange. *Organization Science, 8*(1), 23-41.

Hlupic, V., Pouloudi, A., & Rzevski, G. (2002). Towards an integrated approach to knowledge management: 'hard,' 'soft' and 'abstract' issues. *Knowledge and Process Management.*

Huysman, M., & de Wit, D. (2000). Knowledge management in practice. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 324-333).

Irani, Z., & Sharp, J. M. (1997). Integrating continuous improvement and innovation into a corporate culture: A case study. *The International Journal of Technological Innovation, Entrepreneurship and Technology Management (Technovation), 17*(4), 199-206.

Kidd, J. (2000). Us and them: Obstructing knowledge management in MNEs. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 397-410).

Kuhn, O., & Abecker, A. (1997). Corporate memories for knowledge management in industrial practice: Prospects and challenges. *Journal of Universal Computer Science, 3*(8), 929-954.

Leonard-Barton, D. (1995). *Wellsprings of knowledge — Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Madhaven, R., & Grover, R. (1998). From embedded knowledge to embodied knowledge: New product development as knowledge management. *Journal of Marketing, 62*(4), 1-29.

Malhotra, Y. (1997). *Current business concerns and knowledge management.* Available at http://www.brint.com/interview/times.htm

McAdam, R. , & McCreedy, S. (2000). *A Critical Review of KM Models in the Learning Organisational, 6*(3), 91-100.

Miles, R., & Snow, C. (1992). Causes of failure in network organizations. *California Management Review,* (Summer), 53-72.

Muller, J. P., Wooldridge, M., & Jennings, N. R. (Eds.). (1996). *Intelligent agents III, agent theories, architectures and languages.* Reading, MA: Springer-Verlag.

Myers, P. (Ed.). (1996). *Knowledge management and organisational design.* Boston: Butterworth-Heinemann.

Nickols, F. (1998). The difficult process of identifying processes. *Knowledge and Process Management, 5*(1), 14-19.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* Oxford: OUP.

OECD. (1999). *The science, technology and industry scoreboard: Benchmarking the knowledge-based economies.*

Phillips, N., & Patrick, K. (2000). Knowledge management perspectives, organisational character and cognitive style. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 90-102).

Ratnasingham, P. (1998). The importance of trust in electronic commerce. *Internet Research: Electronic Networking Applications and Policy, 8*(4), 313-321.

Ruggles, R. (1997). *Knowledge tools: Using technology to manage knowledge better.* Ernst & Young Center for Business Innovation Working Paper (April 1997).

Selvin, A. M. , & Buckingham Shum, S. (2000). Rapid knowledge construction and dissemination: A case study in corporate contingency planning using collaborative hypermedia. In J. Edwards & J. Kidd (Eds.)*, Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham (pp. 48-58).

Smith, R. G., & Farquhar, A. (2000). The road ahead for knowledge management: An AI perspective. *AI Magazine,* (Winter), 17-40.

Snowden, D. (1998). A framework for creating a sustainable knowledge management program. In J. W. Cortada & J. A. Woods, J. A. (Eds.), *The knowledge management yearbook 1999-2000*. Boston: Butterworth-Heinemann.

Swan, J., Newell, S., Scarborough, H., & Hislop, D. (1999). Knowledge management and innovation: Networks and networking. *Journal of Knowledge Management, 3*(4), 262-275.

Takeuchi, H. (2001). Towards a universal management concept of knowledge. In I. Nonaka & D. Teece (Eds.), *Managing industrial knowledge: Creation, transfer and utilization* (pp. 314-329). London: Sage.

Tapscott, D., Ticoll, D., & Lowy, A. (2000). *Digital capital: Harnessing the power of business Webs.* Boston: Harvard Business School Press.

Timmers, P. (1999). *Electronic commerce: Strategies and models for business-to-business trading.* Chichester: John Wiley & Sons.

Trauth, E. M. (1999). Who owns my soul? The paradox of pursuing organizational knowledge in a work culture of individualism. *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research* (pp. 159-163).

Walsham, G. (1995). Interpretive case studies in IS research: Nature and method. *European Journal of Information Systems, 4*, 74-81.

Wilson, S. (1997). Certificates and trust in electronic commerce. *Information Management & Computer Security, 5*(5), 175-181.

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Chapter 2.43
Knowledge Management for Agent-Based Tutoring Systems

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ABSTRACT

As the education field is becoming increasingly technology heavy, more educational systems involve line or interactive training and tutoring techniques, and lots of educational information becomes available via the intranet and World Wide Web. Managing large volumes of learning information and knowledge is one of the crucial issues for these educational systems, as appropriate knowledge management is the key to more effective and efficient learning. The chapter first discusses that an intelligent agent system could be successfully applied to the education field and then focuses on how knowledge management techniques play an important role in agent-based tutoring systems.

INTRODUCTION

Computer technologies are making progress rapidly and are becoming more specialized. Many different fields have benefited from newly invented and powerful computer technologies. Therefore, it is not a surprise that education adopts more computer technologies, and students and learners use computers in a lot of courses and labs. New technology integrated into the education or tutoring system can enhance the access to knowledge and improve the efficiency of knowledge transferring to learners. But such integration often requires additional training in order for its users to become familiar with a new learning environment before they can actually benefit from these technology advances; otherwise, new technology will confuse and distract, instead of helping, its users, and slow the learning process. Agent-based tutoring systems can overcome such technical obstacles between knowledge and common users. Then, users are able to focus on information and knowledge that they are interested in and try to learn. Unlike traditional tutoring systems characterized by a stand-alone approach, i.e., autonomous and complete in itself, an agent as a software entity can work continuously and autonomously in a particular environment usually occupied by other agents. And, an agent as a software entity is able to interact with its environment in a flexible and intelligent way without demanding constant human interference or orientation. An agent working continuously for long periods of time should be able to learn from experience. In sharing its environment with other agents, it should be able to communicate and cooperate with them. Therefore, an agent can have the following attributes: reactiveness, autonomy, cooperative behavior, communication ability at knowledge level, interference competence, temporal continuity, personality, adaptability, and mobility. All of these properties will make an agent-based tutoring system more effective and efficient (Silveira, 1998).

Agent-based human-machine interaction was first commonly used in the 1930s, in such applications as autopilot systems, etc. Such agents aided or performed some automatic and simple tasks that human beings would otherwise perform. A human operator will perform supervisory tasks (involving cognitive processing and situation awareness skills) instead of old manipulation tasks (usually involving sensory-motor skills) (Sheridan, 1992).

The use of software agents as intelligent assistant systems was proposed (Alchourron, 1985) to facilitate human-computer interaction to transfer information, as well as human-human interaction for better understanding through new software technology. The adoption of agents in an educational and tutoring system is natural, because information and knowledge transfer is the most important part of learning. Agents can enable the understanding and learning of various kinds of concepts, because they involve active behaviors of the users. They enable users to focus on the content and index content in accordance with specific situations that they will better understand. To be specific, the advantages of using software agents in education may include the following:

- Customized learning environment for individuals
- Unified learning environment
- Integration of local and remote resources
- Transparent process to make users focus on knowledge to be conveyed, not how to use the tutoring tools

In this chapter, we will talk about an agent-based tutoring system architecture design and how to manage knowledge and "knowledge about knowledge" (metaknowledge) in an agent-based educational environment.

BACKGROUND

Learning is an active, interactive, and constructive social process. Technology, especially computer technology, can help learning greatly. Initially, the learning technology focused on individualized instruction, i.e., stand-alone tutoring, a universal environment for all students. The current view of training and education environments must support customized inquiry-based learning and collaboration, and such an environment has the following advantages over the old learning technologies:

- Intelligent tutoring systems have explicit tutoring models and domain knowledge that can serve each individual in a more customized and efficient way.
- Interactive learning systems enable the student to manipulate cognitive artifacts from several perspectives or viewpoints (Norman, 1992).

- Cooperative learning systems provide students with access to other people's ideas and concepts, and this makes it possible to exchange, discuss, negotiate, defend, and synthesize viewpoints (SIGCUE, 1992).

Also, the advances in network technology enable learners far away to communicate with each other more efficiently. A Web-based tutoring system is not only technically possible but also mostly desirable.

Another technical advance comes from object-oriented technology. An instructional technology called "learning objects" currently is the most popular choice in the next generation of instructional design, development, and delivery, due to its potential for reusability, generativity, adaptability, and scalability (Learning Technology Standards Committee).

Learning objects are elements of computer-based instruction based on the object-oriented paradigm (Wiley, 2002). The Learning Technology Standards Committee (LTSC) uses "learning objects" to describe these small instructional components and provides a working definition:

Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of technology-supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology-supported learning.

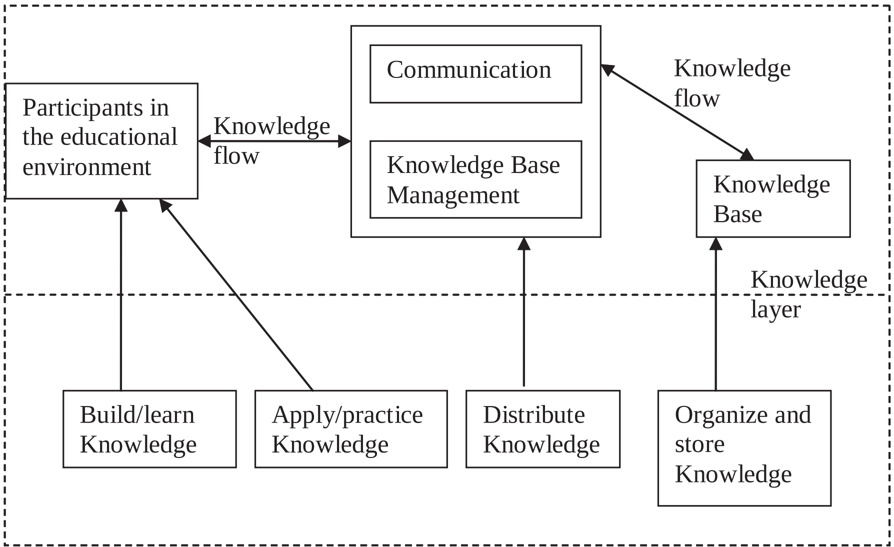
"Learning" is a process in which learners obtain and understand information and knowledge from knowledge bases. How information and knowledge is acquired, stored, represented, accessed, updated, and transferred in an educational environment will determine how effective and efficient the educational system and learning process will be. According to Taylor (Taylor, n.d.), knowledge management is about using models, methods, structures, and techniques for better management and organization of resources. Knowledge management as an ongoing management process is to be embedded in the knowledge-based system. The purpose of knowledge management is to enable effective usage of information and human resources, and based upon this, to act intelligently and be more flexible, and as a result, to be able to improve basic processes of research, production, and maintenance.

Implied in the term "knowledge management" is the notion that every knowledge-based system possesses knowledge and needs mechanisms to gather, store, manipulate, and manage it in order to accomplish the most effective usage of the knowledge.

Karl Wiig described four main knowledge flows functions (Wiig, 1995):

- Building knowledge is achieved through learning, importing knowledge from existing resources, or creating new knowledge through research and development.
- Knowledge is stored in memory, knowledge bases, books or other written materials, videotaped instruction material, and organized in order to be available for specific purposes.
- Knowledge is distributed by assembling relevant knowledge from different sources and distributing it to places of use, and is pooled by assembling different persons in a team and by exchanging knowledge between them.
- Knowledge is used when it is needed to apply to work objects. Value is added by using knowledge to make products or to provide services. Here, the value of knowledge is realized.

Figure 1. Knowledge layer in networked education



Diana and Aroyo used Figure 1 to show where these function are fulfilled (De Diana).

The approach does not specify the details about communication and knowledge base management modules, and there may exist many different ways to implement them. The main advantage of using an agent-based approach in educational systems is that the central control function is devolved to different agents, and there is no need for a centralized control process to oversee the communication and interaction and database management among learners, interfaces, and databases. This results in a robust system with better performance, more availability, and a more customized student learning session (Bruff, 2000).

Diana and Aroyo (De Diana) pointed out that the main tasks and knowledge involved in education can be divided into two levels: (a) tasks and knowledge related to learning and instructional processes and (b) tasks and knowledge (knowledge about knowledge, which is knowledge about how to manage knowledge in the first level) related to the organizational and management level. This two-level model reflects the necessity to separate the knowledge to be learned from managing knowledge (metaknowledge). We will talk more about this in the following sections.

MULTI-AGENT-BASED EDUCATIONAL ENVIRONMENT

Wooldridge and Jennings (Wooldridge, 1994) gave one of the most comprehensive definitions of agents:

…a hardware or (more usually) a software-based computer system that enjoys the following properties: autonomy—agents operate without the direct intervention of humans or others, and have some kind of control over their actions and internal state; social ability—agents interact with other agents (and possibly humans) via some kind of agent-communication language; reactivity—agents perceive

their environment and respond in a timely fashion to changes that occur in it; pro-activeness—agents do not simply act in response to their environment, they are able to exhibit goal-directed behavior by taking initiative.

We call agents used in an education environment the "educational agents." The role of the educational agent is to provide task-related feedback and assistance to the learner and to guide the learner through the learning process and help the learner reach his or her learning goals. In an education environment, multiple agents are usually involved, and each agent plays different roles. There are two aspects to be considered in designing and building educational agents:

- Reusability: Reuse agents in different kinds of systems and environments.
- Interaction: In an environment containing multiple educational agents, tutor agents interact with each other and customize their behaviors based on the behaviors of other agents in the environment.

Norrie and Gaines proposed the following agents in an agent-oriented model for an education environment (Norrie, 1995):

- Knowledge Agent has knowledge in a particular area.
- Knowledge Server Agent stores, retrieves, and manages knowledge; answers queries; and provides information by inferring or reasoning using the stored knowledge bases.
- Interface Agent serves as an interface to learners, monitors and learns from the user's actions, and then functions as an intelligent assistant.
- Coach or Tutor Agent provides guidance to assist in the learning process.
- Mediator Agent coordinates the activities of other agents and resolves conflicts between them.
- Knowledge Management Agent provides the high-level coordination of knowledge activities, such as creation, assembly, manipulation, and interpretation of knowledge, within either an individual or a collective project.
- Information Search Agent searches for specific information and sends the results back to learners.
- Directory Agent points to an appropriate agent, service, or resource.
- Mentor Agent is envisaged as acting in a rather analogous way in the learning environment, as a kind of coach for the higher-level strategies of learning.

Bruff and Williams illustrated an agent-based intelligent tutoring system architecture with the following three kinds of agents:

- Knowledge Management Agent responds to requests from other agents.
- Student Agent is assigned to each student and manages the evolution of a student model, which may include a representation of the student's current knowledge and history about the topic and the student's personal goals and preferences, etc. The student agent's goals will typically vary from student to student or from time to time, even for the same student, and can be customized by a third party such as a human tutor. These goals determine the learning strategies and tasks to be used during a given learning session. The learning strategies together with the database describing the current state of the agent and its knowledge about the student's capabilities will largely control the agent's behaviors, that is, a customized agent for each individual learner.
- Inference Agent provides preset inference mechanisms, which include a group of agents, such as deduction, abduction, and induction agent, belief revision agent,

possibility reasoning agent, nonmonotonic reasoning agent, and theory extraction agent, etc.

In general, all these three kinds of agents can be called tutoring agents, which are able to interact and cooperate with the student for tutoring and learning purposes. In the above architecture, we have three kinds of agents, and we assign more functions to each agent. Many different architectures have been proposed for an agent-based tutoring system. For example, Silveira and Viccari (Silveira, 1998) proposed several different agents: curriculum manager (the agent responsible for registering and controlling the curriculum attended by the students); agent communicator manager (the agent responsible for the agent's society administration and for controlling the communication between agents); interface communication (the agents responsible for peer-to-peer communications between the student's environment and the network environment); and presentation manager (the agent responsible for the browser control in the student's environment). In a finer model, every tutoring agent will perform only one tutoring function. All of these functions should be performed as session-based actions. Tutoring functions may include the following (Morin, 1998):

- Select a subject element.
- Format and present a subject element.
- Format and present an explanation of a subject element.
- Compare different concepts.
- Select, format, and present an example.
- Answer a student's question.
- Evaluate the student's answer to a system-asked question.
- Send feedback to a student about his answer to a system-asked question.
- Diagnose a student's behaviors.
- Update student model.

Tutoring systems for different courses or topics, or for students with different backgrounds, may have different preferences or requirements on system architecture (types and amount of agents, their responsibilities and interactions), and there is no existing universal architecture that will fit all. When designing agents for a learning environment, we have to understand the requirements of the to-be-built learning system first, consider the backgrounds and goals of its users, determine the types and numbers of agents we need, predict the interactions among them, and assign tasks accordingly.

KNOWLEDGE MANAGEMENT FOR A TUTORING SYSTEM

Knowledge is a principal factor that makes personal, organizational, and societal intelligent behavior possible (Wiig, 1995). Knowledge management consists of activities focused on the organization gaining knowledge from its own experience and from the experience of others, and on the judicious application of that knowledge to fulfill the mission of the organization (Wiig, 1995). In the context of a learning environment, such an organization consists of a group of students. These activities are executed by integration of technology, organizational structures, and cognitive-based strategies to convey existing knowledge and produce new knowledge. The critical step is the enhancement of the cognitive system in acquiring, storing, and utilizing knowledge for learning, problem solving, and decision making.

Knowledge management is stated as the management of the organization (an individual student or a group of students in our context of learning environment) toward the continuous renewal of the organizational knowledge base, which may include the creation of supportive organizational structures, facilitation of organizational members, application of IT instruments, with an emphasis on teamwork and diffusion of knowledge (as in groupware) (Bertel). As such, knowledge management is a strategy that turns an organization's intellectual assets (recorded information and the talents of its members) into greater productivity, new value, and increased competitiveness.

For a tutoring system, obviously we need a framework that can support knowledge management: a framework that offers a computational environment in which well-represented knowledge can serve as a communication medium between students and their activities. The indicated framework can consist of a shared knowledge representation and mechanisms for customized routing of knowledge to appropriate students (De Diana).

Models, methods, tools, and techniques for effective knowledge management become increasingly available, which is very important for education, because learning is a highly interactive process, and different kinds of knowledge are transferred among learners, tutoring systems, and human tutors.

An essential aspect of knowledge is that it is contextualized and dependent. This is the reason why knowledge is so difficult to acquire, represent, access, and transfer. Bruff and Williams pointed out that intelligent tutoring systems have to provide mechanisms to deal with the following interrelated knowledge-modeling problems (Bruff, 1999):

- Uncertainty of knowledge
- Conflicts among knowledge
- Dependency among knowledge
- The problem of knowledge granularity
- Incompleteness of knowledge, i.e., all relevant knowledge may not be known
- Fusion of knowledge, where knowledge is merged from different sources
- Revision of existing knowledge base when new knowledge is obtained (This new knowledge may be inconsistent with the existing knowledge base.)

Knowledge that is uncertain or incomplete may need to be revised and refined over time. Therefore, revision of a knowledge base is closely related to modeling both the uncertainty and the incompleteness of information. If readers are interested in these topics, more references can be found in Further Readings section at the end of this chapter.

Besides the problems of knowledge incompleteness, updating, conflicts, granularity, and uncertainty, one of the problems from knowledge modeling in an agent-based tutoring system is dealing with different kinds of knowledge. We discuss how to manage these different kinds of knowledge existing in a tutoring system in the following subsections, which are based mainly on the research by Morin (1998):

1. Domain knowledge (conceptual and procedural) (DK)
   Domain knowledge is the real knowledge we want to teach a student; it contains all conceptual and procedural aspects of the knowledge of one topic or area. Different topics or courses may have domain knowledge with different structures. Usually, domain knowledge may include concepts and relations among concepts, and often, these relations will organize concepts into a hierarchical structure, which will help the learning process greatly and provide a foundation for problem solving or inferential knowledge. For example, concepts can be basic entities like the binary tree or binary search tree. And, there is a "subclass of" relation between them.
2. Problem-solving knowledge (inferential) (PSK)
   Problem-solving knowledge is the knowledge that a student uses to learn domain knowledge. It is usually modeled and stored as procedures, and it contains inferential processes used to solve a problem using re-

lation information from domain knowledge (Lelouche, 1997).

3. Tutoring knowledge (TK)
   Tutoring knowledge includes information about common student errors and misconceptions. Tutoring knowledge is the most important knowledge, because it is the key for us to use to build a customized learning system for each student. This customized learning system can deliver appropriate individualized instruction to help students learn more effectively and efficiently. This ability depends heavily on the availability and accuracy of the information held about the student in the student agent, which holds different types and levels of sophistication of the knowledge and also includes methods with which to elicit and incorporate the new information into the student model.
   Tutoring knowledge is usually session-based, because it varies from topic to topic, from student to student, and from time to time, even for the same student. Moreover, to make a learning process more interesting and efficient, a tutoring system should use a variety of stimuli, such as multimedia techniques, to present a topic in different ways, even to the same student, and to change the ways of presentations of the explanations or answers provided to the student.

FUTURE TRENDS

We believe that agent-based tutoring systems will provide a means of dealing with the knowledge acquisition, revision, and transfer that are essential in a learning process. Agents will use a variety of communication and representation modes to help us to understand and make use of course materials or knowledge. We are sure that learning environments employing multiagents systems allow students, teachers, and courseware developers to add flexibility in achieving their learning objectives. To make such a system more helpful, future study may concern the following problems:

- Different architecture design for different courses, topics, or disciplines
  Because different courses, topics, or disciplines involve knowledge that is very different in presentation or nature, such as history and mathematics, we may need different knowledge management architectures and techniques for them.
- How will Internet technology affect an agent-based tutoring system?
  Modern tutoring systems should be Web-based to maximize accessibility. With the integration of Web technologies, further investigation on tutoring system architecture and knowledge management is needed.
- Cooperation between an agent-based tutoring system and existing software tools
  Existing software tools can help in the development of an agent-based tutoring system and provide insights to a better learning environment. Such cooperation can also help reduce costs.

FURTHER READING

Some researchers (Mizoguchi et al., 1988; Kono et al., 1992; Giangrandi & Tasso, 1995) applied truth (or reason) maintenance systems (TMSs) (Doyle, 1979; DeKleer, 1986) to overcome conflicts between new and old knowledge. The TMS identifies the conflicts, and some domain-specific reasoning system will resolve them. Huang and McCalla (1992) and Huang (1994) developed "Logic of Attention," a variant of the TMS that focuses on the parts of the student model and instructional planner that are relevant to the current subgoals. Bruff and Williams (2000) proposed an architecture in which the problem of conflicting information is resolved using methods based on the AGM paradigm for belief revision (Alchourron et al., 1985). Bruff and Williams used possibility theory (Dubois, 1992) to address the problems of uncertain information, nonmonotonic reasoning, and default logic (Reiter, 1980); the formalism (Antoniou, 1996) to process incomplete information; and Theory Extraction for fusion. Knowledge granularity has been widely discussed (e.g., McCalla & Greer, 1994). Levels of granularity fit naturally into the agent architecture and can be used to help the agent choose an appropriate plan.

CONCLUSIONS

In this chapter, we discussed how agent technology could be used in an education environment and how knowledge is managed in such a system. Although many problems remain to be solved, we believe that agents can model and manage knowledge in an appropriate way, and agent technology will be an important step to improve the effectiveness and efficiency of a tutoring system.

REFERENCES

Alchourrón, C., Makinson, D., & Gärdenfors, P. (1985). On the logic of theory change: Partial meet functions for contraction and revision. *Journal of Symbolic Logic, 50,* 510-530.

Antoniou, G., & Williams, M.-A. (1996). Reasoning with incomplete and changing information. *Journal of Information Science, 99*(1 & 2), 83-99.

Bertel, T. (n.d.). *What is Knowledge Management? The Knowledge Management Forum*. Available at http://www.km-forum.org/what_is.htm

Bruff, C. M., & Williams, M-A. (1999). An intelligent tutoring system architecture based on knowledge representation and reasoning. In *Proceedings of the Seventh International Conference on Computers in Education* (pp. 736-743). IOS Press.

Bruff, C. M., & Williams, M-A. (2000). An agent-based intelligent tutoring system. *Eighth International Conference on Computers in Education* (pp. 427-433). IOS Press.

De Diana, I., & Aroyo, L. (n.d.). *Knowledge management for networked learning environments: Applying intelligent agents.* Available at http://projects.edte.utwente.nl/ proo/italo.htm

De Kleer, J. (1986). An assumption-based TMS. *Artificial Intelligence, 28*, 127-162.

Doyle, J. (1979). A truth maintenance system. *Artificial Intelligence, 12,* 231-272.

Dubois, D., & Prade, H. (1992). Epistemic entrenchment and possibilistic logic. *Artificial Intelligence, 50,* 223-239.

Giangrandi, P., & Tasso, C. (1995). Truth maintenance techniques for modelling students' behaviour. *J. Artificial Intelligence in Education, 6,* 153-202.

Huang, X. (1994). Modeling a student's inconsistent beliefs and attention. In J. E. Greer & G. I. McCalla (Eds.), *Student modeling: The key to individualized knowledge-based instruction* (pp. 267-280).

Huang, X., & McCalla, G. (1992). Instructional planning using Focus of Attention. In C. Frasson, G. Gauthier, & G. McCalla (Eds.), *Second International Conference on Intelligent Tutoring Systems* (pp. 443-450). Montreal, Canada.

Kono, Y., Ikeda, M., & Mizoguchi, R. (1992). To contradict is human—Student modeling of inconsistency. In C. Frasson, G. Gauthier, & G. McCalla (Eds.), *Second International Conference on Intelligent Tutoring Systems* (pp. 451-458). Montréal, Canada.

Lelouche, R., & Morin, J. F. (1996). Using qualitative reasoning in cost engineering. The Role of Qualitative Reasoning Techniques in Intelligent Tutoring Systems, *proceedings workshop held at the Third International Conference, ITS'96*, Montréal, Canada.

Lelouche, R., & Morin, J. F. (1997). Knowledge types and tutoring interactions in an ITS in a problem-solving domain. In *Proceedings of the 10th Florida Artificial Intelligence Research Symposium (FLAIRS-97)—Special Track on Intelligent Tutoring Systems* (pp. 62-66). Daytona Beach, Florida. *Journal of Man-Machine Studies, 11,* 97-124.

Lelouche, R., & Morin, J. F. (1997). Use of abstraction and complexity levels in intelligent educational systems design. In *Proceedings of the 15th International Joint Conference on Artificial Intelligence (IJCAI-97)* (pp. 329-334). Nagoya, Japan.

LLTSC. *Learning technology standards committee Web site.* Available at http://ltsc.ieee.org/

McCalla, G. I., & Greer, J. E. (1994). Granularity based reasoning and belief revision in student models. In J. E. Greer, & G. I. McCalla (Eds.), *Student modeling: The key to individualized knowledge-based instruction* (pp. 39-62).

Mizoguchi, R., Ikeda, M., & Kakusho, O. (1988). An innovative framework for intelligent tutoring systems. In P. Ercoli & R. Lewis (Eds.), *Artificial intelligence tools in education* (pp. 105-120).

Morin, J. F., & Lelouche, R. (1998). Agent-oriented tutoring knowledge modeling in a problem-solving ITS. In *Proceedings of the ACM-SIGART Workshop on Interaction Agents (IA 98)* (pp. 26-32). L'Aquila, Italy.

Norman, D. A. (1992). Cognitive artifacts. In J. M. Carroll (Ed.), *Designing interaction: Psychology at the human-computer interface* (pp. 17-38). London; New York: Cambridge University Press.

Norrie, D. H., & Gaines, B. R. (n.d.).*The learning Web: A system view and an agent-oriented model*. Available at http://ksi.cpsc.ucalgary.ca/articles/LearnWeb/EM95J/

Reiter, R. (1980). A logic for default reasoning. *Artificial Intelligence, 13*, 81-132.

Sheridan, T. B. (1992). *Telerobotics, automation, and human supervisory control.* Cambridge, MA: MIT Press.

SIGCUE. (1992). Computer-supported collaborative learning. *Bulletin of the Special Interest Group for Computer Uses in Education (SIGCUE),* 21(3), 1-65.

Silveira, R. A., & Viccari, R. M. (1998). Distance learning: From the intelligent tutor paradigm to a multi-agents architecture. In F. Oliveira (Ed.), *Lectures Notes on Artificial Intelligence - SBIA'98*. Heidelberg: Springer-Verlag.

Taylor, R. (n.d.). *What is knowledge management? The Knowledge Management Forum.* Available at http://www.km-forum.org/what_is.htm

Tecuci, G. (1998). *Building intelligent agents: An apprenticeship multi-strategy learning theory, methodology, tool and case studies.* New York: Academic Press.

Wenger, É. (1987). *Artificial intelligence and tutoring systems*. Los Altos, CA: Morgan Kaufmann.

Wiig, K. (1995). *Knowledge flows, knowledge management methods: Practical approaches to managing knowledge.* Arlington, TX: Schema Press.

Wiley, D. A. (Ed.). (2002). *The instructional use of learning objects.* The Agency for Instructional Technology and the Association for Educational Communications and Technology.

Wooldridge, M., & Jennings, N. R. (1994). Agent theories, architectures, and languages: A survey.

In ECAI Workshop on Agent Theories, Architectures, and Languages (pp. 1-39).

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Chapter 2.44 The Use of Fuzzy Logic and Expert Reasoning for Knowledge Management and Discovery of Financial Reporting Fraud

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ABSTRACT

This chapter examines the use of fuzzy clustering and expert reasoning for the identification of firms whose financial statements are affected by fraudulent financial reporting. For this purpose, we developed a database consisting of financial and nonfinancial variables that evaluated the risk of fraud. The variables were developed using fuzzy logic, which clusters the information into various risk areas. Expert reasoning, implemented in an Excel spreadsheet model, is then used as a form of knowledge management to access the information and develop the variables continuously over the life of the company. At the conclusion of the chapter, the authors discuss emerging trends and future research opportunities. The combination of fuzzy logic, expert reasoning and a statistical tool is an innovative method to evaluate the risk of fraudulent financial reporting.

INTRODUCTION

In the light of recent reporting of the alleged financial reporting abuses in some of the major publicly-held companies in the U.S. (e.g., Enron and WorldCom), it has become increasingly important that management, auditors, analysts and regulators be able to assess and identify fraudulent financial reporting. This chapter is an attempt to use some of the latest statistical methods, expert reasoning and data mining techniques to achieve this objective.

Knowledge management can be used to a company's advantage in day-to-day decision-making. From a financial standpoint, a company must accumulate and disclose information to its employees, customers and investors. This information database can enable a company to support and maintain a competitive position. For instance, one way that a company can justify its financial health is by developing a knowledge management database of financial and nonfinancial variables to evaluate the risk of employee and financial reporting fraud. Collecting data using information processing and organizing the data through knowledge management can create a database for fraud detection and facilitate organizational data mining. Such a database can assist in knowledge discovery and help a company acquire and develop variables useful for the detection of fraud. The database can consist of historical data about the company as well as data for other companies in the industry. This database may be used by banks for lending decisions, by audit firms in an audit or by the company's management to gather and assess new information. These variables could also be evaluated to determine if the company has reached a stress level susceptible to fraud or for identifying fraud indicators.

The auditor's responsibility for detecting financial statement fraud is described in SAS No. 82, Consideration of Fraud in a Financial Statement Audit (American Institute of Certified Public Accountants (AICPA), 1997). Because fraud detection often involves an auditor's judgment in an unstructured environment, there is a possibility that the auditor may enhance the decision-making process with the assistance of a decision model. Using publicly available information, models can be designed to aid an auditor in detecting and evaluating financial statement fraud. Previous studies have focused on the examination of "red flags," or fraud risk factors, as likely indicators of fraud (Bell & Carcello, 2000; Pincus, 1989). Today, the auditor has the responsibility for detecting financial-statement fraud along with the audit of the company's financial statements.

This chapter presents a description, testing and summary of methods of analysis used in fraud determination. First, it is shown how financial and nonfinancial statement data (data based on analysis of company annual reports) can be used to develop membership coefficients that are evaluated in a fuzzy logic approach to data analysis. The fuzzy logic analysis applied to fraud detection is used to cluster the information into various risk areas. The cluster approach also identifies variables that can be used in a logistic regression (logit) model for fraud determination. Expert reasoning can then be applied to "mine" new information and develop the variables continuously over the life of the company. In this chapter, we also discuss the use of an additional fuzzy model for comparison purposes and to assess model accuracy. The chapter contributes to the fraud literature by incorporating a nonfinancial fuzzy logic variable in a statistical model.

The following sections of the chapter provide the background of fraud modeling and of fuzzy logic, and the methodology used to develop the study, including a description of the sample firms. The sample description is followed by a discussion of the financial variables that are developed and used in the models presented in the chapter. The discussion of variables includes a description of the research procedure that identifies nonfinancial variables used in the fuzzy logic clustering method. The next section presents results and analysis of the models. The last part of the chapter discusses emerging trends and future opportunities in this line of research, along with a conclusion.

LITERATURE REVIEW

Fraud Detection

When investigating financial reporting fraud, the auditor looks for “red flags” that might indicate a problem with the financial statements. Lists of questions that an auditor or an analyst should consider asking the client that may help raise red flags have been included in SAS No. 82 (AICPA, 1997), identified in previous studies and have been gathered for this chapter in consultation with auditing experts. SAS No. 82 provides over 30 red flags that may be used to detect fraud in financial statements, but it does not give any guidance of how these factors could be combined to detect fraud. Loebbecke, Eining and Willingham (1989) divided their list into low-, medium- and high-risk indicators of fraud.

Prior research shows that various kinds of decision aids may be used to assist the auditor in detecting financial reporting fraud. Pincus (1989) used a questionnaire and gathered data to predict the presence of management fraud. She found that subjects without the decision aid outperformed those who had the decision aid. Bell, Szykowny and Willingham (1993) used bivariate and cascaded logit to assess the likelihood of management fraud. Their model achieved within-sample correct classification of 97 percent on the fraud observations and 75 percent on the nonfraud observations. Hansen, McDonald, Messier and Bell (1996) used a generalized qualitative response model to predict management fraud. They reported 89.3 percent predictive accuracy over 20 trials. When they adjusted their model for asymmetric misclassifications costs, the model’s accuracy dropped to 85.5 percent but, at the same time, the rate of type II errors, or failure to predict fraud when it was present, decreased considerably. Bell and Carcello (2000) also developed a logistic regression model as a decision aid to assist in the auditor’s fraud decision.

More recently, studies have shown the effect of the company’s internal auditors, auditor tenure and auditor judgment in suggesting reasons for financial reporting failures. Church, McMillan and Schneider (2001) found that internal auditors assign a higher likelihood of fraud when income is greater than expected, and when there is a combination of restrictive debt covenants that impose high costs for additional borrowing and an earnings-based bonus plan for management. In research focused on a company’s external auditors, Geiger and Raghunandan (2002) looked for an association between auditor tenure and audit reporting failures. They found significantly more audit reporting failures in the earlier years of an auditor’s tenure, perhaps indicating a temptation to appease new clients or a lack of knowledge regarding specific tasks associated with a new client (Geiger & Raghunandan, 2002). Other research has examined factors affecting the generation of financial reporting alternatives in a setting where a client uses aggressive financial reporting. Johnstone, Bedard and Biggs (2002) found that auditors with high understanding of accounting rules are better able to negotiate with clients interested in aggressive financial reporting. By proposing various alternatives to a complex accounting issue, an auditor is able to convince the client to use a more conservative financial accounting alternative, thus minimizing the possibilities of a future litigation. These studies show that the auditor’s knowledge of the task or the ability to accumulate knowledge of the task is of utmost importance in the ability to detect fraudulent financial reporting.

Auditors may also use expert systems as a decision aid to assist in fraud determination. Eining, Jones and Loebbecke (1997) examined the effect that the use of an expert system has on auditor decision-making ability in detecting fraud. Their research showed that in allowing the interaction between the auditor and the system, the expert systems that have been used to assist auditors in complex decision processes often give results that are more accurate and consistent. Similarly, Whitecotton and Butler (1998) found that allowing decision makers to select information for the decision aid increases decision aid reliance.

Fuzzy Clustering

When data does not suggest a precise answer, decision makers often recognize patterns or can form groups in the data in order to make a decision (Alam, Booth, Lee & Thordarson, 2000). While discriminant and logit analysis assign observations to groups that were defined in advance, cluster analysis is the art of finding groups in data (Kaufman & Rousseeuw, 1990). Fuzzy set theory, introduced by Zadeh (1965), attempts to classify subjective reasoning (e.g., a human description of "good," "very good" or "not so good") and assigns degrees of possibility in reaching conclusions (Lenard, Alam & Booth, 2000). As opposed to hard clustering, where there is a clear-cut decision for each object, fuzzy clustering allows for ambiguity in the data, by showing where a solution is not clearly represented in any one category or cluster. Fuzzy clustering shows the degree to which (in terms of a percentage) an item "belongs" to a cluster of data. In other words, a data item may belong "partially" in each of several categories. The strength of fuzzy analysis is this ability to model partial categorization.

Lau, Wong and Pun (1999) used neural networks and fuzzy modeling to control a plastic injection-molding machine. They suggested that the neural network and fuzzy technology complement each other and offset the pitfalls of computationally intelligent technologies. Alam et al., (2000) also used a combination of fuzzy clustering and self-organizing neural networks, and were successful in identifying potentially failing banks. Ahn, Cho, and Kim (2000) reported results using these technologies to predict business failure, and stressed the importance of these predictions as useful in aiding decision makers. Lenard, Alam and Booth (2000) used fuzzy clustering to identify two different categories of bankruptcy. Companies placed in the second bankruptcy category exhibited more extreme values in terms of the financial ratios used in the study. Companies either showed much better results (such as a high current ratio) than would be expected for a company facing bankruptcy, or the companies showed very poor results, such as a much higher debt ratio than any of the other bankrupt companies in the data sample. Nolan (1998) used expert fuzzy classification and found that fuzzy technology enables one to perform approximate reasoning (e.g., as when a student assignment is graded as "very good" or "not so good") and improves performance in three ways. First, performance is improved through efficient numerical representation of vague terms, because the fuzzy technology can numerically show representation of a data item in a particular category. The second way performance is enhanced is through increased range of operation in ill-defined environments, which is the way that fuzzy methodology can show partial membership of data elements in one or more categories that may not be clearly defined in traditional analysis. Finally, performance is increased, because the fuzzy technology has decreased sensitivity to "noisy" data, or outliers. Ammar, Wright and Selden (2000) used a multilevel fuzzy rule-based system to rank state financial management. The authors used fuzzy set theory to represent imprecision in evaluated information and judgments.

METHODOLOGY

Sample

The sample of fraud firms was identified using the Wall Street Journal Index for the time period 1992 through 1997. Financial statement data for 30 fraud firms was matched with data from 30 healthy firms, for a total sample of 60 firms. The sample was then randomly divided into a training data set of 15 fraud firms and 15 healthy firms. The remaining 30 firms comprise the test data set on which the predicted results are evaluated. The data for the firms in the study were obtained from the 1998 Compustat tape.

Fuzzy and Logit Models

The fuzzy clustering procedure used here is called FANNY (Kaufman & Rousseeuw, 1990). The program FANNY uses "fuzziness" to partition objects by avoiding "hard" decisions, or clustering into fixed, definite categories. For each item in the data set, the algorithm provides k+1 pieces of information, where k is the number of clusters that are used in the clustering algorithm. The k+1 pieces of information are: Uiv , the membership coefficient of item i in cluster v, v = 1 ... k, and Si , the silhouette coefficient of item i. A higher value of Uiv indicates a stronger association of item i and cluster v. The silhouette coefficients satisfy the constraints $-1 \leq Si \leq 1$ and indicate how a well-clustered object uses average distances from its own cluster to the closest neighboring clusters. The closer Si is to 1 the better the clustering of an individual item. A value of Si close to -1 indicates that an item may be assigned to more than one cluster (Alam et al., 2000). The Euclidean distance measure is used to compute distances between objects and to quantify the degree of similarity for each object. The degree of similarity for each object i and j iscomputed as:

$$d(i,j) = \sqrt{(x_{i1} - x_{j1})^2 + (x_{i2} - x_{j2})^2 + ... + (x_{ip} - x_{jp})^2}, \quad (1)$$

where the pth measurement of the ith object is given by xip and d(i,j) is the actual distance between objects i and j.

For the testing of variables in this chapter, we used a logit model to determine whether a company is likely to commit financial reporting fraud. Our SPSS procedure, which runs the logit model, accepted a variable for entry into the model, if it had a probability of 0.05 or above.

Variables

Various financial accounting textbooks recommend using financial ratios from the three areas representing liquidity, leverage and profitability to evaluate the financial health of a firm (e.g., Meigs, Williams, Haka & Bettner, 2001). Bankruptcy studies recommend similar financial ratios for assessing the financial health of a firm (Altman, 1968; Ohlson, 1980; Mutchler, Hopwood & McKeown, 1997). Additional studies recommend that these variables use logistic regression or discriminant models to predict whether the auditor should modify the audit report to reflect that the firm may not continue as a going concern (Mutchler, 1986; Chen & Church, 1992; Lenard, Alam & Madey, 1995; Nogler, 1995). Person (1997) has suggested the use of a sales variable, or sales weighted by total assets (SATA), to identify what may be fictitious trends in growth. Because we have a relatively small sample size of 30 items each in the training data set and the test data set, we believe that a selection of three to five variables is appropriate. As a result, we have used one financial variable from each financial health assessment category of liquidity, leverage and profitability, based on the most frequently used and successful variables from previous studies. We have also used a second liquidity variable, representing cash flow from operations, because of the reliance on cash in fraud schemes as implied by the high-risk categories featured in the fraud questionnaire reported in this chapter. Therefore, the financial statement variables that are considered in our preliminary analysis of fraud assessment are: (1) CACL: current assets divided by current liabilities; (2) TLTA: total liabilities divided by total assets; (3) NITA: net income divided by total assets; and (4) CFOTL: cash flow from operations divided by total liabilities. CACL and CFOTL are liquidity variables. Healthy firms would have higher values of these variables than a stressed or an unhealthy firm. TLTA determines a company's leverage. A healthy firm would have a lower percentage of total liabilities divided by total assets than a stressed or an unhealthy firm. NITA is a profitability variable, generally referred to as return on assets. In summary, it is expected that for fraud firms the variables CACL, CFOTL and NITA will be relatively small than for healthier firms. On the other hand, the TLTA variable will be relatively large for fraud firms than for healthier firms.

Research Procedure

The first step in defining the nonfinancial variables is to develop a decision table based on all possible answers to a list of fraud questions ("Yes" answers equal high or medium risk; "No" answers equal low risk) as input into the fuzzy logic program. The list of fraud questions appears in Figure 1. These questions were gathered from SAS No. 82 (AICPA, 1997), and modified in consultation with an auditing expert, a manager at a "Big Five" accounting firm. This method of expert system development follows Gal (1985), who used one expert for knowledge acquisition and validation. The four risk categories, described in the questionnaire, are cash risk, earnings risk, industry risk and operations risk. All possible combinations of the answers to the fraud questions are then coded as input into the fuzzy clustering program. For example, cash risk can be low (score of 0) or high (score of 1). Each of the other categories can have low or medium risk — our expert felt that the cash risk was the only category that warranted a high risk. As a result, the risk of fraud is considered high for cash transactions and where fiduciary responsibility exists. Fraud risk can be low or medium in the area of earnings management, where specific industry conditions are indicated, or because of operational characteristics. The score for medium risk in the earnings risk or industry risk categories can range from 0.4 to 0.7. Medium risk for operations is scored as 0.5, if any one of the questions is answered "yes," otherwise risk is low (scored as 0). Again, the expert we consulted felt that any one "yes" answer reflected medium risk in the operations category. So a possible score combination could be a 0 (low) for cash risk, 0.4 (medium risk) for earnings risk, 0.4 (medium risk) for industry risk and 0.5 (medium risk) for operations risk.

The systematic coding of all the possible combinations resulted in 84 observations. These observations represent the database that is used for data mining. Based on membership coefficients of clusters produced by the fuzzy run, each decision situation (combination of high-, medium- and low-risk values for the fraud questions) is then assigned a fraud variable, one variable for each of the clusters produced by the fuzzy clustering program. Once the fraud questions are answered for a company in our data set, the particular observation from the knowledge base is retrieved, and the values of each fraud variable can be entered into the logit model. The logit model predicts the probability of fraud, and the fuzzy model is operationalized in an expert system rule-base or in an Excel spreadsheet, using the spreadsheet's logic capabilities. The logit model accomplishes the prediction of fraud using the financial statement variables and one or more of the fuzzy cluster variables.

RESULTS

We ran the fuzzy clustering program for the red flag indicators, using 2 through 6 clusters. For our variable choices, we used the fuzzy clustering run with four clusters (see Table 1). Table 1 shows the membership coefficients for the four closest hard clustering of each of the data items. The fuzzy clustering program computes Dunn's partition coefficient (Kaufman & Rousseeuw, 1990), which is the sum of the squares of all the

Figure 1. Excel spreadsheet: Implementation of the fraud questionnaire

Fraud Questionaire

Answer each of the questions in the boxes with a "Y" or "N"

Score	**"Y" or "N"**		**Risk Factors**
			Management's Characteristics and Influence
			Cash transactions / fiduciary responsibility - low or high risk
0	Y		Are all officer salaries and bonuses approved and disclosed?
0	Y		Are transactions legitimate / appropriate for stock compensation plans?
0	Y		Are related party transactions properly disclosed?
			Earnings Management - low or medium risk
0.1	Y		Must the company support a high stock price?
	N		Was last audit unqualified, does the company change auditors often?
0	N	OR	Does co. change / have more than one legal counsel, significant legal issues?
0			Is the credit rating high?
0.1	Y	OR	Is the credit rating satisfactory?
0		OR	Is the credit rating poor?
0	N		Is there domination by one person, or are there many officers, directors?
			Industry Conditions - low or medium risk
0.1	Y		Is there a high degree of competition, or is this a rapidly changing industry?
0	N		Are costs and expenses rising faster than sales and profits?
0			Concerning expansion of the business:
0			Is expansion slow?
0.1	Y	OR	Is expansion medium?
0		OR	Is expansion rapid?
0	N		Does co. have little variety of products, a narrow range of customers?
			Operational Characteristics - low or medium risk
0	N		Does the company have trouble meeting debt payments?
0	N		Are there unusual or highly complex transactions?
1	Y		Are there cash flow problems while also reporting earnings growth?
			Total Risk Analysis
			Low risk = 0, Medium risk = .4 through .7, High risk = 1
0			Management (Cash) Risk
0.5			Earnings Risk
0.5			Industry Risk
0.5			Operating Risk
			Link to database to find fraud category:

Link

membership coefficients divided by the number of objects. The normalized version of the Dunn's coefficient falls between 0 and 1, with a coefficient of 0 being completely fuzzy clustering and a coefficient of 1 being completely hard clustering. The normalized value of the coefficient for our model with four clusters was 0.21, which suggests a fuzzy clustering. The membership coefficient values show the portion to which the observation belongs to a cluster.

As noted above, the fuzzy run identified four clusters or variables. We introduced these four

Table 1. Fuzzy clustering membership coefficients: "Red flag" statements

	1	2	3	4
001	.3510	.2819	.1913	.1758
002	.4003	.2834	.1653	.1509
003	.4038	.2837	.1633	.1493
004	.3995	.2849	.1646	.1509
005	.3886	.2868	.1690	.1556
006	.4003	.2834	.1653	.1509
007	.4038	.2837	.1633	.1493
008	.3995	.2849	.1646	.1509
009	.3886	.2868	.1690	.1556
010	.2934	.3329	.1827	.1910
011	.6119	.2143	.0913	.0825
012	.6513	.1952	.0805	.0729
013	.6260	.2084	.0868	.0789
014	.5555	.2419	.1059	.0967
015	.6513	.1952	.0805	.0729
016	.7057	.1673	.0666	.0604
017	.6733	.1847	.0743	.0676
018	.5832	.2299	.0976	.0893
019	.6260	.2084	.0868	.0789
020	.6733	.1847	.0743	.0676
021	.6452	.1996	.0811	.0741
022	.5653	.2388	.1021	.0938
023	.5555	.2419	.1059	.0967
024	.5832	.2299	.0976	.0893
025	.5653	.2388	.1021	.0938
026	.5136	.2614	.1170	.1080
027	.2223	.5874	.0909	.0994
028	.1966	.6381	.0788	.0865
029	.1999	.6289	.0815	.0897
030	.2270	.5684	.0975	.1072
031	.1966	.6381	.0788	.0865
032	.1587	.7106	.0622	.0686
033	.1644	.6974	.0656	.0725
034	.2052	.6128	.0865	.0955
035	.1999	.6289	.0815	.0897
036	.1644	.6974	.0656	.0725
037	.1695	.6855	.0688	.0762
038	.2074	.6056	.0888	.0982
039	.2270	.5684	.0975	.1072
040	.2052	.6128	.0865	.0955
041	.2074	.6056	.0888	.0982
042	.2299	.5531	.1031	.1140
043	.1913	.1758	.3510	.2819
044	.1653	.1509	.4004	.2834
045	.1633	.1493	.4038	.2837

Table 1. Fuzzy clustering membership coefficients: "Red flag" statements (continued)

	1	2	3	4
046	.1646	.1509	.3995	.2849
047	.1690	.1556	.3886	.2868
048	.1653	.1509	.4004	.2834
049	.1633	.1493	.4038	.2837
050	.1646	.1509	.3995	.2849
051	.1690	.1556	.3886	.2868
052	.1827	.1910	.2934	.3329
053	.0913	.0825	.6119	.2143
054	.0805	.0729	.6514	.1952
055	.0868	.0789	.6260	.2083
056	.1059	.0967	.5555	.2419
057	.0805	.0729	.6514	.1952
058	.0666	.0604	.7058	.1672
059	.0743	.0676	.6734	.1847
060	.0975	.0893	.5833	.2299
061	.0868	.0789	.6260	.2083
062	.0743	.0676	.6734	.1847
063	.0811	.0741	.6453	.1996
064	.1021	.0938	.5654	.2387
065	.1059	.0967	.5555	.2419
066	.0975	.0893	.5833	.2299
067	.1021	.0938	.5654	.2387
068	.1170	.1080	.5137	.2613
069	.0909	.0994	.2223	.5874
070	.0788	.0865	.1966	.6381
071	.0815	.0897	.1999	.6289
072	.0975	.1072	.2269	.5684
073	.0788	.0865	.1966	.6381
074	.0622	.0685	.1587	.7106
075	.0656	.0725	.1644	.6975
076	.0865	.0955	.2052	.6129
077	.0815	.0897	.1999	.6290
078	.0656	.0725	.1644	.6975
079	.0688	.0761	.1695	.6856
080	.0888	.0982	.2074	.6057
081	.0975	.1072	.2269	.5684
082	.0865	.0955	.2052	.6129
083	.0888	.0982	.2074	.6057
084	.1031	.1139	.2299	.5531

PARTITION COEFFICIENT OF DUNN = .41
ITS NORMALIZED VERSION = .21

Note: The membership coefficients represent the degree to which an observation belongs to a cluster. For instance, for observation 1, 35% belongs to cluster 1, 28% to cluster 2, 19% to cluster 3, and 18% to cluster 4. The combined "belonging" percent adds up to 100%.

variables along with the four financial statement variables in a logit run. We achieved the highest prediction when only one of the fuzzy variables, FR_1, and the four financial statement variables were used. Results of the logit run, containing five variables and using the training set of 30 firms, appear in Table 2, Panel A. The dependent variable is coded as 1 for fraud firms and 0 for healthy firms. The classification accuracy of the model in the training set is 80.0 percent and the fraud variable is significant. Overall accuracy rate in the test data set is 86.7 percent (see Table 2, Panel B). It is interesting to note in Table 2, Panel A that the sign of the coefficient of the variable CACL is not in the anticipated direction for firms reporting financial reporting fraud. But this variable is one that a company would want to disguise, if they were trying to commit fraud. In addition, by including the fuzzy variable (FR_1), we have operationalized the use of fuzzy logic, which is also the significant variable in our logit regression. The negative sign of the FR_1 coefficient indicates that the probability of fraud is low, when the value of the FR_1 variable is high. Companies with higher values of this variable have lower cash and operating risk. An important component of this analysis is that the auditor or the analyst still gets to apply judgment in responding to fraud questions (see Figure 1), but now has quantitative support for the decision about whether there is fraud in the financial statements.

Sensitivity Analysis

Logit Results

Since the logit model presents its results in terms of a probability, we can analyze the model based

Table 2. Panel A: Results of logistic regression for fraud vs. healthy companies with selected financial variables and a fraud variable

Variable	Expected Sign	Coefficient	T-Value
TLTA	+	1.3402	0.8966
CFOTL	-	- 7.0083	- 0.9811
NITA	-	- 0.3639	- 0.0275
FR_1	-	- 4.6858	- 1.6471 *
CACL	-	0.8308	0.6138
Constant		- 1.6537	- 0.2861

- * Significant at 0.10 level, two-sided test
- Overall prediction accuracy in training set 80%
- Cox & Snell R-square = 0.404

Table 2. Panel B: Prediction accuracy of logistic regression model on test dataset to predict fraud

	Predicted Fraud --	No	Yes	Total	Percent correct
Actual	No	11	4	15	73.3%
Fraud	Yes	0	15	15	100.0%
	Total	11	19	30	86.7%[a]

[a](11 correctly predicted "No" + 15 correctly predicted "Yes") / 30 total = 86.7%

Table 3. Analysis of classification accuracy for logit model

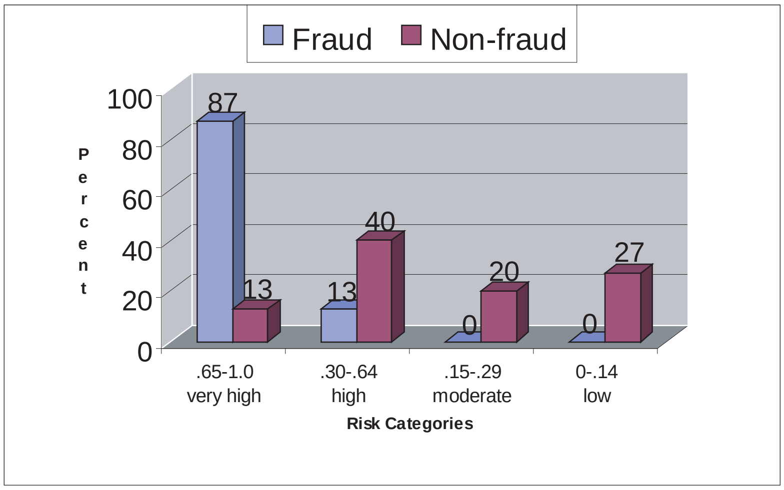
Predicted Probability of Fraud	% of Observations Correctly Classified Fraud	Non-fraud
.95	33	93
.90	33	87
.85	47	87
.80	66	87
.75	80	87
.70	80	87
.65	87	87
.60	93	73
.55	100	73
.50	100	73
.45	100	73
.40	100	73
.35	100	60
.30	100	47
.25	100	47
.20	100	40
.15	100	27
.10	100	27
.05	100	27

on the likelihood estimate of fraud occurrence. In our model represented in Table 2, we used a cutoff point of 0.5, meaning that a probability of 0.5 or above predicts a "fraud" company. In order to analyze the value of a cutoff point in determining the fraud prediction, we followed the approach of Bell and Carcello (2000) and assessed prediction accuracy for a range of cutoff points from 0.05 to 0.95 (see Table 3). The results show that the logit model is quite sensitive to fraud prediction because the highest accuracy is when the cutoff point for fraud is 0.65 or above. Using this cutoff point, 87 percent of fraud companies and 87 percent of nonfraud companies are correctly classified. That means there are still two nonfraud companies that exhibit fraud characteristics in our test data set. However, that also means the remainder of the fraud companies are correctly classified. We represent this analysis graphically in Figure 2. If we use four subjective fraud categories, representing the risk of fraud as low, moderate, high or very high, according to cutoffs of 0-0.14, 0.15-0.29, 0.30-0.64 and 0.65-1.0, respectively, we see that 87 percent of the fraud companies in the sample are in the very high category. But 40 percent of the nonfraud companies are still in a high-risk category, with a fraud prediction between 30 percent and 64 percent. However, this is possible for companies that have complex transactions that should be looked at more closely.

Fuzzy Clustering

Fuzzy clustering can also be used on the test data set itself, using the variables previously defined in our analysis. This is done for comparison purposes to assess the accuracy of our logit model and also to gain more knowledge about whether a company belongs in a fraud or nonfraud category. As mentioned earlier, fuzzy clustering finds groups in data, instead of assigning data to groups that were defined in advance. The variables that

Figure 2. Graphical categorization of classification accuracy for logit model in various risk categories



achieve a definitive analysis for fuzzy clustering are the financial statement variables SATA, TLTA, CFOTL and NITA and the fraud variable, FR_1. Again, we have maintained the CFOTL variable for liquidity analysis, the TLTA variable to represent leverage and the NITA variable to analyze profitability, along with the SATA variable for firm size. When the test data set is grouped into three clusters, there is a group representing fraud companies, a group representing healthy companies and a mixed group (see Table 4).

The fraud group (cluster 2) has one misclassified firm and the nonfraud group (cluster 3) has two misclassified firms, for a total classification accuracy of 27/30 = 90.0 percent. In the mixed group (cluster 1), the healthy firms that are included are firms 17, 21, 22 and 26. These firms are also classified as marginal firms or fraudulent firms by the logit model. Using the logit model from Table 2 and the analysis of Figure 2, firm 17 has a predicted probability of 0.39, which is in the high-risk group. Similarly, firm 22 has a predicted probability of 0.63, also in the high-risk group. Firm 21, with a predicted probability of 0.98, is in the very high-risk group, while firm 26 is in the moderate-risk group, with a probability of 0.16. For those fraud firms in the mixed group, firm 2 has a predicted probability of fraud of 0.64, which is in the high-risk group. Firms 1 and 6, with predicted probabilities of 0.78 and 0.96, respectively, are in the high-risk group but share similar characteristics to those of the nonfraud companies in the mixed group. So the fuzzy clustering provides additional support for our logit analysis, by creating a separate cluster that includes nonfraud firms that are uncharacteristic of other nonfraud firms and may require closer scrutiny.

Implementation of the Data Mining Application

The determination of the fraud variable, FR_1, for inclusion in the logit model is implemented in an Excel spreadsheet. The spreadsheet runs like an application, with the components of the application linked by macros. A flowchart of the process is depicted in Figure 3.

Table 4. Fuzzy clustering with selected financial statement variables and a fraud variable

	1	2	3
001	.3383	.3376	.3241
002	.3575	.3574	.2851
003	.3638	.3641	.2721
004	.3654	.3655	.2691
005	.3782	.3797	.2420
006	.3523	.3520	.2957
007	.3168	.3163	.3670
008	.3524	.3530	.2946
009	.3340	.3340	.3320
010	.3603	.3609	.2788
011	.3002	.2994	.4003
012	.3501	.3506	.2993
013	.3683	.3694	.2623
014	.3701	.3713	.2586
015	.3581	.3589	.2830
016	.2762	.2753	.4484
017	.3442	.3440	.3118
018	.2817	.2807	.4376
019	.3328	.3323	.3348
020	.3051	.3041	.3908
021	.3560	.3560	.2881
022	.3390	.3384	.3226
023	.3687	.3693	.2620
024	.2738	.2728	.4534
025	.2943	.2936	.4121
026	.3449	.3449	.3102
027	.2853	.2845	.4302
028	.3210	.3205	.3585
029	.2718	.2710	.4572
030	.2860	.2852	.4288

PARTITION COEFFICIENT OF DUNN = .34
ITS NORMALIZED VERSION = .01

Figure 3 indicates that the process starts with the questionnaire, which uses the logic features of Excel to build a rule-base and compute a score for fraud analysis (see Figure 1). As stated previously and shown in Figure 1, the cash risk (or management risk), can have low risk (a score of 0) or high risk (a score of 1). Each of the other three categories (earnings risk, industry risk and operations risk) can have low or medium risk. The medium-risk scores for earnings risk and industry risk can range from 0.4 (a "yes" answer to one risk question) to 0.7 (four "yes" answers). The medium-risk score for operations risk is 0.5 (a "yes" answer to any of the risk questions). When the spreadsheet has displayed the score for each risk factor, the user presses the "Link" button to progress to the data-mining feature and is instructed through the process that will result in a match of one of the 84 fraud combinations (see Figure 4).

Once the fraud combination has been retrieved, or "mined," from the database, the fraud variable that has been derived for that situation from the fuzzy clustering run can be located. Then the user can link to the model page and enter the fraud variable and the financial statement variables into the spreadsheet. In each cell that is requesting a financial statement variable, the user can double click and see a definition of the variable, described

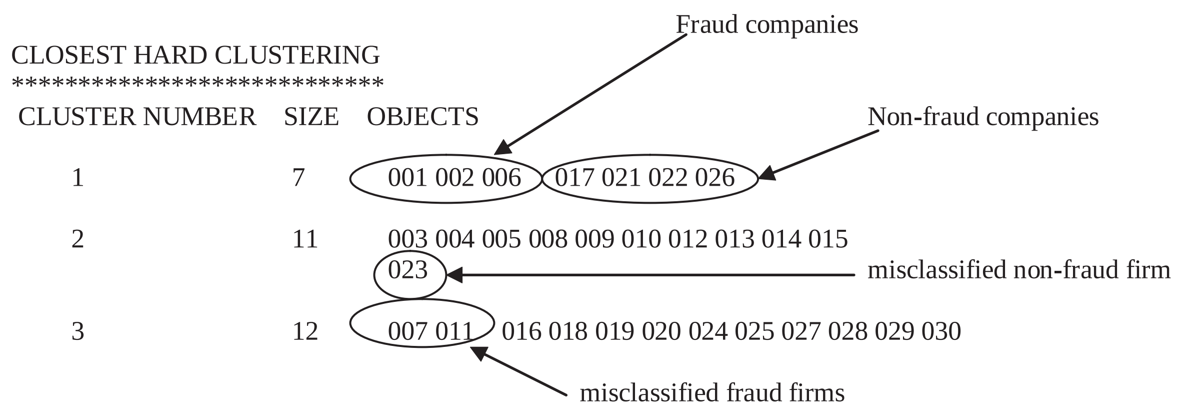


Figure 3. Flowchart: Implementation of the data mining application

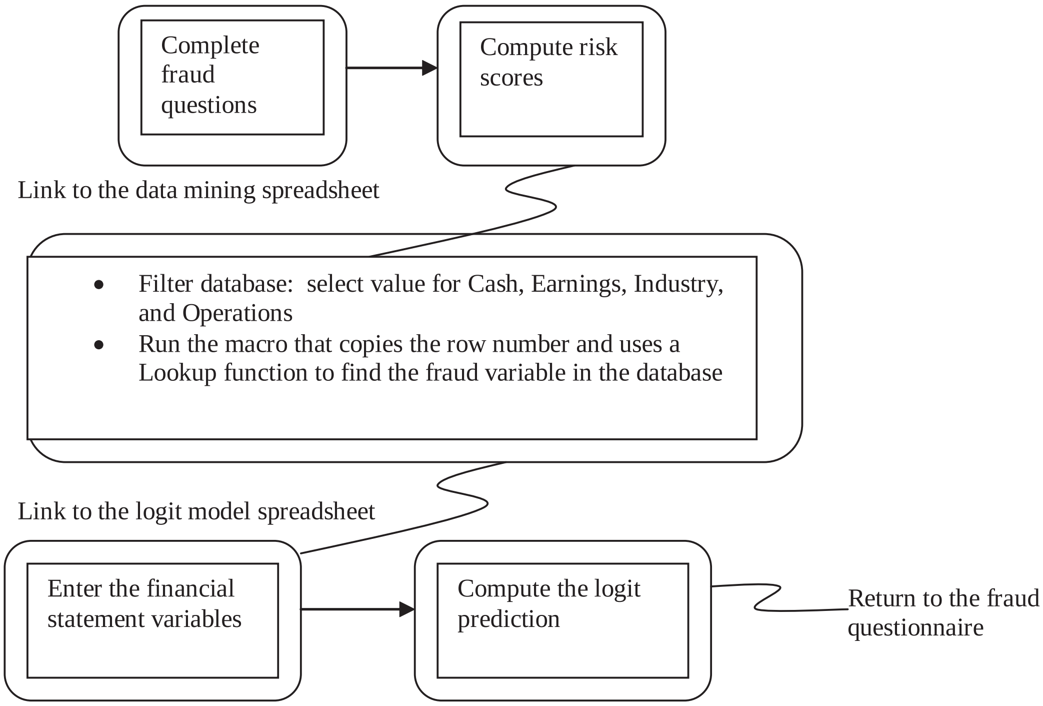
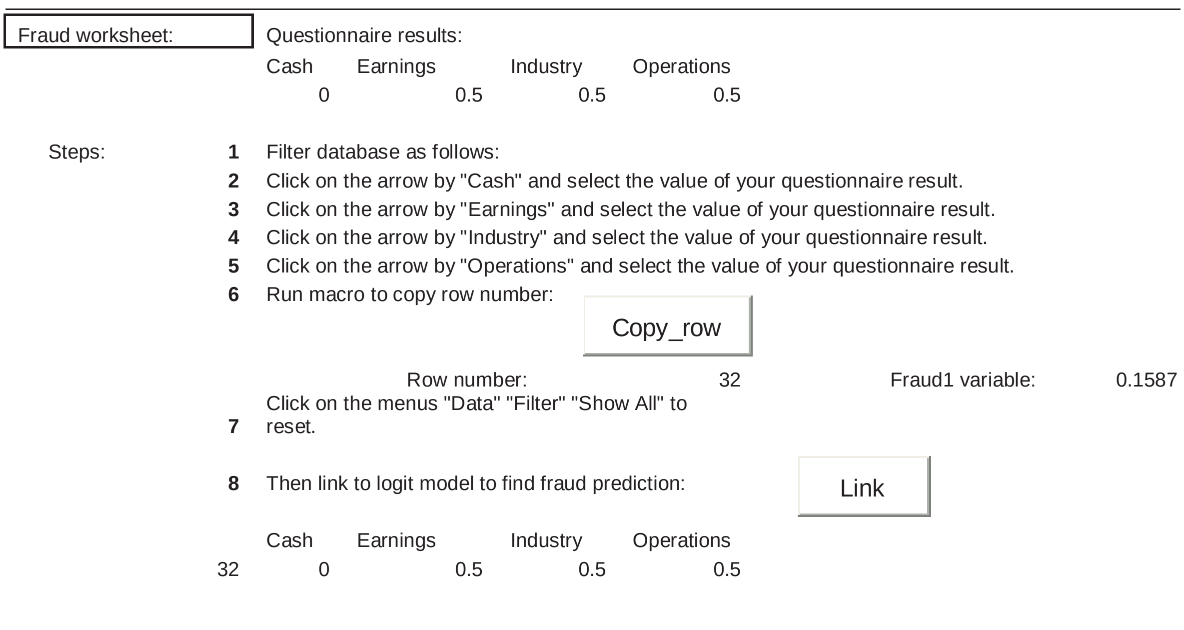
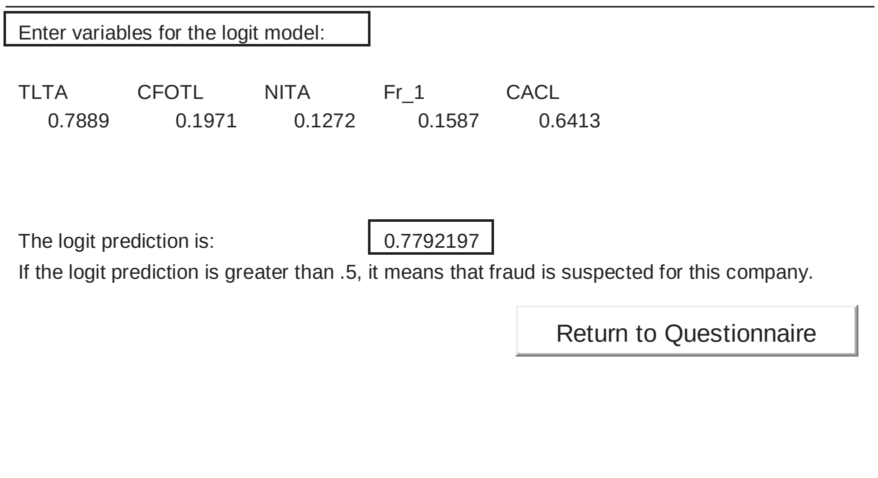


Figure 4. Excel spreadsheet with data mining capability



Using the "Auto Filter" feature of Excel, the above figure shows that for this particular example, with cash risk of 0, earnings risk of .5, industry risk of .5, and operations risk of .5, the row in the database that matches this score is line 32, and the value of the fraud variable, FR_1, at this location is .1587.

Figure 5. Excel spreadsheet implementation of the logit model



On this page of the spreadsheet application, each of the variables is explained using the "note" feature of Excel (not visible in this reproduction). TLTA is total liabilities divided by total assets, CFOTL is cash flow from operations divided by total liabilities, NITA is net income divided by total assets, FR1 is the fraud variable derived on the previous page with the data mining feature, and CACL is current assets divided by current liabilities. We make our recommendation of whether to suspect fraud based on the convention used by the logit model, which is that a value or "prediction" of .5 or above from the logit equation is an indication of fraud.

using Excel's "Note" feature. The spreadsheet is programmed with the logit equation and automatically computes a prediction (see Figure 5). This prediction is the probability that a company fits the characteristics of a fraud firm.

CONCLUSION

This chapter has introduced a procedure, implemented through the use of fuzzy logic, to show that red flags in a company's annual audit do contribute to the information that is available to assist in the decision about whether the company may commit financial statement fraud. By using the fuzzy logic model to develop clusters for different statements representing red flags in the detection of fraud, nonfinancial data can be operationalized and included with financial statement variables as a database for knowledge management and discovery of fraud.

Emerging Trends

Financial statement information is used by management, employees, outside analysts, investors and creditors to assess the health of publicly traded companies. Just as this information is now readily available through the Internet and online financial services, so should tools that help in the analysis of that information be readily available or easily obtainable. Although the data mining application described in this chapter is a research model, its implementation through the use of an Excel spreadsheet emphasizes its portability. The application can easily be downloaded for individual use, and the database can be easily updated. It then becomes an important tool for all users.

Future Research Opportunities

The data mining model in this study has been used on a limited basis with a relatively small sample of firms. Further study in fraud research could result in a larger database that involves a more detailed questionnaire. This approach can also be applied to other unstructured decisions. Specifically, in the field of auditing, there is the auditor's decision, reflected in the audit report, about whether the company can continue as a going concern. The auditor uses the analysis of financial variables and a framework of questions to make this judgment. The auditor also applies judgment in the consideration of materiality. Materiality judgment is closely linked to the analysis of fraud, because the auditor must decide the extent to which a discrepancy will affect the financial statements. These decisions can be supported by the use of data mining tools and provide a continuing demand for the development of knowledge management.

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REFERENCES

Ahn, B. S., Cho, S. S., & Kim, C. Y. (2000). The integrated methodology of rough set theory and artificial neural network for business failure prediction. *Expert Systems with Applications, 18,* 65-74.

Alam, P., Booth, D., Lee, K., & Thordarson, T. (2000). The use of fuzzy clustering and self-organizing neural networks for identifying potentially failing banks: An experimental study. *Expert Systems with Applications, 18,* 185-199.

Altman, E. I. (1968, September). Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *The Journal of Finance, 23,* 589-609.

American Institute of Certified Public Accountants (AICPA). (1997). *Consideration of fraud in a financial statement audit. Statement on Auditing Standards No. 82.* New York: AICPA.

Ammar, S., Wright, R., & Selden, S. (2000). Ranking state financial management: A multilevel fuzzy rule-based system. *Decision Sciences, 31*(2), 449-481.

Bell, T. B., & Carcello, J. V. (2000). A decision aid for assessing the likelihood of fraudulent financial reporting. *Auditing: A Journal of Practice & Theory, 19*(1), 169-184.

Bell, T. B., Szykowny, S., & Willingham, J. J. (1993). *Assessing the likelihood of fraudulent financial reporting: A cascaded logit approach.* Working paper, KPMG Peat Marwick, Montvale, NJ.

Chen, K. C. W., & Church, B. K. (1992). Default on debt obligations and the issuance of going-concern opinions. *Auditing: A Journal of Practice & Theory, 11*(2), 30-49.

Church, B. K., McMillan, J. J., & Schneider, A. (2001). Factors affecting internal auditors' consideration of fraudulent financial reporting during analytical procedures. *Auditing: A Journal of Practice & Theory, 20*(1), 65-80.

Eining, M., Jones, D. R., & Loebbecke, J. K. (1997). Reliance on decision aids: An examination of auditors' assessment of management fraud. *Auditing: A Journal of Practice & Theory, 16*(2), 1-19.

Gal, G. (1985). *Using auditor knowledge to formulate data model constraints: An expert system for internal control evaluation*. Unpublished doctoral dissertation, Michigan State University, Lansing, Michigan.

Geiger, M. A., & Raghunandan, K. (2002). Auditor tenure and audit reporting failures. *Auditing: A Journal of Practice & Theory, 21*(1), 67-78.

Hansen, J. V., McDonald, J. B., Messier Jr., W. F., & Bell, T. B. (1996). A generalized qualitative-response model and the analysis of management fraud. *Management Science, 42*(7), 1022-1032.

Johnstone, K. M., Bedard, J. C., & Biggs, S. F. (2002). Aggressive client reporting: Factors affecting auditors' generation of financial reporting alternatives. *Auditing: A Journal of Practice & Theory, 21*(1), 47-65.

Kaufman, L., & Rousseeuw, P. T. (1990). *Finding groups in data: An introduction to cluster analysis.* New York: John Wiley & Sons.

Lau, H. C. W., Wong, T. T., & Pun, K. F. (1999). Neural-fuzzy modeling of plastic injection molding machine for intelligent control. *Expert Systems with Applications, 17,* 33-43.

Lenard, M. J., Alam, P., & Booth, D. (2000). An analysis of fuzzy clustering and a hybrid model for the auditor's going concern assessment. *Decision Sciences, 31*(4), 861-864.

Lenard, M. J., Alam, P., & Madey, G. R. (1995). The application of neural networks and a qualitative response model to the auditor's going concern uncertainty decision. *Decision Sciences, 26*(2), 209-227.

Loebbecke, J. K., Eining, M. M., & Willingham, J. J. (1989). Auditors' experience with material irregularities: Frequency, nature, and detectability. *Auditing: A Journal of Practice & Theory, 9*(2), 1-28.

Meigs, R. F., Williams, J. R., Haka, S. F., & Bettner, M. S. (2001). *Financial accounting* (10th ed.). Boston, MA: Irwin/McGraw-Hill.

Mutchler, J. F. (1986, Fall). Empirical evidence regarding the auditor's going-concern opinion decision. *Auditing: A Journal of Practice & Theory, 6*, 148-163.

Mutchler, J. F., Hopwood, W., & McKeown, J. M. (1997). The influence of contrary information and mitigating factors on audit opinion decisions on bankrupt companies. *Journal of Accounting Research, 35,* 295-310.

Nogler, G. E. (1995). The resolution of auditor going concern opinions. *Auditing: A Journal of Practice & Theory, 14*(2), 54-73.

Nolan, J. R. (1998). An expert fuzzy classification system for supporting the grading of student writing samples. *Expert Systems with Applications, 15,* 59-68.

Ohlson, J. A. (1980). Financial ratios and the probabilistic prediction of bankruptcy. *Journal of Accounting Research, 18,* 109-131.

Person, O. S. (1997). Using financial statement data to identify factors associated with fraudulent financial reporting. *Journal of Applied Business Research, 11*(3), 38-46.

Pincus, K. (1989). The efficacy of a red flags questionnaire for assessing the possibility of fraud. *Accounting, Organization and Society, 14,* 153-163.

Whitecotton, S. M., & Butler, S. A. (1998, Supplement). Influencing decision aid reliance through involvement in information choice. *Behavioral Research in Accounting, 10,* 182-201.

Zadeh, L. A. (1965). Fuzzy sets. *Information and Control, 8,* 338-353.

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Chapter 2.45

Enhanced Knowledge Warehouse

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INTRODUCTION

Enhanced knowledge warehouse (eKW) is an extension of the enhanced data warehouse (eDW) system (Abramowicz, 2002). eKW is a Web services-based system that allows the automatic filtering of information from the Web to the data warehouse and automatic retrieval through the data warehouse. Web services technology extends eKW beyond the organization. It makes the system open and allows utilization of external software components, thus enabling the creation of distributed applications.

The enhanced knowledge warehouse is an add-in to the existing data warehouse solutions that offers a possibility of extending legacy data-based information resources with processed information acquired from Web sources of business information.

eKW is characterized by transparent filtering and transparent retrieval. The system automatically acquires interesting documents from Web and internal sources and enables business users, who view data warehouse reports, to access these documents without the necessity of formulating any document retrieval queries. Instead, the system takes advantages of meta-information stored in business metadata and data warehouse reports, and builds and runs appropriate queries itself. The system also has an event-alerting capability.

eKW, by design, is a part of the semantic Web. The main role of eKW in the semantic Web is mediation between the world (external information) and internal information systems utilized within the organization. One of the most popular ways of conforming to semantics is to use ontologies, which provide a means for defining the concepts of the exchanged data. eKW is a kind of data mediator that employs ontologies as a conceptualization layer (W'cel, 2003).

BACKGROUND

Document management systems may be divided into two major categories: information retrieval (IR) and information filtering (IF) systems.

The classical models of information retrieval systems were defined by Salton (1983). As distinct from structured data management, information retrieval is imprecise and incomplete. This is due to the inaccurate representations of document contents and user information needs. The distinctive feature of information retrieval systems is a relatively constant document collection. The collection stores documents and their representations (indices). When a user submits a query to the information retrieval system, the query is compared against all indices in the collection. Documents whose indices match the query are returned as the resulting subset of the collection. Most search engines on the Web and digital libraries available on the market can serve as examples of information retrieval systems (Baeza-Yates, 1999).

The main objective of information filtering systems is to block unwanted information from the incoming stream of documents. As distinct from IR systems, filters do not have any fixed collection of documents. Instead, they hold a collection of standing queries (profiles). The profiles represent long-term information interests of their owners. When a new document arrives at the filter its representation is created and compared against all profiles in the collection. Some libraries maintain systems that inform users about new volumes included in the library. Such systems are usually based on the server-side filtering architectures and their profiles usually consist of semi-structured elements (e.g., author, subject, title). This idea is referred to as selective dissemination of information (SDI).

JUSTIFICATION

Possessing and maintaining large information resources does not itself provide any guarantees that users will manage to find the piece of information (document) they need. First of all, users must be aware that the particular piece of information already exists in their resources. Yet, even if they are aware, searching may be very labor consuming. Such a situation is highly undesirable for organizations, as they do not exploit their potentials to increase the effects. That is why knowledge management is nowadays considered the capability of re-use of information and is becoming an increasingly vital issue.

Usually, users are not eager to learn how to operate in several different information systems. Integration of information resources enables the exploitation of the capabilities of many systems through a single user interface (UI). Data warehouse users should be capable of finding interesting documents through a single UI. Not only should the users be aware that the desired information does exist, but also relevant documents should be disseminated to them mechanically. Such a mechanical distribution of the relevant information gives more time for other tasks.

Business users have certain problems with finding information sources, building correct retrieval queries and formulating proper filtering profiles. Thus, introducing the system capable of relieving the users from the necessity of formulating queries and solving the most commonly reported problems with accessing information on the Web would increase productivity of those seeking relevant external information.

The constantly growing number of content providers and the exploding volume of business information are not accompanied by the corresponding growth of capabilities of exploitation of the resources by the contemporary organizations. Therefore, automatic acquisition, organization and presentation of information became not only possible but also essential for the performance of today's businesses.

THE IDEA OF EKW

The term data warehouse was defined by Bill Inmon in 1992 as a collection of integrated, subject-oriented databases to support the DSS function, where each unit of data is relevant to some moment in time. Since then a rapid growth of this relatively new idea has been observed.

In the eKW model, Web documents are assumed to be business news published in English by major content providers on the Web (e.g., Reuters, Cnn.com), because this type of external information is the one in favor of business people (Abramowicz, 2000; Webber, 1999). The solution proposed is based on the existing standards in the area of data warehousing, document management, communication among software agents, internetworking and storage.

The basic idea of data warehousing is to create a data model common for the whole organization (metamodel). The model provides a framework for uploading legacy data, stored in heterogeneous databases across the organization, to the warehouse. Before data are uploaded they need transformation that includes filtering, consistency check, field mapping and aggregation.

Data warehouses proved to be useful for the purpose of legacy data analysis and they are commonly implemented by organizations. They provided novel data processing techniques like data mining, basket analysis, dimensional data analysis, drill-down, drill-through or slice-and-dice. These techniques are based on the characteristic features of data and information stored in the data warehouse: non-volatility, relevance to some moment in time (timeliness), correctness, consistency, completeness, business subject orientation, and business descriptions in metadata (Adelman, 1997; Kimball, 1996).

In terms of the data warehouse, metadata1 (warehouse metadata) are data about data. Metadata consist of facts and events concerning database objects. Metadata are usually stored in a database referred to as the metadata repository or the metadata collection. Nowadays, metadata are considered to be an integral part of the data warehouse (Gleason, 1997; Inmon, 1999).

Due to its destination and the sophisticated methods of data processing, the enterprise data warehouse is often claimed to be the corporate knowledge repository. However, we argue that information derived only from structured information (data) produced by the organization is just a fraction of corporate knowledge that may be stored in the repository.

As distinct from database systems, document management systems deal with unstructured and semi-structured information. Because machines are not capable of understanding text, they must rely on mathematical representations of the document content and user information needs.

The most distinctive feature of eKW is that information acquisition, organization and dissemination are performed without any additional actions taken by data warehouse users. In particular, no formulation of keyword-based queries is necessary to access external business news relevant to user information needs. Instead, the queries are formulated mechanically based on business metadata and information stored in the enterprise data warehouse. The system mechanically collects external documents that are potentially interesting to users and stores them in the local collection. Business users who access corporate data are mechanically supplied with documents that match both the context of the data accessed and user interests at the same time. In this way users have easy access to relevant information resources acquired from outside the organization. These resources are being continuously extended and integrated with the data warehouse. In this way enhanced knowledge warehouse provides a framework for more effective (faster and based on more relevant information) decision making in the organization.

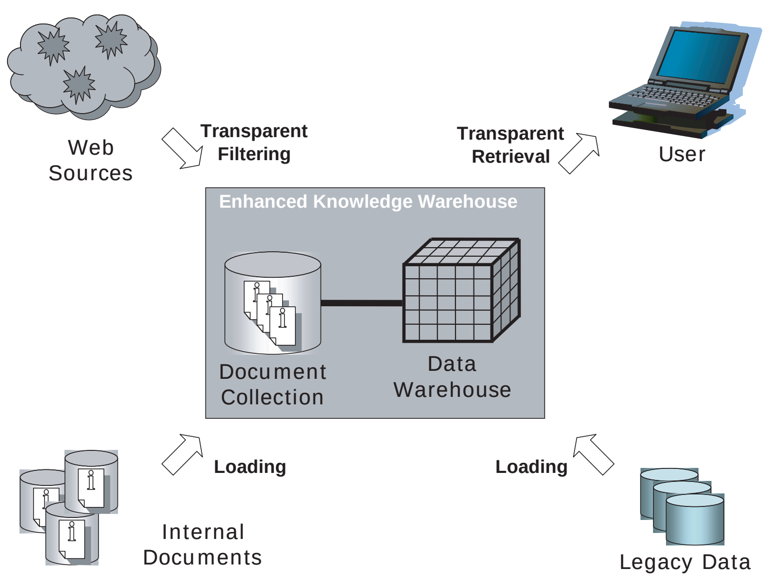
Based on the previous experience with augmenting documents and data, we decided to create a model that would relieve business users from the necessity of connecting to diverse and volatile sources on the Web, formulating queries, and browsing through the results. In order to do this, our system must be capable of mechanical information acquisition from Web sources, adding appropriate descriptions (indices) and precise information retrieval. The first two features imply a continuous series of actions, while the latter requires a trigger that makes the retrieval part of the system run.

The four arrows in Figure 1 represent main processes in the system. The process of loading legacy data to the data warehouse is a typical warehouse loading process defined by the organization. The process of loading internal documents is based on the principles of loading a digital library. In other words, there are two processes that distinguish the enhanced data warehouse model: transparent filtering (continuous) and transparent retrieval (spontaneous). The prefix "transparent" indicates that both processes are see-through for business users.

The enhanced knowledge warehouse is composed of the following Web services that can act independently:

a) Library Service, an implementation of data warehouse library
b) Profiling Service, responsible for data warehouse profiling
c) Filtering Service, responsible for retrieving business information from the Web utilizing filtering machine
d) Indexing Service, responsible for organizing the documents in DWL (Indexing parser)
e) Reporting Service, the front office of the system, responsible for delivering the results to the users.

Figure 1. Overview of the enhanced knowledge warehouse



FUTURE TRENDS

Although both document management and data warehousing systems are designed to supply business users with relevant information that is necessary to solve business problems, they are usually implemented and used separately. Most often, there is no system to store, organize and disseminate information published on the Web. This forces users, who need a broader view of business, to switch between data warehouse applications and content providers on the Web. The latter are usually overloaded with information, require navigation and formulating queries, entering passwords and flood users with commercials. Researchers report that the two most wanted attributes of external information sources are speed and convenience (Webber, 1999), whereas most sources cause frustration and discourage business users from taking any advantages of information available on the Web.

Therefore, the main future trend will be the integration of documents and data. In the eKW model, the problem of consistency of warehouse data and Web documents is addressed.

CONCLUSIONS

Enhanced knowledge warehouse model has certain advantages for business users over non-integrated solutions: instant/extended search, cross-organizational knowledge exchange, personalized event-alerting, and continuous information acquisition.

Because the amount of information produced by content providers on the Web is growing, it is impossible for a human user to process it in the traditional way. Web searches cause frustration, rarely lead to success and waste precious time. eKW was designed to help business people extend their knowledge about the organization by supplying them automatically with documents acquired from Web sources, relevant to their current context and information needs. Transparent filtering function mechanically collects documents potentially interesting to the organization, describes them with commonly accepted terms, and organizes them according to the existing business metadata. Transparent retrieval function supplies data warehouse users with documents relevant to their contexts and their personal interests in business information. The contexts are mechanically extracted from the state of the currently browsed report and personal needs are based on implicit feedback.

The enhanced knowledge warehouse system supplies business users with information based on the legacy data extended by information acquired from the business environment. This gives additional possibilities of business data analysis and provides a framework for better understanding of business processes related to the organization.

REFERENCES

Abramowicz, W., Kalczynski, P., & , K. (2000). Information filters supplying data warehouses with benchmarking information. In W. Abramowicz & J. Zurada (Eds.), *Knowledge discovery for business information systems* (pp. 1-28). Kluwer Academic Publishers.

Abramowicz, W., Kalczynski, P.J., & , K (2001a). Profiling the data warehouse for information filtering. *Proceedings of IRMA 2001 International Conference*, Toronto (pp. 810-814).

Abramowicz, W., Kalczynski, P.J., & , K (2001b). Time consistency among structured and unstructured contents in the data warehouse. *Proceedings of IRMA 2001 International Conference*, Toronto (pp. 815-818).

Abramowicz, W., Kalczynski, P.J., & , K (2001c). Common semantic layer to support integration of the data Warehouse and the Web. *Human Computer Interaction – HCI 2001,* Sopot, Poland.

Abramowicz, W., Kalczynski, P., & , K. (2001d, November 27-29). Information ants to filter business information from Internet sources. *Proceedings of the CAINE-2001 Conference,* Las Vegas (pp. 134-137).

Abramowicz, W., Kalczynski, P., & , K. (2002). *Filtering the Web to feed data warehouses.* London: Springer-Verlag.

Adelman, S. (1997). Data quality. In J. Bischoff & T. Alexander (Eds.), *Data warehouse – practical advice from the experts* (pp. 122-134). Prentice Hall Inc.

Baeza-Yates, R., & Ribeiro-Neto, B. (1999). *Modern information retrieval*. NY: Addison-Wesley, ACM Press.

Gleason, D. (1997). Metadata. In J. Bischoff & T. Alexander (Eds.), *Data warehouse – practical advice from the experts* (pp. 135-150). Prentice Hall Inc.

Inmon, W. (1999). *Metadata in the data warehouse environment.* Bill Inmon's Library.

Kalczynski, P. (2002). *Software agents to filter business information from the Internet to the data warehouse.* PhD dissertation. The Poznan University of Economics, Poland.

Kalczynski, P., Abramowicz, W., , K., & Kaczmarek, T. (2003). Time indexer: A tool for extracting temporal references from business news. *2003 Information Resource Management Association International Conference* (pp. 832-835).

Kimball, R. (1996). *The data warehouse toolkit.* NY: John Willey & Sons, Inc.

Llido, D., Berlanga, R., & Aramburu, M. (2001). Extracting temporal references to assign document event-time periods. In H. Mayr et al. (Eds.), *DEXA 2001 Conference Proceedings* (pp. 62-71). Berlin: Springer-Verlag.

Salton, G., & McGill, M. (1983). *Introduction to modern information retrieval.* McGraw-Hill Book Company

Webber, S., Allcock, S., Plenty, A., & Yeates, R. (1999). Business information and the Internet: Use of the Internet as an information resource for small and medium-sized enterprises: Final report. *British Library Research and Innovation Report,* 136.

, K. (2002). *Profiling the data warehouse for business information filtering.* PhD dissertation. The Poznan University of Economics, Poland.

, K. (2003). Towards an ontological representation of knowledge on the Web. In W. Abramowicz (Ed.)*, Knowledge-based information retrieval and filtering.* Kluwer Academic Publishers

ENDNOTE

1 Greek meta means going beyond.

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Chapter 2.46
Autopoietic Approach for Information System Development

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INTRODUCTION

In the last decade a new generation of information systems (IS), such as enterprise resource planning, Web-based information systems and knowledge management support systems, have emerged in response to ever-changing organizational needs. As these systems are socio-technical phenomena in which social and technical factors interweave the ways in which people work, the issue of "how to integrate the work activity and social context of users into the IS which is being designed" becomes one of the principal problems of IS development (Bai et al., 1999). Therefore, the need for new information system design theories is recognized. According to Walls et al. (1992), an "IS design theory" must have two aspects—one dealing with the description of the system and one dealing with the prescription, that is, the process of developing of the system. The prescription aspect includes a description of procedures and guidelines for system development. In addition, these two aspects have to be grounded on theories from natural or social sciences, that is, kernel theories. Therefore, the development of new IS design theories requires a closer look at the system theories that go beyond the traditional system theory that is based, among other things, on Cartesian dualism, that is, mind/body or cognition/action, and on a model of cognition as the processing of representational information (Mingers, 2001). One of the candidate theories is the theory of autopoiesis, which can be best viewed as a system-grounded way of thinking with biological foundations, together with its extension into social domain.

THEORY OF AUTOPOIESIS

In order to conceive of living systems in terms of the processes that realized them, rather in terms of their relationships with an environment, Maturana and Varela (1980) coined the word autopoiesis (autos = self, poienin = creation, production) to denote the central feature of their organization, which is "autonomy". The meaning of this word coveys the very nature of living systems as systems that maintain their identity through their own operations of continuous self-renewal. Moreover, these systems could only be characterized with reference to themselves and whatever takes place in them, takes place as necessarily and constitutively determined in relation to themselves, that is, self-referentiality.

One of the key concepts of autopoiesis is the distinction between organization and structure. On one hand, organization is the capability of a system to re-produce its identity by referring constantly to itself, through the alternate re-production of its components together with the component-producing processes, that is, the capability of a recursive self-reproduction. On the other hand, structure is the realization of a system's organization through the presence and interplay of its components in a specific realization space. While organization is necessary to establish system unity and identity, structure is necessary because different spaces of its actualization impose different constraints on systems' components (Maturana & Varela, 1980). By rough analogy, an algorithm for solving certain problem can be viewed as a description of the system's organization, whereas the corresponding computer program can be viewed as the realization of this organization (structure) in a certain space (programming language).

Autopoietic Systems

An autopoietic system is defined by Maturana and Varela as

"a network of processes of production, transformation and destruction of components. These components constitute the system as a distinct unity in the space of its actualization and they continuously regenerate and realize, through their interactions and transformations, the network of processes that produce them." (Maturana & Varela, 1980, p. 135)

Among the distinct characteristics of the autopoietic systems, the most relevant ones are:

- The simultaneous openness and closure. Autopoietic systems are open with respect to structural interaction with the environment, that is, structural openness, which is unavoidable consequence of the fact that system elements must satisfy the particular requirements of the physical domain in which they occur, while they are closed with respect to their own organization, that is, organizational closure. The recognition of the simultaneous openness and closure of autopoietic systems is in opposition to the tradition for which a system is one or the other but not both. This interpretation is possible only because of the clear distinction between organization and structure (Bednarz, 1988).
- Structural determination. The state transition a system undergoes in response to environmental perturbations is entirely determined by its structure at that time. Moreover, a system specifies which environmental perturbations may trigger which structural changes. In other words, the environmental perturbations could trigger the system's structural changes but can never determine or direct these changes. Moreover, a system specifies which environmental perturbations may trigger which structural changes. Over time, through ongoing interactions with the environment, an autopoietic system will experience what Maturana and Varela (1992) describe as a structural drift, or a gradual change to their structure. The nature of this change is determined by previous system's history of structural changes, that is, its ontogeny.

Higher-Order Autopoietic Systems

Two (or more) lower-order autopoietic systems can be "structurally coupled" to form higher-order autopoietic system. Structural coupling is the ongoing process of the congruent structural changes between two (or more) systems that results from recurrent interactions between (among) them. Therefore, structural coupling has connotations of coordination and co-evolution. Moreover, following structural determination principle, two structurally coupled systems means that each of them selects from its possible structural changes those which are compatible with those in the other system and, at the same time, are suitable for the maintenance of its identity.

Social systems, such as enterprises, are constituted through the process of third-order structural coupling, or social coupling, the one that occurs between (or among) two (or more) second-order autopoietic systems. However, the unique feature of any human social system, such as an enterprise, is that the social coupling among its constituents occurs through "language in the network of conservations which language generates and which, through their closure, constitute the unity of a particular human society" (Maturana & Varela, 1992, p. 196). From this perspective, language is viewed as an example of social structural coupling that generates the self and creates meaning through interactions with others. Moreover, language represents what Maturana and Varela would describe as a consensual domain, which is the domain of arbitrary and contextual interlocking behaviors (Mingers, 1995a, p. 78). Within a consensual domain, two autopoietic systems would be able to observe the attribution of meaning to common events and undertake coordinated actions.

Autopoiesis and Cognition

Cognition is the term conventionally used to denote the process by which a system discriminates among differences in its environment and potential states of that environment. The evidence for this cognition is effectiveness of system behavior in response to the environmental perturbations. Today's dominant perspective on cognition, and consequently IS, is the idea that effective action is explainable in terms of manipulating formal and static representations of the objective reality (Mingers, 2001).

According to theory of autopoiesis, perception is neither objectivist nor purely constructivist (Varela, 1992, p. 254). Rather, it is co-determined by the linking of the structure of the perceiver and the local situations in which it has to act to maintain its identity. This is the basis of enactive (embodied) cognition, which implies that the autopoietic system's activities condition that can be perceived in an environment, and these perceptions, in turn, condition future actions. In this view, "A cognitive system is a system whose organization defines a domain of interactions in which it can act with relevance to the maintenance of itself, and the process of cognition is the actual (inductive) acting or behaving in this domain" (Maturana & Varela, 1980, p. 13). In addition, cognitive domain of an autopoietic system is defined as the domain of all the interactions in which it can enter without loss of identity (Maturana & Varela, 1980, p. 119).

APPLICATIONS OF THE CONCEPTS OF AUTOPOIESIS IN IS DEVELOPMENT RESEARCH

The use theory of autopoiesis in IS research can be classified into two main categories: metaphoric and theory-oriented approaches (Beeson, 2001).

Metaphoric Approaches

Kay and Cecez-Kecmanovic (2002) used the concepts of social coupling and consensual domain to explain processes underlying the IS-organization relationship and how it impacts on the competitive advantage of an organization. They showed how processes of recurrent interactions between members of different groups, that is, analysts, the IS team, and external clients, within the organizations work environment gave rise to commonalities in understanding, which in turn enabled continual IS organization co-emergence. In the same vein, Maula (2000) used the concepts of structural openness and organizational closure to identify two major knowledge management (KM) functions in four consulting firms. The first KM function, sensory function, is the realization of the structural openness of the firm and its structural coupling with its environment. The second KM function, memory function, is the realization of the concepts organizational closure and self-referentiality that enable the firm's effective functioning and continuous renewal. Finally, Carlsen and Gjersvik (1997) used autopoiesis metaphor to analyze possible organizational uses of workflow technology. They argued against "generic" business processes except as starting points for organizational adaptation. In addition, they indicated that the concept of autopoiesis implies that process models should include references to richer descriptions of the organizational environment and the environment the work process is situated in.

Theory-Oriented Approaches

Bai and Lindberg (1999) used first and second order cybernetics, together with Luhmann's social autopoiesis theory (Luhmann, 1995) and Engeström's activity theory (Engeström, 1987) to develop a framework for studying the relationship between IS design activity, use activity, and the embedded social context. This framework sheds light on the complex social context within which IS development takes place, and provides an epistemological understanding of the relationship among the elements involved in IS development. Moreover, it can be used to develop methodologies for the practice of IS development, and guide various research activities, such as the socio-technical approach.

IMPLICATIONS FOR IS DEVELOPMENT AND RESEARCH

The autopoietic metaphor provides ways of thinking about the mechanisms underpinning the development and the introduction of IS in an enterprise. Here third-order autopoietic system is used as a metaphor to explore referential correspondence between the characteristics of autopoietic systems and an enterprise and its IS. For example, organizational closure of autopoietic system implies that it is homeostatic and its own organization is the fundamental variable to be maintained constant. This concept may be used to explain why the behavior of IS developers and users seems to be stuck sometimes in persistent patterns or repertoires (Beeson, 2001). Moreover, the difficulties of system integration may be better understood from a perspective of structural coupling than from one of rational design or negotiation (Beeson, 2001). Structural coupling concept can also be used to explore the way common understandings between an enterprise's members emerge as a function of interactions in the work environment (Kay & Cecez-Kecmanovic, 2002).

From autopoietic view introducing a new IS in an enterprise can be conceptualized as a kind of perturbation that provokes or triggers an enterprise's structural-determined responses. Therefore, IS development process can be viewed as the means for realizing structural coupling between an enterprise and its new IS and becomes an integrated aspect of the recurrent interactions between developers and users in the work environment. Table 1 summarizes the implications of theory of autopoiesis for IS development process.

Table 1. Autopoietic implications for IS development

Characteristics of Autopoietic Systems	**Implications for IS Development**
Organizational Closure and Self-Referentiality	**Insider frame of reference.** The organizational closure and self-referentiality of an enterprise suggest it is best understood from *inside*. Therefore, an interpretive or hermeneutic approach could more reliably and intelligibly account for the experiences, intentions and interpretations of its members. Moreover, the main role of system developer is the role of "*catalyst* and/or *emancipator*" (Hirschheim et al., 1989), who helps an enterprise's members to develop the necessary inquiring, collaborative and communicative patterns needed to continuously explicate their information requirements. **Historicity.** As an enterprise is continuously reproducing itself, it must do so with constant reference to itself, its past practices, values, decisions, contracts, and commitments (Truex et al., 1999). Therefore, explicating an enterprise's history is an essential element in developing new knowledge and in introducing a new IS (von Krogh et al., 1994)
Structural Determination and Structural Coupling	**Context-dependency of IS development methodology.** Viewing ISD methodology as the means for realizing structural coupling between an enterprise and its new IS implies that it cannot be separated from an enterprise's context. In other words, autopoietic metaphor of an enterprise and its IS suggests "strong" approaches to systems development instead of the commonly used "weak" approaches (see key terms).
Embodied Cognition	**Minimal set of initial requirements.** The autopoietic view of cognition implies that requirements are always in motion, unfrozen, and negotiable (Truex et al., 1999). Therefore, information system development can be viewed as open-ended bootstrapping process that starts with a minimal set of requirements. Moreover, formal representation must be subordinated to the fostering of mutual understanding and coordinated action in the development team and between the team's members and the stakeholders (Beeson, 2001; Kay & Cecez-Kecmanovic, 2002).

REFERENCES

Bai, G., & Lindberg, L.-A. (1999). A sociocybernetic approach to information systems development. *Kybernetes, 28*(6/7), 792-809.

Bednarz, J. (1988). Autopoiesis: The organizational closure of social systems. *System Research, 5*(1), 57-64.

Beeson, I. (2001). Implications of the theory of autopoiesis for the discipline and practice of information systems. *Proceedings of the IFIP WG 8.2 Working Conference on Realigning Research and Practice in Information Systems Development: The Social and Organizational Perspective,* Boise, ID (pp. 317-332).

Carlsen, S., & Gjersvik, R. (1997). Organizational metaphors as lenses for analyzing workflow technology. *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work: The Integration Challenge,* Phoenix, AZ (pp. 261-270).

Engeström, Y. (1987). *Learning by expanding. An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit.

Hirschheim, R., & Klein, H. (1989). Four paradigms of information systems development. *Communications of the ACM, 32*(10), 1199-1216.

Kay, R., & Cecez-Kecmanovic, D. (2002). Toward an autopoietic perspective on information systems crganization. *Proceedings of the Twenty-Third Annual International Conference on Information Systems*, Barcelona, Spain (pp. 383-390).

Luhmann, N. (1995). *Social systems*. Stanford, CA: Stanford University Press.

Maturana, H., & Varela, F. (1980). *Autopoiesis and cognition.* Dordrecht: Reidel.

Maturana, H., & Varela, F. (1992). *The tree of knowledge: The biological roots of human understanding* (rev. ed.). Boston: Shambhala.

Maula, M. (2000). The senses and memory of a firm - Implications of autopoiesis theory for knowledge management. *Journal of Knowledge Management, 4*(2), 157-161.

Mingers, J. (1995a). Information and meaning: Foundations for an intersubjective account. *Information Systems Journal, 5*, 285-306.

Mingers, J. (1995b). *Self-producing systems: Implications and applications of autopoiesis.* New York: Plenum Publishing.

Mingers, J. (2001). Embodying information systems: The contribution of phenomenology. *Information and Organization, 11*(2), 103–128.

Truex, D., Baskerville, R., & Klein, H. (1999). Growing systems e organizations. *Communications of the ACM, 42*(8), 117-123.

Varela, F. (1992). Whence perceptual meaning? A cartography of current ideas. In F. Varela & J. Dupuy (Eds.), *Understanding origins: Contemporary views on the origin of life, mind and society* (pp. 235-263). Dordrecht: Kluwer Academic.

Vessey, I., & Glass, R. (1998). Strong vs. weak approaches systems development. *Communications of the ACM, 41*(4), 99-102.

von Krogh, G., Ross, J., & Slocum, K. (1994). An essay on corporate epistemology. *Strategic Management Journal, 15*, 53-71.

Walls, J., Widmeyer, G., & El-Sawy, O. (1992). Building an information system design theory for vigilant *EIS*. *Information Systems Research, 3*(1), 36-59.

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Section 3
Knowledge Management:
Tools and Technologies

This section presents extensive coverage of various tools and technologies available in the field of knowledge management that practitioners and academicians alike can utilize to develop different techniques. Readers are enlightened about fundamental research on one of the many methods used to facilitate and enhance the knowledge sharing experience while exploring the intrinsic value of technology and knowledge management. It is through these rigorously researched chapters that the reader is provided with countless examples of the up-and-coming tools and technologies emerging from the field of knowledge management. With more 28 chapters, this section offers a broad treatment of some of the many tools and technologies within the knowledge management community.

Chapter 3.1
ICT and Knowledge Management Systems

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INTRODUCTION

Rapid changes in the field of knowledge management (KM) have to a great extent resulted from the dramatic progress we have witnessed in the field of information and communication technology. ICT allows the movement of information at increasing speeds and efficiencies, and thus facilitates sharing as well as accelerated growth of knowledge. For example, computers capture data from measurements of natural phenomena, and then quickly manipulate the data to better understand the phenomena they represent. Increased computer power at lower prices enables the measurement of increasingly complex processes, which we possibly could only imagine before. Thus, ICT has provided a major impetus for enabling the implementation of KM applications. Moreover, as learning has accrued over time in the area of social and structural mechanisms, such as through mentoring and retreats that enable effective knowledge sharing, it has made it possible to develop KM applications that best leverage these improved mechanisms by deploying sophisticated technologies.

In this article we focus on the applications that result from the use of the latest technologies used to support KM mechanisms. Knowledge management mechanisms are organizational or structural means used to promote KM (Becerra-Fernandez, Gonzalez, & Sabherwal, 2004). The use of leading-edge ICT (e.g., Web-based conferencing) to support KM mechanisms in ways not earlier possible (e.g., interactive conversations along with the instantaneous exchange of voluminous documents among individuals located at remote locations) enables dramatic improvement in KM. We call the applications resulting from such synergy between the latest technologies and social or structural mechanisms knowledge management systems. We discuss the topic of KM systems in detail in the next sections.

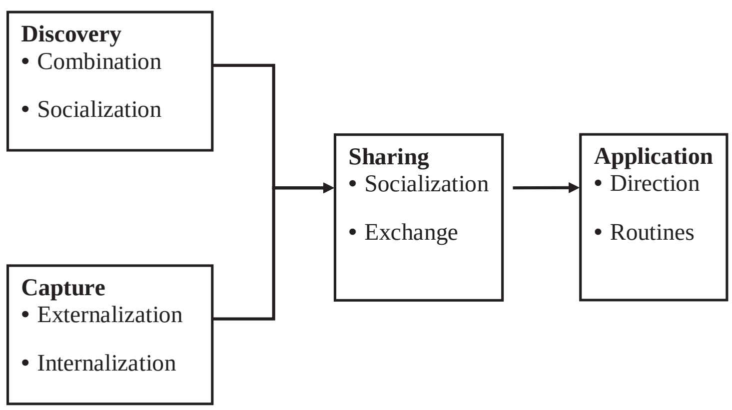
BACKGROUND

We describe the variety of possible activities involved in KM as broadly intending to (a) discover new knowledge, (b) capture existing knowledge, (c) share knowledge with others, or (d) apply knowledge. Thus, KM relies on four kinds of KM processes as depicted in Figure 1 (Becerra-Fernandez et al., 2004). These include the processes through which knowledge is discovered or captured, and the processes through which this knowledge is shared and applied. These four KM processes are supported by a set of seven KM subprocesses as shown in Figure 1, with one subprocess, socialization, supporting two KM processes (discovery and sharing).

Polyani's (1967) distinction between explicit and tacit is at the heart of most KM papers. These constructs follow in that explicit knowledge is knowledge about things, and tacit knowledge is associated with experience. Nonaka (1994) identified four ways of managing knowledge: combination, socialization, externalization, and internalization. Of the seven KM subprocesses presented in Figure 1, four are based on Nonaka, focusing on the ways in which knowledge is shared through the interaction between tacit and explicit knowledge. New explicit knowledge is discovered through combination, wherein the multiple bodies of explicit knowledge (and/or data and/or information) are synthesized to create new, more complex sets of explicit knowledge. Therefore, by combining, reconfiguring, recategorizing, and recontextualizing existing explicit knowledge, data, and information, new explicit knowledge is produced. In the case of tacit knowledge, the integration of multiple streams for the creation of new knowledge occurs through the mechanism of socialization. Socialization is the synthesis of tacit knowledge across individuals, usually through joint activities rather than written or verbal instructions. Externalization involves converting tacit knowledge into explicit forms such as words, concepts, visuals, or figurative language (e.g., metaphors, analogies, and narratives; Nonaka & Takeuchi, 1995). It helps translate individuals' tacit knowledge into explicit forms that can be more easily understood by the rest of their group. Finally, internalization is the conversion of explicit knowledge into tacit knowledge. It represents the traditional notion of learning.

The other three KM subprocesses—exchange, direction, and routines—are largely based on Grant (1996a, 1996b) and Nahapiet and Ghoshal (1998). Exchange focuses on the sharing of explicit knowledge and it is used to communicate or transfer explicit knowledge between individuals, groups, and organizations (Grant, 1996b).

Figure 1. KM processes



Direction refers to the process through which the individual possessing the knowledge directs the action of another individual without transferring to him or her the knowledge underlying the direction. This preserves the advantages of specialization and avoids the difficulties inherent in the transfer of tacit knowledge. Finally, routines involve the utilization of knowledge embedded in procedures, rules, and norms that guide future behavior. Routines economize on communication more than direction as they are embedded in procedures or technologies. However, they take time to develop, relying on constant repetition (Grant, 1996a).

Other KM system characterizations present similar models to describe KM systems. For example, the acquire, organize, and distribute (AOD) model (Schwartz, Divitini, & Brasethvik, 2000) uses a similar characterization to describe organizational memories. Comparing the two models, the acquisition process relates to how we collect knowledge from members of the organization or other resources, and it is related to the processes of knowledge discovery and knowledge capture. The organizing process refers to structuring, indexing, and formatting the acquired knowledge, and it is related to the process of knowledge sharing. Finally, the process of distribution relates to the ability to get the relevant knowledge to the person who needs it at the right time, and it is related to the process of knowledge application.

Knowledge management systems utilize a variety of KM mechanisms and technologies to support the knowledge management processes. Depending on the KM process most directly supported, KM systems can be classified into four types: knowledge-discovery systems, knowledge-capture systems, knowledge-sharing systems, and knowledge-application systems (Becerra-Fernandez et al., 2004). In the next sections, we provide a brief overview of these four kinds of systems and examine how they benefit from KM mechanisms and technologies.

TYPES OF KNOWLEDGE MANAGEMENT SYSTEMS

Knowledge-discovery systems support the process of developing new tacit or explicit knowledge from data and information or from the synthesis of prior knowledge. These systems support two KM subprocesses associated with knowledge discovery: combination, enabling the discovery of new explicit knowledge, and socialization, enabling the discovery of new tacit knowledge. Thus, mechanisms and technologies can support knowledge-discovery systems by facilitating a combination and/or socialization.

KM mechanisms that facilitate combination include collaborative problem solving, joint decision making, and the collaborative creation of documents. For example, at the senior-management level, new explicit knowledge is created by sharing documents and information related to mid-range concepts (e.g., product concepts) augmented with grand concepts (e.g., corporate vision) to produce new knowledge about both areas. This newly created knowledge could be, for example, a better understanding of the products and corporate vision (Nonaka & Takeuchi, 1995). Mechanisms that facilitate socialization include apprenticeships, employee rotation across areas, conferences, brainstorming retreats, cooperative projects across departments, and initiation processes for new employees. For example, Honda "set up 'brainstorming camps' (tama dashi kai)—informal meetings for detailed discussions to solve difficult problems in development projects" (Nonaka & Takeuchi, p. 63).

Technologies facilitating combination include knowledge-discovery or data-mining systems, databases, and Web-based access to data. According to Nonaka and Takeuchi (1995, p. 67), the "reconfiguration of existing information through sorting, adding, combining, and categorizing of explicit knowledge (as conducted in computer databases) can lead to new knowledge." Repositories of information, best practices, and lessons learned also facilitate combination. Technologies can also facilitate socialization, albeit to less extent than they can facilitate combination. Some of the technologies for facilitating socialization include videoconferencing, electronic discussion groups, and e-mail.

Knowledge-capture systems support the process of retrieving either explicit or tacit knowledge that resides within people, artifacts, or organizational entities. These systems can help capture knowledge that resides within or outside organizational boundaries, including within consultants, competitors, customers, suppliers, and prior employers of the organization's new employees. Knowledge-capture systems rely on mechanisms and technologies that support externalization and internalization.

KM mechanisms can enable knowledge capture by facilitating externalization, that is, the conversion of tacit knowledge into explicit form, or internalization, that is, the conversion of explicit knowledge into tacit form. The development of models or prototypes and the articulation of best practices or lessons learned are some examples of mechanisms that enable externalization.

Learning by doing, on-the-job training, learning by observation, and face-to-face meetings are some of the mechanisms that facilitate internalization. For example, at one firm, "the product divisions also frequently send their new-product development people to the Answer Center to chat with the telephone operators or the 12 specialists, thereby 're-experiencing' their experiences" (Nonaka & Takeuchi, 1995, p. 69).

Technologies can also support knowledge-capture systems by facilitating externalization and internalization. Externalization through knowledge engineering is necessary for the implementation of intelligent technologies such as expert systems, case-based reasoning systems, and knowledge-acquisition systems. Technologies that facilitate internalization include computer-based communication. Using such communication facilities, an individual can internalize knowledge from a message or attachment thereof sent by another expert, from an AI- (artificial intelligence) based knowledge-acquisition system, or from computer-based simulations.

Knowledge-sharing systems support the process through which explicit or implicit knowledge is communicated to other individuals. They do so by supporting exchange (i.e., the sharing of explicit knowledge) and socialization (which promotes the sharing of tacit knowledge). Mechanisms and technologies supporting socialization also play an important role in knowledge-sharing systems. Discussion groups or chat groups facilitate knowledge sharing by enabling an individual to explain his or her knowledge to the rest of the group. In addition, knowledge-sharing systems also utilize mechanisms and technologies that facilitate exchange. Some of the mechanisms that facilitate exchange are memos, manuals, progress reports, letters, and presentations. Technologies facilitating exchange include groupware and other team collaboration mechanisms, Web-based access to data, databases, and repositories of information, including best-practice databases, lessons-learned systems, and expertise-locator systems.

Knowledge-application systems support the process through which some individuals utilize knowledge possessed by other individuals without actually acquiring or learning that knowledge. Mechanisms and technologies support knowledge-application systems by facilitating routines and direction.

Mechanisms facilitating direction include traditional hierarchical relationships in organizations, help desks, and support centers. On the other hand, mechanisms supporting routines include organizational policies, work practices, and standards. In the case of both direction and routines, these mechanisms may be either within an organization (e.g., organizational hierarchies) or across organizations (e.g., software-support help desks).

Technologies supporting direction include experts' knowledge embedded in expert systems and decision-support systems, as well as troubleshooting systems based on the use of technologies like case-based reasoning. On the other hand, some of the technologies that facilitate routines are expert systems, enterprise resource-planning systems (ERPs), and traditional management-information systems. As mentioned for KM mechanisms, these technologies can also facilitate directions and routines within or across organizations.

Table 1 summarizes the above discussion of KM processes and KM systems, and also indicates some of the mechanisms and technologies that might facilitate them. As may be seen from this table, the same tool or technology can be used to support more than one KM process.

Table 1. KM systems, subprocesses, mechanisms, and technologies

KM Processes	KM Systems	KM Subprocesses	Illustrative KM Mechanisms	Illustrative KM Technologies
Knowledge Discovery	Knowledge-Discovery Systems	Combination	Meetings, telephone conversations, and documents, collaborative creation of documents	Databases, Web-based access to data, data mining, repositories of information, Web portals, best practices, and lessons learned
		Socialization	Employee rotation across departments, conferences, brainstorming retreats, cooperative projects, initiation	Videoconferencing, electronic discussion groups, e-mail
Knowledge Capture	Knowledge-Capture Systems	Externalization	Models, prototypes, best practices, lessons learned	Expert systems, chat groups, best practices, and lessons-learned databases.
		Internalization	Learning by doing, on-the-job training, learning by observation, and face-to-face meetings	Computer-based communication, AI-based knowledge acquisition, computer-based simulations
Knowledge Sharing	Knowledge-Sharing Systems	Socialization	See above	See above
		Exchange	Memos, manuals, letters, presentations	Team collaboration tools, Web-based access to data, databases, and repositories of information, best-practices databases, lessons-learned systems, and expertise-locator systems
Knowledge Application	Knowledge-Application Systems	Direction	Traditional hierarchical relationships in organizations, help desks, and support centers	Capture and transfer of experts' knowledge, troubleshooting systems, and case-based reasoning systems, decision-support systems
		Routines	Organizational policies, work practices, and standards	Expert systems, enterprise resource-planning systems, management-information systems

INFORMATION AND COMMUNICATION TECHNOLOGY INFRASTRUCTURE IN KNOWLEDGE MANAGEMENT SYSTEMS

The knowledge management infrastructure is the foundation on which knowledge management resides. It includes five main components: organization culture, organization structure, communities of practice, information technology infrastructure, and common knowledge. In this section, we concentrate on the role of ICT infrastructure on KM systems.

Knowledge management is facilitated by the organization's ICT infrastructure. While certain information technologies and systems are directly developed to pursue knowledge management, the organization's overall ICT, developed to support the organization's information-processing needs, also facilitates knowledge management. The ICT infrastructure includes data processing, storage, and communication technologies and systems. It comprises the entire spectrum of the organization's information systems, including transaction-processing systems and management-information systems. It consists of databases and data warehouses, as well as enterprise resource-planning systems. One possible way of systematically viewing the IT infrastructure is to consider the capabilities it provides in four important aspects: reach, depth, richness, and aggregation (Daft & Lengel, 1986; Evans & Wurster, 1999).

Reach pertains to access and connection, and the efficiency of such access. Within the context of a network, reach reflects the number and geographical locations of the nodes that can be efficiently accessed. Keen (1991) also uses the term reach to refer to the locations an ICT platform is capable of linking, with the ideal being able to connect to anyone, anywhere. Much of the power of the Internet is attributed to its reach and the fact that most people can access it quite inexpensively (Evans & Wurster, 1999). Reach is enhanced not just by advances in hardware, but also by progress in software. For instance, the standardization of cross-firm communication standards and languages such as XML (extensible markup language) make it easier for firms to communicate with a wider array of trading partners, including those with whom they do not have long-term relationships.

Depth, in contrast, focuses on the detail and amount of information that can be effectively communicated over a medium. This dimension closely corresponds to the aspects of bandwidth and customization included by Evans and Wurster (1999) in their definition of richness. Communicating deep and detailed information requires high bandwidth. At the same time, it is the availability of deep and detailed information about customers that enables customization. Recent technological progress, for instance, in channel bandwidth, has enabled considerable improvement in depth.

Communication channels can be arranged along a continuum representing their relative richness (Carlson & Zmud, 1999). The richness of a medium is based on its ability to (a) provide multiple cues (e.g., body language, facial expression, tone of voice) simultaneously, (b) provide quick feedback, (c) personalize messages, and (d) use natural language to convey subtleties (Daft & Lengel, 1986). ICT has traditionally been viewed as a lean communication medium. However, given the progress in information technology, we are witnessing a significant increase in its ability to support rich communication.

Finally, rapid advances in ICT have significantly enhanced the ability to store and quickly process information (Evans & Wurster, 1999). This enables the aggregation of large volumes of information drawn from multiple sources. For instance, data mining and data warehousing together enable the synthesis of diverse information from multiple sources, potentially to produce new insights. Enterprise resource-planning systems also present a natural platform for aggregating knowledge across different parts of an organization. A senior IS executive at Price Waterhouse Coopers, for example, remarks, "We're moving quite quickly on to an intranet platform, and that's giving us a greater chance to integrate everything instead of saying to people, 'use this database and that database and another database.' Now it all looks—and is—much more coordinated" (Thomson, 2000, p. 24).

To summarize, the above four ICT capabilities enable knowledge management by enhancing common knowledge or by facilitating the four KM processes. For example, an expertise-locator system (also called knowledge yellow pages or a people-finder system) is a special type of knowledge repository that pinpoints individuals having specific knowledge within the organization (Becerra-Fernandez, 2000, 2001). These systems rely on the reach and depth capabilities of ICT by enabling individuals to contact remotely located experts and seek detailed solutions to complicated problems. Another KM solution attempts to capture as much of the knowledge in an individual's head as possible and archive it in a searchable database (Armbrecht et al., 2001). This is primarily the aim of projects in artificial intelligence, which capture the expert's knowledge in systems based on various technologies, including rule-based systems and case-based reasoning, among others (Wong & Radcliffe, 2000). But the most sophisticated systems for eliciting and cataloging experts' knowledge in models that can easily be understood and applied by others in the organization (see, for example, Ford, Coffey, Cañas, Andrews, & Turner, 1996) require strong knowledge-engineering processes to develop. Such sophisticated KM systems are typically not advocated for use in mainstream business environments primarily because of the high cost involved in the knowledge-engineering effort.

FUTURE TRENDS

The future of knowledge management will be highlighted by three continuing trends: (a) KM will benefit from progress in ICT, (b) KM will continue the shift toward integrating knowledge from a variety of different perspectives, and (c) KM will continue to make trade-offs in numerous important areas.

First, in the future, KM will benefit from continual, and even more dynamic, progress in ICT. Improvements in cost and performance ratios of ICT have caused the cost of digitizing information to approach zero, and the cost of coordinating across individuals, organizational subunits, and organizations to approach zero as well (Grover & Segars, 1996). ICT progress also includes developments in autonomous software-based agents. Thus, the future of KM will be dramatically different due to the inevitable and unpredictable over any long period of time, and quantum changes in ICT and underpinning technologies such as artificial intelligence.

Second, in the future, KM will continue the shift toward bringing together, and effectively integrating, knowledge from a variety of different perspectives. Knowledge management originated at the individual level, focusing on the training and learning of individuals. Over time, the emphasis of knowledge management shifted to groups and entire organizations, and now examples of interorganizational impacts of knowledge management are becoming increasingly common. This trend in the impact of KM is expected to continue with its use across networks of organizations and across governments, enabling collaborations across historical adversaries and integrating knowledge across highly diverse perspectives and disciplines.

Finally, in the future, knowledge management will continue to make trade-offs in numerous important areas. One such trade-off pertains to the use of ICT for sharing. The same communication technologies that support the sharing of knowledge within an organization also enable the knowledge to leak outside the organization to its competing firms. Another trade-off concerns the balance between technology and people. It is essential to maintain a balance between using technology as substitutes for people (e.g., software agents) and using technology to enable collaboration from a wider range of people within and across organizations.

In conclusion, the future of knowledge management is one where people and advanced technologies will continue to work together, enabling knowledge integration across diverse domains with considerably higher payoffs. However, the new opportunities and greater benefits will require the careful management of people and technologies, a synthesis of multiple perspectives, and effectively dealing with a variety of trade-offs. The future of knowledge management will clearly be exciting due to the new opportunities and options, but interesting challenges definitely lay ahead for knowledge managers.

CONCLUSION

We have described the key aspects of knowledge management in this article. We have provided a working definition of knowledge management systems and presented the four types of KM systems: knowledge-discovery systems, knowledge-capture systems, knowledge-sharing systems, and knowledge-application systems. We also discussed how KM systems serve to support KM processes based on the integration of KM mechanisms, technologies, and infrastructure.

REFERENCES

Armbrecht, F. M. R., Chapas, R. B., Chappelow, C. C., Farris, G. F., Friga, P. N., Hartz, C. A., et al. (2001). Knowledge management in research and development. *Research Technology Management, 44*(4), 28-48.

Becerra-Fernandez, I. (2000). The role of artificial intelligence technologies in the implementation of people-finder knowledge management systems. *Knowledge Based Systems, 13*(5), 315-320.

Becerra-Fernandez, I. (2001). Locating expertise at NASA: Developing a tool to leverage human capital. *Knowledge Management Review, 4*(4), 34-37.

Becerra-Fernandez, I., Gonzalez, A., & Sabherwal, R. (2004). *Knowledge management: Challenges, solutions and technologies.* Upper Saddle River, NJ: Prentice Hall.

Becerra-Fernandez, I., & Stevenson, J. M. (2001). Knowledge management systems and solutions for the school principal as chief learning officer. *Education, 121*(3), 508-518.

Carlson, J. R., & Zmud, R. W. (1999). Channel expansion theory and the experiential nature of media richness perceptions. *Academy of Management Journal, 42*(2), 153-170.

Daft, R. L., & Lengel, R. H. (1986). Organization information requirements, media richness, and structural design. *Management Science, 32*(5), 554-571.

Evans, P., & Wurster, T. S. (1999). Getting real about virtual commerce. *Harvard Business Review,* 85-94.

Ford, K. M., Coffey, J. W., Cañas, A. J., Andrews, E. J., & Turner, C. W. (1996). Diagnosis and explanation by a nuclear cardiology expert system. *International Journal of Expert Systems, 9,* 499-506.

Grant, R. M. (1996a). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Grant, R. M. (1996b). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*, 109-122.

Grover, V. & Segars, A. H. (1996). IT: The next 1100102 years. *Database, 27*(4), 45-57.

Keen, P. (1991). *Shaping the future: Business design through information technology*. Boston: Harvard Business School Press.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Polyani, M. (1967). *The tacit dimension*. Garden City, NY: Anchor Books.

Schwartz, D. G., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D. G. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based knowledge management and organizational memory* (pp. 1-23). Hershey, PA: Idea Gruop Publishing.

Thomson, S. (2000). Focus: Keeping pace with knowledge. *Information World Review, 155*, 23-24.

Wong, W., & Radcliffe, D. (2000). The tacit nature of design knowledge. *Technology Analysis and Strategic Management, 12*(4), 493-512.

ENDNOTE

[1] Some sections of this article were adapted from Becerra-Fernandez, Gonzalez, and Sabherwal (2004).

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Chapter 3.2

Exploring the Selection of Technology for Enabling Communities

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INTRODUCTION

Communities, whilst represented and apparent in their members, are most evident in the technological entity—the technology and tools that support the common and communal activities. Technology acts as the enabler linking a group of individuals who are most likely dispersed, in terms of time and place, and facilitates their interaction.

So you have decided or been asked to create or facilitate the activities of a community, but how do you select an appropriate solution for the requirements of a particular community and its members? Do you follow a traditional systems and software acquisition route: establish the requirement, develop the system, approach a consultant, call the IS department to see how you can adapt existing technologies? Or do you adopt an approach that can also be viewed as part of the community development process through the generation of involvement, engagement leading to ownership of the community and therein its future activities?

The bottom line is that technology—either a system or a tool—is still required; the following exploration is based on the original research of the Knowledge Library project (Cox, Patrick & Abdullah, 2003). The K-Library project, facilitated by Research Development funding from London South Bank University, started from the premise that it would be useful to assemble a group of librarians from across the library sectors to share their understanding of the concept of knowledge management (KM), and to look at how some of the ideas drawn from the KM literature could be applied to library practice. It also reflects the considerations of a project team with its participants for the selection of a suitable system to support this community of interest. This project and subsequent work provided the basis for this exploration of tools and technologies that support communal activity; be that a community of intent, interest, purpose, or practice, which seeks to identify the user requirements for the technology or systems to support the building of an online community. The aim is to review the type of technologies and varying features, and to explore how they can assist a community through its initiation and maintenance phases without intruding or hampering the intention and activities of that community. This has enabled the creation of a list of features supported by explanation of these functions and options, and the creation of a checklist (see Appendix). This checklist can be used to help potential users identify their expected needs by distinguishing essential, useful, and non-essential features. The resulting checklist can be found at the end of the exploration and explanation of functions and functionality that could be adopted in the technology to support a community. From this exercise and other user requirements, it is possible to evaluate different systems for their compliance with user requirements. In the K-Library project, this enabled the selection of a suitable system, replicating the majority of the features the community considered to be appropriate for their activities. This exploration is augmented with observation by the authors and the reflections of the communities arising from the selection and use of a system/technology and the building of the community.

BACKGROUND

On commencing the K-Library project, we found that there was little to directly lead us toward making a choice of supporting technology. A difficulty that lay in the wide and expanding range of technologies available for supporting communities, extending from simple bulletin boards or e-mail archiving systems through to sophisticated suites of integrated software with document repositories and content/records management, calendars, task management, and workflow. Also it was found that at the time of initiating the project, the literature on communities was focused toward the conceptual and practical aspects of running communities. This literature was focussed on selecting technologies rather than more generally on systems and software development, and texts were geared to specific software—groupware or intranets. These texts, whilst relevant, did not offer the fuller picture we initially perceived and then revealed as relevant in the discussions with the K-Library Communities membership.

Additionally, the speed of technological development has continued apace, making much material dated with the arrival of newer technologies and the convergence and integration of these technologies with other broader ranging technologies and standards, like instant messaging, Weblogs, and RSS feed. These are significantly changing how information can be collated and distributed, with increasing opportunity for customisation and personalisation. This is coupled with systems becoming more pervasive with enterprise information portals, integrated content management systems, wireless networks, and mobile commerce, and these devices becoming smaller and more mobile themselves. An important impact can be seen in the increasing standardisation occurring as useful technologies and practice evolve, particularly the Web-based metaphor for the look and feel of systems for familiarity and ease of use, with many of these technologies or practices being viewed as standards in the field. Although in terms of a true defining of a standard reflecting the technology domain, these may be transitional, emerging, de-facto, or proprietary standards like XML, XHTML, Java, or DHTML.

The essential aspect being that this semblance of a common standard is facilitating the development of more consistent systems, and the genuine use and reuse of documents and artefacts for a range of the devices without the need for re-creation, providing the ability to use or adapt them with relative ease, and enabling a group of individuals to form and evolve into a genuine and mutually beneficial community.

MAIN FOCUS

Identifying the Necessary Features

The question therefore is what functions or functionality does your community require? A simple bulletin board or mailing list (e.g., listserv, jiscmail) based on specific software, or a Web-based group with discussion threading and the ability to push e-mails (e.g., e-group or Yahoo group) may be enough. Is real time functionality—like chat or instant messenger (e.g., AOL, MSN, ICQ) or Internet telephony (e.g., Skype)—required? What about reminders for outstanding action 'to-do' or task list activity areas/places (e.g., Groove, Lotus Notes/Domino, First Class)? Are options required relating to the creation and dissemination of work via content management systems, record management, workflow, sign-offs, and portal-based enterprise systems (e.g., Opentext Livelink, or Hyperwave or Microsoft's Sharepoint)? Wenger (2001), in analysing tools for the suitability to run communities of practice, argues that "the ideal system [for this purpose] at the right price does not yet exist." He points out that most available systems were developed primarily with other applications in mind; specifically he identifies tools developed such as: knowledge portals, project type software, Web site communities, discussion groups, online meeting spaces, e-learning spaces, knowledge exchange, and knowledge repositories.

It is very easy in choosing a system to overlook the lack of important features that can be critical as to whether members are encouraged or discouraged from actively and consistently engaging with a community. The stress in functionality varies from system to system; for example, project management tools will stress document management and task listings much more than a Web site community tool. Also the specific terminology used may be appropriate to a particular application—that is, 'task lists' would more appropriately be called 'activity lists', say, in a Web site community as opposed to a project management system. Clearly it makes sense in selecting software for one type of community as far as possible to look for a system that was developed with that type of community in mind.

Conversation Space

This represents the core of any system or tool, the appropriate communication tools being vital to the success of a potential community. The more sophisticated tools will often provide several different spaces for shared and individual activities, and synchronous and asynchronous communication.

Asynchronous Communication

Asynchronous communication comes in two main forms: (1) e-mail-based systems where e-mails to a central account are forwarded to members, with a Web archive existing for reference; and (2) bulletin board systems, where messages are posted on the Web and users have to log in to read messages.

An issue that impacts on discussions lies in how messages are delivered or read via e-mail and reply can be made via e-mail or the Web site. Impacted can be the number of e-mails received in a single day according to energy of the debate and length, when in digest form, characteristically containing messages plus the replies, creates long and difficult-to-comprehend e-mails/documents. It is possible to reply via the individual message and reflect in the discussion as the thread has evolved. How previous messages are shown is significant if they are differentiated from the new message through the use of quotes or indentation, and these can be quite critical to readability. Some systems encourage the use of emoticons to partially overcome the limitations of communication based just on text; or an alternative allows users to add formatting to text, sometimes with HTML coding.

An addition to this is the potential for taking activities offline for contribution, that is, editing or contributing to collaborative documents; however, some form of synchronisation is beneficial for managing version control and ensuring the correct document is being improved.

It may be useful to offer the option to make anonymous contributions, to give users the opportunity to experiment with points of view that are controversial. This would need to address in the communities the development of operating protocols as to how it is used to ensure that it is not used negatively or to the determent of free-flowing discussions.

Synchronous Communication

For highly spontaneous interactions many community building systems offer real-time chat. Ideally there should be some means of archiving these discussions, though the most effective way may be through human reporter. Transcripts are difficult to read, and to respond to, particularly if there are multiple participants, and can quickly disappear off the screen with the lack of threading.

Often the chat facility has the ability to allow a user to check ‘who else’ is logged on—this is apparently a popular feature in some community building systems, even where communication is actually continued using asynchronous channels. This can also include shared activity spaces that allow co-viewing and co-editing.

Announcements

This is different than alerts, which are explained below. It is possible to simply make announcements through the asynchronous communication channel, but it is useful to have another channel through which to issue important community-wide news. Announcements are often posted at the top of the homepage. In some systems different types of announcements are distinguished and colour coded.

What’s New

There are two main approaches to defining what is new: either this can be determined by when the user last logged on, or more simply by elapsed time. The system we selected used the latter, and it was obviously not as satisfactory if one had been away a week; it also alerted one to one’s own postings and uploads.

Ideally the administrator should be able to control what types of items are monitored for changes and be given some options about how new items are marked, such as where they appear on the homepage, colours, and so forth.

Alerts

An alternative approach to making people aware of changes is the option to alert all, or some, users of changes when they are made. This has the merit of putting the choice in the hands of the community member as to who to notify of a particular change. With the system adopted by K-Library, the alerts only contained links to the site, not a direct link to the source of the alert. This additional step to using the system was viewed as detrimental and a hindrance by the members.

Polling

Polls are a powerful tool for helping communities to foster active participation and even to make collective decisions. While it is possible to canvas opinion simply through asynchronous communication channels, this is haphazard and difficult to control. The ability to automatically close a poll at a specific time will also encourage members to cast their votes within the allotted period.

A poll posted on the front page of the site allows members to follow its progress from the start to when the poll is finished and is especially important in circumstances where members are allowed to change their mind while the poll is still open. An additional option to allow anonymous votes can also be beneficial in encouraging members to vote freely.

Ideally there should be the flexibility for the member to add his or her own answer, if the option he or she wants to choose is not listed. Some systems provide automatic e-mail notifications when polls are running, closed, and when results are posted on the site.

Membership Directory

The importance of a membership directory lies in its ability to encourage users to share information about themselves, such as their areas of expertise, interests, and work experience, and so connect people. It might be useful to build a link from postings to membership entry or vice versa.

Ideally the administrator should be able to define suitable fields for entries in the directory, and select what level of information is required to be provided. Users should be able to have latitude to express themselves and reflect their interest and personality. The richer the record they can generate, the more other members will be able to relate to that person. It is useful to allow users to add a photograph of themselves—or links or documents; equally, users must be able to withhold information if they wish. This an area for the community to decide what the criteria is to be; a deadline for this information is also useful, as whilst members may agree, they may still abstain from publishing the agreed information.

Contacts List

Users can be encouraged to share contacts through a dedicated contacts directory; this can allow access or publication of a restricted set of information to that of the membership directory. This also overcomes any potential reluctance to enter full information within the Membership Directory, arising from concern over who will be able to see, use or pass on that information. Some members will find the real value of the community is to be able to access expertise through the back-channel, although the group experts may not take the same viewpoint.

Document Repository

The document repository can be one of the core features of a communications system. It is possible simply to e-mail files to a discussion list, but there are advantages in having a specific document store. Documents in a repository are easier to locate than those that are somewhere in a long-threaded discussion. Some systems offer something approaching a full document management system with check-in/check-out of documents and version control, and an archive of previous versions. This is essential where multiple authors are expected to be working on the same document, as in project work. In other contexts this may feel unnecessarily cumbersome and inhibit usage of the files. We felt it would be useful to build associated discussion areas around a document or to link to other parts of the system.

A large number of documents being shared can rapidly eat into storage space, possibly affecting system performance—or incurring extra expense if an Application Service Provider (ASP) is hosting the service. It is essential that commonly used document formats are supported with the ability to add new ones. If it is a hosted service, the evaluation should include looking for evidence that they will support new file types as they emerge. In a small community it should be possible and fair to negotiate standards about what authoring software to use. In projects it is common to standardise on a version of Word, for example. Selective alerting of major document changes to named individuals or groups is useful.

Link Store

The ability to add links to the site encourages members of the community to share online resources. Systems that have the ability to create folders and sub-folders with clear headings, ideally with additional details such as who added it, a short description, and the dates and times it was created, can make it even easier for members to access the information. Some systems provide additional features that allow for the creation of personal links, which are only visible to the individual member. This can be useful for members to personalise the site, and can help encourage them to visit and use the site regularly, but at the same time can also create an insular environment and can cause barriers to sharing.

Calendar

The calendar can be used as a record of events and to alert users of community events or relevant events in the outside world.

Task Lists

This lists the tasks and activities of the community, typically chronologically ordered, with additional attributes for start/finish, individuals taking part, and can be subdivided. Some systems provide integration with Calendar and Alerts features.

Help

The most common form of help facility is online documentation, which users can access by clicking the help button and going through a series of links. Ideally, the help button should be prominently situated on the front page so that users can see it clearly, and information should be obtained in no more than three clicks. There should also be context-sensitive help.

It would be useful if the administrator could customise the help screens, to use the local version of the language. In our experience we found that the use of American English proved to have a negative impact on the users in attempting to use help, and therein use the tool and participate in the community.

An addition found was the availability of personalised help through an online ‘Live Person’ support through a chat-like system. Off-line telephone communications are similar forms of help facilities that some systems offer, usually during normal office hours. The latter should also be considered in light of global time zones and where the provider may be based, as the K-Library community found there was only a short period where any real-time help was available. Finally, whilst useful, it needs due consideration if the service is not free.

Searching

The internal search facility is important once the size of data archived in the community has reached any size. The search facility should ideally be able to search all internal documents, links, and messages, with an option to search by type of file. Some systems we looked at only searched messages. Full-text searching of deposited documents would be ideal, failing that users should be required to attach an abstract at the point of adding the document or link; otherwise the search will only be on document/link titles.

Many systems offered a ‘search the Web’ option; this only seemed to be of added value if the target search engine could be chosen or if it worked to expand a search on the internal archive.

User Tracking and Statistics

Typically the user tracking functions on most of the systems examined during the study were minimal at best, improving with regard to the size and cost of the system/tool. This feature was more prevalent on the larger and high-end systems/technologies, particularly those with workflow, sign offs, or record management. We wanted to know who was using the site, how often they logged in at what time of day, whether they responded to announcements or alerts by logging in, or primarily used the site habitually at one time of day. It would have been interesting to see whether members were logging in work hours or not. Such tracking is essential, especially as such a high proportion of community members are 'lurkers'.

Clearly there are issues arising from the data protection and privacy perspectives, with this data at an individual level, but pseudonymous data would be invaluable to judge how well the community was working.

Usability and Terminology

It may well be critical to a community how usable the tool or system is perceived to be regardless of whether it is or is not. We found that simple things such as speed of response times may be a key to use of the system. This is obviously a function of many factors: the host system, but also user network connections and the speed of their own machines. For users with a modem connection, a simple e-mail system may be preferred.

Customisation

This is the ability to reorder or personalise the view presented on opening a tool to suit the priorities and interest of the individual user. Typically this is by choosing a theme for the layout or colouring, or the selection via on or off buttons of a series of features available. These methods are not untypical of common applications and grow with the sophistication of the product, especially portal-based solutions.

Security

In a private community a level of security is required, depending on how sensitive the discussions or documents posted are. The option to save one's password as a cookie on one's own machine can be useful.

In the system we used, there was a guest access facility, with very limited rights to view some areas of the site. Ideally there should be scope for the administrator of the community to define precisely what guests can and cannot do at a fine granular level.

Integration and Synchronisation

It most cases the community being created will not be core to participants' work, so it is essential that mechanisms exist to exchange data with other systems, and to maintain some form of version control.

Additional Factors

Clearly in choosing a system or tool, functionality is not the only criteria that is significant or impacts on the selection process.

Cost

There are a number of free services in the marketplace, but there is a price to be paid in using them in terms of intrusive advertising or the risk of the service being withdrawn probably on short notice.

The alternative is to licence software and install it, or to find a third-party ASP who for a fee will run the site for you. The total cost of running a server securely and reliably, along with the support for self-hosting, is likely to be significant.

Third-party services are generally cheaper to set up, but there are likely to be drawbacks. We found limitations on the level of customisation of interfaces and functions, and of usage statistics. Some of these limitations would probably also have existed if we had installed a system ourselves, at least from an out-of-the-box installation. There were limits on the total size of files we could save. We also found that one service (synchronous communication channel) was withdrawn without notice. When we finished using the service, there was no way to archive the site.

Moderation/Facilitation

Is the community to be self-maintaining or does it require a moderator? It should be noted that some systems like e-groups/Yahoo groups require at least one individual to be designated as the administrator/moderator.

Skill Levels

This relates to the technical skills of the community levels of competence and ease with technology, which introduces issues of usability and accessibility, and how adaptable the selected technology is or needs to be. There is also the aspect of the competence and technical skills of those facilitating the community; obviously in-house IS department will have skill levels, if not time. There is an increasing amount of Open Source options, these are packages based on PHP and MYSQL (e.g., Metadot, TYPO3, Invision Power Board). These offer an application-based, typical Web-based front end for the design and administration of a community without the need for detailed knowledge of either PHP or MYSQL, although the ability to customise and differentiate your communities from another design with such a tool is enhanced.

FUTURE ISSUES

As we indicated in the introduction, technological developments continue a pace, with new roles determined for older technologies, and new or recent technologies coming of age as the infrastructure also evolves to cope with their requirements. Changes are reflected in functionality and capability regarding the software, hardware, and the devices we use to access technologies, such as Web-logs—commonly known as blogs—for individual journal/diary-like software publishing via the Internet, which has evolved with a group-based authoring version. RSS feeds are becoming increasingly available, more ubiquitous means of linking and collating disparate information sources and data streams. Many of the 'coffee-and-book' shopping chains offer Internet connections via wireless networks. Link this to the expansion of the 3G mobile telephony networks and the success of the Blackberry handheld device. The technology does not need to be new, but recognition of an existing technology that is underused or could be used differently may be appropriate. The most successful (financially) technology in 2G mobiles was the initially overlooked 'texting' (SMS) facility. Do 3G mobiles have a community-orientated facility yet to be discovered or acknowledged?

CONCLUSION

As with any exercise in gathering users' conscious requirements prior to experience of a specific application, the results can be misleading as a guide to how people will actually use the system that is chosen and value particular functions. The K-Library found this to be an issue with several requested features being turned off, particularly the alerts, although this was followed by comments about not realising anything was happening on the communities online entity! Other analysis is required to identify the full user requirements, but forms a basis for the community, and encouraging involvement and engagement—two prime attributes for creating a successful community.

The checklist tool and descriptions presented here could also be applied to gather users' evaluations of software they have used in a community building exercise, and to triangulate with the results of actual user behaviour captured through site statistics or direct observation of behaviour.

Selecting the most appropriate technology in the form of a system or a tool is a significant part of creating and facilitating a community and can be part of the process of forming the community. It does not have to be sophisticated or heavily featured; it should be related to the community objectives and the community members, its formality or informality, its location outside an organisation or inside an organisation, or bridging organisations or interest groups.

To finish, one should remember Wenger's (2001) consideration that in analysing tools for their suitability to run communities of practice, he argues that "the ideal system [for this purpose] at the right price does not yet exist." It is our hope that our experiences can help you to consider what features your community requires prior to selecting a suitable system/tool for your community.

REFERENCES

Cox, A., Patrick, K., & Abdullah, R. (2003). Seeding a community of interest: The experience of the Knowledge Library project. *Aslib Proceedings*, *55*(4), 243-252.

K-Library. (2002). *The Knowledge Library project archive*. Retrieved from http://litc.sbu.ac.uk/klibrary/ [note: this Web site is no longer available online].

Lloyd, P., & Boyle, P. (1998). *Web-weaving: Intranets, extranets and strategic alliances*. Boston: Butterworth-Heinemann.

Ruggles, R.L. (1997). *Knowledge management tools*. Boston: Butterworth-Heinemann.

Webopedia. (2004). *Definitions* Retrieved November 14, 2004, from http://www.webopedia.com

Wenger, E. (2001). *Supporting communities of practice—A survey of community-oriented technologies*. Retrieved November 14, 2004, from http://www.ewenger.com/tech/executive_summary.htm

Wenger, E., McDermott, R., & Snyder, W.M. (2002). *Cultivating of practice: A guide to managing knowledge*. Boston: Harvard Business School Press.

Further materials have been taken from the relevant product Web sites, demonstrations, and personal use of versions of the products described, including:

Opentext Livelink—www.opentext.com

Groove Networks—www.groove.net

Lotus Notes/Domino—www.lotus.com/notes/

First Class—www.firstclass.com

Hyperwave—www.hyperwave.com

Microsoft Sharepoint—www.microsoft.com/sharepoint/

Skype—www.skype.com

Metadot—www.metadot.com

TYPO3—www.typo3.com

Invision Power Board—www.invisionboard.com

[All accessed May/June 2002 and/or June/November 2004]

Additionally, a number of reviews from a range of computing and Internet magazines have been drawn upon:

.Net, publisher Future Publishing—www.netmag.co.uk

Internet Magazine, publisher Emap—www.internet-magazine.com

Internet Works, publisher Future Publishing—www.iwks.com

Internet World, publisher Penton Media Inc.—www.internetworld.com

Mac User, publisher Dennis Publishing—www.macuser.co.uk

Mac Format, publisher Future Publishing—www.macformat.co.uk

APPENDIX: A COMMUNITY AND FEATURES CHECKLIST

Characteristics			Rating		
Function	*Attributes*		*Essential*	*Desirable*	*Neutral*
1. Asynchronous Channel					
	Pushed E-Mail				
		Individual			
		Daily Digest			
	Bulletin Board				
		Threading			
		Emoticons			
		Formatting			
	Anonymous Posting Option				
2. Synchronous Channel					
	Whiteboard				
	Instant Messaging				
	Chat				
		Automatic Archiving			
	Who-Is-Logged–On-Now Check				
	Shared Surfing				
	Conferencing				
		Video			
		Audio			
3. Announcements					
	Posted To Homepage?				
4. What's New					
	Since Last Log In				
	In the Last n Days				
	Customisation of Items Monitored				
5. Alerts					
	For New Documents				
	For New Polls				
	Tasks				
	Messages				

Characteristics			Rating		
Function	*Attributes*		*Essential*	*Desirable*	*Neutral*
6. Polling					
	Can Set Open Other Answer				
	User Can Only Vote Once				
	User Can Change Vote				
	Pre-Set Closing Time				
7. Membership Directory					
	Customisation of Fields in Entries				
	Customisation of What Are Required Fields				
	Photo Can Be Added				
	Links or Documents				
8. Contacts List					
9. Document Repository					
	Metadata Required				
	PDF, Word Supported				
	Check In/Version Control				
	Discussion Can Be Directly Associated with Document				
	Directory Structure				
10. Link Store					
	Metadata Required				
	Directory Structure				
11. Calendar					
12. Task Lists					
	Individual				
	Activity Based				

Characteristics			**Rating**		
Function	***Attributes***		*Essential*	*Desirable*	*Neutral*
13. Help					
	System				
	Community				
	Context Sensitive				
	Local Customisation by Administrator				
	Online Help				
14. Internal Searching					
	Includes Full Text of Messages and Metadata on Documents/Links				
	Includes Full Text of All Files				
	Full Boolean				
	Search Can Be Limited by Type of File, e.g., E-Mails or Documents				
15. External Search					
	Choice of Search Engine				
	Automatic Expansion of Internal Search				
16. Usability					
	Server Response Time < 1 Second				
17. Customisation					
18. Security					
	Encrypted Sessions				
	Cookie-Based Password Save				
19. Integration and Synchronisation					

Characteristics			**Rating**		
Function	***Attributes***		*Essential*	*Desirable*	*Neutral*
20. Technical Requirements					
	Support Netscape Pre-Version 6				
Administrators Only					
21. Cost					
	(For Self-Hosted)				
		Licence Cost			
		Cost of Support			
	(For Third-Party Service)				
		Cost Per User			
		One Off Costs			
16. User Tracking					
	Total Usage Per Individual Over Time				
	Analysis of Usage by Time of Day				
	Paths Taken Through Site				
	Most Popular/Least Popular Pages Analysis				
	Data Protection Compliance				

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Chapter 3.3
Intranet and Organizational Learning

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INTRODUCTION

In this article, we will analyze the cultural dimension of intranets as knowledge management tools within organizations. An intranet is an information communication technology (ICT) based upon Internet technology (http://www, TCP/IP). The intranet phenomenon was introduced in the early 1990s following the idea that it can integrate all the computers, software, and databases within a particular organization into a single system that enables employees to find and share all the information they need for their work (Bernard, 1997; Cortese, 1996). Intranets function as a computer-mediated communication (CMC) tool and are used as computing networks used for sharing organizational information. While Internet technology is leading, access is restricted exclusively to organizational members (by means of electronic firewalls). In a study to the role of intranets in strategic management decisions, Curry and Stancich (2000) define Intranets as "…private computing networks, internal to an organization, allowing access only to authorized users" (p. 250). The term private indicates that an intranet is a network that can be accessed only by members of a particular organization. The term network emphasizes the connection between computers that enables corporate communication. Intranets run on open but controlled networks that enable organization members to employ the same WWW servers and browsers, which are distributed over the local area network (LAN).

In recent debates on strategic management and learning, an organizational learning culture has been introduced as one of the main 'critical success factors' underlying the effective use of intranets (Carayannis, 1998). The aim of this article is to analyze the cultural aspects of intranets as tools in organizational learning processes. It is not so much a presentation of the instrumental effects of intranets for the learning organization culture—the way an intranet influences organizational learning processes is not taken for granted, but studied by the way it is used in different settings. We will present a framework for analyzing the cultural dimension of intranets within specific organizational contexts.

Many studies of intranets dealing with the effectiveness and efficiency of knowledge sharing and knowledge management take a static and deterministic point of view. That means that the focus is on structural constrains, without paying attention to the actual use of intranets. In contrast with this, we plea for an approach focusing upon communicative actions, and stress the communication between people on the intranet on the basis of normative agreement and feelings of mutual understanding and belonging. We furthermore highlight three dimensions from which this cultural context of an intranet can be defined, studied, and analyzed. These dimensions, which indeed apply to any enterprise system (ES) and which in a way also represent historical phases in the development of technology (Silverstone & Haddon, 1996), will in our contextual analysis be specified as the 'constitution' of an intranet, the intranet as a 'condition' of the learning organization, and the (unintended) 'consequences' of intranet use. An analysis on these levels is crucial for those scholars who want to grasp the cultural dimension in the actual use of intranets as a knowledge management tool.

INTRANET AND ORGANIZATIONAL CULTURE

Often, the objective for the implementation of an intranet is that it will facilitate knowledge sharing among members within a single organization. There is a growing body of publications that see an intranet as a tool for organizational learning (e.g., Carayannis, 1998; Curry & Stancich, 2000; Scott, 1998; Sridhar, 1998; Ottosson, 2003). With regard to knowledge management, it has been analyzed in terms of knowledge banks, e-learning platforms, expert networks, online information sharing tools, and the like. Recently, intranets were identified as an infrastructure supporting knowledge management (Harvey, Palmer, & Speier, 1998; Damsgaard & Scheepers, 2001). In this body of literature, intranets are presented as promising knowledge management ICT tools in the sense that intranets will be complementary to or even replace existing information and communication carriers within and among organizations. In addition, intranets are seen as promising instruments for information sharing and collaboration across departments, functions, and information systems (Damsgaard & Scheepers, 1999). Internet-based ICTs like an intranet are even introduced as radical and disruptive innovations, since the implementation is intended strongly to influence the knowledge base of the organization (Lyytinen & Rose, 2003; Mustonen-Ollila & Lyytinen, 2003).

Together with the stories on the promising aspect of intranets, however, came the stories about organizational restrictions, misalignments, and user resistance. Discussions can be found about organizational constraints, such as the lack of standards, immature interfaces, weak linkages to other information systems, bandwidth availability and information overload, and the lack of an internal organization to authorize, support, and organize the quality of the information. On many occasions, it is the organizational culture that has been introduced as an explanation for misalignments or as a condition for a successful implementation and use of intranets (Damsgaard & Scheepers, 2001, p. 5). Curry and Stancich (2000) state: "To obtain maximum value from an intranet, both the 'soft' cultural issues of information sharing and change in work processes must be addressed alongside the 'hard' systems issues of managing the intranet as an information system and a business resource" (p. 255). Moreover, it has been argued that a cultural shift to information sharing is necessary to solve problems of information sharing by means of intranets (Harvey et al., 1998). A positive culture, in this respect, is the motivation to create, share, and use information and knowledge to solve problems with each other within the organization.

It is, however, difficult and often misleading to establish direct causal links between organizational culture and the performance of intranets, since we must realize that culture is part and parcel of the entire organization and affects all kinds of actions and relations (Alvesson, 2002). The definition of 'organizational culture' is itself problematic. It has been described in the literature as a pattern of shared assumptions often produced by top management (Schein, 1992). Such a description of culture as a set of shared assumptions is rather oversimplified (Martin, 1992). Empirical research provides us with a far more complex picture, and shows that tensions can grow and remain between the individuals' interests and organization aims. Because of cognitive and normative diversity within an organization, the attribution of meaning (which is an important part of the cultural process) is complicated and leads to integration as well as fragmentation, and unity as well as diversity.

In line with this, organizational culture has been defined as a sensemaking process (Weick, 1995). That means that we have to study how individual workers give meaning to their actions. In using intranets, like texts such as reports, statistics, protocols, and minutes, the organizational members give meaning to their activities. In this way "…we can understand such interpretations as stemming from the very use of intranet itself" (Edenius & Borgerson, 2003, p. 131). The use of an intranet can generate a kind of consensual knowledge and, as long as different workers get into mutual trust, this can lead to a feeling of belonging. To use an intranet is making sense of experiences, routines, and insights. On a more abstract level, Wenger introduced the term 'communities of practice' to describe the process of people who share common goals or interests and how the people interact with each other to learn how to do better. These communities are formed by people who engage in a process of collective learning in a shared domain of human endeavor (Wenger, 1998; Wenger, McDermott, & Snyder, 2002). Communities of practice enable practitioners to share knowledge, to create a link between learning and performance, and to make connections among others across structural organizational boarders. Because of this, we will discuss intranet and organizational culture in terms of 'shared' meaningful work practices, while at the same time recognizing the existence of multiple working cultures dealing with intranets.

INTRANET AND ORGANIZATIONAL LEARNING

As argued above, an intranet can facilitate knowledge sharing among organization members. The idea is that the knowledge put on the intranet is explicit knowledge (in the terms of Polanyi) that can easily be shared by members of the user group. However, the term 'knowledge sharing' is problematic, because the people's tacit knowing—that is, how to do things—is never fully shared (Walsham, 2002). Only if the data (the explicit knowledge) on the intranet is connected to the tacit knowing, then can the intranet offer something interesting to that user—it can generate a kind of consensual knowledge. That implies that the user must have the skills and competence in selecting the appropriate explicit knowledge. In other words, the knowledge is not in the computer system, but within the human being. It is the end-users that give sense to the data and messages on the intranet by means of their tacit knowing.

Like other ICTs, intranets are the outcome of choices made by individual actors or groups and of organizational constraints that together influence the character of this particular technology. This is known in the literature as the process of mutual shaping (Williams & Edge, 1996; Orlikowski, 2000). While using intranets, actors produce and reproduce communication and information patterns within organizations. Organizational learning on intranets thus can be analyzed as a social process of structuration (in line with Berends, Boersma, & Weggeman, 2003). From this structurationist framework it has been stressed, in particular by Orlikowski (2000), that individual actors are always situated actors. In using ICT tools actors reproduce at the same time important normative and power relations. Thus linkages can be specified between on the one hand the meanings attributed to technologies and on the other hand the normative prescriptions and power relations of organizations.

It has been argued before that an intranet is as good as its content (Curry & Stancich, 2000; White, 2004). Intranets facilitate communication and information sharing among organization members only if the employees can find the data they need, can judge the information to be valid and current, and can trust the persons—gatekeepers—who are responsible for the content of the intranet. However, Edenius and Borgerson (2003) argue that this idea of the intranet as being a container-like tool, where knowledge is seen as a stable stock of fixed information, takes a conventional rational discussion about knowledge management as a starting point. According to them, this view underestimates that an intranet works as a dynamic configuration that also produces knowledge. In other words, the use of an intranet is part of the living act of knowing.

The use of intranet as a tool for knowledge management needs actors who creatively realize learning practices and communication patterns as part of organizational cultures. That means that organizational learning consists of changing organizational practices via the development of knowledge, realized in social practices (Gherardi & Nicolini, 2001). The benefit of knowledge sharing (i.e., learning processes) throughout the organization via an intranet cannot be reduced to individual learning, or individual learning plus something extra such as the sharing of knowledge. Individuals will benefit from intranets in terms of information sharing only if the technology 'fits' into their daily routines embedded within organizational cultures. In this perspective, the organizational knowledge is part of and lives in a constellation of communities of practice (Wenger, 1998). The intranet can be a challenge for these communities, because it offers a platform for sharing knowledge and mutual understanding.

In defining an intranet from this point of view, three different but mutually related dimensions should be taken into account. These dimensions include the constitution of the intranet (stressing the redefinition of learning practices), the intranet as a condition of organizations (stressing the virtualization of organizations), and the intended as well as unintended consequences of the intranet (stressing the globalization of organizations and power relations). In the interaction between these three dimensions of intranet, we find how organizational cultural aspects shape this technology and how this technology in its turn influences organizational cultures.

THREE DIMENSIONS OF AN INTRANET

The first dimension in our approach is the study of the constitution of an intranet. This dimension refers to the material, time-spatial, appearance of intranets. It concerns the artifacts and persons intranets are made of, including PCs, cables, mainframes, software packages, interfaces, reports, and intranet programmers and operators. Similar to the argument Downey (2001) makes for the Internet, intranet workers can only be revealed if we consider the artifacts, labor, and space simultaneously. Therefore a cultural study of the intranet should pay serious attention to the material and geographical aspects of these systems. Conceptions of organizational culture usually not only refer to values and rules, but also to material artifacts (Schein, 1992), which increasingly consist of ICT systems. In line with the discussion above, the evolution of intranets can only be interpreted by studying the interests and perceptions of the various actors that use this ES. An intranet is not a given technology, although it has some scripts (i.e., standard procedures for users), but is a malleable tool shaped by social forces within the organization.

The second dimension, the intranet as a condition for organizations, refers to the functional integration of knowledge (sub)systems by the use of an intranet. An intranet may contribute to the development of 'network enterprises', defined by Castells (1996). This type of organization is rather flexible because it can both reallocate its means of production and change its goals. The intranet, as a knowledge-sharing tool, can function within network organizations as an enabling tool to reconfigure themselves. Like the Internet, intranets create new patterns of social behavior and communication (DiMaggio, Hargittai, Neuman, & Robinson, 2001). Knowledge sharing within network organizations is facilitated but not determined by ICT systems like intranets. In this respect, the borders within and between organizations are constantly reinterpreted, because the structure of the intranet makes it possible to bind people working at different locations together—it is the virtual space of the intranet that is the new condition for a learning environment. In a way, intranets link employees, divisions, and companies, and provide information anytime and anyplace, and enable and reinforce network structures. The aspect of an intranet as a virtual dimension of an organization where partners are located over a wide area linked seamlessly together, however, is yet to be reached due to the relative recency of the system (Kim, 1998).

The third dimension highlights the consequences of the use of an intranet for organizational culture and the wider environment. This dimension refers to the actual effects of an intranet, and concerns the intended as well as unintended consequences. Effects concerning the scaling-up and globalization and the managerial control over knowledge flows seem particularly relevant for the cultural analysis of an intranet. Organizations are embedded in extended networks and operate often in global markets. In some way they have to control these global operations and manage knowledge flows in this context in a coordinated manner. The intended and unintended use enhances the capacity of panoptic control and disciplinary power—an architecture of power closely associated with ICT systems (Zuboff, 1988). Management can use the stored information on the intranet to monitor and interfere with the performance of individuals and groups. At the same time individuals can be empowered by the system and carry out their tasks with more responsibility based on their own insights, preferences, and information from the intranet. However, there are unintended consequences due to these virtual aspects. While the use of an intranet can lead to a sense of belonging, a possible decrease in face-to-face communication is the other side of the coin (Hine, 2000). This can easily lead to a loss of shared identity and weaken social relationships with colleagues within the same organization. Participation on the intranet in this respect is rather anonymous, without much engagement, and therefore maybe less effective as a tool for knowledge management.

FUTURE RESEARCH

Intranets are likely to be further developed in many organizations in the near future as a new communication infrastructure. It is presented both within popular management literature as in international journals as another promising bandwagon for organizations (Lynch, 1997). There is a growing number of managers that implement intranets as a solution for knowledge sharing within the organization. Future research should study the consequences of intranets as a tool for knowledge management to understand the organizational cultural aspects in the way it is presented in this article. It is the people who work with the system that give meaning to the data on an intranet. To understand how people give meaning to the (data on) an intranet, we have to follow the evolution of intranets (within specific contexts) over a longer period of time. This means that "attempts to create unified, universally applicable models or 'best practice' guidelines for designing and implementing intranets are futile. Instead we have to recognize organizational diversity and that the technology is embedded in, and shaped by, its social context" (Bansler, Damsgaard, Scheepers, Havn & Thommesen, 2000, p. 18). We want to argue that it is necessary to integrate both the individual contributions (i.e., the use of technology), group dynamics, and the organizational cultural aspects in a well-balanced manner during the implementation and use of intranets in the process of organizational learning.

Important questions to raise in this respect are inspired by the way Hine (2000) questions the 'virtual life' on the Internet:

- How do the users of an intranet understand its capacity, and how do they interpret it as a medium of communication?
- How does the intranet affect the organization of social relationships within the organization, and is this different to the way in which 'real life' is organized?
- What are the implications of an intranet for the authority and power relations within the organization?
- How do people define the boundary between the real data and the virtual data on the intranet?

CONCLUSION

Because users give meaning to the intranet, "…organizations need to carefully consider how their intranet should be deployed so as to reap the maximum benefit in terms of knowledge creation" (Damsgaard & Scheepers, 2001, p. 11). Intranets are not a pre-given and unproblematic tool for knowledge management. Instead, the implementation and use of an intranet as a tool for knowledge sharing needs a careful understanding of its social-cultural impact and at the same time has to be seen as a cultural phenomenon in itself. This means that an intranet should not be treated as the explanans (the thing or solution that explains the communication problem); in other words, with the help of the intranet, we can solve our communication problems—but rather as the explanandum (the thing or solution that has to be explained): What are the cultural features that shaped the intranet, and in what way does the use of intranets shape and reshape communication patterns within the organization?

In order to understand the cultural aspects of intranets, we have to incorporate the sensemaking processes both during the managerial implementation process as well as in a socio-cultural analysis. In our approach this means a careful analysis of the condition of intranets (what socio-technical choices are made to build the technology), intranet as a constitution (what kind of organization is made possible by the intranet), and the consequences of intranets (how the intranet affects the communication patterns within the organization). This perspective offers the possibility to integrate the 'virtual' communication on the intranet with the patterns of social behavior in the 'real' world.

REFERENCES

Alvesson, M. (2002). *Understanding organizational culture*. London: Sage Publications.

Bansler, J.P., Damsgaard, J., Scheepers, R., Havn, E., & Thommesen, J. (2000). Corporate intranet implementation: Managing emergent technologies and organizational practices. *Journal of the Association for Information Systems, 1*, 1-25.

Berends, H., Boersma, K., & Weggeman, M. (2003). The structuration of organizational learning. *Human Relations, 56*(9), 1035-1056.

Bernard, R. (1997). *The corporate intranet* (2nd Ed.). New York: John Wiley & Sons.

Carayannis, E.G. (1998). The strategic management of technological learning in project/program management: The role of extranets, intranets and intelligent agents in knowledge generation, diffusion, and leveraging. *Technovation, 18*(11), 697-703.

Castells, M. (1996). *The rise of the network society*. (Vol. 1) Oxford: Malden, Blackwell.

Cortese, A. (1996). Here comes the intranet. And it could be the simple solution to companywide information-on-demand. *Business Week*, (February).

Curry, A., & Stancich, L. (2000). The intranet: An intrinsic component of strategic information management? *International Journal of Information Management, 20*, 249-268.

Damsgaard, J., & Scheepers, R. (1999). Power, influence and intranet implementation. A safari of South African organizations. *Information Technology & People, 12*(4), 333-358.

Damsgaard, J., & Scheepers, R. (2001). Harnessing intranet technology for organisational knowledge creation. *Australian Journal of Information Systems*, (December), 4-15.

DiMaggio, P., Hargittai, E., Neuman, W.R, & Robinson, J.P. (2001). Social implications of the Internet. *Annual Review of Sociology, 27*, 307-336.

Downey, G. (2001). Virtual webs, physical technologies, and hidden workers. The spaces of labor in information Internetworks. *Technology and Culture, 42*(2), 209-235.

Edenius, M., & Borgerson, J. (2003). To manage knowledge by intranet. *Journal of Knowledge Management, 7*(5), 124-136.

Gherardi, S., & Nicolini, D. (2001). The sociological foundations of organizational learning. In M. Dierkes, A.B. Antal, J. Child, & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 35-60). Oxford: Oxford University Press.

Harvey, M., Palmer, J., & Speier, C. (1998). Implementing intra-organizational learning: A phased-model approach supported by intranet technology. *European Management Journal, 16*(3), 341-354.

Hine, C. (2000). *Virtual ethnography*. London: Sage Publications.

Kim, J. (1998). Hierarchical structure of intranet functions and their relative importance: Using the analytic hierarchy process for virtual organizations. *Decision Support Systems, 23*, 59-74.

Lynch, G. (1997). Intranets: Just another bandwagon? *Industrial Management & Data Systems, 97*(4), 150-152.

Lyytinen, K., & Rose, G.M. (2003). Disruptive information system innovation: The case of Internet computing. *Information Systems Journal, 13*, 301-330.

Martin, J. (1992). *Cultures in organizations. Three perspectives*. Oxford: Oxford University Press.

Mustonen-Ollila, E., & Lyytinen, K. (2003). Why organizations adopt information system process innovations: A longitudinal study using Diffusion of Innovation theory. *Information Systems Journal, 13*, 275-297.

Orlikowski, W.J. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*(4), 404-428.

Ottosson, S. (2003). Dynamic product development of a new intranet platform. *Technovation, 23*, 669-678.

Schein, E.H. (1992). *Organizational culture and leadership.* San Francisco: Jossey-Bass.

Scott, J.E. (1998). Organizational knowledge and the intranet. *Decision Support Systems, 23,* 3-17.

Silverstone, R., & Haddon, L. (1996). Design and the domestication of information and communication technologies: Technical change and everyday life. In R. Mansell & R. Silverstone (Eds.), *Communication by design* (pp. 44-74). Oxford: Oxford University Press.

Sridhar, S. (1998). Decision support using the intranet. *Decision Support Systems, 23,* 19-28.

Walsham, G. (2002). What can knowledge management systems deliver? *Management Communications Quarterly, 16*(2), 267-273.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. (2002). *Cultivating communities of practice: A guide to managing knowledge.* Boston: Harvard Business School Press.

Weick, K. (1995). *Sensemaking in organizations.* London: Sage Publications.

White, M. (2004). Does your intranet have a win-win strategy? *EContent, 27*(3), 41.

Williams, R., & Edge, D. (1996). The social shaping of technology. *Research Policy, 25*(6), 865-899.

Zuboff, S. (1988). *In the age of the smart machine.* New York: Basic Books.

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Chapter 3.4
Description Logic-Based Resource Retrieval

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INTRODUCTION

Resource retrieval addresses the problem of finding best matches to a request among available resources, with both the request and the resources described with respect to a shared interpretation of the knowledge domain the resource belongs to. The problem of resource matching and retrieval arises in several scenarios, among them, personnel recruitment and job assignment, dating agencies, but also generic electronic marketplaces, Web services discovery and composition, resource matching in the Grid. All these scenarios share a common purpose: given a request, find among available descriptions those best fulfilling it, or at "worse," when nothing better exists, those that fulfill at least some of the requirements.

Exact, or full, matches are usually rare and the true matchmaking process is aimed at providing one or more "promising" matches to be explored. Non-exact matches should take into account both missing information—details that could be positively assessed in a second phase—and conflicting information—details that could leverage negotiation if the proposed match is worth enough pursuing.

Because of its intangibility, it is now a widely shared opinion that knowledge has to be modeled to make unambiguous the interpretation of any information domain. This disambiguation process is usually obtained through an ontology, that is, a specification of a representational vocabulary for a shared domain of discourse—definitions of classes, relations, functions, and other objects (Gruber, 1993).

Once a knowledge domain has been modeled, and several different resources have been described using such a model, issues that need to be faced for efficient knowledge management are: What, if any, kind of retrieval is possible on these resources? How could we benefit both of the model and formalisms used to build the model, in order to perform a "smart" search of described resources matching a request? The above questions focus on important aspects of knowledge-based retrieval:

- formalisms used to model a knowledge domain
- retrieval services that fully use the expressiveness of the formalism to infer new knowledge from the model in order to perform a knowledge-based search

Knowledge domain is modeled with a formalism, whose expressiveness is used in the retrieval process to infer not elicited information from the model. In such a context, choosing this formalism strongly affects the complexity, as well as success probability, of the retrieval process.

In recent years description logics (DLs) have been investigated by both the academic and industrial world as a formalism for knowledge representation. Modeling an information domain through the formalism of a DL allows one to employ reasoning services provided by DLs to perform a knowledge-based search. Knowledge domains are formalized in ontologies, which resource descriptions refer to. The use of ontologies allows elicited descriptions to be stored so that information can be inferred from them to retrieve a resource.

The remainder of this article is structured as follows: Background work is revised, including DL basics with associated reasoning services and previous approaches to resource retrieval, including non-logic- and logic-based alternatives. Then, we introduce semantic-based resource retrieval, first highlighting new non-standard inference services and then showing how they can be used for "smart" resource retrieval. Finally, we propose some future trends and draw a conclusion.

BACKGROUND

Description Logics Basics

Description, or terminological, logics (Baader, Calvanese, Mc Guinness, Nardi, & Patel-Schneider, 2002; Donini, Lenzerini, Nardi, & Schaerf, 1996) are a family of logic formalisms for knowledge representation. All DLs are endowed of a syntax and a model-theoretic semantics. The basic syntax elements of DLs are: concept names, role names, individuals. Intuitively, concepts stand for sets of objects, and roles link objects belonging to different concepts. Individuals are special named elements of the sets of objects concepts represent.

We give a more formal definition of the outlined basic elements by introducing the concept of semantic interpretation.

Definition 1: A semantic interpretation is a pair $I=(\Delta, \cdot I)$ made up of a domain Δ and an interpretation function $\cdot I$, which maps every concept to a subset of Δ, every role to a subset of $\Delta\times\Delta$, and every individual to an element of Δ.

Usually, a so-called Unique Name Assumption (UNA) is made which ensures different individuals to be mapped to different elements of Δ, i.e., $a^I \neq b^I$ for individuals $a \neq b$.

Every DL allows one to combine basic elements using constructors to form concept and role expressions. Each DL has its distinguished set of constructors, though all of them provide the conjunction of concepts, usually denoted as $\sqcap$. Among the distinguishing concept expressions constructors we enumerate disjunction $\sqcup$ of concepts and complement $\neg$ to close concept expressions under Boolean operations.

Role expressions can be obtained by combining roles with concepts using existential role quantification and universal role quantification. Other constructs may involve counting, as number restrictions.

Many other constructs can be defined, increasing the expressive power of the DL, up to n-ary relations (Calvanese, De Giacomo, & Lenzerini, 1998). Nevertheless, it is a well-known result that usually leads to an explosion in computational complexity of inference services (Brachman & Levesque, 1984). Hence, a trade-off is needed between expressivity and expected performance of reasoning services.

Once expressions have been built, they are given semantics by defining the interpretation function over each construct. Concept conjunction is interpreted as set intersection, and the other Boolean connectives also have the usual set-theoretic interpretation. The interpretation of constructs involving quantification on roles needs to make domain elements explicit.

Concept expressions can be used in inclusion assertions, and definitions, which impose restrictions on possible interpretations according to the knowledge elicited for a given domain. Definitions are useful to give a meaningful name to particular combinations. Sets of such inclusions are called TBox (terminological box). A TBox, which basically amounts to an ontology, represents a formal, shared, and objective intensional knowledge on a domain. Individuals can be asserted to belong to a concept using membership assertions in an ABox. An ABox is the extensional knowledge of the domain that can be described based on the TBox. The semantics of inclusions and definitions is based on set containment: An interpretation I satisfies an inclusion $C \sqsubseteq D$ if $C^I \sqsubseteq D^I$, and it satisfies a definition $C = D$ when $C^I = D^I$. A model of a TBox T is an interpretation satisfying all inclusions and definitions of T. DL-based systems are equipped with reasoning services: logical problems whose solution can make explicit knowledge that was implicit in the assertions.

DL-based systems usually provide at least two basic reasoning services for T:

- Concept Satisfiability: Given a TBox T and a concept C, does there exist at least one model of T assigning a non-empty extension to C?
- Subsumption: Given a TBox T and two concepts C and D, is C more general than D in any model of T?

The previous services can be seen, from a knowledge management perspective, in a more informal way:

- Concept Satisfiability: Given an ontology (T) modeling the domain we are investigating on and a description (C) of a resource referring to the ontology: Is the information modeled in the description consistent with the one in the ontology?
- Subsumption: Given an ontology (T) modeling the domain we are investigating on and two resources described by expressions (C, D) referring to the information modeled in the ontology: Is the information about a resource more general than the one related to the other one?

Both Subsumption and Satisfiability are adequate in all those knowledge management contexts where a yes/no answer is enough. For example, given a resource and a request represented respectively by a concept O and a concept R, using Concept Satisfiability we are able to determine whether they are compatible, that is, O models information that is not in conflict with the one modeled by R. This task can be performed checking the satisfiability of the concept $O \sqcap R$.

On the other hand, Subsumption can be used to verify, for example, if a resource described by O satisfies a request R, namely, if the relation $O \sqsubseteq R$ holds, then O is more specific than R and it contains at least all the requested features.

For ABoxes, other standard inference services have been defined. Among the various devised, we point out:

- Instance checking: An assertion α is entailed by an Abox A, if every interpretation that satisfies A also satisfies α.
- Retrieval problem: Given an Abox A and a concept C, find all individuals α such that A entails C(α).
- Realization problem: Given an individual α and a set of concepts, find the most specific concept C from the set such that A entails C(α).

Together with standard inference problems, non-standard ones have been proposed and investigated. The least common subsumer (lcs), most specific concept (msc), unification, matching and concept rewriting have been thoroughly presented by Baader et al. (2002). The application field for lcs and msc is the construction of DL knowledge bases using a bottom-up approach instead of the usual top-down one (Baader & Turhan, 2002). The unification and matching services are useful for large knowledge bases maintenance, allowing knowledge engineers to catch equivalence or subsumption relationships among concept expressions (Baader & Turhan, 2002). With concept rewriting the readability of large concept descriptions can be increased, by using concepts defined in an ontology.

Although the general approach proposed in this article does not depend on a particular DL, it has been fully devised for a particular DL, namely the ALN (Attributive Language with Number Restrictions). Constructs allowed in an ALN DL are:

- $\top$ Universal Concept: All the objects in the domain
- $\bot$ Bottom Concept: The empty set
- A Atomic Concepts: All the objects belonging to the set represented by A
- $\neg A$ Atomic negation: All the objects not belonging to the set represented by A
- $C \sqcap D$ Intersection: The objects belonging both to C and D
- $\forall R.C$ Universal restriction: All the objects participating to the R relation whose range are all the objects belonging to C
- $\exists R$ Unqualified existential restriction: There exists at least one object participating in the relation R. Notice that $\exists R \equiv (\geq 1\ R)$
- $(\geq n\ R) \mid (\leq n\ R) \mid (= n\ R)$ Unqualified number restrictions: Respectively, the minimum, the maximum, and the exact number of objects participating in the relation R. We write $(= n\ R)$ for $(\geq n\ R) \sqcap (\leq n\ R)$

We adopt a simple-TBox, that is, in all the axioms (for both inclusion and definition) the left side is represented by a concept name, and there is only one axiom for each atomic concept.

Ontologies using this logic can be easily modeled using languages for the Semantic Web. These languages have been conceived to allow for representation of machine-understandable, unambiguous, description of Web content through the creation of domain ontologies, and aim at increasing openness and interoperability in the Web environment. The strong relation between DLs and the introduced languages for the Semantic Web also is evident in the definition of the OWL language. In fact, there are three different sub-languages for OWL:

- OWL-Lite: It allows class hierarchy and simple constraints on relation between classes.
- OWL-DL: Based on description logics theoretical studies, it allows a great expressiveness keeping computational soundness and completeness.
- OWL-Full: Using such a language, there is a huge syntactic flexibility and expressiveness. This freedom is paid in terms of no computational guarantee.

The ALN DL is basically a subset of OWL-DL.

Approaches to Resource Retrieval

We start with a description of various approaches to resource retrieval, highlighting limitations of non-logical approaches, then discussing the general knowledge representation principles that a logical approach may yield.

Modeling a resource retrieval framework using standard relational database techniques would require to completely align the attributes of the available and requested resources descriptions, in order to evaluate a match. On the other hand, if requests and offers are simple names or terms, the only possible match would be identity, resulting in an all-or-nothing approach to the retrieval process. Vague query answering, proposed by Motro (1988), was an initial effort to overcome limitations of relational databases, with the aid of weights attributed to several search variables.

Vector-based techniques taken by classical information retrieval can be used as well, thus, reverting the search for a matching request to similarity between weighted vectors of stemmed terms, as proposed in the COINS matchmaker (Kuokka & Harada, 1996) or in LARKS (Sycara, Klusch, & Lu, 2002). Such a formalization for resource descriptions makes retrieval only probabilistic because descriptions lack a document structure, causing strange situations to ensue. Let us consider for example the following sentences, describing respectively competences required for a job in a company and competences provided by a worker: "engineer, with experience of two years as project manager, not full time employed, available to transfers" and "experienced project manager, full time employed as engineer for two years, not available to transfers."

The former is a simple example in which two descriptions in obvious conflict may be considered an exact match because of the formalism chosen to represent them. A further approach structures resource descriptions as a set of words. This formalization allows one to evaluate not only identity between sets but also some interesting set-based relations between descriptions, such as inclusion, partial overlap, and cardinality of set difference. Modeling resource descriptions as set of words is anyway too much sensible to the choice of words employed to be successfully used: the fixed terminology misses meaning that relate words. Such a problem can be overcome by giving terms a logical and shared meaning through an ontology (Fensel, van Harmelen, Horrocks, McGuinness, & Patel-Schneider, 2001). Nevertheless, set-based approaches have some properties we believe are fundamental in a resource matching and retrieval process. If we are searching for a resource described through a set of words, we also are interested in sets including the one we search, because they completely fulfill the resource to retrieve. Moreover, even if there are characteristics of the retrieved resource not elicited in the description of the searched resource, an exact match is still possible because absent information have not to be considered negative. The two statements may be summarized in the following property:

- Property 1 [Open-world descriptions]: The absence of a characteristic in the description of a resource to be retrieved should not be interpreted as a constraint of absence. Instead, it should be considered as a characteristic that could be either refined later or left open if it is irrelevant for the user searching for the resource.

The set-based match evaluation is non-symmetric: If we search for a resource A, whose describing set of words is included in a set characterizing resource B, we may consider B a resource perfectly satisfying the request for A. On the other hand, if we use the description of B for the search, A also may satisfy the request only partially, as some of the terms describing B may be not included in the A set. We formalize this behaviour as follows:

- Property 2 [Non-symmetric evaluation]: Given two resource descriptions A and B, a resource retrieval system may give different rankings depending on whether it is searching A using B description as query, or B using A as query.

From now on, we assume that resource descriptions, requested and offered, are expressed in a DL. This approach includes the sets-of-keywords one, since a set of keywords also can be considered as a conjunction of concept names. We also assume that a common ontology is established, as a TBox in DL.

With reference to recent related work on logic-based matching and retrieval of resources, approaches are concentrated on electronic marketplaces, where resources are supplies and demands, and Web services discovery, where resources are e-services to be discovered and composed. Finin, Fritzson, McKay, and McEntire (1994) and Kuokka and Harada (1996) introduced matchmaking based on KQML, as an approach whereby potential producers/consumers could provide descriptions of their products/needs to be later unified by a matchmaker engine to identify potential matches. A rule-based approach using the knowledge interchange format (KIF) (Genesereth, 1991), the SHADE prototype (Kuokka & Harada, 1996), or a free-text comparison (the COINS prototype) (Kuokka & Harada, 1996) were used. Approaches similar to the previous ones were deployed in SIMS (Arens, Knoblock, & Shen, 1996), which used KQML and LOOM as description language and InfoSleuth (Jacobs & Shea, 1995), which adopted KIF and the deductive database language LDL++. LOOM also is at the basis of the matching algorithm addressed by Gil and Ramachandran (2001).

Sycara et al. (2002) and Paolucci, Kawamura, Payne, and Sycara (2002) proposed the LARKS language, specifically designed for agent advertisement. The matching process is a mixture of classical IR analysis of text and semantic match via Q-subsumption. Nevertheless, a basic service of a semantic approach, such as inconsistency check, seems unavailable with this type of match.

First approaches based on standard inference services offered by DL reasoners were proposed by Di Sciascio, Donini, Mongiello, and Piscitelli (2001), Gonzales-Castillo, Trastour, and Bartolini (2001), and Trastour, Bartolini, and Priest (2002). Di Noia, Di Sciascio, Donini, and Mongiello (2003b, 2003c) described and motivated properties that a matchmaker should have in a DL-based framework, and algorithms to classify and rank matches into classes were presented. Matchmaking of Web services, providing a ranking of matches based on this DL-based approach was presented by Colucci, Di Noia, Di Sciascio, Donini, and Mongiello (2003b). An extension to the approach by Paolucci et al. (2002) was proposed by Li and Horrocks (2003) where two new levels for service profiles matching were introduced. Notice that the intersection satisfiable level was introduced, whose definition is close to the one of potential matching proposed by Di Noia et al. (2003b), but no measure of similarity among intersection satisfiable concepts was given.

Benatallah, Hacid, Rey, and Toumani (2003) proposed an approach to Web services discovery based on the difference operator in DLs (Teege, 1994), followed by a set covering operation optimized using hypergraph techniques.

SEMANTIC-BASED RESOURCE RETRIEVAL

The Need for New Non-Standard Reasoning Services

In all those approaches where no explanation on the obtained results is requested or no belief revision is admitted, Subsumption and Consistency Checking are enough. The following are typical examples of the behaviour the reasoning services would have for resource retrieval:

- Subsumption: "Yes, your request is completely satisfied by resourceX"

  resourceX $\sqsubseteq$ request

- Consistency Checking: "No, your request is not compatible with resourceX"

  resourceX $\sqcap$ request $\equiv \bot$

Unfortunately, in a semantic-based resource retrieval system a simple yes/no answer cannot be enough; the requester is often interested in explanations especially when the system returns a negative answer. Some of the questions are:

- "What should I give up in my request in order to regain satisfiability with the offered resource?"
- "How should I contract my request?"
- "What should I revise in my request in order to be completely satisfied?"
- "What should I abduce in the available resource?"

Colucci et al. (2003a) and Di Noia et al. (2003a) introduced and defined Concept Abduction—for no-Subsumption explanation—and Concept Contraction—both for un-Consistency Checking explanation and for belief revision suggestion—as new non-standard inference services for DLs. In this subsection, we briefly recall their definitions, explaining their rationale and the need for them in resource retrieval.

Concept Contraction

Starting with the concepts O and R, if the conjunction O $\sqcap$ R is unsatisfiable in the TBox T representing the ontology—that is, they are not compatible with each other—we may want to retract requirements in R, G (for Give up), to obtain a concept K (for Keep) such that K $\sqcap$ O is satisfiable in T. This scenario can be formally depicted as:

Definition 2: Let L be a DL, O, R, be two concepts in L, and T be a set of axioms in L, where both O and R are satisfiable in T. A Concept Contraction Problem (CCP), identified by $\langle$L,R,O,T$\rangle$, is finding a pair of concepts $\langle$G,K$\rangle$ $\in$ L×L such that T $\models$ R $\equiv$ G $\sqcap$ K , and K $\sqcap$ O is satisfiable in T. We call K a contraction of R according to O and T.

We use Q as a symbol for a CCP, and we denote with SOLCCP(Q) the set of all solutions to a CCP Q. We note that there is always the trivial solution $\langle$G,K$\rangle$ = $\langle$R,T$\rangle$ to a CCP. This solution corresponds to the most drastic contraction, that gives up everything of R. In our resource retrieval framework, it models the (infrequent) situation in which, in front of some very appealing resource O, incompatible with the requested one, a user just gives up completely his or her specifications R in order to meet O. On the other hand, when O $\sqcap$ R is satisfiable in T, the "best" possible solution is $\langle$T,R$\rangle$, that is, give up nothing, if possible. Hence, a

Concept Contraction problem is an extension of a satisfiable one. Since usually one wants to give up as few things as possible, some minimality in the contraction must be defined (Gärdenfors, 1988). In most cases, a pure logic-based approach could not be sufficient to decide between which beliefs to give up and which to keep. There is the need of modeling and defining some extra-logical information to be taken into account. One approach is to give up minimal information (Colucci et al., 2003a). Another one considers some information more important than other and the information that should be retracted is the least important one, that is negotiable and strict constraints are introduced (Di Noia, Di Sciascio, & Donini, 2004).

Concept Abduction

If the offered resource O and the requested one R are compatible, the partial specifications problem still holds, that is, it could be the case that O—though compatible—does not imply R. Then, it is necessary to assess what should be hypothesized (H) in O in order to completely satisfy R.

Definition 3: Let L be a DL, O, R, be two concepts in L, and T be a set of axioms in L, where both O and R are satisfiable in T. A Concept Abduction Problem (CAP), identified by L,R,O,T$\rangle$, is finding a concept H $\in$ L such that $T \models O \sqcap H \sqsubseteq R$, and moreover $O \sqcap H$ is satisfiable in T. We call H a hypothesis about O according to R and T.

We use P as a symbol for a CAP, and SOL(P) to denote the set of all solutions to a CAP P. Observe that in the definition, we limit to satisfiable O and R, since R unsatisfiable implies that the CAP has no solution at all, while O unsatisfiable leads to counterintuitive results ($\neg$R would be a solution in that case). If $O \sqsubseteq R$, then we have H = T as a solution to the related CAP. Hence, Concept Abduction extends subsumption. On the other hand, if $O \equiv T$ then $H \sqsubseteq R$.

Notice that both Concept Abduction and Concept Contraction can be used for, respectively, subsumption and satisfiability explanation. For Concept Contraction, having two concepts not compatible with each other, in the solution $\langle G,K \rangle$ to the CCP $\langle L,R,O,T \rangle$, G represents "why" O and R are not compatible. For Concept Abduction , having R and O such that $T \not\models O \sqsubseteq R$, the solution H to the CAP $\langle L,R,O,T \rangle$ represents "why" the subsumption relation does not hold. H amounts to what is specified in R and not in O.

Expected performances of inference services are obviously of paramount importance to evaluate the feasibility of an approach. We hence provide some insight into complexity issues of the services. We note that since Concept Abduction extends Concept Subsumption w.r.t. a TBox, complexity lower bounds of the latter problem carry over to decision problems related to a CAP.

- Proposition: Let P $\langle L,R,O,T \rangle$, be a CAP. If Concept Subsumption w.r.t. a TBox in L is a problem C-hard for a complexity class C, then deciding whether a concept belongs to SOL(P) is C-hard.

As Concept Abduction extends Subsumption, Concept Contraction extends satisfiability—in particular, satisfiability of a conjunction $K \sqcap R$.

- Proposition: Let L be a DL containing $\mathcal{AL}$, and let Concept Satisfiability w.r.t. a TBox in L be a problem C-hard for a complexity class C. Then, deciding whether a pair of concepts is a solution of a CCP Q=$\langle L,R,O,T \rangle$, is C-hard.

Both for Concept Abduction and Concept Contraction, for every single CAP—conversely CCP—there is not only one solution. Different kinds of solution can be classified with respect to different minimality criteria. Colucci et al. (2003a), Di Noia et al. (2003a), and Colucci et al. (2004) present the definition of some minimality criteria and corresponding complexity results.

Approximate Resource Retrieval via Concept Abduction and Concept Contraction

We now show how the previously introduced services can help in an approximate, semantic-based search of resources, fully exploiting their structured description. Let us suppose to have request R and an appealing resource O such that $T \models R \sqcap O \equiv \bot$, that is, they are incompatible. In order to gain compatibility, a Concept Contraction is needed so that giving up G in R, the remaining K can be satisfied by O. Now, if $T \not\models O \sqsubseteq K$, the solution HK to the CAP ⟨L,R,O,T⟩ represents what is in K and is not specified in O.

As the O obtained is an approximated match of R, then a measure is needed on how good the approximation is. Given more than one appealing resource, which one is the best approximation? How can it be assigned a numerical score to the approximation, based on K, H and G, in order to rank the resources?

In table 1, we present a simple algorithm to provide answers to the raised issues.

Notice that H = abduce(O,R,T) [rows 3,6] determines H is a solution for the CAP ⟨L,R,O,T⟩; ⟨G,K⟩ = contract(O,R,T) [row 2] determines ⟨G,K⟩ is a solution for the CCP ⟨L,R,O,T⟩.

The algorithm retrieve returns values useful in a retrieval system where explanation of the results is needed and/or a belief revision process is admitted.

[rows 1-4] Having a requested resource R and an offered one O, if their descriptions conjunction is not satisfiable w.r.t. the ontology they refer to (i.e., they are not compatible with each other for some concepts in their descriptions), first a contraction on R is performed in order to regain compatibility [row 2], and then what is to be hypothesized in O in order to completely satisfy R (its contraction) is computed [row 3]. The returned values represent:

- G: What is to be given up in the request in order to continue the process, or, in other words, why R is not compatible with O.
- HK: After the contraction of R, the request is represented by K, that is, the portion of R which is compatible with O. HK represents what is to be hypothesized in O in order to completely satisfy K, or, in other words, why O does not completely satisfy K.

Table 1.

```
algorithm Retrieve(O,R,T,L)
input O, R η K6G concepts in L such that both T □ O and T □ R.
output ⟨G, H⟩,  respectively, the part in R that should be given up and the part in O
that should be hypothesized in order to find an exact match between O and R.
begin algorithm
1:      if T □ R6O η ∩ then
2:              ⟨G,K⟩ = contract(O,R,T);
3:              H_K = abduce(O,K,T);
4:              return ⟨G, H_K⟩;
5:      else
6:              H = abduce(O,R,T);
7:              return ⟨∅, H⟩;
end algorithm.
```

[rows 5-7] If the conjunction of R's and O's description is satisfiable w.r.t. the ontology they refer to, then no contraction is needed and only an abductive process is carried out.

The algorithm does not depend on the particular DL adopted. Based on the minimality criteria proposed by Di Noia et al. (2003a), the length |H| of the solution to a CAP for an ALN DL can be computed as proposed by Di Noia et al. (2003c). Hence, a relevance ranking score can be computed by an utility function defined as U(|G|,|K|,|HK|).

The rationale of the retrieve algorithm is hereafter presented with the aid of a simple example. Let $\mathcal{T}$, R, O be a set of axioms, a searched resource description, and an available resource description, respectively, defined as follows:

$\mathcal{T}$ = {
PC ⊑ Computer ⊓ ∃hasOS
HomePC ⊑ PC ⊓ ∀hasOS.MS ⊓ ∃pointer
HighLevel ⊑ ∃cost ⊓ ∀cost.Expensive
Expensive ⊑ ¬Cheap
MS ⊑ ¬Unix
}

R = HomePC ⊓ ∃monitor ⊓ ∀pointer. ∀cost.Cheap
O = PC ⊓ ∃pointer ⊓ ∀pointer.(Mouse ⊓ HighLevel) ⊓ ∀hasOS.Unix

First, we observe that T ⊨ R ⊓ O ≡ ⊥, due to the specifications on both Operating System and cost of the pointer. Hence, the algorithm performs a Concept Contraction solving the CCP ⟨$\mathcal{L}$,$\mathcal{R}$,$\mathcal{O}$,$\mathcal{T}$⟩. A solution for the previous CCP is:

⟨G,K⟩ = ⟨HomePC ⊓ ∀pointer.∀cost.Cheap, PC ⊓ ∃pointer ⊓ ∃monitor⟩

After the contraction operation, the remaining part of R is not yet satisfied by O. That is, O ⊑ K does not hold. To compute what is needed in order to realize the subsumption relation, retrieve solves the CAP ⟨L,K,O,T⟩. A solution for the previous CAP is: HK = ∃monitor

If the searching agent—with the term agent used in its broadest sense—is interested in O, it must give up HomePC ⊓ ∀pointer.∀cost.Cheap in its R and ask for further information about ∃monitor.

Retrieval performances have been usually evaluated in classical full text information retrieval in terms of precision and recall. Although such measures require large datasets to have any significance, it can be expected that semantic-based retrieval can provide at least a noteworthy improvement in precision, with respect to free-text probabilistic approaches.

FUTURE TRENDS

As the Semantic Web initiative gets momentum, more and more resources described using structured descriptions—based on ontologies—will become available (Schwartz, 2003). Current and future application scenarios of the semantic-based retrieval techniques presented here include: electronic-marketplaces of tangible or intangible goods, skill management systems, mediators for Web service discovery and for grid-based computational resources, and dating and personnel recruitment agencies. The increased availability of semantically annotated descriptions will hence boost the emergence of knowledge-based systems able to take full advantage of these structured descriptions to obtain accurate and efficient retrieval. The framework and services described in this article are general enough to be used in the approximate search and retrieval of a variety of resources, and systems using them can provide—adopting different minimality criteria—logically motivated relevance-based rankings in the retrieval process. The necessary trade-off between expressivity and performance of semantic-based systems is likely to be exploited adopting various approaches. Among them, tableaux-based algorithms (Colucci et al., 2004); careful choice of constructs able to keep complexity tractable, as proposed for example with DL-Lite by Calvanese, De Giacomo, Lenzerini, Rosati, & Vetere (2004), and combined use of DL-based easoners with classical relational databases to face scalability issues when dealing with large numbers of individuals (Horrocks, Li, Turi, & Bechhofer, 2004).

CONCLUSION

We have presented and motivated new DL-based inference services for semantic-based resource retrieval. Currently, our approach is fully devised, and algorithms and a prototype system have been implemented for an ALN description logic. Work also is in progress to extend the approach to more expressive DLs, while keeping time performances still acceptable.

REFERENCES

Arens, Y., Knoblock, C.A., & Shen, W. (1996). Query reformulation for dynamic information integration. *Journal of Intelligent Information Systems, 6,* 99-130.

Baader, F., Calvanese, D., Mc Guinness, D., Nardi, D., & Patel-Schneider, P. (Eds.). (2002). *The description logic handbook*. Cambridge, MA: Cambridge University Press.

Baader, F., & Turhan, A. (2002). On the problem of computing small representations of least common subsumers. *KI 2002: Advances in Artificial Intelligence, 25th Annual German Conference on AI, Vol. 2479 of Lecture Notes in Computer Science* (pp. 99-113). Berlin: Springer.

Benatallah, B., Hacid, M.-S., Rey, C., & Toumani, F. (2003). Request rewriting-based Web service discovery. *International Semantic Web Conference, vol. 2870 of Lecture Notes in Computer Science* (pp. 242-257). Berlin: Springer.

Brachman, R., & Levesque, H. (1984). The tractability of subsumption in frame-based description languages. *Proceedings of the 4th National Conference on Artificial Intelligence (AAAI-84)* (pp. 34-37). Cambridge, MA: Morgan Kaufmann.

Calvanese, D., De Giacomo, G., & Lenzerini, M. (1998). On the decidability of query containment under constraints. *Proceedings of the 17th ACM SIGACT SIGMOD SIGART Symposium on Principles of Database Systems (PODS'98)* (pp. 149-158).

Calvanese, D., De Giacomo, G., Lenzerini, M., Rosati, R., & Vetere, G. (2004). DL-Lite: Practical reasoning for rich Dls. *Proceedings of the 17th International Workshop on Description Logics (DL'04)*, vol. 104 of CEUR Workshop Proceedings.

Colucci, S., Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2003a). Concept abduction and contraction in description logics. *Proceedings of the 16th International Workshop on Description Logics (DL'03),* vol. 81 of CEUR Workshop Proceedings.

Colucci, S., Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2003b). Logic based approach to Web services discovery and matchmaking. *Proceedings of the E-Services Workshop at ICEC'03.*

Colucci, S., Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2004). Uniform tableaux-based approach to concept abductiona and contraction in ALN DL. *Proceedings of the 17th International Workshop on Description Logics (DL'04),* vol. 104 of CEUR Workshop Proceedings.

Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2003a). Abductive matchmaking using description logics. *Proceedings of the 18th*

International Joint Conference on Artificial Intelligence (IJCAI 2003) (pp. 337-342). Morgan Kaufmann.

Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2003b). Semantic matchmaking in a P-2-P electronic marketplace. *Proceedings of the Symposium on Applied Computing (SAC '03)* (pp. 582-586). ACM.

Di Noia, T., Di Sciascio, E., Donini, F., & Mongiello, M. (2003c). A system for principled matchmaking in an electronic marketplace. *Proceeding for the International World Wide Web Conference (WWW '03)* (pp. 321-330). ACM.

Di Noia, T., Di Sciascio, E., & Donini, F. (2004). Extending semantic-based matchmaking via concept abduction and contraction. *Proceedings of the 14th International Conference on Knowledge Engineering and Knowledge Management (EKAW 2004),* vol. 3257 of Lecture Notes in Computer Science (pp. 307-320). Springer.

Di Sciascio, E., Donini, F., Mongiello, M., & Piscitelli, G. (2001). A knowledge-based system for person-to-person e-commerce. *Proceedings Workshop on Applications of Description Logics (KI 2001)*, vol. 44 of CEUR Workshop Proceedings.

Donini, F. M., Lenzerini, M., Nardi, D., & Schaerf, A. (1996). Reasoning in description logics. In Brewka, G. (Ed.), *Principles of knowledge representation: Studies in logic, language and information* (pp. 193-238). Stanford, CA: CSLI Publications.

Fensel, D., van Harmelen, F., Horrocks, I., McGuinness, D., & Patel-Schneider, P.F. (2001). OIL: An ontology infrastructure for the Semantic Web. *IEEE Intelligent Systems, 16*(2), 38-45.

Finin, T., Fritzson, R., McKay, D., & McEntire, R. (1994). KQML as an agent communication language. *Proceedings of the 3rd International Conference on Information and Knowledge Management (CIKM'94)* (pp. 456-463). ACM.

Gärdenfors, P. (1988). *Knowledge in flux: Modeling the dynamics of epistemic states.* Cambridge, MA: Bradford Books, MIT Press.

Genesereth, M.R. (1991). Knowledge interchange format. *Principles of Knowledge Representation and Reasoning: Proceedings of the 2nd International Conference* (pp. 599-600). Cambridge, MA: Morgan Kaufmann.

Gil, Y., & Ramachandran, S. (2001). PHOSPHORUS: A task based agent matchmaker. *Proceedings for AGENTS '01* (pp. 110-111). ACM.

Gonzales-Castillo, J., Trastour, D., & Bartolini, C. (2001). Description logics for matchmaking of services. *Proceedings of the Workshop on Application of Description Logics (KI 2001),* vol. 44 of CEUR Workshop Proceedings.

Gruber, T. (1993). Toward principles for the design of ontologies used for knowledge sharing. *International Journal of Human-Computer Studies, 43*(5), 907-928.

Horrocks, I., Li, L., Turi, D., & Bechhofer, S. (2004).The instance store: DL reasoning with large numbers of individuals. *Proceedings of the 17th International Workshop on Description Logics (DL'04),* vol. 104 of CEUR Workshop Proceedings.

Jacobs, N., & Shea, R. (1995). Carnot and Infosleuth: Database technology and the Web. *Proceedings of the ACM SIGMOD International Conference on Management of Data* (pp. 443-444). ACM.

Kuokka, D., & Harada, L. (1996). Integrating information via matchmaking. *Journal of Intelligent Information Systems, 6,* 261-279.

Li, L., & Horrocks, I. (2003). A software framework for matchmaking based on Semantic Web technology. *Proceedings of the International World Wide Web Conference (WWW '03)* (pp. 331-339). ACM.

Motro, A. (1988). VAGUE: A user interface to relational databases that permits vague queries. *ACM Transactions on Office Information Systems, 6*(3), 187-214.

Paolucci, M., Kawamura, T., Payne, T., & Sycara, K. (2002). Semantic matching of Web services capabilities. *The Semantic Web—ISWC 2002, number 2342 in Lecture Notes in Computer Science* (pp. 333-347). Berlin: Springer-Verlag.

Schwartz, David G., Open IS (2003). Semantics and the Semantic Web: The road ahead. *IEEE Intelligent Systems, 18*(3), 52-58.

Sycara, K., Widoff, S., Klusch, M., & Lu, J. (2002). LARKS: Dynamic matchmaking among heterogeneus software agents in cyberspace. *Autonomous agents and multi-agent systems, 5,* 173-203.

Teege, G. (1994). Making the difference: A subtraction operation for description logics. *Proceedings of the 4th International Conference on the Principles of Knowledge Representation and Reasoning (KR'94)* (pp. 540-550). Cambridge, MA: Morgan Kaufmann.

Trastour, D., Bartolini, C., & Priest, C. (2002). Semantic Web support for the business-to-business e-commerce lifecycle. *Proceedings of the WWW '02* (pp. 89-98). ACM.

Chapter 3.5
Knowledge Flow

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INTRODUCTION

Various models and frameworks have been used to represent the flows of knowledge in an organization. The first and most popular of these remains the spiraling SECI (socialization, externalization, combination, internalization) model presented by Nonaka and Konno (1998), Nonaka and Takeuchi (1995), and Nonaka and Toyama (2003), which presents the various knowledge interactions and creations between tacit and explicit knowledge. Knowledge flows can also be represented and assessed through the knowledge life cycle.

Knowledge creation, discovery, capture
⇩
Knowledge storage, retention, organization
⇩
Knowledge transfer, sharing, distribution
⇩
Knowledge use & maintenance

In this article, we describe knowledge flows through a third lens that is based on how people obtain and/or share the knowledge that they need to perform their work. We found a certain agreement on a typology defining two main strategies for knowledge flows: codification vs. personalization.

BACKGROUND

The Codification Strategy

The codification strategy is intended to collect, codify, and disseminate information. It relies heavily on information technology. One of the benefits of the codification approach is the reuse of knowledge. According to Davenport and Prusak (1998, p. 68):

The aim of codification is to put organizational knowledge into a form that makes it accessible *to those who need it. It literally turns knowledge into a code (though not necessarily a computer code) to make it as organized, explicit, portable, and easy to understand as possible.*

The codification strategy has been named and described in different ways by various authors. In 1999, Hansen, Nohria, and Tierney published an article in the Harvard Business Review titled "What's your strategy for managing knowledge?" In this article, they describe how different companies focus on different practices and strategies in order to manage their knowledge. The first approach is called codification, where the strategy centers on the computer:

Knowledge is codified and stored in databases, where it can be accessed and used easily by anyone in the company. Knowledge is codified using a people-to-documents approach: it is extracted from the person who developed it, made independent of that person, and reused for various purposes. (Hansen et al., p. 108)

Hansen et al. illustrate this strategy with the case of two consulting companies, Anderson Consulting and Ernst & Young, which adopted this strategy due to the fact that their activity mainly focused on implementation projects rather than on purely innovative projects. Stephen Denning (1998), former CKO of the World Bank, describes two different ways of sharing knowledge: the collecting dimension and the connecting dimension. The collecting dimension is described as the "capturing and disseminating of know-how through information and communication technologies aimed at codifying, storing and retrieving content, which in principle is continuously updated through computer networks" (Denning, p. 10).

Know-Net (2000), a "Leading Edge Total Knowledge Management [KM] Solution" developed by an European consortium, incorporates such an approach. Know-Net calls it the product view and the process view. The product-view approach is described as focusing on products and artifacts containing and representing knowledge. This implies the management of documents, and their creation, storage, and reuse in computer-based corporate memories. The competitive strategy is to exploit organized, standardized, and reusable knowledge.

Natarajan and Shekhar (2000) present two models, the transformation model and the independent model, that clearly comply with the previous descriptions. The transformation model deals with explicit knowledge, relying mainly on document capture, structured databases, knowledge-extraction tools, text mining, and search and retrieval applications.

A Lotus white paper, describing KM and collaborative technologies, categorizes KM applications as distributive or collaborative: "Distributive applications maintain a repository of explicitly encoded knowledge created and managed for subsequent distribution to knowledge consumers within or outside the organization" (Zack & Michael, 1996).

As we can observe, all these descriptions and definitions are very closely related in depicting a codification strategy. For the remainder of this article, we will adopt the codification naming in order to refer to the type of approaches previously described.

The Personalization Strategy

The personalization strategy focuses on developing networks for linking people so that tacit knowledge can be shared. It invests moderately in IT. This approach corresponds to the Nonaka and Takeuchi (1995), and Nonaka and Toyama (2003) personalization phase of the SECI model where knowledge flow and creation happen during an exchange of tacit knowledge. The authors, who previously defined the codification strategy, also provide their own definition of the personalization strategy. Hansen et al. (1999) named it personalization. It focuses on dialogue between individuals as opposed to knowledge in a database: "Knowledge that has not been codified—and probably couldn't be—is transferred in brainstorming sessions and one-on-one conversations" (Hansen et al.). An investment is made in building networks of people, where knowledge is shared not only face-to-face, but also over the telephone, by e-mail, and via videoconference. Hansen et al. illustrate this strategy with the case of three consulting companies, McKinsey, BCG, and Bain, which adopted this strategy since they mainly focus on customized and innovative projects. Stephen Denning (1998) defines this strategy as the connecting dimension:

It involves linking people who need to know with those who do know, and so developing new capabilities for nurturing knowledge and acting knowledgeably. For example, help desks and advisory services (small teams of experts whom one can call to obtain specific know-how or help in solving a problem) can be very effective in the short term in connecting people and getting quick answers to questions, thus accelerating cycle time, and adding value for clients.

Know-Net (2000) defines this as the process-centered approach, which focuses on knowledge management as a social communication process. It facilitates conversations to exchange knowledge and can be improved by various aspects and tools of collaboration and cooperation support.

Natarajan and Shekhar (2000) use the independent-model designation to describe the tools that attempt to find solutions for the sharing of tacit knowledge. They list a number of technologies that could be used to facilitate the sharing of knowledge. Among them are technologies such as Web-based training used for skill-enhancement programs. Yellow pages, Web crawlers, broadcast applications, communities of practice (using expert locators, collaboration, virtual work-space applications), and the sharing of best practices (using knowledge repositories and discussion-group-based applications) are also examples of knowledge sharing.

Zack and Michael (1996) talk about the collaborative approach that focuses primarily on supporting interaction and collaboration among people holding tacit knowledge. They highlight that:

in contrast to distributive applications, the repository associated with collaborative applications is a by-product of the interaction, rather than the primary focus of the application. This repository of messages is dynamic and its content emergent. The ability to capture and structure emergent communication within a repository provides a more valuable, enduring, and leverageable knowledge by-product than the personal notes or memories of a traditional conversation or meeting. Collaboration technologies, therefore, can support a well-structured repository of explicit knowledge while enabling the management of tacit knowledge. The knowledge repository represents a valuable means to manage the explication, sharing, combination, application, and renewal of organizational knowledge. (Zack & Michael).

Once again, we can observe that all of these descriptions and definitions are very similar and depict the same type of processes and tools. Personalization approaches facilitate the person-to-person knowledge transfer. For the rest of this article, we will adopt the personalization designation in order to refer to the type of approaches previously described.

Codification vs. Personalization

What is the best strategy for managing knowledge? Hansen et al. (1999) noted that effective organizations excel by primarily emphasizing one of the strategies and using the other in a supporting role. They postulate that companies trying to excel at both strategies risk failing at both. They refer to a 20-80 split between codification and personalization. This proposal raised much discussion in the literature (Koenig, 2004) and in the HBR

Figure 1. The codification strategy

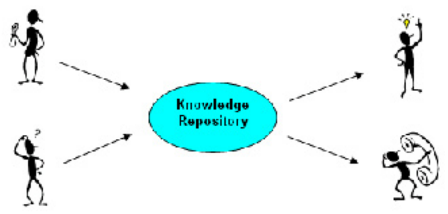
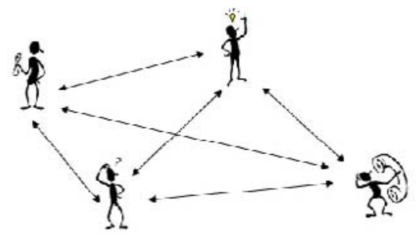


Figure 2. The personalization strategy



forum referring to this article (HBR Forum, 1999). Denning (1998) mentioned that organizations that focus entirely on a personalization approach, with little or no attempt at codification, can be very inefficient.

In order to select an adoption strategy, Tiwana (2002) designed a checklist based on the recommendations of Hansen et al. They recommended examining the company's competitive strategy (What value do customers expect from the company? How does the knowledge that resides in the company add value to customers' goals?). Once the competitive strategy is clear, three additional questions might be investigated.

- Does your company offer standardized or customized products?
- Does your company have a mature or innovative product?
- Do people rely on explicit or tacit knowledge to solve problems?

Companies having standardized products and/or mature products might want to focus on a codification approach. In contrast, companies having customized and/or innovative products might want to focus on a personalization approach. People relying on explicit knowledge will also be more disposed to adopt a codification approach. Furthermore, recent research highlights the critical role that organizational culture and interpersonal trust have in the selection of these two KM strategies (Ribière, 2001; Ribière & Tuggle, 2005; Román-Velázquez, 2004; Román, Ribière, & Stankosky, 2004). They demonstrated that the success of a KM strategy might be directly impacted by the type of organizational culture present in the organization.

The next section of this article presents the findings of an empirical study of U.S. organizations, covering the government, for-profit, and nonprofit sectors. The study was conducted to characterize the strategic approach for knowledge flow within the different sectors.

EMPIRICAL STUDY

The data analyzed in this article were collected during two independent research studies performed by Ribière (2001) and Román-Velázquez (2004), which evaluated the KM strategy (codification and personalization) that employees predominantly use to facilitate the flow of knowledge throughout the organization. Ribière's research developed a list of 23 items that were theoretically divided into two groups: one for codification and one for personalization. However, Román-Velázquez modified and reduced the list to 20 items based on an extensive literature review (Hoyt, 2001; Kemp, Pudlatz, Perez, & Munoz Ortega, 2001; Marwick, 2001; McKellar & Haimila, 2002; Shand, 1998) and after detailed conversations with expert practitioners in the field of KM, human resources, experiment design, and information technology (Boswell, 2002; Naus, 2002; Reed,

Table 1. Responses by category

	Frequency	Percent	Cumulative Percent
For-Profit	66	15.3	15.3
Government	313	72.6	87.9
Nonprofit	52	12.1	100.0
Total	431	100.0	

2002; Rhoads, 2002). In addition, the model was validated during previous research and found to be accurate and reliable (Román-Velázquez; Román-Velázquez et al., 2004).

For this study, the data were concatenated, creating a new data set with 431 respondents (N = 431) as described in Table 1. A total of 13 indicator variables were retained for analysis. The variables were evaluated using a seven-point scale where 1 is Very Minimum Extent, 7 is Very Great Extent, and 0 is assigned to responses for Don't Know and Don't Exist. This study employed inferential statistical analysis, using the data collected from respondents to make estimates about a much larger population. The confidence levels and confidence intervals are two key components of the sampling error estimates and refer to the probability that our estimations are correct (Babbie, 1998; Sekaran, 1992). Using N = 431 as the responses collected and a 95% confidence level, the confidence interval is calculated to be ± 4.72.

The data analysis revealed mean score values for the 13 indicator variables ranging from 5.47 to 3.14 as shown in Table 2. Their mean score provides an indication of their usage and popularity. The table can be analyzed using two perspectives: by

Table 2. Descriptive statistics for the technologies, support tools, and processes utilized throughout the organization

Technologies, Support Tools, & Processes[1]	**C/P**	**Mean**	**Standard Deviation**
Intranet/Extranet	C	5.74	1.55
Phone calls/Teleconferencing	P	5.40	1.81
Search Engines/Information-Retrieval Systems	C	4.77	1.98
Working Groups/Communities of Practice	P	4.26	2.02
Document Management/Content Management	C	4.05	2.05
Web-Based Training/E-Learning	C	3.97	1.92
Mentoring/Tutoring	P	3.87	2.04
Videoconferencing	P	3.77	2.04
Benchmarking/Best Practices	C	3.69	2.00
Multimedia Repositories	C	3.45	2.09
Data Mining/Knowledge-Discovery Tools	C	3.30	2.11
Expertise Locator/Directory of Expertise	P	3.19	2.23
Storytelling	P	3.14	2.13

N = 431   C: codification; P: personalization the absolute mean score compared to all items, and by considering the KM strategy that each item represents independently.

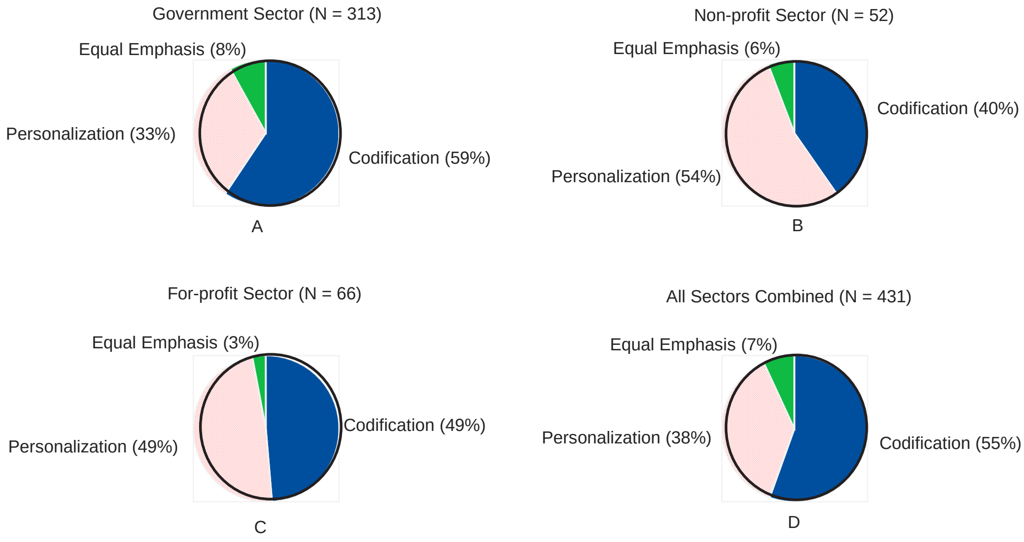
A closer inspection of the results showed that a total of five items had high scores: mean scores above 4.0 (midpoint). They were intranets and extranets, phone calls and teleconferencing, search engines and information-retrieval systems, working groups and communities of practice, and document management and content management. The frequent use of these technologies and tools by employees increases the flow of knowledge within the organization, therefore having a greater impact than all the others.

Intranet/extranet scores at the top of the tools usage for a codification strategy. It is not surprising since intranets and extranets are often the first technology that organizations deploy in order to facilitate intra- and extraorganizational collaboration and knowledge exchange. It is the core component necessary to deploy a portal. Intranet/extranet is followed by search engines and information-retrieval systems, and document management and content management. The easy retrieval and archival of documents and content remain core functionalities of the codification approach that increase the velocity of codified knowledge flow. These technologies within the codification strategy can be categorized as enabling the sharing of knowledge from one to many or many to many, and were utilized by the majority of the respondents within the government, for-profit, and nonprofit sectors.

Regarding the personalization strategy, phone calls and teleconferencing were found to be the most utilized ways to share tacit knowledge between people within all the sectors included in the study. This finding can be explained by the fact that this technology has been available for decades and knowledge workers are familiar with them. Their use is often the employees' first and instinctive reaction when looking for help or advice. In second position are working groups and communities of practice. During the past years, a strong emphasis on communities and their benefits has emerged in the KM literature. This success is due to the fact that their implementation is simple, and knowledge workers perceived them as a good way to learn and connect with other knowledge workers. Furthermore, organizations that have silos utilized them as a good way to breach boundaries across silos and to foster collaboration and knowledge exchanges. Mentoring and tutoring tools take the third position of the personalization strategy. One way to pass on or share the tacit knowledge that older employees have acquired throughout their career is to mentor and/or tutor new or younger colleagues. Once again, this practice is not new, but it remains one of the most popular and the most efficient way to transfer tacit knowledge. Both communities and mentoring and tutoring are support tools and processes that are being widely used within the government sector to address the potential human-capital crisis that is looming with the exodus of baby boomers from the workforce. As of fiscal year 2002, approximately 71% of the government's permanent employees will be eligible for either regular or early retirement by 2010. Of those eligible, 40% are expected to do so (The President's Management Agenda Fiscal Year 2002).

A more in-depth analysis of the data was performed using the validated knowledge-flow model in order to identify the dominant KM strategy within the different sectors under consideration. The analysis reveals that codification is the dominant strategy employed by 59.4% (N = 186) of respondents in the government sector, with 32.6% (N = 102) utilizing a dominant personalization strategy. Only 8% (N = 25) utilized both in a balanced manner (equal emphasis) as shown in Figure 3A. This outcome could be an indication that the large numbers of rules and statutory regulations that guide and define the nature of government business is a major factor driving the dominant KM strategy of codification. However, Figure 3B shows the nonprofit sector having a nearly opposite strategic approach, with

Figure 3. Codification and personalization factors as dominant strategic approaches for the flow of knowledge within the organization



53.8% (N = 28) of respondents utilizing a dominant personalization strategy and 40.4% (N = 21) a dominant codification strategy. It also shows a reduction to 6% in the number of respondents that are utilizing a balance codification and personalization strategies. The results provide evidence that the nonprofit sector leverages more on the flow of knowledge between people than on documents. This characteristic could be due to the business nature of most nonprofit organizations. On the other hand, the data analyzed in the for-profit sector show the respondents are equally divided in their selection of a dominant KM strategy. Figure 3C shows that a total of 49% of respondents utilize a dominant codification strategy with the same number utilizing a dominant personalization strategy. In addition, only 3% of respondents employ a completely balanced approach utilizing both dominant strategies. This balanced approach is the lowest of all the three sectors. Lastly, Figure 3D illustrates all sectors combined.

Based on the above results, if we were to describe the KM strategic approach for knowledge flow as a continuum, we would have the government sector at one end and the nonprofit sector at the other end. The for-profit sector would fall approximately in the middle of the continuum. Moreover, it demonstrates that the sectors are considerably different from each other. This highlights the fact that many organizations have found that both codification and personalization approaches are needed for an effective knowledge-management effort. The emphasis of one approach over the other or its balance depends heavily on the organization's overall strategy. The correct emphasis depends on the manner in which the organization serves its clients and stakeholders, the economics of its business (e.g., for-profit, nonprofit, government), the human capital it possesses, and the culture of the organization. The above results demonstrate that the types of technologies, tools, and processes that CKOs, KM architects, KM managers, and other decision makers should select for implementation need to be carefully evaluated based on the many influencing factors identified above in order to achieve their expected benefits.

FUTURE TRENDS

KM practices and technologies are constantly evolving. The Gartner (2003) research group published a knowledge-management "hype cycle" that describes the evolution and maturity of KM technologies. During the past years, an emergence of synchronous collaborative technologies has emerged, and some have been rapidly adopted to facilitate knowledge flows. As an example, instant messaging is increasingly used for business purposes in order to facilitate presence awareness and knowledge exchange. Portal solutions like Microsoft Sharepoint 2003 already embed this capability. When employees access information on the portal (document, electronic discussion posting, expertise profile, etc.), they can see if the author is currently logged in and can eventually contact him or her by instant messaging or by e-mail. New wireless devices will also provide new ways to facilitate knowledge exchange. New tools, practices, and technologies will provide new knowledge-flow channels, but the underlying knowledge-flow strategies (codification and personalization) will remain the same. We believe that companies will attach more and more importance to personalization strategies since it can be viewed by some companies and authors (Wick, 2000) as a logical evolution from the codification approach.

CONCLUSION

It is important to remember that the codification and personalization KM strategies are not incompatible. Companies must use both strategies simultaneously, but might need to put more emphasis on one of these strategies than on the other. Hansen et al. (1999) suggested a 20-80 split between these two strategies, but our empirical study demonstrated that in practice, there is not such a clear distinction between the emphasis associated to each. Companies interested in launching a KM initiative or companies working on taking their KM initiative to the next level need to asses what strategy will best fit their needs and which will be the most likely to succeed based on their organizational culture. Focusing on the right knowledge-flow strategy is one of the keys to a successful KM journey.

REFERENCES

Babbie, E. (1998). *The practice of social research* (8th ed.). Belmont, CA: Wadsworth Publishing Company.

Boswell, H. W. (2002). *KM survey suggestions.* In J. Roman (Ed.). Greenbelt, MD: COMPANY.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Denning, S. (1998). *What is knowledge management?* Retrieved from http://www.worldbank.org/ks/index.html

Encyclopedia Britannica Ready Reference (10th ed.) [CD]. (2001). Encyclopaedia Britannica, Inc.

Gartner. (2003). *Hype cycle for knowledge management* (No. R-20-0010).

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

HBR Forum. (1999). Retrieved January 2001 from http://www.hbr.org

Hoyt, B. J. (2001). *KM technology & tools listing.* Retrieved October 15, 2004, from http://www.kmnews.com

Kemp, J., Pudlatz, M., Perez, P., & Munoz Ortega, A. (2001). *KM technologies and tools*. European KM Forum.

Know-Net. (2000). *The approach*. Retrieved from http://www.know-net.org

Koenig, M. E. D. (2004). Knowledge management strategy: Codification versus personalization (A false dichotomy). In M. E. D. Koenig & K. T. Srikantaiah (Eds.), *Knowledge management lessons learned: What works and what doesn't?* Medford, NJ: Information Today.

Marwick, A. D. (2001). Knowledge management technology. *IBM Systems Journal, 40*(4), 814-830.

McKellar, H., & Haimila, S. (Eds.). (2002). *KM-World buyers' guide* (Fall 2002 ed.). Medford, NJ: KM World & Information Today.

Merriam-Webster Dictionary & Thesaurus. (Version 2.6) [CD]. (2002). Merriam-Webster's, Inc.

Natarajan, G., & Shekhar, S. (2000). *Knowledge management: Enabling business growth*. New Delhi, India: Tata McGraw-Hill.

Naus, S. A. (2002). *KM server suggestions*. Greenbelt, MD.

Nonaka, I., & Konno, N. (1998). The concept of Ba: Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. Oxford: Oxford University Press.

Nonaka, I., & Toyama, R. (2003). The knowledge-creation theory revisited: Knowledge creation as a synthesizing process. *Knowledge Management Research and Practice, 1*(1), 2-10.

Pollock, N. (2002). *Knowledge management and information technology encyclopedia* (1st ed.). Fort Belvoir, VA: Defense Acquisition University Press.

Reed, D. E. (2002). *KM survey suggestions*. In J. Roman (Ed.), Greenbelt, MD.

Rhoads, E. (2002). *KM survey suggestions*. Washington, DC.

Ribière, V. (2001). *Assessing knowledge management initiative successes as a function of organizational culture*. DSc dissertation, George Washington University, Washington, DC.

Ribière, V., & Tuggle, F. D. (2005). The role of organizational trust in knowledge management tools and technology use and success. *International Journal of Knowledge Management, 1*(1).

Román-Velázquez, J. A. (2004). *An empirical study of knowledge management in the government and nonprofit sectors: Organizational culture composition and its relationship with knowledge management success and the approach for knowledge flow*. DSc dissertation, George Washington University, Washington, DC.

Román-Velázquez, J. A., Ribière, V., & Stankosky, M. A. (2004). Organizational culture types and their relationship with knowledge flow and knowledge management success: An empirical study in the US government and nonprofit sectors. *Journal of Information & Knowledge Management (JIKM), 3*(2).

Sekaran, U. (1992). *Research methods for business* (2nd ed.). New York: John Wiley & Sons.

Shand, D. (1998). Harnessing knowledge management technologies in R&D. *Knowledge Management Review, 3*, 20-26.

Tiwana, A. (2002). *The knowledge management toolkit: Orchestrating IT, strategy, and knowledge platforms* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Wick, C. (2000). *Knowledge management and leadership opportunities for technical communicators*. Technical Communications.

Zack, M. H., & Michael, S. (1996). *Knowledge management and collaboration technologies* (White paper). The Lotus Institute, Lotus Development Corporation.

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Chapter 3.6
Use and Methods of Social Network Analysis in Knowledge Management

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INTRODUCTION

Whilst the primary importance of informal communities of practice and knowledge networks in innovation and knowledge management is widely accepted (see Armbrecht et al., 2001; Brown & Duguid, 1991; Collinson & Gregson, 2003; Jain & Triandis, 1990; Lesser, 2001; Liyanage, Greenfied & Don, 1999; Nahapiet & Ghoshal, 1998; Nohria & Eccles, 1992; Wenger, 1999; Zanfei, 2000), there is less agreement on the most appropriate method for their empirical study and theoretical analysis. In this article it is argued that social network analysis (SNA) is a highly effective tool for the analysis of knowledge networks, as well as for the identification and implementation of practical methods in knowledge management and innovation.

Social network analysis is a sociological method to undertake empirical analysis of the structural patterns of social relationships in networks (see, e.g., Scott, 1991; Wasserman & Faust, 1994; Wellman & Berkowitz, 1988). This article aims at demonstrating how it can be used to identify, visualize, and analyze the informal personal networks that exist within and between organizations according to structure, content, and context of knowledge flows. It will explore the benefits of social network analysis as a strategic tool on the example of expert localization and knowledge transfer, and also point to the limits of the method.

BACKGROUND

Words have meanings: some words, however, also have a 'feel'. The word 'community' is one of them. It feels good: whatever the word 'community' may mean, it is good 'to have a community', 'to be in a community'. (Bauman, 2001, p. 1)

The term "community" is widely used, yet imprecisely defined in the sociological literature.

Whilst there is consensus that community is a fundamental unit of social organization, there is little agreement on how best to describe it as a sociological entity (see Poplin, 1979, pp. 11-12). The fact that the term "community" refers to different things, depending upon who is using it and upon the context in which it is used, can render it useless for scientific purposes (see Poplin, 1979, p. 4). Nevertheless, the use of the community concept, or community "metaphor," is flourishing in the social sciences, as well as in political debates and management strategies. One of the foremost applications of the term is in the domain of knowledge communities or communities of practice.

One alternative approach is to view communities as networks. Drawing on the methods and tools of sociometry, the development of formal approaches to social networks began with Moreno (1934), and was systematized and fundamentally elaborated by means of graph theory (König, 1936) through Cartwright and Harary (1956). The breakthrough of social network analysis as a method of structural analysis was reached in the 1960s by White and his Harvard colleagues (see Scott, 1991, pp. 33-38; for a review of the large number of applications of social network analysis, see, e.g., Wellmann & Berkowitz, 1988).

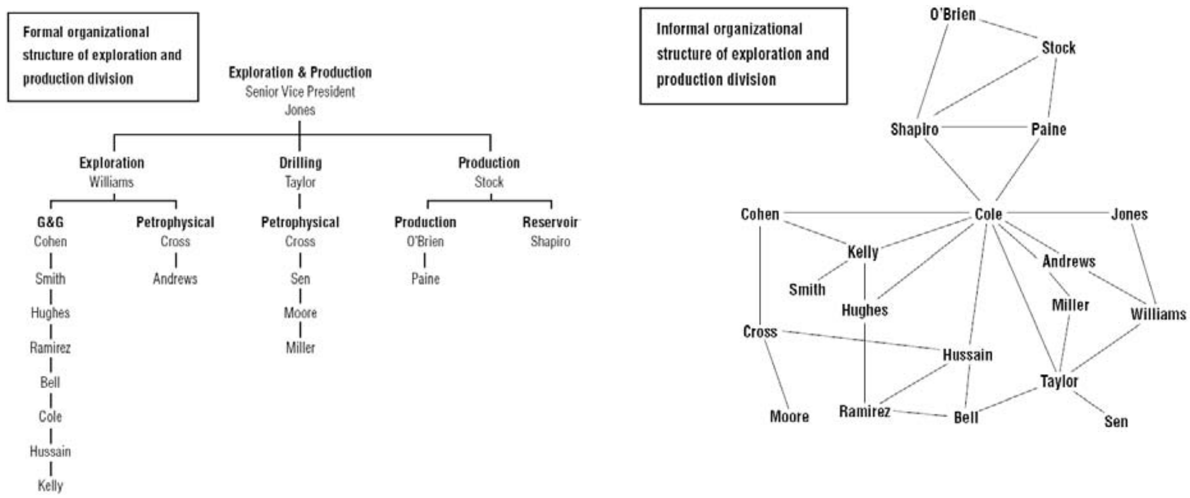
A conceptualization of communities as social networks was outlined by Poplin (1979) in his analysis of community literature as a "network of interaction" (pp. 14-18). In Poplin's view, there is at least one major advantage in conceptualizing communities in this way: "It serves well as a tool by which to describe systematically the interrelationships of the various units that compose the community. This alone can help increase our understanding of community structure and process" (p. 16). Poplin's perspective helps us to build the case of communities of practice as social networks. In doing so, it provides us with both a unit of analysis and the means to develop and employ an empirical method and practical tool, that of social network analysis. The provision of a conceptual framework and powerful tool for the analysis of informal social structures is emphasized here as its major advantages.

USE

Informal knowledge networks are not a new invention in the knowledge management literature. Crane (1972), for example, published her widely recognized study on the diffusion of knowledge in scientific communities. Even earlier, the classic Hawthorne studies included in their principal report of 1939 various sociograms that the research team saw as reflecting the "informal organization" of a bank's wiring room (as opposed to the formal organization depicted by the organization chart) (see Roethlisberger & Dickson, 1947, pp. 500-548). Whether speaking about communities of practice, knowledge communities, or knowledge networks, all these concepts have a common core that can be subsumed under the "social capital" construct. Burt (2000) elaborates upon this point and suggests that the social capital concept is essentially "a metaphor about advantage" (p. 2), that is, the better the social connections between people, the higher the collective and individual returns for them. Cross, Parker, and Borgatti (2002) describe this advantage of connection as "who you know has a significant impact on what you come to know" (p. 2). From here, we can identify the logical underpinning of social network analysis as the empirical study of connections between individuals within communities.

Social network analysis uses several techniques to empirically identify underlying patterns of social structure. It then compares these individual patterns with their influence on specific network behavior variables and performance outcomes. From a knowledge management perspective, social network analysis helps us identify basic network properties, positions of network members, characteristics of relations, cohesive sub-groups, and bottlenecks of knowledge flows. By point-

Figure 1. Formal vs. informal in a petroleum organisation (IBM Institute for Business Value, 2002)[1]



ing to who shares knowledge with whom, social network analysis shows us the informal relations within and between organizations (see Figure 1). In doing so, it allows the researcher to identify and maybe influence a network's and its members' ability to create and to share knowledge.

Although social network analysis must always begin with some initial populations, one important advantage of the method is that it does not view formal boundaries (such as departments) as truly social boundaries. Rather, it traces social relationships wherever they may exist and extend. (Laumann, Marsden & Prensky, 1989, discuss the boundary specification problem in network analysis at length.) In this way, we can identify the following core knowledge management applications from social network analysis that are explained in the following example:

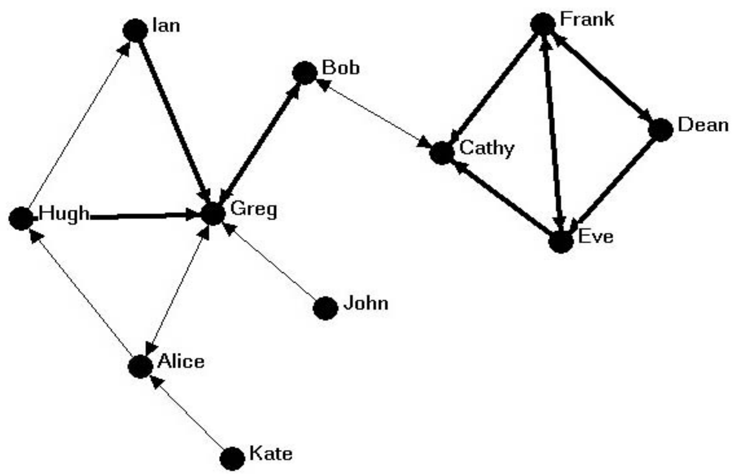
- identification of personal expertise and knowledge,
- research into the transfer and sustainable conservation of tacit knowledge, and
- discovery of opportunities to improve communication processes and communication efficiency.

Other knowledge management applications from social network analysis that go far beyond the scope of this article include studies into the development of core competencies (like leadership development), the identification and support of communities of practice, approaches for the harmonization of knowledge networks (for example after mergers and acquisitions), and the sustainable management of relationships between distributed sites and external partners.

METHODS AND MEASURES

Social network analysis perceives social structure as the pattern organization of network members and their relationships. Network data are defined by the members of the network and their relationships. (Note: Social network analysts talk of

Figure 2. A graph of social relationships



"actors" rather than of "members.") Using graph theory, a sociogram consists of "nodes" (or points), representing individual network members, and "ties" (or lines), representing the connections between the members (relations); these graphs clearly record and visualize social relationships (see Figure 2). Another advocated means to represent information about social networks is in matrices. In their simplest form, network data consist of a square matrix, the rows of the array represent the persons, the columns of the array represent the same set of persons, and the elements represent the ties between the persons (so-called "adjacency matrix"—see Figure 3). Matrices are

Figure 3. Adjacency matrix of social relationships as visualized in Figure 2

	Alice	Bob	Cathy	Dean	Eve	Frank	Greg	Hugh	Ian	John	Kate
Alice	0	0	0	0	0	0	1	1	0	0	0
Bob	0	0	1	0	0	0	2	0	0	0	0
Cathy	0	1	0	0	0	0	0	0	0	0	0
Dean	0	0	0	0	2	2	0	0	0	0	0
Eve	0	0	2	0	0	2	0	0	0	0	0
Frank	0	0	2	2	2	0	0	0	0	0	0
Greg	1	2	0	0	0	0	0	0	0	0	0
Hugh	0	0	0	0	0	0	2	0	1	0	0
Ian	0	0	0	0	0	0	2	0	0	0	0
John	0	0	0	0	0	0	1	0	0	0	0
Kate	1	0	0	0	0	0	0	0	0	0	0

also used as data input for social network analysis processing. (For an introduction to graph theory and the use of matrices in social network analysis, see, e.g., Scott, 1991, pp. 39-65, or Hanneman, 2001, pp. 2-4 & pp. 26-36.)

As this article serves only as an introduction to social network analysis in knowledge management, what follows is a short guide to the analytical concepts and measures that sit at the heart of the technique and are of primary importance for a pragmatic adaptation as a method and practical tool in knowledge management. For a more comprehensive introduction to social network analysis see Scott (1991) or Hanneman (2001).

- Knowledge Flows Within Large and Small Networks—Size: Size is a basic property of a network—sharing knowledge between all members of a large network (say for example, between a total of 25,000 members of a whole business unit) would be extremely difficult compared to sharing knowledge between all members of a small network (say for example, between a total of 11 members—as presented in Figures 2 and 3).
- Linkages of Networks—Density: Density describes the global level of linkage of a network. Even if fully saturated networks are empirically rare (where all possible ties are actually present), measures of density look at "how closely a network is to realizing this potential" (Hanneman, 2001, p. 41). As a measure that is especially relevant for the case of communities of practice, density describes the overall linkage between the community members.
- Expertise and Power—Degree Centrality: Degree centrality is a measure of the incoming and outgoing connections held by an individual network member. Incoming connections (in-degree) define the popularity of a member; those with many ties are members who are considered particularly prominent or—in the case of knowledge networks—have high levels of expertise (like Greg in Figures 2 and 3 for example). Out-degree defines the number of outgoing connections or the power of a member; having a high out-degree, a person is considered as particularly influential in the network (like Frank in Figures 2 and 3). Insufficient member links (as well as links between sub-groups—see below) might indicate the potential resources of network members that are not used. Excessive linkages might indicate the stress and overload of individual members. Degree centrality is a measure that helps to purposefully support individual members of a community of practice.
- Integration or Isolation—Closeness Centrality: While degree centrality is a measure of the immediate ties of a network member, closeness centrality (as well as betweenness centrality) measures the reachability of members. This is achieved by including indirect ties. Closeness centrality focuses on the distance of a member to all others in the network through means of geodesic distance. It determines a member's integration in the network (in Figures 2 and 3, Greg displays high in-closeness and Frank high out-closeness). Thus, high closeness centrality indicates the greater autonomy of an individual person, since he or she is able to reach the other members easily. Low closeness centrality on the other hand indicates higher individual member dependency, that is, the willingness of other members to gain access to the network's resources. By determining the average closeness centrality of a network, the relative isolation or integration of persons can be identified. People who are not well integrated into a group could represent untapped skills. They may be highly expert people who are not being utilized appropriately (see Cross et al., 2002, p. 6).

- Knowledge Brokers and Gatekeepers—Betweenness Centrality: Betweenness centrality is a measure of the extent that a network member's position falls on the geodesic paths between other members of a network. Thus, it determines whether an actor plays a (relatively) important role as a broker or gatekeeper of knowledge flows, with a high potential of control on the indirect relations of the other members (like Greg and Bob in Figures 2 and 3).
- Strength and Weakness of Ties—Multiplexity: Network members may maintain a tie based on one relationship type only (a narrowly specialized relationship, for example, sharing news on only one topic of research). Alternatively, they may maintain a variety of relations—broadly multiplex relationships, for example, sharing information, working together in different projects, and playing golf together. The latter are known as multiplex ties (the example in Figures 2 and 3 shows only two strengths of ties: 1 or 2). On the one hand, multiplex (strong) relationships share more intimate, voluntary, supportive, and durable ties (see Wellman & Wortley, 1990), and thus, form a solid basis for trust. On the other hand, most people only share a small number of strong relationships, so that especially weak ties are warranty for access to a large variety of resources (Granovetter's (1973) popular "strength of weak ties"). With regard to communities of practice, the importance of multiplex relationships gives reason for various kinds of community-building activities.
- Sub-Cultures and Clusters of Expertise—Sub-Groups and Cliques: Sub-sets of members can build dense connections and develop cohesive sub-groups of the network (like Cathy, Dean, Eve, and Frank in Figures 2 and 3). These are known as cliques and clusters (Watts & Strogatz, 1998; Roethlisberger & Dickson, 1947, already wrote about "cliques" in their 1939 report, pp. 508-510).2 Cliques or clusters are of special interest to network analysts as they are important for understanding the behavior of the whole network. For example, organizational subgroups or cliques can develop their own "sub"-cultures and attitudes toward other groups (Cross et al., 2002, p. 6). They can also gain influence over the overall network. Exploitation and integration of the subgroups' potential resources can be a critical factor to failure or success of a community of practice.
- Bottlenecks and Knowledge Gaps—Cut-Points and Structural Holes: Often, networks are not only clustered into cohesive subgroups, but are also split into loosely coupled components. In this case, not all possible connections are present: there are structural holes (Burt, 1992). Persons of pivotal significance in holding components together are called cut-points or bridges: central nodes that provide the only connection between different parts of the network (like Bob in Figures 2 and 3). Cut-points build bridges between sub-groups that would otherwise have been cut-off and split into separate, unconnected components. They represent the network's bottlenecks and are critical to the knowledge flow of a network. Yet too many links can lead to inefficiency of knowledge exchange. Generally speaking, links between sub-groups (for example, between members of different departments) must be coordinated effectively and efficiently (see for example the role of hubs described below).
- Enablers of Effective Knowledge Transfer—Hubs: As networks are clustered, some members are important as simultaneous actors in many clusters. These are known as hubs (Kleinberg, 1999; Rosen, 2000). As Barabási (2003) puts it, these persons "have played in very different genres during their

careers" (p. 61). They can effectively link different sub-groups of the network and can facilitate knowledge flows between different departments or to external organizations.

EXAMPLE

Consider for example that you are working in a research and service organization.3 You have to acquire funding for new research projects, and you know that programs and financing are available from the EU to help you. You have an idea for a new project, but you do not know how best to prepare a project proposal. However, there are other people in your organization who have successfully acquired EU funding for their projects. The question is: How do you acquire the knowledge to know who knows about developing a winning proposal for an EU project acquisition? Who are the experts in your organization, and who do you need to know and contact outside of your organization to assist you (at the European Commission, for example)?

- First, you will have to define the knowledge domain that is relevant. This is what you did already: you want to learn about experts for the acquisition of EU projects within the organization and then contact appropriate persons external to your organization.
- Second, you will need to formulate questions that address your goal adequately and operationalize the survey. Typical questions might be: Who do you know who is an expert about project acquisition? Who do you know who is currently working on an EU project or has just finished one? Whom did you help with regard to project acquisitions? Additionally, your data collection would be best complemented by analyzing other available documents and resources such as project documentations, team meetings, conferences, and so forth.
- Third, after encoding the data you perform procedures of formal network analysis and visualization—for example, using the popular and very sophisticated software for network analysis called UCINET (see Borgatti, Everett & Freeman, 2002).
- Fourth, you will need to analyze your findings from the previous step and interpret the results.
- Finally, you will try to sustainably improve knowledge flows with regard to EU project acquisition. Indeed, you might perform a social network analysis on the same topic on a frequent basis to evaluate success or failure of your interventions.

Based upon the results and their interpretation, interventions (like workshops, dialogues, establishment of communities of practice) are recommended to improve knowledge flows (examples of interventions are outlined in more detail in Müller-Prothmann & Finke, 2004, pp. 697-698). These can be designed to foster knowledge communication, strengthen relationships within the network, build relationships to other networks, and develop strategies for the creation of flourishing knowledge environments and for sustainable knowledge transfer. One very basic intervention would be to simply ask people to spend five minutes on their network visualizations and "to identify what they 'see' in the map, the structural issues impeding or facilitating group effectiveness, and the performance implications for the group" (Cross et al., 2002, p. 11).

This example shows that social network analysis provides a method to trace knowledge flows, analyze network structures and personal expertise, with additional value to a simple knowledge map or yellow pages. On the one hand, social network analysis tries to identify knowledge flows wherever they may go. On the other hand, social network analysis gives us a detailed picture of actors' positions, the characteristics of their connections, and the overall structure of relationships. Social network analysis provides us with a well-elaborated set of methods and measures for various applications in knowledge management that especially help us to foster the development of communities of practice.

FUTURE TRENDS

The application of social network analysis as illustrated in the example above affects all four dimensions that Cross et al. (2002, p. 7) found to be critical for a relationship to be effective in terms of knowledge creation and use. These are: (1) knowing what someone knows, (2) gaining timely access to that person, (3) creating viable knowledge through cognitive engagement, and (4) learning from a safe relationship. Despite the assertions of Cross et al., the use of social network analysis as a practical tool in knowledge management has been limited. To become more widely adopted in practice, the sophisticated scientific methods of social network analysis will need to be pragmatically adapted to suit practical needs.

The future focus of research must be put at two distinct levels of analysis, the individual networker and the organizational level. For both levels, the challenge will be to develop new methods in social network analysis that deliver practical value to knowledge management and provide for new models of interpretation and intervention. This includes methods for: (1) the clear definition of network members and network boundaries (for example based upon focused knowledge domains), (2) faster data collection, (3) efficient analysis and interpretation of results, and (4) effective intervention to improve knowledge sharing, knowledge flows, and network structure based on the given results.

In addition, the success or failure of social network analysis as a valuable knowledge management method depends on the successful integration of specific organizational conditions and requirements into the methodological process. This demands research activities on the cultural factors that influence network structure and performance. Then, insights from the application of social network analysis could provide the basis to develop measures for assessing the contribution of knowledge communities and networks to overall organizational performance and innovation. Especially, it should be strongly considered to integrate basic measures of social network analysis into a knowledge-orientated, balanced score card, and to expand techniques of social network analysis for examination and support of mobile networking and collaboration; without doubt, these technologies will gain influence as communication tools in distributed communities of practice and raise demands for thorough explorations.

CONCLUSION

Social network analysis is a powerful empirical tool for assessing network ties and structure and their influence on knowledge creativity, sharing, and innovation. The brief sociological discussion about the use of the term “community” early in this article shows that the development of a network perspective from a theoretical view on communities provides an adequate analytical framework for communities of practice, knowledge communities, and other social constructs subject to the knowledge management debate. As introduced in this article, social network analysis has practical application beyond a narrow theoretical perspective. By focusing on the social aspects of knowledge management in a methodically rigorous manner, the technique has much potential.

Of course, the limitations of social network analysis cannot be neglected. Since social network analysis is based on the study of bilateral interactions, it provides a merely descriptive picture of structures and positions. Further, aspects and characteristics of communities and social networks, like shared identity or shared norms of the network members for example, cannot be covered through social network analysis in a strict sense. Therefore, knowledge management processes focusing on communication structures and its related aspects, like advice and support networks, knowledge flows, and communication efficiency for example, are best explored through methods of social network analysis. These fields of application could make use of social network analysis as a powerful tool, as well as approaches for sustainable support of communities of practice.

Nevertheless, the use of social network analysis in knowledge management may be limited in environments characterized by high social complexity and a large variety of organizational constraints. Thus, a widespread adoption of social network analysis as a method and tool for knowledge management will depend on evidence provided by further research, case studies, and practical implementation in organizational business strategies in the various fields of application as proposed here.

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REFERENCES

Armbrecht, F.M.R. Jr., Chapas, R.B., Chappelow, C.C., Farris, G.F., Friga, P.N., Hartz, C.A., McIlvaine, M.E., Postle, S.R., & Whitwell, G.E. (2001). Knowledge management in research and development. *Research Technology Management, 44*(4), 28-48.

Barabási, A.-L. (2003). *Linked. How everything is connected to everything else and what it means for business, science, and everyday life*. New York: Plume.

Bauman, Z. (2001). *Community. Seeking safety in an insecure world*. Cambridge, UK: Polity Press.

Borgatti, S.P., Everett, M.G., & Freeman, L.C. (2002). *Ucinet 6 for Windows*. Harvard: Analytic Technologies. Retrieved from http://www.analytictech.com

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Burt, R.S. (1992). *Structural holes. The social structure of competition*. Cambridge, MA: Harvard University Press.

Burt, R.S. (2000). The network structure of social capital. Pre-print for a chapter in R.I. Sutton & B.M. Staw (Eds.), *Research in organisational behaviour* (vol. 22). Greenwich, CT: JAI Press. Unpublished manuscript.

Cartwright, D., & Harary, F. (1956). Structural balance: A generalization of Heider's theory. *Psychological Review, 63*(5), 277-293.

Collinson, S., & Gregson, G. (2003). Knowledge networks for new technology-based firms: An international comparison of local entrepreneurship promotion. *R&D Management, 33*(2), 189-208.

Crane, D. (1972). *Invisible colleges. Diffusion of knowledge in scientific communities.* Chicago; London: The University of Chicago Press.

Cross, R., Parker, A., & Borgatti, S.P. (2002). *A bird's-eye view: Using social network analysis to improve knowledge creation and sharing.* Retrieved January 14, 2003, from http://www-1.ibm.com/services/strategy/files/IBM_Consulting_A_birds_eye_view.pdf

Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology, 78*(6), 1360-1380.

Hanneman, R.A. (2001). *Introduction to social network methods.* University of California, Riverside, Department of Sociology. Retrieved January 29, 2004, from http://faculty.ucr.edu/~hanneman/SOC157/NETTEXT.PDF

Jain, R.K., & Triandis, H.C. (1990). *Management of research and development organizations. Managing the unmanageable.* New York: John Wiley & Sons.

Jansen, D. (1999). *Einführung in Die Netzwerkanalyse.* Grundlagen, Methoden, Anwendungen. Opladen: Leske und Budrich.

Kleinberg, J.M. (1999). Authoritative sources in a hyperlinked environment. *Journal of the ACM, 46*(5), 604-632.

König, D. (1936). *Theorie der endlichen und unendlichen graphen.* Leipzig: Akademische Verlagsgesellschaft.

Laumann, E.O., Marsden, P.V., & Prensky, D. (1989). The boundary specification problem in network analysis. In L.C. Freeman, D.R. White & A.K. Romney (Eds.), *Research methods in social network analysis* (pp. 18-34). Fairfax, VA: George Mason University Press.

Lesser, E.L. (2001). Communities of practice and organizational performance. *IBM Systems Journal, 40*(4), 831-841.

Liyanage, S., Greenfied, P.F., & Don, R. (1999). Towards a fourth generation R&D management model: Research networks in knowledge management. *International Journal of Technology Management, 18*(3/4), 372-394.

Moreno, J.L. (1934). *Who shall survive? A new approach to the problem of human interrelations.* Washington, DC: Nervous and Mental Disease Publishing Company.

Müller-Prothmann, T., & Finke, I. (2004). SELaKT: Social network analysis as a method for expert localisation and sustainable knowledge transfer. *Journal of Universal Computer Science, 10*(6), 691-701.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 40*(2), 242-266.

Nohria, N., & Eccles, R.G. (1992). Face-to-face: Making network organizations work. In N. Nohria & R.G. Eccles (Eds.), *Network and organizations* (pp. 288-308). Boston: Harvard Business School Press.

Poplin, D.E. (1979). *Communities. A survey of theories and methods of research* (2nd ed.). New York: Macmillan.

Roethlisberger, F.J., & Dickson, W.J. (1947). *Management and the worker. An account of a research program conducted by the Western Electric Company,* Hawthorne Works, Chicago. Cambridge, MA: Harvard University Press.

Rosen, E. (2000). *The anatomy of buzz. How to create word-of-mouth marketing.* New York: Doubleday.

Scott, J. (1991). *Social network analysis. A handbook.* London: Sage Publications.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications.* Cambridge, MA: Cambridge University Press.

Watts, D.J., & Strogatz, S.H. (1998). Collective dynamics of 'small-world' networks. *Nature, 393*(4), 440-442.

Wellman, B. (Ed.). (1988). *Social structures: A network approach*. Cambridge, MA: Cambridge University Press.

Wellman, B., & Wortley, S. (1990). Different strokes from different folks: Community ties and social support. *American Journal of Sociology, 96*(3), 558-588.

Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge, MA: Cambridge University Press.

Zanfei, A. (2000). Transnational firms and the changing organisation of innovative activities. *Cambridge Journal of Economics, 24*, 515-542.

ENDNOTES

1. The example is taken from Cross et al. (2002, p. 4), with kind permission by Rob Cross and the IBM Institute for Business Value, Cambridge, Massachusetts; names have been changed at the request of the company.
2. For a definition and formal description of the concepts outlined above, see the Key Terms section below. The description of formal approaches to analyse clusters, structural holes, and hubs would exceed the scope of this article; for a comprehensive introduction, see for example, Scott (1991) or Jansen (1999).
3. The example given in this section is inspired by a study on expert networks about the acquisition of EU projects in a research and service organisation; see also Müller-Prothmann and Finke (2004).

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Chapter 3.7
Distributed Knowledge Management

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INTRODUCTION

In dynamic markets (characterized by the specialization of work, outsourcing processes, just-in-time and distributed productions, etc.), firms have moved from hierarchical structures to networked models. These are based on both intraorganizational networks among strategic units, divisions, groups, and so on; and interorganizational networks, such as industrial districts and knowledge networks (Hamel & Prahalad, 1990). Production is based on the coordination of a constellation of units, some of which are part of the organization (administration, R&D [research and development], etc.), and others refer to different companies (such as specialized outsourcing production, logistics, etc.). All these units might not totally be controlled by a unique subject, and might grow and differentiate their activities in an autonomous way, coexisting as in a biofunctional system (Maturana & Varela, 1980) and creating unexpected combinations of processes and products (Chandler, 1962).

From a knowledge management (KM) point of view, the need of sharing knowledge among units in a very complex organization, or among networked organizations, increases the importance of introducing new ICT technologies and effective KM systems. For a long time, KM systems and ICT technologies have been proposed and applied as neutral tools whose implementation within the firm does not have any impact on knowledge flows. In particular, for technical reasons, centralized systems (for instance, enterprise knowledge portals [EKPs]) have been developed with the aim of making knowledge sharable and available in a general, objective, context-independent form, avoiding the persistence of noncorrect and non-consistent information. Opposed to that point of view, studies focused on structuration theories (Giddens, 1984; Orlikowski, 1991) do not consider technology as a neutral asset of organizations. According to these theories, there are strong relationships and interdependencies among human actions, institutional roles (the organizational model de facto), and the technology architecture of KM systems applied within the company. One of the most important results in this area is that ICT technologies and KM systems should be shaped on the processes, practices, and the organizational models in which they are implemented; otherwise, they are bound to failure. As a consequence, in a complex organization composed by a constellation of units that manage in an autonomous way specialized processes, ICT technologies and KM systems must take into account the distributed nature of knowledge, and should allow coordination among autonomous units. In such a scenario, a KM system should satisfy two different needs: supporting the creation of specialized knowledge within a unit, and enabling the coordination of knowledge (and activities through which knowledge is exchanged) among units. These dual needs reflect the tension between the necessity for both highly specialized organization of work and flexible intergroup cooperation within and outside the organizations. This is reflected in the duality between the need for highly articulated local perspectives that make up the communication and knowledge-creation tissue of each community, and the need for sharing cultures and instruments that allow communication across different units (Mark, Gonzalez, Sarini, & Simone, 2002).

The first aim of this article is to describe how, according to structuration theories, a centralized KM system can be replaced or supported by a distributed one, in which the fact of having multiple and specialized "local knowledge bodies" is viewed more as an opportunity to exploit than as a problem to solve. The second aim of this article is to present a specific approach to designing systems for managing knowledge distributed across different units, called distributed knowledge management (DKM), whose principles and main concepts will be introduced and explained in the second part of this article.

BACKGROUND

Even though current KM systems use different technologies, tools, and methodologies (for in-depth discussion, see Davenport & Prusak, 1997; Nonaka & Takeuchi, 1995; Stewart, 2001; Wenger, 1998), most projects eventually lead to the creation of large and homogeneous knowledge repositories, in which corporate knowledge is made explicit and is collected, represented, and organized according to a single, supposedly shared, vision. Such a vision is meant to represent a shared conceptualisation of corporate knowledge, and thus to enable communication and knowledge sharing across the constellation of units composing the entire organization. All these activities are based on the common assumption that raw forms of knowledge, called implicit knowledge by Nonaka and Takeuchi, and tacit knowledge by Polany (1966), can be "cleaned up" from all contextual elements, and that the resulting "objective form" of knowledge can be explicitly represented in an abstract (independent from the original context) and general (applicable to any similar situation) form. This standard architecture of KM systems reflects a traditional view of management, in which managers try to centralize the control on the company processes by allocating and distributing resources and tasks to employees, and monitoring the proper execution of tasks and use of resources. This view of the managerial function leads to an approach to KM where processes of knowledge (resource) production and dissemination (tasks) must be centrally driven (allocated) and controlled (monitored). This condition is met only if knowledge is thought of as an object, which can therefore be kept separate from the people who produce it. Otherwise, as far as knowledge remains embedded within subjective dimensions, it becomes a resource that falls outside the boundaries of managerial control.

The typical outcome of this kind of vision is the creation of an EKP, namely, an interface (Web based) that provides a unique access point to corporate knowledge (Davenport & Prusak, 1997). Such an architecture is generally based on the following:

- technologies like content management tools, text miners, search engines, and so forth, which are used to produce a shared view of the entire collection of corporate documents
- common formats, such as HTML (hypertext markup language), XML (extensible markup language), and PDF (Portable Document Format), which are used to overcome the syntactic heterogeneity of documents from different knowledge sources
- chats and discussion groups, which are used to enable social interactions

Most business operators claim that this traditional approach is the right answer to the needs of managing corporate knowledge. However, many KM systems are deserted by users, who instead continue to produce and share knowledge as they did before, namely, through structures of relations and processes that are quite different from those embedded within the corporate-wide KM system. For instance, workers continue to use nonofficial tools such as shared directories, personalized and local databases, and so on (Bonifacio, Bouquet, & Cuel, 2002; Bonifacio, Bouquet, & Manzardo, 2000). In theory, KM systems are sold as systems that combine and integrate functions for the contextualized handling of both explicit and tacit knowledge throughout the entire organization or part of it. But, in practice, traditional KM systems manage knowledge according to a technology-oriented approach, which considers the cleaned-up and objective knowledge as the good and sharable knowledge (best practices, documentations, etc.) within the firm and among companies. In spite of the declared intention of supporting a subjective and social approach (through community and groupware applications), the way most KM systems are designed embodies an objective view of knowledge and reflects a marginal notion of sociality. In other words, KM systems aim at managing knowledge in an abstract, general, and context-independent form without taking into account the fact that knowledge is dependent on the context of production (the particular viewpoint of the individual), is embedded within subjective dimensions (the daily practice of work), and is not straightforwardly replicable.

Many authors who stressed the subjective nature of knowledge argued also that meanings are not externally given; rather, individuals give meaning to situations through subjective interpretation. Interpretation is subjective since it occurs according to some internal interpretation schema not directly accessible to other individuals. These schemas have been called, for example, mental spaces (Fauconnier, 1985), contexts (Ghidini & Giunchiglia, 2001; McCarthy, 1993), or mental models (Johnson-Laird, 1992). Internal schemas can be made partially accessible to other individuals through language since language is not just a means to communicate information, but also a way of manifesting an interpretation schema. As a consequence, when interpretation schemas are deeply different, people will tend to give a very different meaning to the same facts. Conversely, in order to produce similar interpretations, people need to some extent to share interpretation schemas, or at least to be able to make some conjectures on what the other people's schemas are. For in-depth discussion, see the notions of paradigms in Kuhn (1970), sociotechnical frames in Goffman (1974), and thought worlds in Dougherty (1992). Since we are talking about organizations, and thus about a collective level, it is relevant to consider that without this intersubjective agreement (or at least believed agreement), communication cannot take place, coordinated action is impossible, and meaning remains connected just at an individual level (Weick, 1993). Thus, this approach leads to some significant consequences.

- Knowledge is intrinsically subjective as the meaning of any statement is always dependent on the context or on the interpreter's schema, which can be either explicit or implicit.
- At a collective level, groups of people can assume they share (or have a reciprocal view on) some part of their intrinsically subjective schemas. These common parts can emerge from participation and reification processes of the community's members, who share (or understand) the others' meanings through practices (Wenger, 1998). In other words, we can say that the intrinsically subjective schema can be shared, or at least coordinated, in the intersubjective agreements of the community's members.

As a result, the notion of knowledge as an absolute concept that refers to an ideal, objective picture of the world leaves the place to a notion of local knowledge, which refers to the different partial interpretations of portions of the world or domains that are generated by individuals and within groups of individuals (e.g., communities) through a process of negotiating interpretations. According to knowledge network theories (see Cross & Parker, 2004; Hildreth & Kimble, 2004), different and specialized actors that coordinate each other move beyond information sharing to the aggregation and creation of new knowledge, and obtain benefits from network communications and engagement strategies. Finally, the network of relationships, the local knowledge developed within a community, the inner motivation that drives people to share knowledge, and the knowledge they produce lead to the creation of an environment that sustains variety and is rich in creativity, namely, one that is innovative. As a consequence, many big organizations now consider communities, their autonomy, and their contextualized and local knowledge as vital components in their organizational KM strategies. Thus, local knowledge appears as the synthesis of both a collection of statements and the schemas that are used to give them meaning. Local knowledge is then a matter that was (and is continuously) socially negotiated by people that have an interest not only in building a common perspective (perspective making for Boland & Tenkasi, 1995, or single-loop learning for Argyris & Schoen, 1978), but also in understanding how the world looks like from a different perspective (perspective taking for Boland & Tenkasi, or double-loop learning for Argyris & Schoen). Therefore, rather then being a monolithic picture of the world as it is, organizational knowledge appears as a heterogeneous and dynamic system of local knowledge that lives in the interplay between the need of sharing a perspective within a community (to incrementally improve performance) and of meeting different perspectives (to sustain innovation).

MAIN FOCUS OF THE ARTICLE: DISTRIBUTED KNOWLEDGE MANAGEMENT

In this article, we present a new approach to KM called DKM. It provides an original managerial and technological solution to the complementary needs of creating and consolidating (local) knowledge within communities, and of sharing and reproducing knowledge across them. It is based on the assumption that subjectivity and sociality are potential sources of value rather than problems to overcome, and on the idea of modeling organizations as constellations of knowledge nodes

(KNs)-this way taking into account autonomous and locally managed knowledge sources-which need to cooperate and negotiate knowledge with others to sustain innovation. Thus, the continuous interplay of multiple instances of local knowledge and the interactions at the boundaries between different communities are critical factors for innovation and for the creation of new knowledge (Brown & Duguid, 1991).

Principles of DKM

DKM is based on two very general principles:

1. Principle of Autonomy: Each organizational unit should be granted a high degree of autonomy to manage its local knowledge. Autonomy can be allowed at different levels. We are mainly interested in what we call semantic autonomy, that is, the possibility of choosing the most appropriate conceptualisation of what is locally known (for example, through the creation of their own knowledge maps, contexts, ontologies, etc.).
2. Principle of Coordination: Each unit must be enabled to exchange knowledge with other units not through the adoption of a single common interpretation schema (this would be a violation of the first principle), but through a mechanism of projecting what other units know onto its own interpretation schema.

These two principles must support two qualitatively different processes: the autonomous management of knowledge locally produced within a single unit, and the coordination of the different units without a centrally defined view.

If a complex organization can be thought of as a constellation of autonomous units, an important issue is how this socially distributed architecture can be modeled to design an architecturally distributed computer-based system for supporting KM processes. To this end, we introduce the concept of the knowledge Node as the building block of a model for designing DKM systems.

The Definition of Knowledge Node

A KN can be viewed as the reification of organizational units, either formal (e.g., divisions, market sectors) or informal (e.g., interest groups, communities of practice, communities of knowing), that exhibit some degree of semantic autonomy. Each unit, in fact, can cope with KM only if the processes of knowledge (resource) production and dissemination (tasks) can be locally driven (allocated) and controlled (monitored). Moreover, each unit exhibits semantic autonomy through the development of local interpretation schemas (visions of the world). Each KN represents the following:

- Knowledge Owner: An entity (individual or collective) that has the capability of managing its own knowledge both from a conceptual and a technological point of view. Notice that most often knowledge owners within an organization are not formally recognized, and thus their semantic autonomy emerges in the creation of artifacts (e.g., databases, Web sites, collections of documents, archives, practices, and so on) that are not necessarily part of the official information system.
- System of Artifacts: An important assumption of DKM is that different organizational units tend to (autonomously) develop working tools that suit their internal needs, and that the choice and usage of these tools is a manifestation of their semantic autonomy. This may be for historical reasons (for example, people use old legacy systems that are still effective), but also because different tasks may require the use of different

applications and data formats to work out effective procedures and to adopt a specific and often technical language. Examples of local applications are software systems, procedures, and other artifacts, such as relational databases, groupware, and content management tools, and shared directories. Even if technologies and data formats are the same for two or more KNs, the appropriation (i.e., the local understanding and using of specific uses in a given setting) of each KN can be very different, depending, among other things, on the local interpretation schema.

- One or More Locally Shared Conceptual Schemata: It is a special artifact that represents (in an explicit or implicit way) a community's perspective. In simple situations, it can be the category system used to classify documents; in more complex scenarios, it can be an ontology, a collection of guidelines, or a business process. We can say that a schema is the reification of a KN's perspective, and its continuous, autonomous management is a powerful way of keeping a unit's perspective alive and productive.
- Brokers and Boundary Objects: They are individuals and objects (Bowker & Star, 1999; Wenger, 1998) legitimated by people to represent and understand (i.e., has direct access to) the locally shared conceptual schema of a KN. Brokers and boundary objects have the main aim of supporting knowledge owners to create and locally manage one or more shared conceptual schemata, and of meeting other brokers or analysing boundary objects that reify and express other local schemata. For instance, a personal agent could be a broker of a KN that knows its locally conceptual schemata and coordinate it with others.

KNs in a Case Study

In the past, we have analysed some complex organizations. A paradigmatic case study is Pizzarotti & C. S. p. A. Its business is focused on construction and prefabricated buildings, and KNs have been unveiled looking at knowledge owners, the systems of artifacts, the locally shared conceptual schemata, and, more importantly, the kind of knowledge that is exchanged within groups and the way in which people negotiate and coordinate knowledge across the whole organization. Through a large number of interviews, we discovered that building yards, registered offices, and cross-organizational communities have their own structures and their own ways of working to solve specific problems that depend on the kind of production and other local environmental factors (e.g., the weather, local customers and suppliers). Then they can be considered KNs. Though the firm does not formally recognize the existence of some of these units, every KN expresses semantic autonomy through specialized systems of artifacts that are used and appropriated in the way that best suits the local needs. For an in-depth description, see Cuel, Bonifacio, and Grosselle (2004).

A Methodology to Unveil Knowledge Nodes within a Complex Organization

In order to develop a KM system based on the DKM approach, an effective methodology of analysis is necessary. This methodology should take into account two relevant aspects, which reflect the two DKM principles.

- identifying the borders of existing KNs within the firm (principle of autonomy)
- identifying the way knowledge is exchanged across the whole organization through negotiation and coordination processes (principle of coordination)

Both aspects are based on social relations within and across communities in the firm, which can be analysed using different methodologies such as social network analysis (SNA) or ethnography. On one hand, SNA and other quantitative methodologies provide a good and general perspective on the organization, and allow the researcher to perceive the real structure of the organizational model by considering the relations among people and groups. They do not allow one to identify the reason why some groups are strategic and others are not. On the other hand, ethnography and other qualitative methodologies are based on the participation of the observer within the firm. The observer tries to achieve a detailed understanding of the circumstances, the strategies, and the power of the few subjects being studied, but cannot determine the significance of what she or he observes without gathering broad statistical information.

In the DKM approach, these two kinds of analysis are not sufficient to unveil KNs since it is difficult to identify the KNs' boundaries and knowledge-exchanging processes. As a matter of fact, individuals belonging to an organizational unit are socially interconnected to achieve different objectives and are often part of two or more units, thus using more than a conceptual schema. Therefore, it seems necessary to develop both quantitative and qualitative analysis in different phases through multiple series of questionnaires, ethnographic interviews (Spradley, 1979), and focus groups. The analysis should be organized in three phases: understanding the main picture of the firm, unveiling KNs and their relations, and validating the first results through focus groups or meetings with experts and workers involved in the organization activity. For an in-depth description, see Cuel (2003).

FUTURE TRENDS

The distributed approach to KM has many important implications, both from a managerial and technological perspective.

Managerial and Organizational Impacts of DKM

From a managerial standpoint, a distributed approach to KM poses fundamental challenges to the traditional model of the managerial function. In particular, managers should abandon the widespread practice of having a unique and homogeneous materialization of knowledge represented as a knowledge-based asset. Managers are requested to change their control processes, imposing strategic directions on innovation processes and enabling knowledge materialization from the ground.

Moreover, even if socially the attitude of sharing knowledge within a group is embedded in worker practices, managers should try to avoid personal or group behaviours of competitiveness and detention of knowledge, and should promote knowledge sharing and coordination across the whole organization. Therefore, managers should work out new roles (for instance, the roles of knowledge manager and broker) that determine new skills for knowledge coordination and negotiation (Argyris & Schoen, 1978; King & Andersen, 2002), and create a culture (using wage incentives, group bonuses, etc.) that allows people to identify themselves within the company as part of a whole and to share knowledge for a common, real gain. People's power should derive more from sharing useful knowledge within the firm and among groups than from owning it.

Technological Impacts of DKM

From a technological standpoint, distributed architectures presuppose the explicit recognition of the distributed nature of knowledge. Distributed architectures should sustain autonomy at different levels: the technological (different groups may use different technologies), the syntactic (different groups may use different information formats), and, most of all, the semantic (different groups may generate different systems of meaning, namely, local schemata). From a group's or a community's perspective, a distributed system supports the exploitation and representation of a community's schemata; this is the layer upon which a community's members produce and negotiate common views. Contexts can be represented as local ontologies (for instance, using Context OWL; Bouquet, Giunchiglia, van Harmelen, Serafini, & Stuckenschmidt, 2003), taxonomies, and, in general, theories through which community members interpret their environment and make sense of organizational events. Although theories conceptualise local events and thoughts, new methodologies and tools are needed for allowing workers (with no knowledge on formal logic or computer science) to create and manage local schemata. These methodologies and tools should allow both the creation of a schemata from scratch (analysing documents, repeated occurrences within databases, etc.) and the chance for management to make sense of processes on concepts through very simple visualization systems.

CONCLUSION

The DKM approach satisfies the managerial needs of creating and consolidating knowledge within each KN and of coordinating it across a constellation of KNs. Therefore, brokers and boundary objects should assume an important role, facilitating coordination processes and allowing communication between KNs, thus increasing innovation opportunities within the organization. As we said, these processes can be facilitated by the creation of a collaborative culture and attitude. Moreover, new organizational roles are needed that allow people to both identify themselves within the firm as part of a whole and to see knowledge sharing as way to achieve a common gain.

The centralized approach is not necessarily in conflict with the decentralized one. Depending on the type of knowledge, the environment, and the structure of the organization, it is beneficial to apply a more centralized (e.g., for secured and general knowledge) or a more decentralized KM approach (e.g., for ad hoc and specific knowledge). In particular, traditional and centralized KM systems, developed according to the technology-driven approach, can be effectively used in an organization in which the environment is stable and the need of efficiency is stronger than the pressure toward innovation. Problems arise when the KM systems create a mismatch between the social process of knowledge creation and sharing (organizational models de facto, processes and practices of KM) and the technological architecture (Camussone & Cuel, 2003). Therefore, two dual processes can be produced by the introduction of a noncoherent KM system: The information systems' architecture will be appropriated or shaped according to the modus operandi of its users (some functionalities of the system will be deserted by users, and others will be shaped on the users' daily work), or the organizational model, processes, and shared practices will change and adapt to the functionalities imposed by the KM system. From this, it follows that a KM system should be designed to be consistent with the distributed social form in which knowledge is created within organizations, finding its right level of centralization and decentralization. As a consequence, the composition of units in the organizational models and the composition of KNs should be compatible, and from this standpoint, they should therefore be analysed or at least planned during the designing phase. Currently, there is not a unique methodology of DKM architecture design, and different types of groups, units, and so forth can be unveiled as KNs. Finally, there are many technology-driven approaches that allow developers to design KM systems, and only few of them take into account organizational features (see Davenport, Long, and Beers, 1998) to analyse how politics, information strategies, behaviours, and culture should be considered for a successful KM system.

REFERENCES

Argyris, C., & Schoen, D. A. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison-Wesley.

Boland, R. J., & Tenkasi, R. V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Bonifacio, M., Bouquet, P., & Cuel, R. (2002). Knowledge nodes: The building blocks of a distributed approach to knowledge management. *Journal for Universal Computer Science, 8*(6), 652-661.

Bonifacio, M., Bouquet, P., & Manzardo, A. (2000). A distributed intelligence paradigm for knowledge management. *Proceedings of AAAI Spring Symposium Series 2000 on Bringing Knowledge to Business Processes.*

Bouquet, P., Giunchiglia, F., van Harmelen, F., Serafini, L., & Stuckenschmidt, H. (2003). C-OWL: Contextualizing ontologies. *Proceedings of the Second International Semantic Web Conference (ISWC2003),* Sanibel Island, FL.

Bowker, G., & Star, S. L. (1999). *Sorting things out: Classification and its consequences.* Cambridge, MA: MIT Press.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practices: Toward a unified view of working, learning and innovation. *Organization Science, 2*.

Camussone, P. F., & Cuel, R. (2003). Knowledge management e modelli organizzativi: La scelta tra accentramento e distribuzione delle responsabilità. *Proceedings of AIDEA.*

Chandler, A. D. (1962). *Strategy and structure: Chapters in the history of the industrial enterprise.* Cambridge, MA: MIT Press.

Cross, R., & Parker, A. (2004). *The hidden power of social networks: Understanding how work really gets done in organizations.* Boston: HBS Press Book.

Cuel, R. (2003). A knowledge-oriented analysis of organizations. Knowledge nodes: The building blocks of a distributed knowledge management approach. *Proceedings of DCEIS, (Vol. 10, No. 3).* France.

Cuel, R., Bonifacio, M., & Grosselle, M. (2004). Knowledge nodes: The reification of organizational communities. The Pizzarotti case study. *Journal for Universal Computer Science*.

Davenport, T. H., Long, D. W. D., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2).

Davenport, T. H., & Prusak, L. (1997). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dougherty, D. (1992). Interpretative barriers to successful product innovation in large firms. *Organization Science, 3,* 179-202.

Fauconnier, G. (1985). *Mental spaces: Aspects of meaning construction in natural language*. Bradford Books, Cambridge, MA: MIT Press.

Ghidini, C., & Giunchiglia, F. (2001). Local models semantics, or contextual reasoning = locality + compatibility. *Artificial Intelligence, 127*(2), 221-259.

Giddens, A. (1984). *The constitution of society.* Berkeley: University of California Press.

Goffman, I. (1974). *Frame analysis.* New York: Harper & Row.

Hamel, C., & Prahalad, G. (1990). The core competences of the corporation. *Harvard Business Review, 68*(3), 79-91.

Hildreth, P., & Kimble, C. (2004). *Knowledge networks: Innovation through communities of practice*. Hershey, PA: IGP.

Johnson-Laird, P. (1992). *Mental models*. Cambridge, MA: Cambridge University Press.

King, N., & Anderson, N. (2002). *Managing innovation and change: A critical guide for organizations*. London: Thomson.

Kuhn, T. S. (1970). *The structure of scientific evolutions*. Chicago: University of Chicago Press.

Mark, G., Gonzalez, V., Sarini, M., & Simone, C. (2002). Reconciling different perspectives: An experiment on technology support. *Proceedings of COOP02* (pp. 23-37).

Maturana, H. R., & Varela, F. J. (1980). *Autopoiesis and cognition: The realization of the living.* Dordrecht, Holland: D. Reidel.

McCarthy, J. (1993). Notes on formalizing context. *Proceedings of the 13th International Joint Conference in Artificial Intelligence (IJCAI'93)* (pp. 555-560).

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. New York: Oxford University Press.

Orlikowski, W. J. (1991). Integrated information environment or matrix of control? The contradictory implications of information technology. *Accounting, Management, and Information Technology, 1*(1), 9-42.

Polany, M. (1966). *The tacit dimension*. London: Routeledge & Keagan Paul.

Spradley, J. P. (1979). *The ethnographic interview*. New York: Holt, Rinehart, Winston.

Stewart, T. A. (2001). *The wealth of knowledge: Intellectual capital and the twenty-first century organization*. New York: Doubleday.

Weick, E. K. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge, MA: Cambridge University Press.

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Chapter 3.8
Capability Maturity

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INTRODUCTION

The dependence of any organization on knowledge management is clearly understood. Actually, we should distinguish between knowledge management (KM) and knowledge engineering (KE): KM is to define and support organizational structure, allocate personnel to tasks, and monitor knowledge engineering activities; KE is concerned with technical matters, such as tools for knowledge acquisition, knowledge representation, and data mining. We shall use the designation KMKE for knowledge management and knowledge engineering collectively. KM is a very young area—the three articles termed "classic works" in Morey, Maybury, and Thuraisingham (2000) date from 1990, 1995, and 1996, respectively. We could regard 1991 as the start of institutionalized KM. This is when the Skandia AFS insurance company appointed a director of intellectual capital. KE has a longer history—expert systems have been in place for many years. Because of its recent origin, KMKE is characterized by rapid change. To deal with the change, we need to come to a good understanding of the nature of KMKE.

One of the lasting contributions of the business reengineering movement is the view that an enterprise is to be regarded as a set of well-defined processes (Davenport, 1993; Berztiss, 1996). This implies that KMKE also should be a process. Implementation of a process has two aspects: there is need for a procedural definition, and for an understanding of the resources and capabilities needed to implement the procedures and manage the process. Here, we will not be considering the procedures. Our purpose is to set up a model that identifies the capabilities needed to define, implement, and maintain the KMKE process.

The Background section of this article introduces capability models. In the Focus section, we define a capability model for KMKE in general terms and look at the management and engineering sides of this model. Then, we look into the future and offer a conclusion.

BACKGROUND: CAPABILITY MATURITY AND SOFTWARE

One area that has had long experience with processes is software engineering, and we turn to it for guidance on how to construct a capability model for KMKE. The software Capability Maturity Model (CMM-SW) was introduced by Humphrey (1989) and elaborated by a team of researchers at the Software Engineering Institute (1995). A later development is CMMI, which stands for CMM Integration. This is a suite of models where CMMI-SW (CMMI Product Team, 2002) is the model for software development. We shall be guided by the original model for two main reasons: First, there is greater familiarity with CMM-SW than with CMMI; second, the original CMM-SW has inspired a number of models that address the specific capabilities needed for specialized applications. Thus, there are CMMs for reuse (Davis, 1993), formal specification (Fraser & Vaishnavi, 1997), maintenance (Kajko-Mattson, 2001), an initial version for KM (Berztiss, 2002a), e-commerce (Berztiss, 2002b), and data quality management (Berztiss, 2004). An investigation of how to adapt CMM-SW for such nontraditional projects as product-line development, database development, and schedule-driven development also has been undertaken (Johnson & Brodman, 2000). Considerable evidence exists on the effectiveness of CMM-SW and CMMI for improving quality and reducing costs (Goldenson & Gibson, 2003).

The CMM-SW has five maturity levels. Level 1 is the base from which an organization moves upward by satisfying a set of requirements expressed as key process areas (KPAs). This level structure with the total of 18 KPAs is shown in Table 1. All KPAs of Level 2 relate to management, those of Level 3 to management and engineering, and those of Levels 4 and 5 relate primarily to engineering.

In CMM-SW, the definition of a KPA starts with a statement of it "goals," a "commitment to perform," which is essentially a policy statement committing the organization to the satisfaction of these goals, and an "ability to perform" statement, which lists the resources that have to be

Table 1. Key process areas of CMM-SW

Level 3	Level 5
Organizational process focus Organizational process definition Training program Integrated software management Software product engineering Intergroup coordination Peer reviews	Defect prevention Technology change management Process change management
Level 2	**Level 4**
Requirements management Software project planning Software project tracking and oversight Software subcontractor management Software quality assurance Software configuration management	Quantitative process management Software quality management

allocated. Next comes a list of activities that need to be performed in order to achieve the goals of the KPA. This can be regarded as a requirements statement that tells what is to be done without going into details of how the activities are to be performed. In addition, there is an indication of what process measurements are to be made and to what review procedures the activities of a KPA are to be subjected. Both measurements and reviews are important for any CMM. Only by measuring can we tell what does and what does not work, and what is the precise effect of a particular action. The review procedures ensure that the activities are in fact being performed.

FOCUS: A CAPABILITY MODEL FOR KMKE

Considering that the CMM-SW book (SEI, 1995) is about 450 pages, the outline of the CMM-KMKE we present here is very sketchy. The most we can do is define a set of KPAs and assign them to maturity levels. In designing CMM-KMKE, we were guided by our earlier work on the dimensions of the knowledge management process (Berztiss, 2001). Other influences have been the four "success statements" of Smith and Farquhar (2000):

- The organization knows what it knows and uses it, and knows what it needs to know and learns it.
- For any project, for any customer, the project team delivers the knowledge of the overall organization.
- The organization delivers the right information, to the right people, at the right time, with the tools they need to use it.
- The perspective of the employees is aligned with that of the customers.

Reinhardt's (2000) key questions of knowledge management were another source of inspiration. The KPAs of CMM-KMKE are intended to establish capabilities required to answer his questions:

- How can relevant organizational knowledge be identified and new knowledge be created and utilized?
- How can a system of knowledge creation and utilization be designed and organized?
- What measures provide management with information about the quality of the knowledge management process?
- What methods and tools support the implementation of knowledge management?

Table 2. Key process areas of CMM-KMKE

Level 4	Level 5
Integrated KMKE process External knowledge acquisition Qualitative cost-benefit analysis	Technology change management Quantitative cost-benefit analysis
Level 2	Level 3
Knowledge requirements management Internal knowledge acquisition Uncertainty awareness Training	Knowledge representation Knowledge engineering techniques User access and profiling

Table 2 shows the KPAs of CMM-KMKE. We have deviated somewhat from the underlying philosophy of CMM-SW. There, Levels 2 and 3 have a management bias, and Levels 4 and 5 have primarily an engineering orientation. The levels of CMM-KMKE are interleaved: Levels 2 and 4 emphasize KM, Levels 3 and 5 have more to do with the KE aspect. In this way, capability maturity can be achieved for both management and engineering of the knowledge process in parallel. However, it is essential to have in place knowledge requirements management, which is a Level 2 KPA, before any of the Level 3 KPAs are implemented. This KPA establishes what the organization aims to achieve, that is, it draws a road map for all the knowledge-related activities of the organization.

Management-Oriented Levels of the CMM-KMKE

We would need a book, written by a sizable team of experts in knowledge management and knowledge engineering to define the CMM-KMKE in detail. However, by listing a few of the activities for each KPA, we hope at least to suggest the nature and purpose of the KPA. The outlines of the KPAs follow closely their descriptions first presented in Berztiss (2002a).

- Knowledge requirements management (Level 2): The purpose of KMKE has to be clearly understood by the entire organization. The very first step is to set up a KMKE group (K-group) that is to determine the knowledge needs of the organization and to work toward the satisfaction of these needs by institutionalization of KMKE practices. In a smaller organization, the "group" can be a single person. By institutionalization, we mean that the practices are to be documented. A major purpose of a CMM is the distribution of capabilities throughout an organization so that the organization is no longer dependent on single individuals for particular capabilities. The knowledge needs can be expressed as requirements, that is, statements of what is needed without the details of how the needs are to be satisfied. Considerable literature exists on requirements gathering and management for software (for a brief summary, see Berztiss, 2002c). An important part of requirements determination is the identification of stakeholders, who in the KMKE context include gatherers and organizers of knowledge, experts on privacy laws, and people who will benefit from the knowledge.
- Internal knowledge acquisition (Level 2): We distinguish between internal and external knowledge. The former resides in an organization itself, in the form of databases and data warehouses, and, most importantly, the skills of people. External knowledge is gathered via personal contacts and communication media. After the knowledge requirements have been determined, the K-group is to establish a systematic approach to how the requirements are to be satisfied. This means that sources of internal knowledge are to be identified, information gathered from these sources is to be codified, and access to this information is to be facilitated. Abecker, Bernardi, Hinkelmann, Kühn, and Sintek (1998) give an overview of an artificial intelligence approach to the setting up of an organizational memory; Rus and Lindvall (2002) survey the role of KM in software engineering—they provide a very useful list of relevant Web addresses.
- Uncertainty awareness (Level 2): All knowledge is subject to uncertainty to a greater or lesser degree. To begin with, at least the K-group has to understand the issues relating to this. Specifically, it should establish guidelines on how to assign degrees of uncertainty to particular items of knowledge. Klir and Yuan (1995) is still the most useful

text on uncertainty in general; see Berztiss (2002d) for a more recent survey.

- Training (Level 2): The institutionalization of a training program is another priority task for the K-group. Initially, everybody in the organization is to be informed about the purposes of KMKE and how the KMKE processes will affect them. Specialized training needs will become apparent as the KMKE program develops, particularly with respect to KE techniques.
- Integrated KMKE process (Level 4): In order to arrive at an integration of KM and KE, there has to be a thorough understanding of both of them at a state-of-the-practice level, and the organization must make full use of KM techniques. By integration, we mean that KE is being applied to KM itself—KM is to manage the KMKE process, and KE is to look after improvements of this process.
- External knowledge acquisition (Level 4): Organizations do not operate in isolation. They are embedded in an environment—the environment is the context for the operation. It is customary to denote the context as <w, t>, where w is a slice of the "world" at time t. As the context changes over time, an organization has to recognize the changes and has to respond to them. This, of course, has to happen even at Level 1, but this KPA requires that a thorough analysis is undertaken to determine how much of w is relevant, and how this relevant component is to influence the operation of the enterprise.
- Qualitative cost-benefit analysis (Level 4): We should be able to measure the cost of the KMKE process, and we also should be aware of improvements (or the lack of them) in the operation of an organization. But it is difficult to discern cause-effect relationships, that is, to determine that this or that benefit arises from a particular expenditure of resources. The goal of this KPA is to identify cause-effect relationships. Some techniques for this have been developed (Pearl, 2000).

Engineering-Oriented Levels of the CMM-KMKE

- Knowledge representation (Level 3): Various representations of knowledge have been studied, particularly in the context of artificial intelligence (Markman, 1999). For example, Bayesian networks are used to facilitate inferences (Pearl, 2000). A recent trend is the use of ontologies to organize knowledge. There are numerous definitions of ontology. A useful one can be found in a survey by Kalfoglou (2002): An ontology is an explicit representation of a shared understanding of the important concepts in some domain of interest.
- Knowledge engineering techniques (Level 3): These techniques have been developed for extracting knowledge from different representations, but there is no sharp division between knowledge representation and KE techniques. For example, a Bayesian network represents knowledge, but the setting up of the network is a KE technique. Specialized KE techniques include the design of data warehouses, data mining, data filtering, and the management of uncertainty. Note that uncertainty management differs from the Level 2 KPA of uncertainty awareness: To manage uncertainty means that attempts are made to estimate uncertainty quantitatively by, for example, statistical techniques.
- User access and profiling (Level 3): Experience shows that there can be strong resistance to the introduction of KMKE (Kay & Cecez-Kecmanovic, 2000). A common cause of this resistance is that users have to go through complex access procedures and extensive searches to arrive at items of knowledge they are looking for. Moreover, personnel may be unaware of the existence

of knowledge useful to them. User profiles that reflect their interests allow the matching of knowledge needs and knowledge availability.
- Quantitative cost-benefit analysis (Level 5): The advance from qualitative to quantitative cost-benefit analysis requires extensive measurements relating to the KMKE process. Only experience will tell what should be measured, which measurements contribute to cost-benefit analysis in particular instances of benefits, and how a cause-effect relation is to be expressed in quantitative terms.
- Technological change management (Level 5): This is where a transition is made from state-of-the-practice to state-of-the-art. New developments arise constantly. For example, data mining, defined as the analysis of data sets to find unsuspected relationships and to summarize the data in novel ways (Hand et al., 2001), is extending to data mining on the Web. Mining of time series data is one example. Another development is the real-time analysis of streaming data, for example, from cash registers. The K-group must monitor research developments and be ready to introduce new techniques after a careful cost-benefit analysis.

A LOOK TO THE FUTURE

Much remains to be done in the KMKE area, and we cannot expect quick results. Within an organization, even with the best will, the upper levels of a CMM can take a long time to reach. The practices of the KPAs of these levels require reference to measurements relating to the effectiveness of the processes of knowledge gathering, knowledge representation, and knowledge use. In more general terms, the biggest challenge arises from the relative intractability of knowledge. To quote Davenport (1997), "Knowledge can be embedded in machines, but it is tough to categorize and retrieve effectively" (p. 10). We have to find better ways to deal with this aspect of knowledge, which Polanyi (1958) has called personal knowledge.

Most of today's knowledge workers are not particularly knowledgeable in theoretical areas. This will have to change. Data mining cannot be undertaken without statistical skills, and the study of causality is based on probabilities. Increasingly, knowledge workers will have to get accustomed to find out about new developments on the Web. As late as April 2004, the primary source of information about CMMI was the Web. On the other hand, the Web contributes to a managerial information overload (Farhoomand & Drury, 2002). The situation will not improve unless more effective filters based on user profiles are developed.

Under CMM-SW, an organization develops a generic software development process, and this process is adapted to the special needs and circumstances of a software project. The purpose of CMM-KMKE is to define capabilities that will make an organization more effective on its projects, but the knowledge process does not have the same project-dependence as the software process. Still, different organizations may have different needs. Kankanhalli, Tanudidjaja, Sutano, and Tan (2003) classify organizations as being service-based or product-based, and, orthogonally, as operating in a low-volatility or a high-volatility context. Thus, there are four types of organizations, and their KMKE needs will differ. The CMM-KMKE as outlined here is sufficiently general to meet the needs of all four types of organizations.

CONCLUSION

CMMs have provided various application areas with road maps for improvement. The effectiveness of CMM-SW, from which these CMMs derive, is well documented. A comparatively new area, such as knowledge management, can derive greatest benefit from a CMM because a new area is very much in need of guidance based on what has worked elsewhere. The most that has been possible here is to sketch an outline of a CMM-KMKE. Still, the outline should help identify the more critical capabilities needed for effective knowledge management.

REFERENCES

Abecker, A., Bernardi, A., Hinkelmann, K., Kühn, O., & Sintek, M. (1998). Toward a technology for organizational memories. *IEEE Intelligent Systems 13*(3), 40-48.

Berztiss, A.T. (1996). *Software methods for business reengineering.* New York: Springer.

Berztiss, A.T. (2001). Dimensions of the knowledge management process. In *Proceedings of the 12th International Workshop on Database and Expert Systems Applications (DEXA'01)* (pp. 437-441). Los Alamitos, CA: IEEE CS Press.

Berztiss, A.T. (2002a). Capability maturity for knowledge management. In *Proceedings of the 13th International Workshop on Database and Expert Systems Applications (DEXA'02)* (pp.162-166). Los Alamitos, CA: IEEE CS Press.

Berztiss, A.T. (2002b). Capabilities for e-commerce. In *Proceedings of the 13th International Workshop on Database and Expert Systems Applications (DEXA'02)* (pp. 875-879). Los Alamitos, CA: IEEE CS Press.

Berztiss, A.T. (2002d). Uncertainty management. In S.K. Chang (Ed.), *Handbook of software engineering and knowledge engineering* (Vol. 2, pp. 389-418). Singapore: World Scientific.

Berztiss, A.T. (2004). Models for data quality management. In *Proceedings of CAiSE'04 Workshops* (Vol. 2, pp. 37-48). Faculty of Computer Science and Information Technology, Riga Technical University.

CMMI Product Team (2002). Capability Maturity Model Integration, Version 1.1 (CMMI-SW, V1.1) Staged Representation. CMU/SEI-2002-TR-029. Retrieved from www.cmu.edu/sei

Davenport, T.H. (1993). *Process innovation: Reengineering work through technology.* Cambridge, MA: Harvard Business School Press.

Davenport, T.H. (1997). *Information Ecology.* New York: Oxford University Press.

Davis, T. (1993). The reuse capability model: A basis for improving an organization's reuse capabilities. In *Advances in software reuse* (pp. 126-133). Los Alamitos, CA: IEEE CS Press.

Farhoomand, A.F., & Drury, D.H. (2002). Managerial information overload. *Communications of the Association for Computing Machinery, 45*(10), 127-131.

Fraser, M.D., & Vaishnavi, V.K. (1997). A formal specifications maturity model. *Communications of the Association for Computing Machinery, 40*(12), 95-103.

Goldenson, D.R., & Gibson, D.L. (2003). *Demonstrating the impact and benefits of CMMI: An update and preliminary results.* CMU/SEI-2003-SR-009. Retrieved from www.cmu.edu/sei

Humphrey, W.S. (1989). *Managing the software process.* Englewood Cliffs, NJ: Addison-Wesley.

Johnson, D.L., & Brodman, J.G. (2000). Applying CMM project planning practices to diverse environments. *IEEE Software, 17*(4), 40-47.

Kajko-Mattson, M. (2001). *Corrective maintenance maturity model: Problem management.* Doctoral dissertation: Department of Computer and System Sciences, Stockholm University/Royal Institute of Technology.

Kalfoglou, Y. (2002). Exploring ontologies. In S.K. Chang (Ed.), *Handbook of software engineering and knowledge engineering* (Vol. 1, pp. 863-887). Singapore: World Scientific.

Kankanhalli, A., Tanudidjaja, F., Sutano, J., & Tan, B.C.Y. (2003). The role of IT in successful knowledge management initiatives. *Communications of the Association for Computing Machinery, 46*(9), 69-73.

Kay, R., & Cecez-Kecmanovic, D. (2000). When knowledge becomes information: A case of mistaken identity. In *Proceedings of the 11th International Workshop on Database and Expert Systems Applications (DEXA'00)* (pp. 1128-1133). Los Alamitos, CA: IEEE CS Press.

Klir, G.J., & Yuan, B. (1995). *Fuzzy sets and fuzzy logic: Theory and applications*. Englewood Cliffs, NJ: Prentice Hall.

Markman, B. (1999). *Knowledge representation*. Mahwah, NJ: Lawrence Erlbaum.

Morey, D., Maybury, M., & Thuraisingham, B. (Eds.). (2000). *Knowledge management: Classic and contemporary works*. Cambridge, MA: MIT Press.

Pearl, J. (2000). *Causality: Models, reasoning, and inference*. Cambridge, MA: Cambridge University Press.

Polanyi, M. (1958). *Personal knowledge*. London: Routledge & Kegan Paul.

Reinhardt, R. (2000). *Knowledge management: Linking theory with practice*. In Morey et al. (2000), (pp. 187-221).

Rus, I., & Lindvall, M. (2002). Knowledge management in software engineering. *IEEE Software, 19*(3), 26-38.

Smith, R.G., & Farquhar, A. (2000). The road ahead for knowledge management, an AI perspective. *AI Magazine*, *21*(4), 17-40.

Software Engineering Institute (1995). *The capability maturity model: Guidelines for improving the software process*. Reading, MA: Addison-Wesley.

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Chapter 3.9
Clinical Knowledge Management:
The Role of an Integrated Drug Delivery System

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ABSTRACT

Issues and complexities that arise from the adoption of clinical knowledge management are explored within the context of delivering drugs to the lungs. The move towards electronic data capture and information retrieval is documented together with cross-organisational working and sharing of clinical records. Key drivers for change are identified and their effects on, for example, the patient-clinician relationship are investigated. Conclusions drawn indicate the crucial role that all stakeholders play to bring about effective and efficacious patient care.

INTRODUCTION

Clinical knowledge management is the discipline concerned with the collection, processing, visualisation, storage, preservation, and retrieval of health related data and information, whether on an individual patient or a clinical specialty. Its successful adoption into daily clinical practice requires the use of new technologies such as: electronic health records; standardised medical terminologies, tools and methods to support speedier retrieval and dissemination of clinical information; and reliable networks to facilitate electronic communication in “real time.” Recent advances in Information and Communication

Technologies (ICTs) have facilitated the development of mobile communications, offering the opportunity for integration into existing and planned clinical information systems, and offer solutions for data capture and information retrieval at the point of care. Hidden organisational and cultural complexities arise from the anticipated use of ICTs, such as training needs, clinical acceptance, and a shift in empowerment within the patient-clinician relationship towards the patient. Addressing these issues requires commitment, application and tenacity from all stakeholders involved in the healthcare process.

The management of any clinical condition has traditionally been viewed as a clinician's domain. Data collection and information dissemination is still seen in some places as the preserve of an individual clinician with little evidence of sharing clinical knowledge. However, this established model of care in the UK is now being replaced by patient-centred care in which the patient is viewed as an equal partner in the care process. The Department of Health (DH) is committed to bringing together patients, carers and clinicians to create informal and formal relationships that support the self-management of chronic conditions. The DH also recognises this shift in responsibility for healthcare provision in its publication of documents such as “The Expert Patient” (Department of Health, 2001a). The “NHS Plan” (Department of Health, 2001b) developed from consultations with patients, is committed to the development of ‘high quality patient-centred care’ along with the development of modern ICT systems in primary and secondary care. It acknowledges the effective role that patients can play in the effective management of chronic diseases. Key elements of patient-centred care include, a patient's right to have access to their own medical records, access to identified and appropriate clinicians for treatment, access to information relating to waiting times, information on adverse drug effects and care planning, and the expectation that clinicians will keep accurate and accessible healthcare records. Patient knowledge is recognised as a beneficial asset to the healthcare process and as such is becoming a valuable tool in terms of the management of chronic conditions. In the specific area of management of chronic diseases, the opportunity to capture home-based data offers patients, carers and clinicians the possibility to add value in terms of increasing knowledge to manage the care process more effectively and as a consequence, empower key stakeholders in the healthcare experience.

CLINICAL RECORDS MANAGEMENT

A medical record relating to an individual patient is a collection of information that relates to distinct episodes of care. In the past, medical records were associated with one particular GP Practice or secondary healthcare organisation. In the early days of the NHS, patient notes were exclusively hand-written. Recipients of the information complained that they could not read handwriting, the information contained in the document was not always appropriate to the clinical need at that moment, and that too many documents did not reach the intended recipient in time to be of use for planning of ongoing treatment and care. Medical records such as the “Lloyd George” paper folder can still be found in daily use in some primary healthcare organisations. The transition to an electronic healthcare record is not quite complete, as issues such as scanning of paper notes and training staff to use computers is claimed to be an impediment to progress. Both issues require resource allocation that is not always seen as a priority in organisations with limited resources that exist in an environment of constant change.

As far as clinical records management is concerned, prior to the introduction of an electronic healthcare record, all documents relating to an individual patient remained with the originating organisation. Clinical information was collected and recorded by both nurses and doctors for use within one clinical domain. The main problem with paper note keeping in secondary care was ensuring that the patient notes were in the right place at the right time and in a format in which people could easily retrieve information required.

ELECTRONIC CARE RECORDS

Roll out of electronic healthcare records in the UK is currently underway. In 1998 the NHS launched an IT strategy, "Information for Health" (1998), that aimed to link all GPs with the NHS's own intranet, NHSnet, and to procure basic electronic records for all hospitals and healthcare communities. Financial planning, interest in clinical outcomes data, and computer support for clinical decision making at the point of care are examples of some of the original key drivers that led to this development. To expedite progress of this IT initiative, a national programme for NHS IT (NPfIT) has been created (National Programme for Information Technology). The programme has developed a new vision of an integrated care records service (ICRS) which will be designed around patients rather than institutions, and will be accessible 24 hours a day, seven days a week. An electronic clinical noting system reflects a degree of flexibility in order to provide clinicians with the ability to retrieve clinical information in a format that they require. Certain items of information that relate to the patient (such as name and address) that lie outside the scope of clinical information should always appear in the same place in all clinical documents. Electronic healthcare records that can be shared between staff seem like an obvious solution to support clinical knowledge management; although their potential goes far beyond that of recording clinical information.

NPfIT is setting national standards to ensure that clinicians are provided with real-time access to information, which allows them to share patient and relevant documents with other clinicians and allied health professionals. A key concept in this change is that patient information will cross organisational boundaries allowing documents relating to clinical care, care in the community and social care to be integrated. This concept relies on the establishment of best practice in knowledge management. By 2010, it is envisaged that every NHS patient in England will have an electronic healthcare record that they will be able to access via the Internet regardless of location. To support the key drivers and enable successful integration into the healthcare process, electronic healthcare records must be web-based, and be web-enabled allowing interaction with Internet technologies such as web services.

The current situation regarding clinical note keeping in the NHS shows that communication between organisations remains sketchy and fragmented. The technology is available to support communication across organisational boundaries, however it is fair to say that not all secondary healthcare organisations are as advanced as primary care in their adoption of ICT to support clinical note keeping. Integration of primary, secondary and tertiary healthcare electronic healthcare records is a prerequisite of the practice of clinical knowledge management. Failure to link systems to enable seamless transfer of clinical information between relevant organisations will create a situation little different to that brought about by existing paper based systems.

OPPORTUNITIES FOR SUPPORTING CLINICAL CARE: INTEGRATED DRUG DELIVERY

The development of home-based drug delivery systems offers the opportunity to capture data relating to the use of a device by a patient, collect data to support the assessment of clinical conditions, as well as empowering patients to become more involved in the management of chronic conditions. The data captured by a drug delivery device can be used to create useful information for both clinicians and patients/carers. Care should be taken to ensure that the information generated is about the right person, stored in a medium that is accessible to all who are nominated to use the system, and delivered at the right time to any specified delivery device, such as mobile phones, palmtops as well as desktop PC's. A critical element to the successful integration of informatics into the device must be commitment by all stakeholders, at all stages from development, implementation through to adoption into daily use.

Data integration from electronic healthcare record systems is essential in order to achieve state of the art clinical communication between stakeholders. The data collected must be able to be represented in a ubiquitous format that is acceptable to all those who take part in the care process. Critical elements in successful adoption of a home based drug delivery system into daily clinical use include the identification of the right data, the creation of the right structure, and the integration into the right clinical processes to add value. The care of asthmatic patients will be used to exemplify issues associated with home-based delivery of clinical treatment. If the above elements are addressed then the information architecture developed can be transferred to any clinical condition that requires delivery of drugs to the lungs.

Technology can support the diffusion of healthcare to the home through the development of home-based drug delivery systems. However, patient use of these systems may reveal issues that alter the traditional patient/clinician relationship. For example, clinicians who are not specialist in asthma may be confronted with patients who are considerably more knowledgeable about their condition. Acceptance and adoption into daily care will only be achieved through detailed and thorough integration into clinical practice, along with rigorous evaluation of the impact ICT has upon the care process. The effect of cultural issues will require assessment and evaluation and will influence adoption of novel approaches to patient centred care.

Home-based drug delivery systems are one way of managing clinical decision making at the point of care. They offer the opportunity for healthcare professionals to have instant access to a wide range of clinical information that may refer to individual patients, but the ability to access information such as clinical guidelines and protocols will only enhance and support the care process.

CLINICAL EXEMPLAR

Asthma is a condition that affects the airways (bronchi) of the lungs. From time to time the airways constrict in people who have asthma. The condition can commence at any age, but it most commonly starts in childhood. At least 1 in 10 children, and 1 in 20 adults, have asthma in the UK. Around 1500 people die from asthma in the UK each year (National Asthma Campaign, 2001).

Asthma in the UK places a high economic burden on both primary and secondary healthcare systems, at an estimated annual cost of over £850 million (Office for National Statistics). One in ten asthmatics that experience severe or moderately severe symptoms fail to control their condition adequately, even with the best clinical and preventative management available. Integrated drug delivery systems have the potential for easing the economic burden on the NHS with improved patient care. Improved delivery of drugs to the lungs in terms of both the ability to deliver larger quantities of drugs to the correct region of the lung, combined with improved patient compliance to prescribed treatment regimens, will result in better disease management with less need to resort to expensive "relief care" strategies and will slow down progression to severe disease status.

Also, very few asthmatics have a documented self-management plan that explains when to take their medication, the use of peak flow meters to measure the speed of air blown out of the lungs, and what to do if their asthma condition deteriorates (Lorig, K.R., Sobel, D.S., Stewart, A.L., Brown, B.W., Bandara, A., Ritter P., et al., 1999). Traditionally patients are asked to keep a manual diary over a defined time period such as two weeks, charting peak flow readings as a method of assessing a patient's current clinical state. Regular peak flow readings are a recognised method of assessing how well prescribed treatments are working. As a chronic disease, it is essential to involve patients in decisions relating to the development of a tailored care plan for the treatment of asthma, this will result in the more effective delivery of healthcare to the individual patient and to asthmatics as a whole. Patients (and clinicians) must learn how to use their inhalers correctly. The practice nurse or doctors have pivotal roles to play in educating patients how to use an inhaler properly. It is easy to demonstrate in a healthcare environment but ongoing home-based monitoring may ensure better device compliance for specific groups such as the newly diagnosed or teenagers. Empirical evidence shows that these groups may have compliance issues relating to the use of inhaled therapies. Patients must agree on an "asthma action plan" with a nominated clinician. This means that adjustments to the dose of the prescribed inhalers, depending on the symptoms and/or peak flow readings can be made at a relevant point in time.

STAKEHOLDERS

Patients are now increasingly recognised for the central role they play in the healthcare process. They must be involved and consulted at every stage of the process. For a home-based drug delivery device to provide effective treatment and collect relevant information, the patient and/or carer must understand why the device is being used, agree to its use and understand and accept a degree of responsibility for their role in the changing relationship between clinician and patient. The partnership that develops between patient and clinician will benefit patients' individual knowledge and will complement clinicians' general knowledge about a specific chronic disease. The pooling of this knowledge will in effect support the effective management of chronic diseases.

Clinicians should have skills that allow them to embrace novel innovations in drug delivery systems. Many current clinical practitioners are still resistant to the roll out of ICT within the NHS. This resistance may be explained by a fear of change, the inability to embrace changes in clinical practice, and the empowered role of the patient in the care process.

Home-based drug delivery devices are one of the tools that can be utilised to support clinical knowledge management in the modern healthcare setting by delivering concise, appropriate and timely clinical information relating to an individual patient's clinical state in "real time" to key stakeholders involved in the care and management of chronic clinical conditions. Collection and storage of clinical data electronically at the point of care offers healthcare professionals instant access to clinical data such as medication history and test results from remote locations. Mobile access also allows healthcare professionals to access and update care plans, clinical guidelines and protocols, thus tailoring care by having access to detailed information relating to an individual patient.

However, not all clinicians are comfortable or ready to use mobile devices in clinical practice. The benefits of using mobile health technology at the point of care will only be demonstrated by widespread adoption into clinical practice. For example, the use of handheld computers to access clinical guidelines and protocols etc, especially by junior doctors in secondary care is becoming more widespread. Use by all clinical stakeholders at the point of care should be encouraged, in order to benefit patient care. As adoption of these devices becomes more commonplace, the opportunity arises for innovative uses in the clinical setting to be explored.

The management of chronic clinical conditions often involves community healthcare practitioners. Access to timely information relating to a patients condition will support home-based care. In the past, relatives and neighbours often provided clinical care at home, clinicians and allied health professionals played a small role in the care of the average patient due to the related cost of healthcare. When the NHS was established, the focus of care for chronic conditions transferred to the "free" primary and secondary healthcare systems. Today, home- and self-care are re-emerging in response to cost pressures, the emergence of the Internet as a conduit of health information to patients, and by the diffusion of inexpensive computer technology as an aid to medical decision-making at the point of care. The benefits of home based drug delivery systems will be judged on patient outcomes as well as the reduction in costs relating to the provision of healthcare to support the ongoing treatment of chronic conditions.

STANDARDS

Issues surrounding the security of electronic patient records may impede development and implementation of innovative home-based drug delivery systems. Time spent debating this issue without the underpinning knowledge of international standards can often lead to an insular focus on ICT development and its ongoing benefits to the provision of patient centred care. Security and privacy of clinical data are at the forefront of any debate concerning mobile health. It is essential that uniform data standards for patient information and the electronic exchange of that information be adopted on a worldwide basis and are embedded in system development.

Recently, the US government has recommended that Health Level Seven (HL7) be recognised as the core-messaging standard (Health Level 7). Standards development must address issues such as security and the protection of data privacy, while facilitating communication between individuals. In developing a system for home-based drug delivery systems, patient–clinician communication must be structured and secure to ensure reliability and relationships underpinned by trust to be developed. Essential data must be clearly represented within a document structure (Nygren et al., 1998) Adherence to standards will allow analysis of the data collected and enable clinical outcomes to be communicated to the wider clinical community without an individual patient's privacy being compromised.

Communication of electronic clinical data and information across platforms should not be device specific. The electronic provision of clinical information, using an extensible mark up language (XML) format for interoperability, is a stated UK Government target that is endorsed by the National Health Service Information Authority (NHSIA). Regardless of which device is chosen, the use of XML facilitates electronic document management and workflow, and allows tasks to be distributed amongst multi-professional healthcare personnel that will result in the optimisation of patient care.

CURRENT PRESCRIBING PRACTICE

There is a wide range of inhalers available for the delivery of drugs to the lung. Studies have shown that asthmatics do not use prescribed inhalers correctly (Thompson, Irvine, Grathwohl, & Roth, 1994). The most effective inhaler is one that will be used by the patient on a regular basis and in an effective manner. As "poorly" compliant patients are often at risk of frequent attacks, it may be desirable to develop drug delivery devices that can capture data relating to use and feed this information into an electronic healthcare record system, accessible by all stakeholders in the care process, in order to support home based patient care and facilitate clinical knowledge management.

MOBILE DEVICES

Mobile health solutions allow for a point of care interaction regardless of whether the patient is in hospital, at home or elsewhere in the community (Price & Summers, 2004). Mobile devices can assist health professionals in their day-to-day clinical environment by facilitating the provision of timely information. Mobile devices can also be of use in medical research, used for clinical trials to record and transmit data that are costly to capture by traditional methods. It is essential that the clinical information is delivered in “real time” and can be readily accessed and understood by all stakeholders, including patients, who are involved in the care process. The development of an integrated drug delivery system enables all stakeholders, including patients and clinicians, to add value to the care process. The smart interface and the use of a patient diary provide a solution to the management of complex clinical communication issues by allowing documents to be stored electronically and retrieved at will. It is crucial that these documents are available in various formats and have the capability to be delivered to a wide range of platforms, depending on preference and circumstances of use. The device holds information that can be read in context of the recipient—this means that careful choice terms have to be used so as to avoid misinterpretation. It is clear that the integration of mobile devices into the healthcare process will demonstrate considerable benefit to UK plc by reducing the economic burden on primary, secondary and tertiary care.

CLINICAL KNOWLEDGE MANAGEMENT

Data captured by the drug delivery device can be used to create useful information for both clinicians and patients. The information generated must be about the right person, stored in a medium that is accessible and delivered at the right time by any specified delivery device, such as mobile phones, palmtops as well as desktop PC’s. A critical element to the successful integration of mobile-devices must be commitment by all stakeholders, at all stages from development, implementation through to adoption into daily use. Home-based drug delivery systems must provide efficient and cost effective care for patients, focusing on preventing complications through the use of alerts generated by the system when recorded results fall outside the ‘agreed’ patient profile, negotiated by individual patients and their nominated clinician.

Issues relating to the adoption of home based drug delivery devices include awareness of users previous experience relating to ICT in general, the device used to transmit and receive data, the identification of data that has specific relevance to a nominated clinician and the acceptability of filtering information in order to generate appropriate clinical information to the right person at the right point in time. A rigorous evaluation process will identify further issues generated when the device is integrated into the care process.

In order to take advantage of the developments surrounding electronic clinical note keeping, a device has been developed to deliver drugs to the lungs, initially to treat the symptoms of chronic asthma, but with planned exploitation routes to include diabetes and pain management. An integrated drug delivery system including a smart interface and patient diary capability allows documents to be stored electronically and retrieved at will. It is crucial that these documents are available in various formats and have the capability to be delivered to a wide range of platforms, depending on preference and circumstances of use. The device will also hold information that crosses various organisational boundaries, to be read in context of the recipient—this means that careful choice of terms has been used so as to avoid misinterpretation. It is clear that the device possesses considerable benefit to UK plc by reducing the economic burden on primary and secondary care.

In order to investigate the elements to be utilised for data capture and dissemination of clinical information a set of typical Use Cases was generated, describing patient and clinical aspects, the device to systems interfaces, and administrative functions. Investigation and mapping of e-health capabilities, such as generic search, retrieval and visualisation took place. The first draft of the functional specification required for the integration of data generated and captured from the drug delivery device, is described below.

The system is configured to accept sign-on from patients, carers and clinical staff. Demographic information will initially be populated locally, but later will be drawn from the local Community Index (Exeter system). Patient ID, initially populated locally using NHS numbers where possible, will later be drawn from the Community Index. Patient registration can take place by registering the device against a patient—which would need to be managed carefully. If the device is issued to a new patient without the system being updated, then the data will be associated with the wrong patient. Alternatively, all data are supplied with a patient ID (e.g., NHS number). This would mean that the device is either capable of holding an ID for the user or that the patient submits data in a two-phase process, by signing onto the system and then providing a password. Patient folders are automatically created when the patient is positively identified. In order to achieve maximum coverage for "alerts" to nominated health professionals, it is essential that clinicians are able to select a delivery device that they feel most comfortable with. The options available include: mobile phones, PDAs, land line phones, and fax.

Factors to take into consideration when deciding upon appropriate channels of communication include ability to access "real time" information, the need to communicate quickly with the nominated clinician and to agree the method of communication with the patient. The device supports the delivery of clinical information delivered in "real time", which can be readily accessed and understood by all stakeholders, including patients and their carers who are involved in the management of chronic conditions.

The information held within the system covers:

- Schedules for prescription against which alerts/actions may be triggered. These alerts will be negotiated at an individual patient level and after consultation with the nominated clinician. It is envisaged that these alerts will eventually be sent to a nominated pharmacy to ensure and support efficient and timely prescription of the required drugs to patients.
- Drug dosing information (prescription) received from the devices, these data will be tested against the schedule

Figure 1. E-medic platform

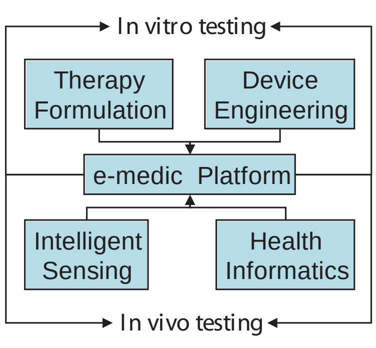
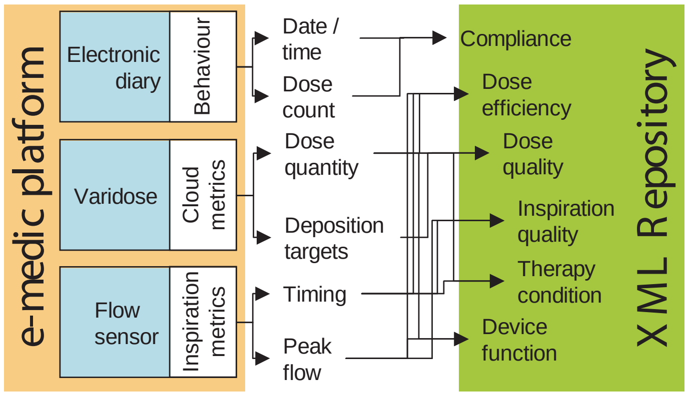


Figure 2. Informatics metrics



    - Drug name—the patient may be taking more that one type of drug therapy and it is therefore important to distinguish which drug has been taken.
    - Dose prescribed
    - Frequency—will enable accurate data to be collected to map actual use against planned use
    - Alerting rules
    - Remaining inhalations
    - Date next prescription is due
- Drug taken—information from the inhaler device
    - Patient ID—NHS number, or device number that matches to the patient
    - Drug name
    - Breathing profile indicator
    - Device malfunction status flag
    - When a drug event is received, it is checked against the most recent schedule.
    - Check for remaining inhalations; if down to last inhalation send "in-tray" alert to nominated clinician
    - Check against Alerting rules; if fails check create "in-tray" item to nominated clinician
    - Check value of Breathing Profile indicator; if outside normal profile create "in-tray" item for nominated clinician
    - Create drug event and store in electronic healthcare record

STRUCTURED EVALUATION

Integration of home based drug delivery devices to capture and disseminate clinical data and information into daily clinical practice must be subjected to thorough and rigorous evaluation at every stage of the procurement and implementation process. A key element of evaluation is the need to identify "best practices" relating to device use and patient feedback, ensuring that is rolled out to the wider clinical community and embedded in the development of future asthma management plans, along with clinical protocols and guidelines.

Unless it can be demonstrated that mobile devices have improved organisational effectiveness as well as contributing to an improvement in patient care, and have subscribed to the development of clinical care in general, their contribution to the clinical knowledge management process will be devalued.

Academic clinical studies will be required to evaluate the benefits of home based drug delivery systems focusing on the possible clinical benefit to the patient and additional benefit to clinical care, looking at the use of the device by patients with little or no ICT skills, an increase in patient involvement in the care management process and the level of patient compliance compared with those patients not using the device. Randomised trials indicate improvement in patient health and reduction in healthcare costs (Simon, Von Korff, Rutter, & Wagner, 2000). The return on investment should be measured in terms of any increase in the level of patient care and any advancement in the knowledge relating to chronic clinical conditions.

FUTURE USES

As adoption of integrated devices into daily clinical practice becomes more commonplace, the opportunity arises for innovative uses in the clinical setting to be explored. The device can be used for clinical trials to record and transmit data that are costly to capture by traditional methods. The ability to record the patients breathing profile could enable the relationship between a successful dose deposition of the drug being delivered to the lungs and the patient ability to match their pre-determined "perfect profile". This information would be of use in the future development of novel drug therapies and would also provide the clinical community with invaluable information relating to patterns of inhaler use and effectiveness.

OUTCOMES

Successful implementation of the device into daily clinical use will require commitment from patients/carers, individual healthcare professionals as well as healthcare organisations. A tailored training infrastructure for all is essential, not only to demonstrate correct use, but also demonstrate benefits that can be achieved from the device on an individual basis. The integration of the device into daily clinical practice will only be achieved if issues associated with it are incorporated into clinical teaching practice and continuous professional development programmes. Although training can be expensive and time consuming, it is an investment that is critical to the acceptance of all home based clinical systems. Home-based drug delivery devices are likely to generate data to populate mature information databases to inform clinical practice and may facilitate the growing trend to decentralisation of care.

CONCLUSIONS

Uptake of novel drug delivery devices will depend on many factors, including organisational support, effective training infrastructure, reliable systems, integration with legacy systems, data standards, workflow patterns, privacy and security, and healthcare standards. In the US, drivers to ensure successful implementation will be improved clinical outcomes and the ability to bill patients for each element of a clinical episode at the point of care. In the UK, more emphasis will be placed on the ability to input and retrieve data and information using an "integrated electronic healthcare record" accessible by clinicians and allied health professionals at the point of care, regardless of location.

It is essential to involve all stakeholders in the debate relating to the goals of clinical knowledge management and the strategies required to achieve them. Presently, clinical information is not currently disseminated in a way that facilitates understanding by patients. Patient awareness of their rights to access clinical data is patchy and channels of access to information are not well developed. The use of abbreviations and codes acts as a barrier to understanding by non-clinicians. Patients with specific knowledge relating to chronic conditions require tailored communication infrastructures to be developed before they can take their place as equal partners in the care process. It is essential that all stakeholders are comfortable with clinicians adopting a supportive role to enable patients to recognise deteriorating asthma and for patients be relaxed about taking a pivotal role in the self-management of their own medication to prevent deterioration in their condition. Discontinuity and lack of communication between primary care, emergency departments, and even within secondary care may hinder the development of an integrated care programme for asthma.

The way to address this is through greater involvement of patients in their own management. The use of a drug delivery device that includes the use of a patient diary will go some way to support an integrated care programme for the management of the asthmatic patient. Thus the drug delivery device is the integrator that underpins the integrated care process. The electronic healthcare record is the repository that is pivotal to the knowledge sharing activity that is required to empower all stakeholders in the care process and capture "real time" clinical information to add to knowledge already held about a chronic clinical condition. Many clinicians complain that they suffer from "information overload"; mobile communication devices are one of the tools that can be utilised to support clinical knowledge management in the modern healthcare setting.

REFERENCES

Department of Health (DOH). (2001a). *The expert patient: A new approach to chronic disease management for the 21st century*. London: DOH.

Department of Health (DOH) (2001b). *Building the information core: Implementing the NHS Plan*. London: DOH.

Health Level 7. Retrieved March 24, 2004 from http://www.hl7.org

Information for Health. (1998). London: NHS Executive.

Lorig, K.R., Sobel, D.S., Stewart, A.L., Brown, B.W., Ritter P., Gonzalez, V.M., Laurent, D.D., & Holman, H. (1999). Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalisation – A randomised trial. *MedCare*, *37*(1), 5-14.

National Asthma Campaign (2001). Asthma audit. Retrieved March 24, 2004, from www.asthma.org.uk

National Programme for Information Technology (2004). Retrieved March 24, 2004, from http://www.dh.gov.uk/PolicyAndGuidance/InformationTechnology/NationalITProgramme/fs/en

Nygren, E., Wyatt, J., & Wright, P. (1998). Helping clinicians to find data and avoid delays. *The Lancet*, *352*, 1462-6.

Office for National Statistics (n.d.). Retrieved from http://www.statistics.gov.uk

Price, S., & Summers, R. (2002). Clinical knowledge management and m-health.*Proceedings of the 24th IEEE Engineering in Medical and Biological Sciences Annual International Conference*, Houston, Texas (pp. 1865-1866) [CD-ROM].

Simon, G.E., Von Korff, M., Rutter, C., & Wagner, E. (2000). Randomised trial of monitoring, feedback and management of care by telephone to improve treatment of depression in primary care. *BMJ*, *320*, 550-554.

Thompson, J., Irvine, T., Grathwohl, K. & Roth, B. (1994). Misuse of metered dose inhalers in hospitalised patients. *Chest*, *105*(3), 715-717.

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Chapter 3.10
The Role of Organizational Trust in Knowledge Management:
Tools & Technology Use & Success

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ABSTRACT

The discipline of knowledge management (KM) is no longer emerging, but some organizations are still struggling to find the right approach that will allow them to fully take advantage of their intellectual assets. Having the proper organizational culture remains an important barrier to knowledge management success. This empirical research project, conducted with data from 97 organizations involved in KM, explores relationships between the level of organizational trust and the use of KM methodologies, in particular the use of codification KM methodologies and personalization KM methodologies. The presence of trust can also be used as an indicator of KM initiative success. The contribution of this research may help organizations seeking to launch or adapt a KM initiative to choose which KM tools and technologies to deploy in order to maximize their chance of success. Finally, a rank-ordered list of KM methodologies in descending order of usefulness is reported.

INTRODUCTION

Knowledge management (KM) initiatives are expanding across all types of organizations and companies worldwide. Many benefits resulting from the successful implementation of KM have been demonstrated and published, but unfortunately not all KM initiatives are successful. Studies and surveys looking at some of the causes of

KM initiative failure (Barth, 2000; Knowledge Management Review, 2001; KPMG Consulting, 2000; Microsoft, 1999; Pauleen & Mason, 2002) all come to the same conclusion: Organizational culture is an important barrier to KM success and is an important precondition for KM success (Tuggle & Shaw, 2000). After having primarily focused KM efforts on information technology (IT), practitioners are now realizing the importance of the "soft" aspect of KM initiatives. It seems that the IT tools designed to facilitate knowledge creation, capture, representation, storage, and sharing are now available, but their efficient use and acceptance by knowledge workers remains constrained by organizational culture.

There is a general agreement that a knowledge-sharing organizational culture must be present or nurtured in order to succeed with KM (see, for example, Alavi & Leidner, 2001, and Jennex & Olfman, 2001). However, the current literature is weak regarding the identification of the critical cultural success factors that lie behind the term "culture". Often mentioned as important cultural factors are altruism, reciprocity, trust, repute, openness, solidarity, sociability, motivation, commitment, and others (Davenport & Prusak, 1998; Malhotra & Galletta, 2003; Park, Ribière & Schulte, 2004). Jennex and Olfman (2004) identify 14 KMS success factors, one of which (SF5) specifically states "An organizational culture that supports learning and the sharing and use of knowledge". Based on a literature review, trust seems to be one of the most critical factors among the ones listed previously. If knowledge workers are reluctant to trust each other, they are not likely to share and exchange knowledge. Without the presence of trust, the benefits of reciprocity, repute, openness, solidarity, and sociability will not occur and levels of motivation and commitment might be seriously affected (negatively). "Without trust, Knowledge Management will fail, regardless of how thoroughly it is supported by technology and rhetoric and even if the survival of the organization depends on effective knowledge transfer" (Davenport & Prusak, 1998). Does having a low trust organizational culture mean that a company should not consider launching a KM initiative? Since culture is difficult to change in the short term, are there some KM approaches/tools that might succeed and might also help to evolve the culture? This article will attempt to shed light on these issues.

STATEMENT OF THE PROBLEM

This study attempts to better understand and to measure how organizational trust affects the choice and use of KM tools and technology and the resulting success of the organization's KM initiative, or lack thereof. Our main research question is as follows:

Does the level of organizational trust influence which KM tools & technology will be successful?

In order to study this research question, the level of organizational trust is assessed through a questionnaire distributed to knowledge workers from different organizations involved in KM. Second, the types of KM tools and technology implemented and used in these organizations were evaluated. Finally, the level of success achieved was assessed. The research project reported on herein is a straightforward extension of these pilot activities. The next sections define these aforementioned variables.

Organizational Trust

Considerable research has been conducted concerning the concept of trust, both interpersonal trust and organizational trust. As with the concept of organizational culture, organizational trust has been defined somewhat differently in the literature by numerous authors (Carnevale & Wechsler, 1992; Culbert & McDonough, 1986;

Griffin, 1967; Luhmann, 1979; Matthai, 1989; McKnight & Chervany, 2000). The definitions of trust are numerous and sometimes confusing, mainly due to each discipline viewing trust from its own perspective. Two definitions of KM were selected:

"Trust consists of a willingness to increase your vulnerability to another person whose behavior you cannot control, in a situation in which your potential benefit is much less than your potential loss if the other person abuses your vulnerability" (Zand, 1997).

"Belief that those on whom we depend will meet our expectations of them" (Shaw, 1997).

Research on trust is often associated with research on organizational commitment and work attitudes (Cook & Wall, 1980; Mowday, Steers & Porter, 1979; Nyhan, 1999). Research conducted by Daley and Vasu (1998) examining employee attitudes of organizational trust toward those in top management positions demonstrated that demographic controls (education, pay level, race and gender) exhibited no substantive effect. Attitudes assessing internal job characteristics (benefits, extrinsic rewards and work environment) demonstrated a relationship in fostering trust. External work characteristics (job satisfaction, supervisory evaluation, and political interference) also emerged as determinants of organizational trust (Daley & Vasu, 1998). In addition to the many definitions of trust, many tools have also been created to assess its level in an organization. Among them is the survey tool designed by Cook and Wall (1980) that has been extended by Wilson (1993). Wilson developed a heuristic conceptualization — in the form of an influence diagram- that can be used by managers in assessing the level of organizational trust. Cummings and Bromiley (1996) designed a survey tool named the Organizational Trust Inventory (OTI). This tool is intended to measure the degree of trust between units of an organization or between organizations. Their questionnaire is based on a (3x3) "definitional matrix of trust as a belief" where three dimensions of trust (keeps commitments, negotiates honestly and avoids taking excessive advantage) are mapped against three components of belief (affective state (feel), cognition (think) and intended behavior). Nyhan and Marlowe (1997) developed a 12-item scale to measure an individual's level of trust in his or her supervisor and his or her work organization as a whole. Two books on trust also offered assessment tools. Built on Trust by Ciancutti and Steding (2000) offers an audit questionnaire based on 21 questions as well as six open-ended questions. This questionnaire is designed to detect both the overall level of trust and the type of issues in which closure is a concern. The second book by Lewis (1999) is more oriented toward how companies build mutual trust and how interpersonal relationships are a critical component. The tool presented in this book is defined as a yardstick for measuring how close your company is to building high trust. A set of 21 trust practices is listed and for each of these a low trust behavior as well as a high trust behavior is listed. "Where you and your partner fall in the continuum between high and low trust determines your ability to rely on each other to reach a common objective" (Lewis, 1999). Five trust factors defined by De Furia (1996, 1997) were determined to be most relevant to our research: sharing relevant information; reducing controls; allowing mutual influences; clarifying mutual expectations; and meeting expectations. These factors are described in more detail in the following section of this article. Very often people think that an organizational culture with a high level of sociability also implies a high level of trust. This is not always true. Consider the example of a parent-child relationship: you love your children but it does not imply that you trust them (e.g., you will not leave them by themselves). The opposite is also true: you might trust someone but might not necessarily like this person (e.g., an airplane pilot). One also needs to remember that trustworthiness takes a long time to build, and yet trust can be destroyed in an instant. These different examples show the complexity and fragility associated with trust. The benefits of high trust include (De Furia, 1997):

- Stimulates innovation
- Leads to greater emotional stability
- Facilitates acceptance and openness of expression
- Encourages risk taking

Consequences of low trust include (De Furia, 1997):

- Values, motives of others are misperceived
- Less accurate communication, poor reception
- Diminished ability to recognize and accept good ideas
- Increased attempt to obtain relevant information (grapevine)
- Increased control mechanisms
- Self-control replaced by external controls
- Delayed implementation of actions and projects
- Increased rejection, defensiveness, hostility
- Win-lose mentality replaces win-win

"Trust is the one essential lubricant to any and all social activities. Allowing people to work and live together without generating a constant, wasteful flurry of conflict and negotiations" (Cohen & Prusak, 2001).

Knowledge Management Tools and Technologies

Numerous publications present knowledge management practice/tool/technology frameworks. Most of them are IT oriented, since IT is the main enabler for KM. Nevertheless, other KM practices that are not driven by IT must also be taken in consideration in order to fully understand the KM strategy of an organization. Two main KM strategies or approaches emerged: codification versus personalization. Hansen, Nohria and Tierney (1999) describe how different companies focus on different practices/strategies in order to manage their knowledge. Additional reasons for this particular categorization of KMS approaches are offered by Jennex and Olfman (2003).

The Codification Approach

The first strategy identified by Hansen et al. (1999) is called "codification," which relies heavily on IT. One of the benefits of the codification approach is the reuse of knowledge. "Knowledge is codified and stored in databases, where it can be accessed and used easily by anyone in the company. Knowledge is codified using a people-to-documents approach: it is extracted from the person who developed it, made independent of that person, and reused for various purposes" (Hansen et al., 1999). It has been named and described differently by authors: the cognitive network model (Swan, Newell, Scarbrough & Hislop, 1999), the collecting dimension (Denning, 1998), the product view approach (Know-Net, 2000), the transformation model (Natarajan & Shekhar, 2000), distributive applications (Zack & Michael, 1998), the document-centered approach and the technological approach (Wick, 2000). After a close analysis of these different portrayals, one can conclude that all of these descriptions and definitions are very similar and depict the same type of practices and tools (Ribière, 2001).

The Personalization Approach

The personalization approach (Hansen et al., 1999) focuses on developing networks for linking people so that tacit knowledge can be shared. It invests moderately in IT. This approach focuses on dialogue between individuals, not knowledge in a database. "Knowledge that has not been codified — and probably couldn't be — is transferred in brainstorming sessions and one-on-one conversations" (Hansen et al., 1999). An investment is made on building networks of people, where knowledge is shared not only face-to-face but also over the telephone, by e-mail, and via videoconference. All the previously cited authors who defined the codification approach also came up with their own definition for this approach: the community networking model (Swan et al., 1999), the connecting dimension (Denning, 1998), the process-centered approach (Know-Net, 2000), the independent model (Natarajan & Shekhar, 2000), the collaborative approach (Zack & Michael, 1998), and socio-organizational knowledge management (Wick, 2000).

KM Initiative Success

It is always difficult and open to controversy to define and measure "success". Different metrics (qualitative and quantitative) can be used to measure success. For example, Jennex and Olfman (2004) offer a success model based upon the Delone and McLean (1992) IS Success Model and discuss four different models of KM success: Knowledge Value Chain (Bots & Bruiin, 2002), Massey, Montoya-Weiss and Driscoll KM Success Model (2002), Lindsey KM Effectiveness Model (2002), and Jennex and Olfman KMS Success Model (2003). Four main indicators defined and used by Davenport et al. in their publication concerning "successful knowledge management projects" were adopted (Davenport, De Long & Beers, 1998).

1. Growth in the volume of knowledge available since the KM initiative has been launched (e.g., number of documents available)
2. Growth in the usage of knowledge available since the KM initiative has been launched (accesses to repositories, or the number of participants for discussion-oriented projects)
3. The likelihood that the project would survive without the support of a particular individual or two; that is, the project is an organizational initiative, not an individual project
4. Growth in the resources (e.g., people, money) attached to KM initiatives

Success was measured based on two dimensions. Since the main purpose of a KMS is to facilitate the flow and dissemination of knowledge, an important dimension for success is the fact that different employees use the system. Success factors #1 and #2 were used to measure this dimension of success. The second dimension of success used is based on the "robustness" of the KM initiative. If KM is given the resources and if there is a clear commitment from senior management to make it happen, then robustness is a success factor. Success factors #3 and #4 were used to measure this second dimension of success. Additional success factors could have been used, such as the 12 KMS success factors presented by Jennex and Olfman (2004), but it was easier to work with a smaller number of core variables.

These factors helped us to differentiate highly successful KM projects from less successful projects.

RESEARCH DESIGN AND METHODOLOGY

Research Hypotheses

Three hypotheses were derived from our main research question:

H1: Companies with a low organizational trust culture use/rely more on codification tools than companies with a high organizational trust culture.

H2: Companies with a high organizational trust culture use/rely more on personalization tools than companies with a low organizational trust culture.

H3: Companies with a high organizational trust culture will be more successful with their KM initiatives than companies with a low organizational trust culture.

Assessment of Variables

A survey tool (a questionnaire) was developed in order to assess:

1. The level of organizational trust
2. The level of use of different KM tools and technologies deployed in each organization (codification emphasis vs. personalization emphasis)
3. The perceived success of the KM initiative

Assessing Organizational Trust

The tool selected, the Organizational Trust Survey (OTS), was developed and validated by De Furia (1996, 1997), where trustworthiness (TW) is based on five behaviors:

TW = SI + RC + AI + CE + ME

- Sharing relevant information (SI) refers to the behaviors whereby one individual transmits information to another person.
- Reducing controls (RC) refers to the behaviors affecting the processes, procedures or activities with which one individual (1) establishes the performance criteria or rules for others, (2) monitors the performance of another person, (3) adjusts the conditions under which performance is achieved, or (4) adjusts the consequences of performance (i.e., positive or negative reinforcements).
- Allowing for mutual influences (AI) occurs when one person makes a decision that affects both individuals. Mutual influence means that both individuals have approximately equal numbers of occurrences of convincing the other or making the decision for both individuals.
- Clarifying mutual expectations (CE) refers to those behaviors wherein one person clarifies what is expected of both parties in the relationship. It involves sharing information about mutual performance expectations.
- Meeting expectations (ME) involves any behaviors in which one individual fulfills the behavioral expectations of another person. It is closely related to confidence, reliability and predictability.

The OTS allows organizations to measure the trust-related behaviors of various categories of people within the organization — upper managers, first line supervisors, and coworkers — in relation to how employees' trust-related expectations are being met. It also measures trust-related behaviors between organizational units and the perceived impacts of organizational policies and values on trust-related behaviors. This tool (questionnaire) is based on 50 questions (10 questions for each of the five factors). Because of the existence of a pretested questionnaire with a small number of variables, necessary because of the somewhat limited size of our dataset, the OTS was used.

Assessing the Use of KM Tools and Technologies

For this section of the questionnaire an assessment tool was developed. The most common tools and technologies used for knowledge management initiatives were listed, based on a literature review. Respondents were asked to list the KM tools and technologies used at the organizational level (cf. Table 1). A sense of the degree of use or utilization ranging from "most used" to "least used"

Table 1. Codification and personalization KM tools and technologies

	KM Tools and Technologies
Codification	Email & Listserv
	Corporate Intranet – Extranet – Internet
	Database Management Systems
	Search Engines - Intelligent Agents
	Data Warehouses – Data Marts
	Web-based training – e-learning
	Help-desk applications
	DMS
	Multimedia repositories
	DSS and Expert Systems
	Data mining- Knowledge Discovery
	Knowledge Mapping
Personalization	Expertise locators – Corporate Yellow pages – Who's who
	Communities of Practice (interests in the same topic, field)
	Communities of Purpose (project, task oriented)
	Groupware
	Teleconferencing (shared applications, whiteboards)
	Best practices repository
	Videoconferencing (using audio and/or video)
	Mentoring - Tutoring
	Story Telling
	Desktop computer conferencing
	Online Chat & Instant Messaging

was employed to enrich this insight. Although it might be argued that some of the personalization tools, for example, corporate yellow pages, in fact are examples of codified knowledge, the critical delineator is how the tools are used in practice. For example, the crucial fact about corporate yellow pages is not that it is a knowledge repository, but that employees use it to connect to experts.

KM Initiative's Success

As mentioned earlier in this article, four indicators were used to assess the level of success. Respondents were asked to assess on a five-point Likert scale to what degree they believed that the following statements corresponded to the current success status of their organizational KM initiative (see Example 1).

Validity and Reliability

Designing a new survey instrument is always a difficult task. Finding relevant variables and factors that capture the appropriate dimensions (that prove to be valid and reliable over different samples and over time) is always a challenge. In order to surmount this difficulty, a previously validated questionnaire was adopted in order to assess the

Example 1

Strongly agree - Agree - Neither agree nor disagree - Disagree - Strongly disagree
2 · 1 · 0 · -1 · -2

- I have noticed a significant growth in the volume of knowledge available since the KM initiative has been launched (number of documents available).
  2 · 1 · 0 · -1 · -2
- I have noticed a significant growth in the usage of knowledge available since the KM initiative has been launched (accesses to repositories and number of participants for discussion-oriented projects)
  2 · 1 · 0 · -1 · -2
- I believe that the project would survive without the support of a particular individual or two
  2 · 1 · 0 · -1 · -2
- I believe that resources (e.g., people, money) attached to KM initiatives are going to grow
  2 · 1 · 0 · -1 · -2

trust dimension. This questionnaire was extended to assess the type of KM tools and technologies used by organizations as well as to assess the level of success of KM initiatives. A pre-test or pilot study was undertaken to create a more sensitive instrument. Content validity was demonstrated by the review of 10 knowledgeable people (academics and professional) highly involved in the field of KM and organizational behavior. Only minor modifications were made to those instruments used in the research reported herein.

Cronbach's alpha value was used to assess the internal consistency of the research instruments (cf. Table 2). The overall raw alpha score of .94 indicates that the scales used to measure trust are reliable. Nevertheless, the table indicates that RC2 has the lowest item-total correlation value (.27). This indicates that RC2 is not measuring the same construct as the rest of the items in the scale are measuring. RC2 was removed from the scale in order to make the construct more reliable for use as a predictor variable. The question associated with Reducing Control #2 (RC2) was "My coworkers take the initiative to solve problems sometimes ignoring rules to do so". This question might have been misunderstood or not properly interpreted, leading to its low correlation with the other factors.

Construct validity was assessed using item-total correlation where the average of each construct was correlated with each item in the same construct. The correlation coefficients for all these constructs were demonstrated to be highly significant.

DATA COLLECTION AND ANALYSIS

Data were collected through two main mechanisms. An online version of the questionnaire posted on the Web (http://www.csis.american.edu/kmsurvey) as well as a paper version were used. Most of the responses received (98%) came from the online version. The target population was chief knowledge officers (CKOs), managers, and other employees involved in knowledge manage-

Table 2. Cronbach Coefficient Alpha regarding "trust" assessment instrument

Cronbach Coefficient Alpha

Variables	Alpha
Raw	0.941218
Standardized	0.940431

Cronbach Coefficient Alpha with Deleted Variable

	Raw Variable		**Standardized Variables**	
Deleted variable	Correlation with total	Alpha	Correlation with total	Alpha
SI1	0.658313	0.938203	0.660621	0.937337
RC1	0.444163	0.940928	0.448380	0.940113
AI1	0.504476	0.940147	0.509213	0.939325
CE1	0.626379	0.938647	0.630604	0.937734
ME1	0.610973	0.938851	0.611148	0.937990
SI2	0.598599	0.939008	0.603039	0.938097
RC2	**0.270124**	**0.942696**	**0.275536**	**0.942320**
AI2	0.544850	0.939685	0.551738	0.938770
CE2	0.636757	0.938515	0.644151	0.937555
ME2	0.593836	0.939073	0.600595	0.938129
SI3	0.744654	0.936924	0.742353	0.936248
RC3	0.623843	0.938681	0.622482	0.937841
AI3	0.533812	0.939803	0.528939	0.939068
CE3	0.600969	0.938977	0.593796	0.938219
ME3	0.668652	0.938092	0.665388	0.937274
SI4	0.671781	0.938010	0.665450	0.937273
RC4	0.641701	0.938449	0.637314	0.937645
AI4	0.578959	0.939266	0.570825	0.938520
CE4	0.706540	0.937540	0.703754	0.936764
ME4	0.599708	0.939022	0.593802	0.938219
SI5	0.632511	0.938580	0.628290	0.937764
RC5	0.699900	0.937675	0.698372	0.936835
AI5	0.680606	0.937921	0.680814	0.937069
CE5	0.648384	0.938392	0.646302	0.937526
ME5	0.569125	0.939439	0.565317	0.938592

ment initiatives at any level in an organization. A total of 1,050 e-mails asking for participation were sent out to targeted people involved with KM (members of KM groups and associations). A total of 129 responses were received. This represents a response rate of 12%. A fundamental premise of the research was that targeted organizations must have had experience with KM initiatives.

Of the 129 questionnaires received only 97 were complete and were representative of organizations involved in KM.

Organizations that participated were predominantly large organizations in the consulting and IT — telecommunications fields as well as agencies in the federal government. Respondents were mainly service-oriented, offering both standardized and customized products/services, and were predominantly located in the U.S.

DATA ANALYSIS

Research Hypothesis 1

This hypothesis tests the difference between the codification factor score (dependent variable) associated with companies with low and high levels of organizational trust (independent variable).

H1: Companies with a low organizational trust culture use/rely more on codification tools than companies with a high organizational trust culture.

The codification factor score variable was measured on an interval/ratio scale of values ranging from 0 to 60. The level of trust factor score variable was measured on an interval/ratio scale of values ranging from 25 to 125. However, a cutoff point of 75 (the mid-point in the range) was used to divide the variable into two sets. Organizations that obtain trust factor scores greater than 75 were categorized as having a high trust culture, while organizations with scores less than or equal to 75 were categorized as having a low trust culture. An independent-sample one-tailed t test was used to analyze the differences of means between the companies with high and low trust. Table 3 provides some descriptive statistics of the two groups studied.

The probability associated with the F-test for homoskedasticity is 0.9051 (Table 4, row (1)); because this is more than .05, it is not reasonably certain that the variance in the use of codification

Table 3. Descriptive statistics of the two groups studied

	n	$\bar{x}$	Std dev.
High Trust	76	33.066	14.016
Low Trust	23	29.87	14.153

Table 4. Comparison between the codification factor scores of organizations with low and high trust culture

	H_0	H_A	Test	Test Value	d.f.	prob-ability	Accept H_A?
(1)	$\Phi_{HT} = \Phi_{LT}$	$\Phi_{HT} \neq \Phi_{LT}$	**F**-test for homoskedasticity	1.02	(22,75)	0.9051	No
(2)	$\mu_{LT} <= \mu_{HT}$	$\mu_{LT} > \mu_{HT}$	Independent samples **t**-test	0.96	97	0.1707	No

tools differs across the two groups. Applying the pooled/standard form of the independent samples t-test (Table 4, row (2)), statistical theory tells us that a ($\bar{x}_{LT} - \bar{x}_{HT}$) difference more positive than the difference seen here would occur 17 times out of every 100 samples if the null hypothesis was true.

Applying the two-step rule, p=0.1707 (greater than the pre-set ± of .05) and directionality of the difference in sample means is not consistent with HA (29.87<33.066). Thus, H0 is not rejected and HA is not accepted (H1).

Research Hypothesis 2

This hypothesis tests the difference between the personalization factor score (dependent variable) associated with companies with low and high levels of organizational trust (independent variable).

H2: Companies with a high organizational trust culture use/rely more on personalization tools than companies with a low organizational trust culture.

The personalization factor score variable was measured on an interval/ratio scale of values ranging from 0 to 55. The level of trust factor score variable was measured on an interval/ratio scale of values ranging from 25 to 125. Again, a cutoff point of 75 (mid-point score) was used to divide the variable into two sets. Organizations that obtain trust factor scores greater than 75 were categorized as having a high trust culture, while scores less than or equal to 75 were categorized as having a low trust culture. An independent-sample one-tailed t test was used to analyze the differences of means between the companies with high and low trust. Table 5 provides some descriptive statistics of the two groups studied.

The probability associated with the F-test for homoskedasticity is 0.0621 (Table 6, row (1)); because this is more than .05, it is not reasonably certain that the variance in the use of personalization tools differs across the two groups. Apply-

Table 5. Descriptive statistics of the two groups studied

	n	$\bar{x}$	Std. dev.
High Trust	76	29.434	12.16
Low Trust	23	18.174	8.5155

Table 6. Comparison between the personalization factor scores of organizations with low and high trust cultures

	H_0	H_A	Test	Test Value	d.f.	prob-ability	Accept H_A?
(1)	$\Phi_{HT} = \Phi_{LT}$	$\Phi_{HT} \neq \Phi_{LT}$	**F**-test for homoskedasticity	2.04	(75,22)	0.0621	No
(2)	$\mu_{HT} <= \mu_{LT}$	$\mu_{HT} > \mu_{LT}$	Independent samples **t**-test	4.14	97	<.00005	Yes

ing the pooled/standard form of the independent samples t-test (Table 6, row (2)), statistical theory tells us that a difference more positive than the difference seen here ($\bar{x}_{HT} - \bar{x}_{LT}$) would occur less than five out of every 100,000 samples if the null hypothesis was true.

Applying the two-step rule, p<.00005 (less than the pre-set ± of .05) and directionality of the difference in sample means is consistent with HA (29.434>18.174). Thus, H0 is rejected and HA is accepted (H2).

Research Hypothesis 3

This hypothesis tests the difference between the success factor score (dependent variable) associated with companies with low and high levels of organizational trust (independent variable).

H3: Companies with a high organizational trust culture will be more successful in their KM initiative than companies with a low organizational trust culture.

The success factor score variable was measured on an interval/ratio scale of values ranging from 4 to 20. The level of trust factor score variable was measured on an interval/ratio scale of values ranging from 25 to 125. Once again, a cutoff point of 75 (mid-point score) was used to divide the variable into two sets. Organizations that obtain trust factor scores greater than 75 were categorized as having a high trust culture, while scores less than or equal to 75 were categorized as having a low trust culture. An independent-sample one-tailed t test was used to analyze the differences of success means between the companies with high and low trust. Table 7 provides some descriptive statistics of the two groups studied.

The probability associated with the F-test for homoskedasticity is .0869 (Table 8, row (1)); because this is more than .05, it is not reasonably certain that the variance of success differs across the two groups. Applying the pooled/standard form of the independent samples t-test (Table 6, row (2)), statistical theory tells us that a difference more positive than the difference seen here (

Table 7. Descriptive statistics of the two groups studied

	n	$\bar{x}$	Sdt. Dev.
High Trust	69	14.145	3.6125
Low Trust	17	10.882	6.2027

Table 8. Comparison between the success factor scores of organizations with low and high trust cultures

	H_0	H_A	Test	Test Value	d.f.	prob-ability	Accept H_A?
(1)	$\Phi_{HT} = \Phi_{LT}$	$\Phi_{HT} \neq \Phi_{LT}$	**F**-test for homoskedasticity	1.84	(16,68)	0.0869	No
(2)	$\mu_{HT} = \mu_{LT}$	$\mu_{HT} > \mu_{LT}$	Independent samples **t**-test	3.72	84	0.0002	Yes

$\bar{x}_{HT} - \bar{x}_{LT}$) would occur only two times out of every 10,000 samples if the null hypothesis was true.

Applying the two-step rule, p=.0002 (less than the pre-set ± of .05) and directionality of the difference in sample means is consistent with HA (14.145>10.882). Thus, H0 is rejected and HA is accepted (H3).

DISCUSSION

The previous findings helped us to validate some assumptions made regarding the critical role of organizational trust in organizations' use of KM technologies. Companies with a low organizational trust culture do not significantly use/rely more on codification tools than companies with a high organizational trust culture (Hypothesis #1). The codification approach is used by all organizations to different degrees but remains always present. Companies with a high organizational trust culture use/rely more on personalization tools than companies with a low organizational trust culture (Hypothesis #2). In the presence of a trusting culture, knowledge workers are more likely to use personalization tools in order to contact, assist, and share knowledge with their trusted co-workers. If organizational trust is low, knowledge workers are "suspicious" and do not want to increase their vulnerability by sharing their knowledge with co-workers through one-to-one interactions/communications (physical, vocal or virtual). They will then mainly rely on codification tools and technologies to manage knowledge. The efficiency of the codification approach might also be affected by lack of trust. Actually, if knowledge workers do not trust their peers and superiors and if they do not feel inclined to use personalization tools, they will likely not trust codified documents either. Since the main benefit of the personalization approach is to leverage individual knowledge, one can suspect that the level of creativity in low trust organizations might also be affected. Such types of organizations will certainly encounter problems in becoming a learning organization. Finally, companies with a high organizational trust culture are more successful in their KM initiatives than companies with a low organizational trust culture (Hypothesis #3). This last finding makes sense since if knowledge workers do not fully trust their coworkers they are not likely to share their knowledge one way or the other. If knowledge sharing and transfer do not occur, then KM is not likely to succeed.

These findings can be used as guide by organizations interested in implementing KM. Before launching a KM initiative, organizations should assess the level of organizational trust. Based on the obtained score they will have an indicator they could use to decide what type of KM tools and technologies to emphasize. If the level of organizational trust is low, the organization might not want to invest too much in personalization tools since knowledge workers might not use them. Those organizations should prefer to focus their effort on a codification approach and on finding ways to improve the level of trust in their culture. The role of management and leadership should be to craft a solution to such problems (Ribière & Sitar, 2003). If an organization obtains a high organizational trust score, it can be confident that in addition to using codification tools and technologies, personalization tools and technologies will bring value in facilitating tacit knowledge transfer and in enabling innovation.

The study also demonstrated that organizations with high levels of trust are more successful in their KM initiatives than organizations with a low level of trust. Once again, organizational trust can be used as a proactive indicator to gauge chances of success. Before launching a KM initiative, organizations might want to seriously consider this factor.

Finally, the most frequently used KM tools and technology for the 97 respondents of our study were examined. They are ordered by the average score obtained (cf. Table 9).

Table 9. KM tools and technologies most frequently used for knowledge exchanges

Ranking	Technology	KM Tools and Technologies	Average score (1-5)
1	C	Email and Listserv	4.83
2	P	Expertise locators – Corporate Yellow pages – Who's who	4.47
3	C	Corporate Intranet – Extranet – Internet	4.36
4	C	Database Management Systems	4.08
5	C	Search Engines - Intelligent Agents	3.95
6	C	Data Warehouses – Data Marts	3.84
7	C	Web-based training – e-learning	3.82
8	P	Communities of Practice (interests in the same topic, field)	3.78
9	P	Communities of Purpose (project, task oriented)	3.73
10	C	Help-desk applications	3.70
11	P	Groupware	3.68
12	P	Teleconferencing (shared applications, whiteboards)	3.62
13	C	DMS	3.59
14	C	Multimedia repositories	3.58
15	P	Best practices repository	3.51
16	P	Videoconferencing (using audio and/or video)	3.47
17	C	DSS and Expert Systems	3.33
18	C	Data mining- Knowledge Discovery	3.25
19	P	Mentoring - Tutoring	3.24
20	P	Story Telling	3.00
21	C	Knowledge Mapping	2.91
22	P	Desktop computer conferencing	2.91
23	P	Online Chat and Instant Messaging	2.89

***C:** Codification* ***P:** Personalization*

Note that e-mails are by far the most frequently used tool to transfer knowledge. This can be explained by the fact that this is a technology that has been around for a long time and also by the fact that a large majority of knowledge workers use them every day for different purposes. People are more likely to use tools that they are familiar with in order to exchange knowledge rather than learning or using new ones. If knowledge workers are very familiar with a technology, one should not force them to use different tools, but instead one should find ways to build on the familiar technology in order to turn it into a more powerful KM tool (e.g., indexing of e-mail content, expertise profile created based on e-mail content, etc.). This table can be interpreted by looking at the ranking of all the factors but also by looking independently at the most frequently used codification tools and personalization tools. Expertise locator tools (personalization) take the second general position and the first position of personalization tool used. An expertise locator (who is who and who knows what in your organization) is often one of the first KM tools implemented by organizations. They are easy to build, simple to use, and provide rapid benefits. Communities of practice and purpose take the eighth and ninth general position and are in the second and third personalization position. During the past years a strong emphasis on communities and their benefits has emerged in the KM literature. Their implementation is also quite simple, but one needs to be aware that knowledge worker participation relies heavily on organizational culture. Once again, assessing the level of organizational trust might be useful before engaging into such practices.

CONCLUSIONS

If an organization is going to be enduringly successful (Collins, 2001), considerable empirical research clearly indicates that such an organization needs, among other attributes, a single culture that aims all employees at disciplined thought and disciplined action. The bedrock of such a "success culture" is that it must characterize a high-trust organization.

The motive behind this research project is to begin empirically testing the proposition that KM success likewise relies upon the KMS being implemented in an organization with a trusting culture. Our research begins to shed some light upon that phenomenon. In particular, this study indicates that organizations with a higher level of trust are more successful in their use of KM than those organizations with a lower level of trust. (Whether or not those higher levels of trust organizations are also more successful in the marketplace is an intriguing research question left for the future.) Additionally, our work indicates an interesting interaction between the type of KMS used (codification versus personalization) and the level of trust in the organization. Specifically, in low trusting organizations, personalization KM tools tend to not be used — and why should they be used, since co-workers have little faith in one another's reliability?

KM is an IT practice that is implemented in the faith that doing so will lead to higher levels of organizational performance. Our empirical research study begins to establish some of the parameter settings in the domain of characteristics of organizational culture that are necessary for KM success. Clearly, much more research is needed. Data were drawn from one set of organizations, primarily from IT consulting, telecommunications, and the federal government. Our results might be a spurious outcome from peculiar characteristics of this set of organizations. Similar studies restricted to manufacturing firms, retailing firms, financial firms, or non-profits/not-for-profits might yield quite different results. Also, our firms in the sample had existing KM systems. Firms developing KMS might simultaneously take steps to alter organizational policy, procedures, and, yes, even culture, to ensure that those investments in KM would enjoy high payoffs — there are no data to report on that front. And, our organizations all had but a few years' experience with their KMS — the results might be quite different after firms have dozens of years' worth of experience with their KMS.

An organization, of course, is a legal fiction — at heart, an organization consists of a set of people who agree to work together for some vaguely common end. KMS are alleged to assist groups of people into behaving more effectively and more efficiently as they pursue those agreed-upon targets. This study helps shed some light on conditions that make that claim true. However, future KMS work might be directed at other issues relating to KMS success and usefulness, such as how do leadership styles in the organization impact KMS success? How do the presence or absence of particular group norms impact KMS success? When a KMS is successful, what radiates from that project success elsewhere in the organization? When a KMS is not successful, what impact does that have on other IT related projects? What are the causes of KMS failure, and are those failures rectifiable through greater funding, technological advances, culture change, better training, stronger leadership, or some other vehicle?

KM is a technology that is still not completely mature. KM technology holds great promise for organizational rationalization, but there are clearly many issues remaining surrounding KMS that need to be studied. Empirical research of all stripes — laboratory studies, field research, case studies, and so forth — will help scientists and managers put KMS to best use. This can only benefit all of us.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25,* 107-136.

Barth, S. (2000, October). KM horror stories. *Knowledge Management Magazine, 3,* 37-40.

Bots, P.W.G., & Bruiin, H. (2002). *Effective knowledge management in professional organizations: Going by the rules.* Paper presented at the 35th Hawaii International Conference on System Sciences.

Carnevale, D.G., & Wechsler, B. (1992). Trust in the public sector. *Administration and Society, 23,* 471-494.

Ciancutti, A., & Steding, T.L. (2000). *Built on trust. Gaining competitive advantage in any organization*. Contemporary Books.

Cohen, D., & Prusak, L. (2001). *In Good Company. How Social Capital Makes Organizations Work*. Harvard Business School Press.

Collins, J. (2001). *Good to great—Why some companies make the leap ... and others don't*. Harper Business.

Cook, J., & Wall, T. (1980). New work attitude measures of trust, organizational commitment and personal need non-fulfilment. *Journal of Occupational Psychology, 53,* 39-52.

Culbert, S.A., & McDonough, J.J. (1986). The politics of trust and organizational empowerment. *Public Administration Quarterly, 10,* 171-188.

Cummings, L.L., & Bromiley, P. (1996). The organizational trust inventory (OTI). In R.M. Kramer & T.R. Tyler (Eds.), *Trust in organizations: Frontiers of theory and research.* Thousand Oaks, CA: Sage Publications.

Daley, D.M., & Vasu, M.L. (1998). Fostering organizational trust in North Carolina. The pivotal role of administrators and political leaders. *Administration and Society, 30*(1), 62-84.

Davenport, T., De Long, D.W., & C., B.M. (1998). Successful knowledge management projects. *Sloan Management Review,* 43-57.

Davenport, T., & Prusak, L. (1998). *Working knowledge. How organizations manage what they know.* Harvard Business School Press.

De Furia, G.L. (1996). *A behavioral model of interpersonal trust.* Unpublished doctoral dissertation. St. John's University, Springfield, LA.

De Furia, G.L. (1997). *Facilitator's guide to the interpersonal trust surveys.* Pfeiffer & Co.

Delone, W.H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3,* 60-95.

Denning, S. (1998). *What is knowledge management?* Available at http://www.worldbank.org/ks/index.html

Griffin, K. (1967). The contribution of studies of source credibility to a theory of interpersonal trust in the communication process. *Psychological Bulletin, 68,* 104-120.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review*, 106-116.

Jennex, M.E., & Olfman, L. (2001). Development recommendations for knowledge management/ organizational memory systems. In M.K. Sein, B.E. Munkvold, T.U. Orvik, W. Wojtkowski, W.G. Wojtkowski, S. Wrycza, & Z. J. (Eds.), *Contemporary trends in IS development* (pp. 209-222). Kluwer Academic.

Jennex, M.E., & Olfman, L. (2003). *A knowledge management success model: An extension of DeLone and McLean's IS success model.* Paper presented at the Ninth Americas Conference on Information Systems.

Jennex, M.E., & Olfman, L. (2004). *Assessing knowledge management success.* Paper presented at the 37th Hawaii International Conference on System Sciences.

Knowledge Management Review. (2001). *KM Review survey reveals the challenges faced by practitioners.*

Know-Net. (2000). *The approach*. Online: http://www.know-net.org

KPMG Consulting. (2000). *Knowledge Management Research Report.*

Lewis, J.D. (1999). *Trusted partners. How companies build mutual trust and win together.* New York: The Free Press.

Lindsey, K. (2002). *Measuring knowledge management effectiveness: A task-contingent organizational capabilities perspective*. Presented at the 8th Americas Conf. on Infor. Systems.

Luhmann, N. (1979). *Trust and Power.* New York: John Wiley.

Malhotra, Y., & Galletta, D.F. (2003). Role of commitment and motivation in knowledge management systems implementation: Theory, conceptual-ization, and measurement of antecedents of success. Paper presented at the *Hawaii International Conference on System Sciences (HICSS 36).*

Massey, A.P., M.M., M.-W., & O'Driscoll, T.M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Matthai, J.M. (1989). *Employee perceptions of trust, satisfaction, and commitment as predictors of turnover intentions in a mental health setting.* Unpublished doctoral dissertation. Vanderbilt University.

McKnight, H.D., & Chervany, N.L. (2000, August 10-13). What is trust? A conceptual analysis and an interdisciplinary model. Paper presented at the *Americas Conference on Information Systems (AMCIS)*, Long Beach CA.

Microsoft. (1999). *Practicing Knowledge Management.*

Mowday, R.D., Steers, R.M., & Porter, L.W. (1979). The measurement of organizational commitment. *Journal of Vocational Behavior, 14*(2), 224-247.

Natarajan, G., & Shekhar, S. (2000). *Knowledge management: Enabling business growth*. New Delhi: Tata McGraw-Hill.

Nyhan, R.C. (1999). Increasing affective organizational commitment in public organizations. The key role of interpersonal trust. *Review of Public Personnel Administration*, 58-70.

Nyhan, R.C., & Marlowe, H.A.J. (1997). Development and psychometric properties of the organizational trust inventory. *Evaluation Review, 21*(5), 614-635.

Park, H., Ribière, V., & Schulte, W.D. (2004). Critical attributes of organizational culture promoting knowledge sharing & technology implementation successes. *Journal of Knowledge Management, 8*(3).

Pauleen, D., & Mason, D. (2002). *2002 New Zealand knowledge management survey: Barriers and drivers of KM uptake*. Retrieved January 10, 2004, from http://www.nzkm.net/mainsite/NewZealandKnowledge ManagementSurveyBarriersandDriv.html

Ribière, V. (2001). *Assessing knowledge management initiative successes as a function of organizational culture*. Unpublished DSc dissertation. The George Washington University, Washington, DC.

Ribière, V., & Sitar, A.S. (2003). Critical role of leadership in nurturing a knowledge-supporting culture. *Knowledge Management Research and Practice, 1*(1), 39-48.

Shaw, R.B. (1997). *Trust in the balance*. *Building successful organizations on results, integrity, and concern*. San Francisco: Jossey-Bass.

Swan, J., Newell, S., Scarbrough, H., & Hislop, D. (1999). Knowledge management and innovation: Networks and networking. *Journal of Knowledge Management, 3*(4), 262-275.

Tuggle, F.D., & Shaw, N.C. (2000, May). *The effect of organizational culture on the implementation of knowledge management.* Paper presented at the Florida Artificial Intelligence Research Symposium (FLAIRS), Orlando, FL.

Wick, C. (2000, November). *Knowledge management and leadership opportunities for technical communicators.* Technical Communications.

Wilson, M.B. (1993). *A new method for assessing Cook and Wall's informal theory of organizational trust: A Coast Guard sample*. Unpublished doctoral dissertation. The George Washington University, Washington, DC.

Zack, M.H., & Michael, S. (1998). *Knowledge management and collaboration technologies.* Available at http://www.lotus. com/services/institute.nsf/550137bfe37d25a18525653a005e8462/000021ca

Zand, D.E. (1997). *The leadership triad - Knowledge, trust, and power.* Oxford University Press.

ENDNOTE

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Chapter 3.11
Virtue-Nets

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INTRODUCTION

David Skyrme (1999) has observed that knowledge workers exploit knowledge generated from business activities and turn it into business opportunities. Technical infrastructures enable knowledge workers and improve knowledge processes (Von Krogh, Ichijo, & Nonaka, 2000). Improving knowledge awareness requires creating a dynamic and generative environment for organizational workers (Senge, 1990). Organizations are faced with developing communication strategies that maintain centralized and fully accessible knowledge bases while at the same time trying to compete in a highly decentralized marketplace. Technological solutions for enabling and enhancing communication among knowledge workers are used for activities such as scheduling, negotiating, checking e-mail, revising documents, making reservations, connecting laptops remotely to the Net, problem solving, and decision making. There are numerous electronic devices for communicating between knowledge workers. These networked devices serve the purpose of connecting human-knowledge capital. For many companies, human-knowledge capital is a significant source of competitive advantage, and the dispersion of this capital without effective communication networks can greatly hinder the decision makers and the overall corporate decision-making process. One place to start examining the practices of knowledge workers is to study the networks in which they work.

This article explores knowledge networks and their advantage in grouping data based on qualitative attributes to support knowledge work. Such networks support and enable individual interactions with knowledge systems to enrich understanding. The next section provides a survey of communication technologies and theories to support the need to develop a network infrastructure to enable intelligent business practices. The next section on knowledge sharing proposes a virtue-net network architecture to support network connectivity using qualitative measures as a method for leveraging knowledge networks. The article concludes with a brief discussion and ideas for future research in this area. A glossary of terms for the virtue net is provided as an appendix to the article.

BACKGROUND

Knowledge management (KM) was popularized in the 1990s at a time when the dominant organizational metaphor was "organizations as computers" (Nonaka & Takeuchi, 1995). Knowledge management can be defined as "the process of identifying, capturing, and leveraging knowledge to help the company compete" (O'Dell & Grayson, 1998). Knowledge is key to organizations learning from and about customers, competitors, business partners, and staffs. Skyrme (1999) lists creating, identifying, gathering, organizing, sharing, learning, applying, exploiting, protecting, and evaluating in his representative sample of KM practices reported as key elements of knowledge-management programs.

One basic assumption of knowledge management contends that resource constraints such as time, capital, and understanding limit the ability to reasonably expect that all necessary and relevant knowledge can be captured and disseminated throughout an organization. Nonetheless, mechanisms to capture, encode, and store process knowledge in organizations provide (a) a starting point for future projects, and (b) a basis for avoiding similar mistakes in future projects. Knowing the how and why (i.e., process knowledge) behind the what (i.e., factual knowledge) leads to greater abilities to generate insight and better understanding.

Knowledge-Sharing Networks

Individuals seek information for both normative and informational reasons. Normative-influence theory suggests that human beings usually seek approval, a sense of belonging, and communality, which in some cases could account for the individual decision maker's drive for knowledge and for his or her communication with other knowledge stakeholders (Huang & Wei, 2000). Shared understanding is a relatively strong component that binds individuals in organizational and group settings. Informational-influence theory suggests the search for factual information and task truth can also act as a driver for decision makers seeking knowledge, including those seeking knowledge confirmation (Guenther & Braun, 2001). This sort of environment requires highly efficient, responsive, and self-adaptive information systems. Ideally, the systems are designed to be able to collect and classify information automatically and keep the system updated promptly. Interconnective knowledge-sharing structures are better ways for today's companies to construct their internal knowledge-sharing mechanism. Interconnective knowledge-sharing structures establish a two-way communication pathway across the intranet. The nodes in the system include individuals as well as aggregates of individuals, such as work groups, departments, and organizations within a company.

There are numerous challenges to overcome to effectively share knowledge among organizational members. Many organizations are faced with their own sets of unique challenges. Literature in knowledge management has shown that studies on knowledge reuse need to consider both the knowledge search and transfer processes simultaneously in order to get a full understanding of how knowledge is reused within an organization (Kraemer, 1998). Locating relevant knowledge sources for reuse during problem solving incorporates two separate processes: locating relevant experts and locating relevant expert knowledge (Housel & Skopec, 2001).

Ackerman and Mandel (1995) suggest that decision makers seek expert knowledge either in the form of knowledge artifacts or connections to known experts. Thus, decision makers require access to a set of knowledge stakeholders. In turn, those stakeholders are part of other networks allowing for further access to additional knowledge resources. Among knowledge-sharing methods, personal networks are the most predominate and convenient way for people to locate relevant expertise (e.g., Faniel & Majchrzak, 2003). Unfortunately, key knowledge stakeholders or decision makers are not always readily available for consultation. Knowledge networks provide a virtual network of key knowledge stakeholders and knowledge artifacts regardless of location or time (Skyrme, 1999). The network exists in n dimensions enabling potential benefits through connections along knowledge pathways. This full-time access to relevant knowledge across time and space provides an environment in which knowledge seekers can gain confidence that their decisions consider the most correct and most appropriate inputs (Festinger, 1957).

Knowledge-sharing networks support and enhance communications by integrating knowledge artifacts from different sources and domains across space and time. Research in knowledge networks endeavors to achieve new levels of knowledge integration, information flow, and interactivity among people, organizations, and communities, and to deepen our understanding of the ethical, legal, and social implications of knowledge networking (Skyrme, 1999). The successful implementation of knowledge networks creates rich communication environments for sharing knowledge and reducing decision uncertainty. Knowledge networks can be used to examine the life cycle of ideas in organizations and the role and characteristics of the people who introduce and diffuse new ideas. Tracking and supporting such life cycles will allow organizations to better understand how innovation and knowledge spreads. Effective knowledge networks increase innovation and improve organizational efficiency, and they can have even greater benefits if they are structured to receive management guidance.

SUPPORTING KNOWLEDGE-SHARING NETWORKS IN ORGANIZATIONS

Beyond individual-driven knowledge-sharing methods, businesses are able to organize in-house networks to deliver value by reusing existing company knowledge. The pace of business is speeding up as customer demands become more intense, and competitors move more quickly to meet their needs. Network nodes and network bandwidth need to be improved and expanded to enable the information-carrying capacity of the network. Combining elements of business intelligence and network performance enable real-time business for activity monitoring, process value measurement, and enterprise performance indicators (Huang & Wei, 2000).

A knowledge-content view has demonstrated the importance of relatedness in the skill base, but it does not shed much light on the integrative mechanisms that would allow one business unit to obtain knowledge from another (Kraemer, 1998). Scholars have demonstrated the importance of having lateral linkages among organization subunits for effective knowledge sharing to occur. Research has shown that a subunit's information-processing capacity is enhanced by lateral interunit integration mechanisms (Keen, 1986). Tiwana (2003) has indicated that individuals began to share information, expertise, best practices, and content in a peer-to-peer network created by affinity, while businesses created organization-spanning affinity that expanded such networks, thus facilitating the exchange and sharing of know-how and tacit expertise. Advanced technology, pervasive computing power, ubiquitous wireless communications, and distributed vast storage are triggering effective business knowledge-sharing platforms based on modern networking technologies.

Jarvenpaa and Ives (1994) indicate that the sharing of knowledge requires a "highly adaptive information architecture that can provide anytime-anyplace, multimedia interconnectivity across a constantly changing network of nodes…and must be independent of any organizational structure." The discussion presented in the previous sections suggests it is necessary to develop communication networks capable of supporting and sharing communication and collaboration among knowledge workers. Implementing these types of networks could provide an infrastructure for determining the most important business processes and value-creation measures. In addition, they could establish a working environment to assemble data warehouses, operational data stores, and enterprise applications to get a real-time view of required data elements. Such systems are able to continuously monitor for anomalies and exceptions, and proactively alert key personnel when performance falls outside expected ranges. Finally, these environments allow teams to collaborate and react to perform analysis and take action on detected anomalies and exceptions.

Connecting Knowledge

Associative relationships are defined as those that describe associations. They can be one-to-one or one-to-many relationships. Guided tours and indexes describe navigation between and among entities. Slices group one or more attributes of an object. Associative relationships are then built on the contents of varying attribute slices. This methodology provides for multiple attribute groupings to be associated with a single object. In this way, it may provide for a way to create dynamic links simply by selecting search criteria based on varying sets of object attributes (i.e., different slices). Traversing associative links differs depending upon what slices of information have been specified. The model allows knowledge workers to view knowledge objects in a specific context.

Berryman and Hockenhull (1996) describe associative relationships using interactive media works. Based on a nonhierarchical graph with multiple connections, data elements (i.e., association objects) contain one or more pointers that viewers can follow to reach other related data elements. The authors' vision differs from others by its shift in paradigms. They argue that hypermedia systems are based on a hunting paradigm in which users arbitrarily navigate space to find information. In contrast, an associative paradigm allows for the gathering of information in global contexts and subsequent arrangements to form local contexts. Association is described as a relational activity in which the viewer builds contexts through interaction with the work. Mixed-initiative searching is introduced as a way in which gathering choices are made jointly by the viewer and the system. The system intelligently builds associations from previous searches. As a viewer builds up his or her work space, successive searches tend to find objects that work, thus the system could support continuity and style. The artifacts of the searches may then be preserved and shared as searchable contexts. This model requires the design of the appropriate database structures to support the required collaborative relationships.

Virtue-Nets

Managers invest in telecommunication technology that "increases direct, flexible contact between people" and that "provide simple access to information, simply organized" (Galbraith, 1973). Knowledge networks can be implemented on network infrastructures that have the potential of giving firms instant communication infrastructure with the ability to engage in direct, flexible, anytime, anyplace information exchange and access. The immediate, systematic, and reciprocal nature of discussing new and novel approaches and confirming understanding and clarity has been shown by Kepner and Tregoe (1965) to increase decision efficiency and decision outcomes.

A virtue net describes a knowledge network where nodes are linked using a set of qualitative and dynamic attributes. There are four principle structures: data structures, nodes, communication links, and representation. A discussion of the various elements along with approaches to the four principles is provided in the following paragraphs. The glossary to this article reviews the elements of the virtue net.

Virtue nets provide an alternative mechanism for creating a distributed architecture for handling data attributes. Each data item would exist as an individual node. This data node would reside in a plane of existence of identical determined attributes. Each node is self-aware such that it can "realize" its own set of attributes or virtues. This self-awareness operation replaces the metadata traditionally used to describe the node. Data nodes automatically realize their place in the virtue net, enabling and enhancing search operations and connections to similar nodes. Planes of existence are created by specialized virtue links of dynamically connected data nodes with multiple connections, each of which is specific to an attribute or virtue. Similar to a virtual private network (VPN), these virtue links exist within the total bandwidth allotted to the virtue net. The virtue net is a set of weighted pathways between data nodes based on various attributes, effectively creating a bond between the data nodes with the same virtues: The stronger the similarity of a given virtue, the stronger the bond between the data nodes in a particular plane of existence. The key to the virtue net is the virtue manager, the decision-making heart of the system that makes decisions as if it were a real person.

Each data node has many bonds to many other data nodes. This nth dimensionality is the power of the virtue network, enabling data nodes to connect with numerous other data nodes based on the level of similarity they have with respect to each other. Since each dimension portrays a certain virtue, the need for querying the information is eliminated. By tapping into the virtue plane, every instance of that virtue is simultaneously available since, by definition, this plane would be the sum links of all data nodes with the given virtue. A table is used to associate files with virtues. That table establishes a virtue map used to track a particular virtue's plane of existence.

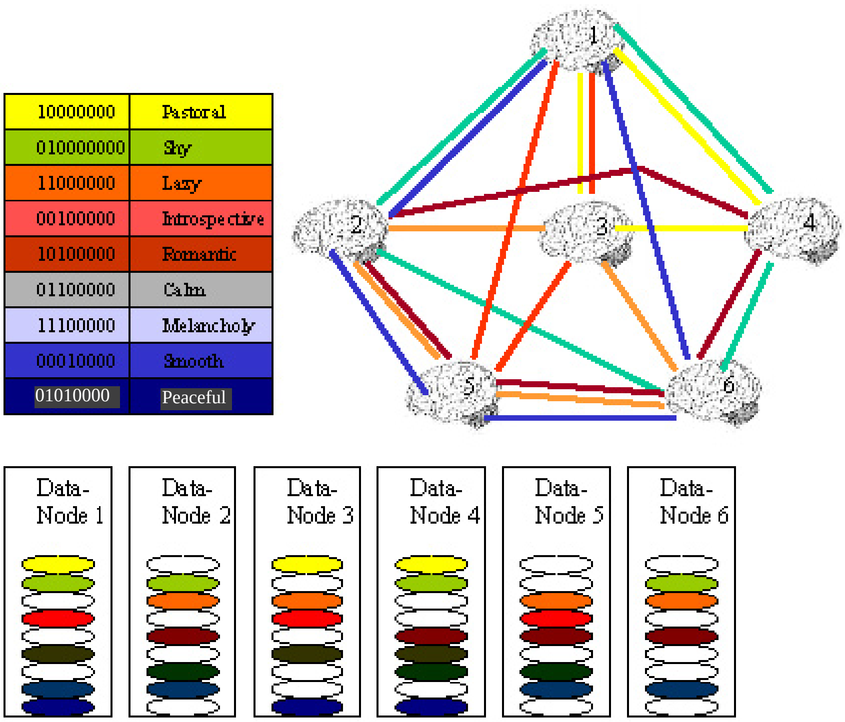
Virtue planes are dynamic since the virtues can be tapped from multiple dimensions. The dynamic nature of these virtue planes suggests network bandwidth must be able to accommodate multiple perspectives. As individuals gain experience with a device or with other entities using a similar device, their total utility with that given device will increase (Carlson & Zmud, 1999). Knowledge networks provide a taxonomy of bandwidth through which the users' manipulation of the bandwidth's attributes yield utility expansion. As people learn to utilize the knowledge bandwidth, or k-band, they learn how to expand their knowledge-accessing capabilities to use a given device by manipulating the k-band attributes.

Naturally, differences in opinion and interpretation will cause conflicts within the system. As such, differences in preference between different users must be managed in some way. One solution is derived from the availability of the fundamental hardware and the more flexible software nature of the system. A virtue map exists in the virtue chip, but it is the virtue manager that manages the links and plane-of-existence assignments. This manager also learns the preferences and habits of the user(s) in a similar way that voice-recognition software learns the nuances of a user's speech. Node managers control files housed within the cognitive node. Owners of each file impose their preferences on their data, so in a file server, the owner—not the server—dictates the preferences. The cognitive node is the computer in which the virtue manager is running. Cognitive nodes are responsible for the management of the files belonging to a user. Servers, SANs, or disk arrays are merely vessels for containing the data. This insures low impact on the server. Cognitive nodes perform the calculations and general housekeeping for the maintenance of the data nodes and their virtue links.

For the purposes of illustration, consider an example in which the virtue links could be color coded (Figure 1).

A table of virtues specifies color-coded virtues. The table is used as an analog for the different paths represented in binary notation readable by the machine. Each data node is connected to other data nodes that have common virtues, thereby creating a web of connections. Connections for a particular color between all the data nodes create a virtue plane for that attribute. For example, in the case of qualifying audio files, sad or happy music types could be recognized by different color codes. Melancholy, contemplative, heartwarming, and funny might be some of the attributes in this group. Once these pathways are in place, the applicable pathways can be connected to all the files they pertain to. So, when searching for performances that contain political humor, the logical intersection of the funny virtue plane and political virtue plane is viewed, which will result in every type of political comedy in all file types. This is of especial value to mobile handheld devices that tend to be more cumbersome to search databases with. Instead of entering all the query, the user can click on the virtue button on the desktop and select one of the primary emotion types (resulting in a specific virtue path) followed by a virtue link, which results in access to the virtue plane for the selected virtue. To widen or narrow

Figure 1. Color code depicts different virtues within each data-node. Each data-node that contains the color of a certain virtue, resides in the plane of existence of that virtue (virtue-plane). The data-nodes existing within the same virtue-plane are linked to each other through that virtue-plane by the virtue-link. The virtue links take advantage of multiple channels that form the knowledge bandwidth.



the search, the previous steps can be repeated using the logical and to narrow the search, or the logical or to widen the search. The virtue paths have the ability to narrow the number of virtues by grouping virtues that are related to one of the fundamental primary emotions.

Virtue-Net Exemplars

There are no examples of systems currently implemented that exhibit all of the characteristics of the virtue net described in this article. However, there are examples of systems that exhibit some of the characteristics. This section compares some of those tools and systems in the context of virtue nets.

ACT-R 5.0 is a cognitive modeling architecture developed at Carnegie Mellon University based on John Anderson's Adaptive Character of Thought: Revised (ACT-R; Anderson & Lebière, 1998). This software is evolving to simulate human thought, knowledge organization, and intelligent behavior.

Lotus Notes and Microsoft Exchange are groupware programs that help people work together collectively even when located remotely from each other. They provide sharing services such as e-mail, calendars, task management, database access, and electronic conferences so that each person is able to communicate and work with others. The groupware programs provide data and information sharing. The links between data or relationships between information must be preset by program or human instruction.

A new generation of search engines has the ability of acquiring, analyzing, and articulating knowledge without the involvement of human intelligence. KartOO.com represents the application of visualized knowledge representation in the practice of virtue nets. Alltheweb.com represents a trend in which language analysis and common-phrase identification technologies are being applied into virtue nets.

CONCLUSION

Virtue nets represent a new way of thinking about managing and utilizing knowledge within organizations. This article has outlined some of the characteristics of such systems. The next step is to design and develop a virtue net that combines the best features of systems described in the previous section. Part of the effort will be to analyze and test prototype systems to determine the effective mechanisms for performing the relevant tasks throughout the knowledge-value life cycle.

Computer and telecommunication networks offer powerful, expressive, and efficient information-access, search, and data-exchange capabilities. Intranet technology dramatically changed the way people are connected within an organization. New technologies built a new way for knowledge-based networks to be perceived, operated, and utilized by their users. However, representing and acquiring knowledge is still a difficult and time-consuming task having to be done by humans. Problem-formulating methods and knowledge-organization approaches are two important issues in further research.

This article has provided a conceptual view of collaborative communication networks to support knowledge processes in organizations. Inherent in such networks are dynamic capabilities for recognizing the value of knowledge elements extant in the network. Virtue nets enhance and support dynamic interactions in organizations by providing necessary knowledge artifacts from different sources and domains across time and space. It has been told that advances in technology will change the way organizations are organized. Knowledge networks and the dynamic support of virtue nets will go a long way toward bringing that vision to fruition.

REFERENCES

Ackerman, M. S., & Mandel, E. (1995). Memory in the small: An application to provide task-based organizational memory for a scientific community. *Proceedings of the 28th Annual Hawaii International Conference of System Sciences,* (vol. 4, pp. 323-332).

Anderson, J. R., & Lebière, C. (1998). *The atomic components of thought.* Lawrence Erlbaum Associates.

Berryman, J., & Hockenhull, O. (1996). *Towards a furious philosophy of the discrete mediabase*. Retrieved February 28, 2004, from http://english.ttu.edu/acw/essay/o.hockenhull.html.done/media-basediscussiondoc.html

Carlson, J., & Zmud, R. (1999). Channel expansion theory. *Academy of Management Journal, 42*(2), 153-170.

Davis, R., Shrobe, H.E., & Szolovits, P. (1993). What is a knowledge representation? *AI Magazine, 14,* 17-33.

Faniel, I. M., & Majchrzak, A. (2003). *Designing IT for knowledge reuse in a complex uncertain environment.*

Festinger, L. (1957). *A theory of cognitive dissonance.* Evanston, IL: Row, Peterson.

Galbraith, J. (1973). *Designing complex organizations.* Reading, MA: Addison-Wesley.

Gray, P.M.D., Preece, A., Fiddian, N.J., & Gray, W. (1997). KRAFT: Knowledge fusion from distributed databases and knowledge bases. *Proceedings of the 8th International Workshop on Database and Expert Systems Applications (DEXA)* (pp. 682-691). IEEE Computer Society.

Guenther, K., & Braun, E. (2001). Knowledge management benefits of intranets. *Online, 25*(3), 17-22.

Housel, T. J., & Skopec, E. (2001). *Global telecommunications revolution*. McGraw-Hill.

Huang, W. W., & Wei, K. K. (2000). An empirical investigation of the effects of group support systems (GSS) and task type on group interaction from an influence perspective. *Journal of Management Information Systems, 17*(2), 181-206.

Jarvenpaa, S., & Ives, B. (1994). The global network organization of the future: Information management opportunities and challenges. *Journal of Management Information Systems, 10*(4), 25-57.

Keen, P. G. W. (1986). *Competing in time: Using telecommunications for competitive advantage*. Cambridge, MA: Ballinger.

Kepner, C. H., & Tregoe, B. B. (1965). *The rational manager: A systematic approach to problem solving and decision-making.* New York: McGraw-Hill.

Kraemer, R. (1998). Visual languages for knowledge representation. *KAW'98: Eleventh Workshop on Knowledge Acquisition, Modeling and Management,* 18-23.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

O'Dell, C., & Grayson, C. J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 144-174.

Schultz, T., & Lepper, M. (1996). Cognitive dissonance reduction as constraint satisfaction. *Psychological Review, 2*, 219-240.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.

Simons, G.L. (1984). *Introducing artificial intelligence*. Manchester: NCC Publications.

Skyrme, D. (1999). *Knowledge networking: Creating the collaborative enterprise*. Oxford: Butterworth Heinemann.

Tiwana, A. (2003). Affinity to infinity in peer-to-peer knowledge platforms. *Communications of the ACM, 46*(5), 77-80.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*. Oxford University Press.

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Chapter 3.12
Coopetition

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INTRODUCTION

Behind the emerging digital façade, companies have started to operate in a distributed fashion. The intricate connectivity among these firms implies the exchange of valuable resources like knowledge and information. Such cooperation or collaboration is what enables organizations and individuals to make decisions collectively, learn from one another, communicate effectively, and thus create knowledge (Brown & Duguid, 1991; Huber, 1991; McDonald, 1995; von Krogh & Roos, 1995).

However, cooperating organizations often simultaneously compete (coopetition). While reciprocal knowledge sharing may enhance the total and individual added value, inter-firm knowledge sharing may also affect the uniqueness and thus competitive contribution of a firm's knowledge repository. Opportunistic behavior of counterparts may erode anticipated benefits of cooperation and result in unevenly distributed value.

The inherent balancing act between cooperation and competition requires designing and implementing specific management processes to enable economic value maximization for participating individuals and firms. The value-driven balancing act is becoming increasingly relevant in business practice.

This article introduces the scientific literature on Knowledge Management Under Coopetition and then describes the concept of Coopetitive Learning and Knowledge Exchange Networks (CoLKENs), their components, and their generic structure. It reviews CoLKEN fundamentals and components, and suggests a CoLKEN taxonomy. Key research questions are followed by generalized key insights from studying CoLKENs as the setting for Knowledge Management Under Coopetition. The article then examines the levers for managing CoLKENs, and closes with future trends and brief conclusions.

BACKGROUND

The following literature review provides broad definitions and discussions relevant to knowledge management under coopetition.

Fundamental Components of Knowledge Management Under Coopetition

Knowledge is a complex concept and difficult to define, and when seen from a management perspective, it exhibits unique properties that are distinctly different from the ones of traditional corporate resources, such as land, labor, and capital. Intellectual resources are not naturally scarce (Suchmann, 1989); knowledge may increase in value the more it is used, with investment in knowledge and knowledge-creating capabilities characterized by increasing returns (Teece, 1998). These properties tend to make knowledge less amenable to management (Polanyi, 1966; Hedlund, 1994; Nonaka, 1994; Boisot, 1995).

Who are appropriate knowledge agents for Knowledge Management Under Coopetition? Who is intellectually capable, the organization or its individual employees? Does knowledge reside at individual and organizational levels? Among others, Drucker (1993) and Grant (1996) stress the predominant importance of individuals. Others (Nonaka & Takeuchi, 1995; Spender, 1996; Boisot, 1998; Lane & Lubatkin, 1998; Matusik & Hill, 1998; Crossan, Lane, & White, 1999; Inkpen, 2000) consider organizational cognition or organizations as cognitive entities a suitable unit of analysis. In the organization science literature, organizational learning is a central tenet (Huber, 1991; Simon, 1991; Argyris & Schön, 1996) and is believed to lead to competitive advantage (Senge, 1990; Moingeon & Edmondson, 1996). It is closely intertwined with inter-organizational learning (e.g., Larsson, Bengtsson, Henriksson, & Sparks, 1998), as the learning entities in both concepts positively affect each other (Doz & Hamel, 1998; Child, 2001; Holmquist, 2003).

Knowledge networks are commonly defined as formally set up mechanisms, structures, and behavioral patterns that connect knowledge agents who were not previously connected because of functional, hierarchical, or legal boundaries between organizations. Inter-organizational knowledge networks (e.g., Mowery, Oxley, & Silverman, 1996; Klein, 1996) provide the setting for Knowledge Management Under Coopetition.

Theoretical Underpinnings of Knowledge Management Under Coopetition

The "resource-based view of the firm," along with its conceptual predecessor, the "industrial organization view," and its extension, the "knowledge-based view of the firm," have shed light on the question of why firms cooperate to learn from one another, share capabilities and knowledge, while—at the same time—manage knowledge as a valuable resource in the competitive environment.

Until the 1980s, competitive thinking—reflected in the "industrial organization view"—has generally been seen focusing on companies' environments (e.g., Porter, 1980; Spender, 1996; Teece, Pisano, & Shuen, 1997). As such, it stands for an outward focus. Since the mid-1980s, the so-called "resource-based approach" (Wernerfelt, 1984; Rumelt, 1987; Prahalad & Hamel, 1990) has partially built on Penrose's conception of the firm as a "collection of productive resources, both human and material" (Penrose, 1959, p. 31). The resource-based approach builds on two basic assumptions: (a) the firm's ultimate objective is to achieve sustained, above normal returns; and (b) a set of resources and their combination transformed into competencies and capabilities are a precondition for sustained superior returns (Rugman & Verbeke, 2002). These resources are to be firm-specific (i.e., imperfectly mobile), valuable to customers, non-substitutable, difficult to imitate, and differently available to firms. Companies are seen as heterogeneous with respect to their resource and capability endowments (Teece et al., 1997). Assets such as knowledge are not readily tradable; they cannot equilibrate through factor input markets. Hence, critical resources can typically not be acquired via the market and consequently need to be developed internally. Competitive advantage is associated primarily with heterogeneous resource endowments of firms (Wernerfelt, 1984; Prahalad & Hamel, 1990; Hamel, 1991; Barney, 1991).

Recent extensions of the knowledge-based perspective (Grant, 1996) are centered around its application to a "network of firms," rather than an individual firm (Hamel, 1991; Prahalad & Ramaswamy, 2000; Dyer & Nobeoka, 2000; Gulati, Nohria, & Zaheer, 2000; Doz, Santos, & Williamson, 2001; Grant & Baden-Fuller, 2004). As developed in the "relational view of the firm," firms ought to look at inter-organizational networks as a source of sustainable competitive advantage (Liebeskind, Olivier, Zucker, & Brewer, 1996; Powell, Kogut, & Smith-Doerr, 1996; Powell, 1998; Dyer & Singh, 1998).

Different scholars hold different views on what criteria need to be applied to differentiate critical from non-critical resources. Barney (1991) proposes "value creation for the company," "rarity compared to competition," "imitability," and "substitutability." Prahalad and Hamel (1990) distinguish "core competencies" from "non-core competencies" by outlining core competencies as being suitable for application in many different markets, creating a significant contribution to customer value, and being difficult for competitors to imitate.

To specify resources that accommodate these criteria is equally controversial (Priem & Butler, 2001a, 2001b; Rugman & Verbeke, 2002). The literature offers a plethora of phrases such as "firm resources" (Barney, 1991, 2001), "invisible assets" (Itami, 1987), or "dynamic capabilities" (Teece et al., 1997).

Roos and Roos (1996) or Drucker (1993) proclaim that knowledge, whether referred to as invisible assets (Itami, 1987), absorptive capacity (Cohen & Levinthal, 1990), core competencies (Prahalad &, Hamel, 1990), core capabilities (Kogut &, Zander, 1996), or organizational knowledge (Nonaka &, Takeuchi, 1995), can be seen as the only—or at least an important resource—that fulfils the foregoing criteria. Teece (1998) even argues that the essence of a firm is its ability to create, transfer, assemble, integrate, and exploit knowledge assets.

These lines of thought match the traditional analysis that both Ricardian and monopoly rent theorists derive in large part from intangible assets, with organizational learning and knowledge being among the most crucial ones (Penrose, 1959; Liebeskind, 1996; McGaughey, 2002). By stressing the outstanding importance of knowledge, they have given birth to the knowledge-based perspective as a special form of the resource-based one.

COOPETITIVE LEARNING AND KNOWLEDGE EXCHANGE NETWORKS (COLKENS) AS THE SETTING FOR KNOWLEDGE MANAGEMENT UNDER COOPETITION

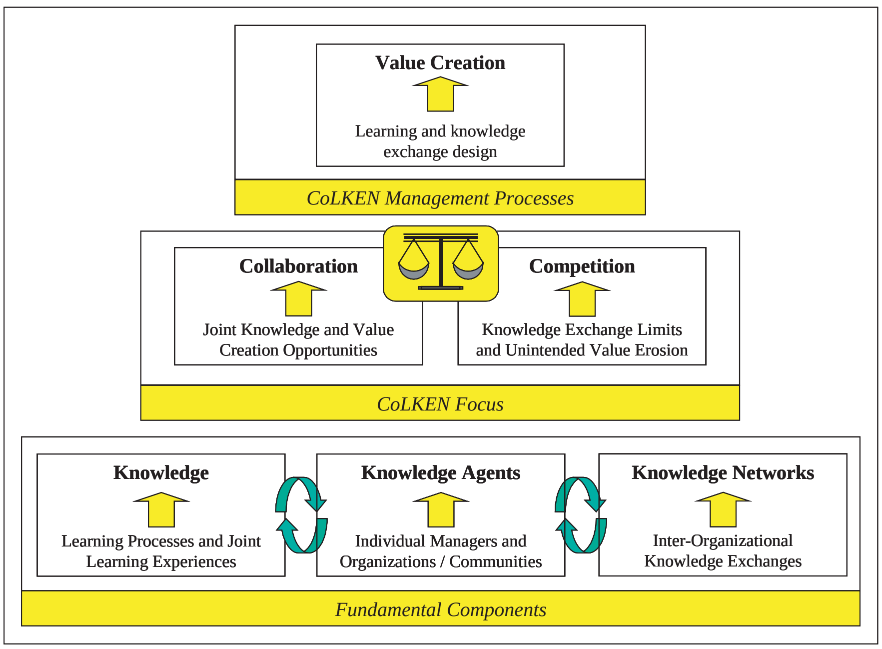
As outlined above, knowledge management has been increasingly considered as a key managerial function necessary for achieving competitive advantage (Tsang, 2002). Economic thinking leaves no doubt that scarcity is a precondition for property and thus commercial value of any resource. Consequently, it puts a question mark on generously sharing knowledge in an economic context. Thus, inter-organizational knowledge-sharing processes revolve around a formidable balancing act between borrowing knowledge assets from partners, while protecting one's own assets (Loebbecke, van Fenema, & Powell, 1999). The challenge is to share enough skills to learn and create advantage vis-à-vis companies outside the network, while preventing an unwanted transfer of core competencies to a partner (Hamel, Doz, & Prahalad, 1989). This challenge is exacerbated when some members in the network are competitors. In such constellations, the danger of becoming "hollowed out" by "predatory" partners (Hamel et al., 1989; Kogut & Zander, 1996) seems particularly evident, suggesting that appropriate steps be taken to ensure mutually beneficial sharing. Nevertheless, many of the skills that migrate between companies are not covered in the formal terms of a knowledge exchange (Loebbecke & van Fenema, 2000). Often, what gets traded—that is, what is learned—is determined by day-to-day interactions between engineers, marketers, and product developers (Hamel et al., 1989).

CoLKEN Fundamental Statements and Components

Following the above insights, a CoLKEN Construct (see Figure 1) is built based on seven fundamental statements (see also Loebbecke & Angehrn, 2003a):

1. Knowledge assets have their foundation not only in data and in information, but also in collaborative learning processes.
2. Both the individual employee as well as the organization should be seen as knowledge agents capable of owning and processing knowledge.
3. Knowledge agents exchange knowledge in knowledge networks within and—in the light of ubiquitous information, communication, and media technologies—increasingly between organizations.

Figure 1. CoLKEN construct



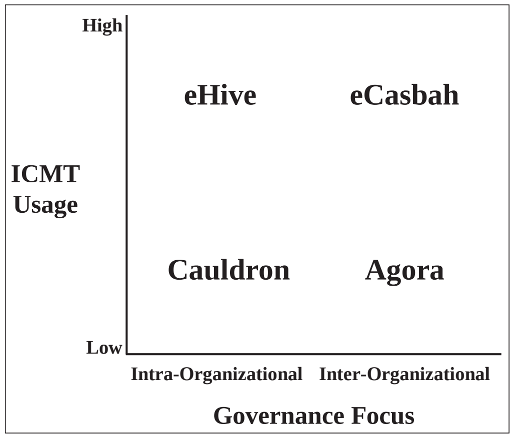
4. The increasing appearance of inter-organizational networks triggers a focus on learning and knowledge exchange processes between organizations during coopetition.
5. Cooperation forms the basis for any knowledge exchange process between organizations as it supports the learning processes through which knowledge is created and acquired, as well as shared and disseminated.
6. In the light of competition, knowledge serves as a critical resource or asset to achieve competitive advantage and above normal rents.
7. Management processes and actively managed strategic interventions (stimuli) in knowledge exchanges allow organizations to create value by significantly impacting the composition, the exploitation and exploitability, as well as the business results of learning, knowledge, and intellectual assets at large.

The three fundamental components, Knowledge, Knowledge Agents, and Knowledge Networks (Statements 1, 2, and 3) lay the foundations for investigating inter-organizational learning and knowledge exchange networks in the context of coopetition (see also 'Background'). The CoLKEN focus is represented as a central platform on which cooperation and competition are performed (Statements 4, 5, and 6). In order to create and extract the maximum economic value, the challenge is to balance both aspects by designing and implementing management processes for active strategic interventions in the CoLKEN (Statement 7).

CoLKEN Taxonomy

Possible dimensions for differentiating CoLKENs are information, communication, and media technology (ICMT) usage, governance focus, size, growth pattern, composition, and degree of internal competition. Selecting the first two dimensions, Figure 2 shows a CoLKEN taxonomy (adapted from Loebbecke & Angehrn, 2003b).

Figure 2. CoLKEN taxonomy



A cauldron, the large kettle or boiler used by witches mixing and cooking ingredients without a clear pattern, stands for intra-organizational and low-technology CoLKENs. An agora, the ancient Greek marketplace, represents inter-organizational, low-tech solutions. An e-hive takes the concept of a hive, a container for housing honeybees, to the virtual level. It describes a busy intra-organizational environment without clear pre-arranged patterns of action or movements. An e-casbah, finally, transfers the concept of the older, native section of a north-African city with its busy marketplaces to the e-world, where it represents inter-organizational settings, with learning and knowledge exchanges taking place solely via ICMT infrastructures.

While the basic assumption of coopetition between organizational units requires some degree of 'inter'-organizational networking, the horizontal axis takes into account the more or less overriding legal structures that may emphasize the 'intra'-setting for competing sub-units.

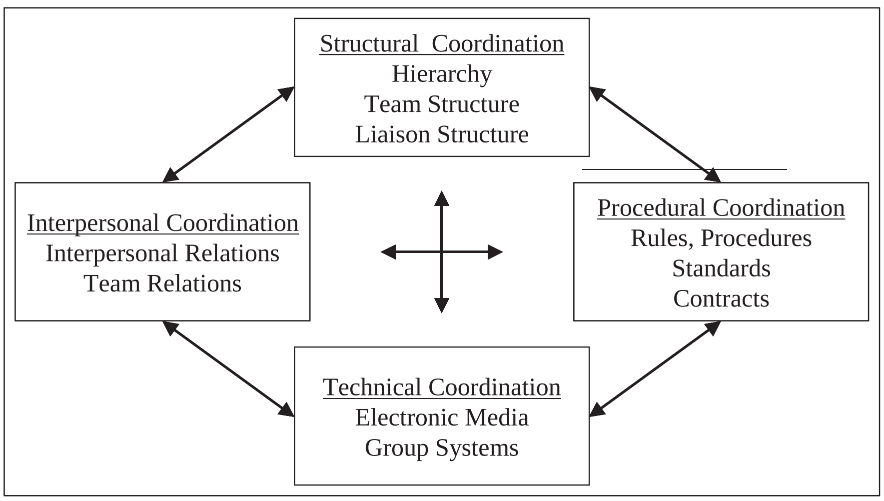
Research Drivers and Key Insights

Research concerning organizational and social aspects of CoLKENs as the setting for Knowledge Management Under Coopetition investigates initiatives ranging from local industry clusters to new forms for organizations with globally distributed knowledge workers operating within Open Source communities. Dominating research drivers are: (1) the motivation for individuals and for companies to participate in the networks (e.g., Argote, McEvily, & Reagans, 2003); (2) issues of leadership, coordination and control strategies, and decision making; (3) the management of collaboration, including knowledge creation, sharing, and management, as well as learning and innovation (e.g., Menon & Pfeffer, 2003); and finally, (4) the management of the competition dimension. These issues ought to be analyzed along the trajectories of who (people), what (topics), and how (processes). Further, various contingencies for inter-organizational knowledge governance based on dominant knowledge types, the assessment of the ease of knowledge sharing and retention, and the direction of knowledge flows (unilateral or bi-directional/reciprocal) play an important role for investigating Knowledge Management Under Coopetition.

Main research insights derived from the above lines of analyses can be summarized as follows:

- Individual managers are mostly motivated by opportunities to engage in new forms of collaborative learning and management development. Organizations aim to achieve their objectives through acquisition of knowledge critical to their processes or strategy.
- The dominant form of collaboration and learning is traditional knowledge transfer, that is, contexts in which members do not need to engage too personally or do not need to contribute their knowledge at all. More experiential forms are rare; they emerge primarily in non-critical domains and after having succeeded in helping members to develop more stable relationships and trust

Figure 3. Coordination and control mechanisms for knowledge management under coopetition



(for the impact of different kinds of interventions, see also Cabrera, 2002).

- The competition dimension limits knowledge exchange to pre-defined domains and formats which are perceived by members as non-competitive in terms of not releasing much critical knowledge to potential competitors.
- By better aligning the motivation of their members and 'selecting' them accordingly, CoLKENs could reduce the negative influence of the competition dimension. On the other hand, ambitious growth strategies lead some CoLKENs to operate less selectively when it comes to assessing and aligning the motivation of their members.
- Appropriate coordination and control mechanisms are crucial for success; structural and interpersonal mechanisms outweigh procedural or technical mechanisms (see Figure 3).

Additionally, for instance, Loebbecke and Angehrn (2003a, 2004), Teigland and Wasko (2003), and Loebbecke and Angehrn (2004) offer contingency-dependent results for various settings of Knowledge Management Under Coopetition.

Levers for Managing CoLKENs

With a significant number of inter-organizational networks failing in some sense (Inkpen & Beamish, 1997; Lam, 1997), there is an established body of literature investigating factors causing such failures together with steps for improvement (Cohen & Levinthal, 1990; Hamel, 1991; Mowery et al., 1996; Powell et al., 1996; Inkpen & Beamish, 1997; Lam, 1997; Dyer & Singh, 1998; Kumar & Nti, 1998; Larsson et al., 1998; Powell, 1998). Possible management levers for dealing with the paradox of simultaneous cooperation and competition have emerged from this literature. The main factors for discussion are: (1) factors influencing the extent of learning and knowledge sharing, (2) factors influencing the stability of the relationship, and (3) factors influencing the ability of CoLKEN partners to collaborate.

As factors influencing the extent of learning and knowledge sharing, Kogut (1988) and Mowery et al. (1996) name alliance contracts and governance structures. For instance, equity joint ventures lead to a higher degree of knowledge sharing than contract-based alliances. Cohen and Levinthal (1990), Dyer and Singh (1998), Kumar and Nti (1998), and Larsson et al. (1998) point to partners' internal capabilities. According to Hamel (1991), Kumar, and Nti (1998), or Larsson et al. (1998), the amount of learning taking place in the relationship depends on each partner's collaborative strategy.

As the main factor influencing the stability of the relationship, Pfeffer and Salancik (1978) relate to bargaining power. If collaboration provides access to other partners' resources (e.g., knowledge and skills), dependencies caused by resource specificity may change or disappear, and the alliance may be terminated (Inkpen & Beamish, 1997). Hence partners who want to ensure alliance stability should prevent outsiders from learning "all there is to learn," create new knowledge, and consider the track record of their partners.

Finally, factors influencing the ability of network partners to collaborate are discussed. For Dyer and Singh (1998), appropriate management processes and governance structures are crucial for turning membership into a source of competitive advantage. They even suggest protection against: (a) opportunistic behavior in the network, (b) high volume of information exchange, (c) knowledge-sharing routines, and also suggest the development of self-enforcing safeguards (trust and incentives) for sharing. The ability to have influence on the network structure and to occupy an information-rich position shall provide network members with promising entrepreneurial opportunities (Powell et al., 1996).

FUTURE TRENDS

Further research is needed to compare traditional settings for Knowledge Management Under Coopetition, where there is less ICMT usage, with more virtual ones. Additional insights are to be sought as to the actual and potential impact of innovative technologies with regard to managing CoLKENs. One should investigate and assess: (a) the real potential of ICMT for the majority of today's CoLKENs, (b) the ICMT-related challenges the organizations in question are likely to face, as well as (c) the new mindsets and competencies members and managers of such networks will require for taking full advantage of distributed approaches to learning and knowledge management.

CONCLUSION

The fact that motivations and incentives for participation vary, makes Knowledge Management Under Coopetition particularly complex. Here CoLKENs as settings for Knowledge Management Under Coopetition represent opportunities for individual managers to engage in new forms of Knowledge Management Under Coopetition: They provide organizations with opportunities to better achieve their objectives through acquisition of knowledge critical to their processes and strategy, or through collaborative knowledge exchanges and initiatives.

Nevertheless, competitive logic can prevent individuals as well as organizations from taking advantage of constructive Knowledge Management Under Coopetition. The competition dimension influences the design of value-creation processes such as collaborative learning, knowledge exchange, and derived initiatives.

To conclude, innovative forms and settings of Knowledge Management Under Coopetition enable contributors to benefit from their participation in such inter-organizational knowledge management initiatives, whereby members may decisively improve learning efficiency and cooperative acting while taking into account competitive positions. To exploit the opportunities derived from Knowledge Management Under Coopetition to the fullest, appropriate coordination and control mechanisms, as well as a deliberate strategic approach towards Knowledge Management Under Coopetition are indispensable.

REFERENCES

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), 571-582.

Argyris, C., & Schön, D. (1996). *Organizational learning II.* Reading, MA: Addison-Wesley.

Barney, J.B. (1991). Types of competition and the theory of strategy: Towards an integrative framework. *Academy of Management Review, 11*(4), 791-800.

Barney, J.B. (2001). Is the resourced-based view a useful perspective for strategic management research? *Academy of Management Review, 26*(1), 41-56.

Boisot, M.H. (1995). *Information space: A framework for learning in organizations, institutions and cultures.* London: Routledge.

Boisot, M.H. (1998). *Knowledge assets: Securing competitive advantage in the information economy.* Oxford: Oxford University Press.

Brown, J.S., & Duguid, P. (1991). Organisational learning and communities-of-practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-55.

Cabrera, Á. (2002). Knowledge-sharing dilemmas. *Organization Studies, 23*(5), 687-711.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Crossan, M.H., Lane, H.W., & White, R.E. (1999). An organizational learning framework: From institution to institution. *Academy of Management Review, 24*(3), 522-537.

Child, J. (2001). Learning through strategic alliances. In M. Dierkes, B. Antal, J. Child, & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge* (pp. 657-680). Oxford: University Press.

Doz, Y., Santos, J., & Williamson, P. (2001). *From international to metanational*. Cambridge, MA: Harvard Business School Press.

Doz, Y. & Hamel, G. (1998). *Alliance advantage*. Cambridge, MA: Harvard Business School Press.

Drucker, P. (1993). *The effective executive*. New York: Harper Business.

Dyer, J., & Nobeoka, K. (2000). Creating and managing a high performance knowledge sharing network: The Toyota case. *Strategic Management Journal, 21*(3), 345-367.

Dyer, J.H., & Singh, H. (1998). The relational view: Cooperative strategy and sources of inter-organizational competitive advantage. *Academy of Management Review, 23*(4), 660-679.

Grant, R. (1996). Toward a knowledge based theory of the firm. *Strategic Management Journal, 17*(Special Issue), 109-123.

Grant, R., & Baden-Fuller, C. (2004). A knowledge accessing theory of strategic alliances. *Journal of Management Studies, 41*(1), 61-85.

Gulati, R., Nohria, N., & Zaheer, A. (2000). Strategic networks. *Strategic Management Journal, 21*(3), 203-215.

Hamel, G. (1991). Competition for competence and inter-partner learning within international strategic alliances. *Strategic Management Journal, 12*(Special Issue), 83-103.

Hamel, G., Doz, Y., & Prahalad, C. (1989). Collaborate with your competitors and win. *Harvard Business Review, 67*(1), 133-139.

Hedlund, G. (1994). A model of knowledge management and the n-form corporation. *Strategic Management Journal, 15*(Special Issue), 73-90.

Holmquist, M. (2003). A dynamic model of intra- and interorganizational learning. *Organization Studies, 24*(1), 95-123.

Huber, G. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Inkpen, A., & Beamish, P. (1997). Knowledge, bargaining power, and the instability of international joint ventures. *Academy of Management Review, 22*(1), 177-202.

Inkpen, A.C. (2000). Learning through joint ventures: A framework of knowledge acquisition. *Journal of Management Studies, 37*(7), 1019-1043.

Itami, H. (1987). *Mobilizing invisible assets*. Cambridge, MA: Harvard University Press.

Klein, S. (1996). The configuration of inter-organisational relations. *European Journal of Information Systems, 5*(5), 92-102.

Kogut, B. (1988). Joint ventures: Theoretical and empirical perspectives. *Strategic Management Journal, 9*(4), 319-332.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science, 7*(5), 502-519.

Kumar, R., & Nti, K.O. (1998). Differential learning and interaction in alliance dynamics: A process and outcome discrepancy model. *Organization Science, 9*(3), 356-367.

Lam, A. (1997). Embedded firms, embedded knowledge: Problems of collaboration and knowledge transfer in global cooperative ventures. *Organization Studies, 18*(6), 973-996.

Lane, P.J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*(5), 461-477.

Larsson, R., Bengtsson, L., Henriksson, K., & Sparks, J. (1998). The interorganizational learning dilemma: Collective knowledge development in strategic alliances. *Organization Science, 9*(3), 285-305.

Liebeskind, J. (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal, 17*(Special Issue), 93-107.

Liebeskind, J., Oliver, A., Zucker, L. & Brewer, M. (1996). Social networks, learning, and flexibility: Sourcing scientific knowledge in new biotechnology firms. *Organization Science, 7*(4), 428-443.

Loebbecke, C., & Angehrn, A. (2003a). Investigating Coopetitive Learning and Knowledge Exchange Networks (CoLKENs) as emerging concept in management literature and practice. *Proceedings of the 4th Conference on Organizational Knowledge, Learning and Capabilities (OKLC)*, Barcelona, Spain.

Loebbecke, C., & Angehrn, A. (2004, July 1-3). Open source communities reflecting 'Coopetitive Learning and Knowledge Exchange Networks'. *Proceedings of the IFIP International Conference on Decision Support Systems (DSS2004)* (pp. 490-500), Prato, Italy.

Loebbecke, C., van Fenema, P., & Powell, P. (1999). Coopetition and knowledge transfer. *The Data Base for Advances in Information Systems (DATABASE), 30*(2), 14-25.

Loebbecke, C., & van Fenema, P. (2000). Virtual organizations that cooperate and compete: Managing the risks of knowledge exchange. In Y. Malhotra (Ed.), *Knowledge management and virtual organizations* (pp. 162-180). Hershey, PA: Idea Group Publishing.

Loebbecke, C., & Angehrn, A. (2003b, June 18-20). Open source platforms under coopetition: A comparative analysis of SourceForge and 'CodeX' (Xerox) as two 'Coopetitive Learning and Knowledge Exchange Networks' (CoLKENs*). Proceedings of the European Conference of Information Systems (ECIS),* Naples, Italy.

Matusik, S., & Hill, C. (1998). The utilization of contingent work, knowledge creation, and competitive advantage. *Academy of Management Review, 23*(4), 680-697.

McDonald, S. (1995). Learning to change: An information perspective on learning in the organization. *Organization Science, 6*(2), 557-568.

McGaughey, S. (2002). Strategic interventions in intellectual asset flows. *The Academy of Management Review*, *27*(2), 248-274.

Menon, T., & Pfeffer, J. (2003). Valuing internal vs. external knowledge: Explaining the preference for outsiders. *Management Science, 49*(4), 497-514.

Moingeon, B., & Edmondson, A. (1996). *Organisational learning and competitive advantage*. London: Sage Publications.

Mowery, D.C., Oxley, J.E., & Silverman, B.S. (1996). Strategic alliances and interfirm knowledge transfer. *Strategic Management Journal, 17*(Special Issue), 77-91.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. New York: Oxford University Press.

Penrose, E. (1959). *Theory of the growth of the firm*. New York: John Wiley & Sons.

Pfeffer, J., & Salancik, G. (1978). *The external control of organizations: A resource dependence perspective*. New York: Harper & Row.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Keegan Paul.

Porter, M. (1980). *Competitive strategy*. New York: The Free Press.

Powell, W. (1998). Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries. *California Management Review, 40*(3), 228-240.

Powell, W., Kogut, K., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116-145.

Prahalad, C., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review, 68*(3), 79-91.

Prahalad, C., & Ramaswamy, V. (2000). Co-opting customer competence. *Harvard Business Review, 78*(1), 79-87.

Priem, R., & Butler, J. (2001a). Is the resourced-based view a useful perspective for strategic management research? *Academy of Management Review, 26*(1), 22-40.

Priem, R., & Butler, J. (2001b). Tautology in the resource-based view and the implications of externally determined resource value: Further comments. *Academy of Management Review, 26*(1), 57-66.

Roos, J., & Roos, G. (1996). Measuring your company's intellectual performance. *Long Range Planning, 30*(3), 413-426.

Rugman, M., & Verbeke, A. (2002). Edith Penrose's contribution to the resource-based view of strategic management. *Strategic Management Journal, 23*(8), 769-780.

Rumelt, R. (1987). Towards a strategic theory of the firm. In D. Teece (Ed.), *The competitive challenge* (pp. 556-570). Cambridge: Ballinger.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. London: Sage Publications.

Simon, H. (1991). Bounded rationality and organizational learning. *Organization Science, 2*(1), 125-134.

Spender, J. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17*(Special Issue), 45-62.

Suchmann, M.C. (1989). Invention and ritual: Notes on the interrelation of magic and intellectual property in preliterate societies. *Columbia Law Review, 89*(6), 1264-1294.

Teece, D. (1998). Capturing value from knowledge assets: The new economy, markets for know-how and intangible assets. *California Management Review, 40*(3), 55-79.

Teece, D., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

Teigland, R., & Wasko, M. (2003). Integrating knowledge through information trading: Examining the relationship between boundary spanning communication and individual performance. *Decision Sciences, 34*(2), 261-287.

Tsang, E. (2002). Acquiring knowledge by foreign partners from international joint ventures in a transition economy: Learning-by-doing and learning myopia. *Strategic Management Journal, 23*(9), 835-854.

von Krogh, G., & Roos, J. (1995). *Organizational epistemology*. London: MacMillan.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

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Chapter 3.13
Knowledge Management Within Collaboration Processes:
A Perspective Modeling and Analyzing Methodology

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ABSTRACT

Collaborative projects are relatively complex and hence are difficult to handle. Managing distributed knowledge among stakeholders in a systematic way is crucial to improving the collaboration productivity. This paper provides a generic modeling approach that explicitly represents the perspectives of stakeholders and their evolution traversing a collaborative process. This approach provides a mechanism to analytically identify the interdependencies among stakeholders and to detect conflicts and reveal their intricate causes and effects. Collaboration is thus improved through efficient knowledge management. This paper also introduces a Web-based information system that uses the perspective model and the social network analysis methodology to support knowledge management within collaboration.

INTRODUCTION

The ability to effectively manage the distributed knowledge and business processes is becoming an essential core competence of today's organizations. Various knowledge management theories and approaches have been proposed and adopted (Earl, 2001). These include ways to align knowledge process with strategies (Spender, 1996), to leverage organizational learning abilities (Nonaka & Takeuchi, 1995), and to build IT infrastructures to support knowledge activities (Zack, 1999; Lu, 2000). Knowledge management systems (KMS) can be viewed as the implementation of the knowledge management (KM) strategy. KMS improve the knowledge processes through IT infrastructures and information processing methodologies. Although the importance of knowledge management has been well recognized, organizations are still facing the problems of how to successfully implement knowledge management. In order to effectively utilize these theories and technologies to support teamwork, it is necessary to gain more fundamental understandings of the characteristics of knowledge management within collaboration processes.

Previous knowledge management approaches can be generally classified into two categories (Hanson et al., 1999). The strategies supporting knowledge replication provide high-quality, fast, and reliable information systems implementation by reusing codified knowledge. The strategies supporting knowledge customization provide creative, analytically rigorous advice on high-level strategic problems by channeling individual expertise. The codification approaches view information technology (IT) as the central infrastructure of knowledge-based organizations. KMS are thus treated as system integration solutions or applications that retain employees' know-how. The major concern of these approaches is how to help organizations monitor the trends of rapidly changing technologies and inventions in order to recognize new applications which may provide competitive advantage (Kwan & Balasubramanian, 2003). However, IT is just one of the elements of KMS. As knowledge management involves various social and technical enablers, the scope, nature, and purpose of KMS vary during the collaboration processes. Researches from the knowledge customization perspective focus on understanding knowledge and its relationships with organizations (Nonaka & Takeuchi, 1995; Becerra-Fernanaez & Sabherwal, 2001). A typology of knowledge creation and conversion of tacit and explicit knowledge was proposed (Nonaka et al., 1998). The conversion involves transcending the self of individuals, teams or organizations and reveals the importance of organizational architecture and organizational dynamics to capitalize on knowledge. Recent researches on knowledge management have been focusing on developing models that interconnect knowledge management factors, such as collaboration, learning, organizational structure, process, and IT support (Lee & Choi, 2003). These research works have been mainly addressing understanding the nature of knowledge and knowledge management. Both approaches provide workable models and methods for implementing knowledge management.

In fact, knowledge replication is interlaced with knowledge customization within a collaborative process. In collaborative projects, it is important to systematically integrate these two groups of KM approaches to build methodologies and systems to facilitate the team work. First, KM methodologies should be coupled with process management in collaborative projects. An organization and its members can be involved in multiple knowledge management process chains. The tangible tasks are accompanied by the implicit knowledge integration activities. As such, knowledge management is not a monolithic but a dynamic and continuous organizational phenomenon (Alavi & Leidner, 2001). Second, KM and KMS have to take account of various social factors within collaboration processes. Collaborative projects involve various stakeholders (i.e., all of the human participants and organizations who influence the collaboration process and the results) from different disciplines to work cooperatively over the distance and time boundaries. When many heterogeneous groups work together on large projects over a long period of time, their knowledge of the system, the product, and other people will keep on evolving (Dym & Levitt,1991; O'Leary,1998). The professional expertise in particular is framed by a person's conceptualization of multiple, ongoing activities, which are essentially identities, comprising intentions, norms, and choreographies (Carley & Prietula, 1994; Erickson & Kellogg, 2000; Sowa & Zachman, 1992; Siau, 1999). Although the collaboration process might appear relatively technical, it is essentially a social construction process when different persons perform their tasks within various adaptive situations (Berger & Luckman, 1966; Clancey, 1997; Clancey, 1993).

The situations will eventually impact the evolution of participants' roles and form a shared understanding (Arias et al., 2000). Even within well-defined technical roles, every stakeholder makes the role "his own" by adapting or executing the role based on his conceptions and circumstances. It is the social interaction that determines the variation or adaptability of these roles in a particular application context. As their roles evolve, stakeholders' learning customs and attitudes will vary, which will directly or indirectly affect their internal knowledge and the knowledge creation and conversion processes. Therefore, to manage the distributed knowledge within the complicated collaborative process, it is necessary to have well-developed methodologies for describing and analyzing the social interactions in collaborative contexts of the emerging practice.

This paper presents a methodology for supporting knowledge management within collaboration by modeling and analyzing the stakeholders' perspectives. The methods to depict and control the evolution of distributed knowledge are introduced. This paper also describes a prototype knowledge management system developed for a US government research institute. It implements the methodology and uses the advanced network computing techniques to facilitate stakeholders' interaction within their work practice.

MODELING PERSPECTIVES TO SUPPORT KNOWLEDGE MANAGEMENT

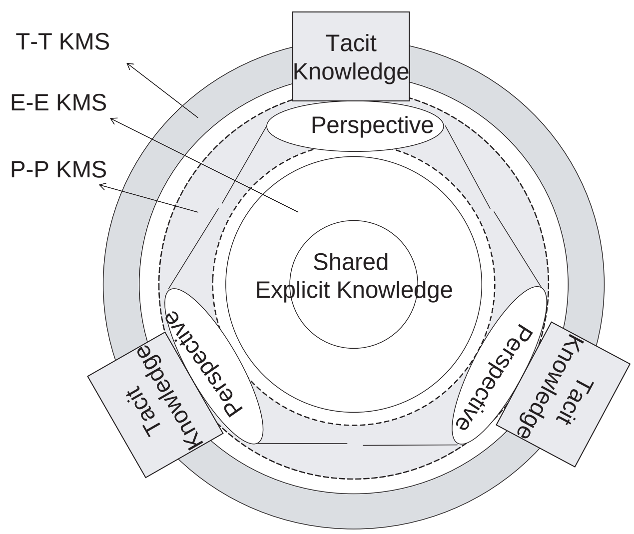
The previous approaches and methodologies for supporting KM in collaborative work have been mainly concentrating on either modeling the explicit knowledge or supporting communication of implicit knowledge. The knowledge management systems built upon these approaches included three types of functions: (1) the coding and sharing of best practices, (2) the creation of corporate knowledge directories, and (3) the creation of knowledge networks (Alavi & Leidner, 2001). Recent researches have proposed systems to support information and knowledge seeking and use within the decision or problem solving process (Rouse, 2002, Shaw et al., 2003, Kwan & Balasubramanian, 2003). Modeling approaches are widely used for developing such methodologies and systems. For instance, activity modeling approach was used to develop a knowledge management system to provide a computer-based guidance and interactive support for office workers (Reimer et al., 2000). Knowledge-engineering processes were modeled to capture, store, and deploy company knowledge (Preece et. al., 2001). However, most of the existing approaches still view stakeholders as homogeneous and do not emphasize their intricate needs at various stages of the processes. Nevertheless, lack of understanding of stakeholders' needs to know—and provision of support systems accordingly—is precisely the missing link in the success of many information and knowledge management systems (Rouse, 2002). This requires understanding multiple aspects of stakeholders' needs in seeking and using of information and knowledge within the collaboration.

Recent published studies have shown that besides technologies, the social aspects are essential to the success of collaboration (Briggs et al., 2003; Erickson & Kellogg, 2000; Easley et al., 2003; Hardjono & van Marrewijk, 2001). One of the key social factors is the cognitive interaction process. As stakeholders' preferences, environments, and knowledge are dynamically changing during their interactions, collaborative activity over the Internet is more than an online data accessing and information sharing process. Accordingly, frequently occurred conflicts influence the project schedule and team performance. Team coordination has to be achieved through not only sharing of data and information, but also the realization of the decision contexts of each other (Kannapan & Taylor, 1994; Chung et al., 1999). The decision context consists of at least two parts:

the circumstances of the decision makers and the stages of the process. When people exchange information, they should understand under what circumstances this information is generated and in which situation it can be potentially used. Otherwise, it is difficult for them to interpret the purposes and implications of each other during the activity coordination. Therefore, to represent and organize the situated knowledge (i.e. the context) is essential to support the coordination among different groups. It is also of immense importance to understand how to design knowledge management systems so that they mesh with human behavior at the individual and collective levels. By allowing users to "see" one another and to make inferences about the activities of others, online collaboration platforms can become environments in which new social forms can be invented, adopted, adapted, and propagated—eventually supporting the same sort of social innovation and diversity that can be observed in physically based cultures (Erickson & Kellogg, 2000).

To address these issues, our research uses a socio-technical framework to model the interactions within collaborations (Lu & Cai 2001). The framework addresses that one cannot utilize information to map from "what-to-do" to "how-to-do" in the collaboration process without knowing the perspective of the "who" that generates the information. A collaborative project is modeled as a co-construction process among a group of stakeholders. The key feature is to explicit model the "who" (i.e. the stakeholders' perspectives) within the process (i.e. the "what", "how", and "when"). During collaboration, each individual has a perspective that evolves over time and acts like a "lens" through which she understands and collects information external to her. Each individual builds over her lifetime an evolving base of information that is "internal" to her. The information that each individual produces, or exchanges through any medium (e.g., computers, speech, and writing), is the external manifestation of her internal information, appropriately filtered through her "perspective lens". Based on the socio-technical framework, knowledge management systems require the explicit modeling of stakeholders' perspectives within their

Figure 1. The perspective modeling approach of knowledge management in collaboration



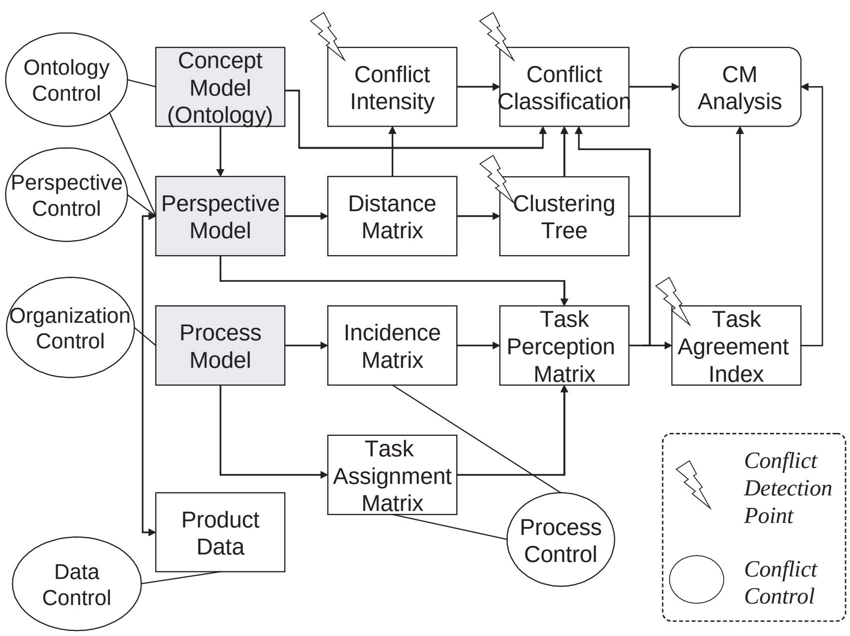
social interactions. The perspective modeling and analyzing methodology focuses on representing and handling the interactions among the heterogeneous stakeholders. It provides associations with other knowledge management and decision support models. It also provides ways to build and integrate various processes with the realization of sharing knowledge and managing conflict. Different from traditional KMS which either focus on the codification of explicit knowledge (E-E KMS) or communication of tacit knowledge (T-T KMS), the perspective modeling approach will realize a new way of building KMS (P-P KMS) through controlling the interfaces between the explicit and tacit knowledge (i.e. stakeholders' perspectives) (Figure 1).

PERSPECTIVE MODELING AND SOCIO-TECHNICAL ANALYSIS

Methodology Overview

The central function of the research framework is the "socio-technical analysis" to model and analyze the perspectives of stakeholders at each step of the collaboration process. The socio-technical analysis methodology takes three input parameters (i.e. the concept model, and the perspective model, the process model) (Figure 2). The concept model is a structure which organizes the ontology models representing the shared or private notions of the stakeholders. The process model is a feasible computational model which represents the interactions of individual tasks. It specifies the sequences and dependencies of de-

Figure 2. The socio-technical analysis methodology for knowledge management



cisions and actions to be jointly performed. The perspective model provides a generic means to formally capture, represent, and analyze stakeholders' perspectives and their interactions with each other. The concept model and perspective models represent the shared knowledge and social characteristics of various stakeholders during the collaboration process. They are derived from the surveys of stakeholders' attitudes towards the ontology models at a point of time.

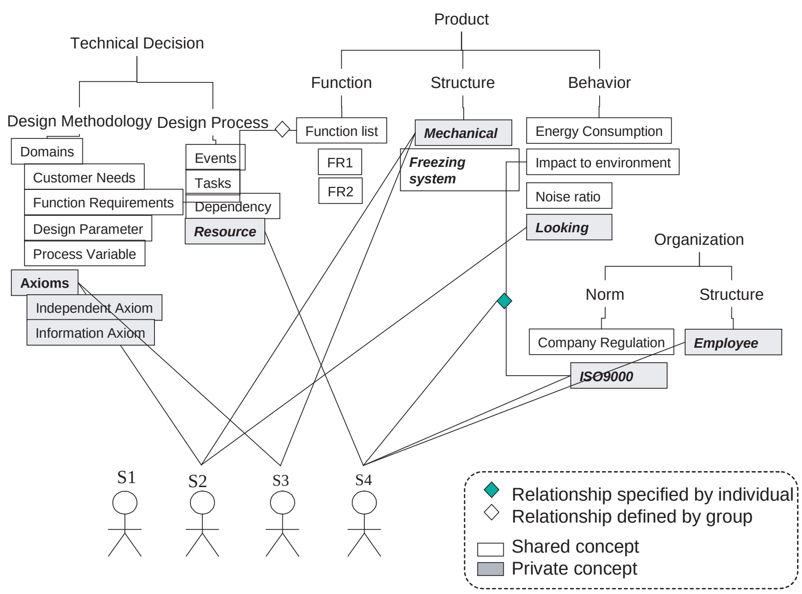
The dependencies among these models are represented as matrices for mathematical analysis. Conflict analysis applies systematic strategies to analyze inconsistencies among these matrices. At a certain stage within the process, conflicts can be detected by tracking and comparing the "perspective states" of different stakeholders associated with a certain task. This analysis will derive three major outputs (i.e., process feasibility, conflict possibility, and perspective network). Then, based on these outputs, the systems can apply various control strategies so that the quality of the collaboration is enhanced. Control mechanisms adaptively handle the interplay among the three factors by systematically reconciling various perspectives, improving the processes, and controlling the product data and organizational structure.

Perspective Modeling

The perspective modeling mainly consists of building the concept model and the perspective model. While the process model depicts the tangible activities of the project, the concept model and perspective model track the knowledge evolution and changes of social behaviors.

The first step is to generate the concept structure hierarchy. A concept model is a hierarchical structure that represents the organization of the ontology (Huhns & Stephens, 1999, Staab et al., 2001) that stakeholders propose and use in their collaboration. Figure 3 shows a concept structure example of a product development

Figure 3. A concept structure built by stakeholders in a collaborative design project



team. Stakeholders may use both top-down and bottom-up construction methods (Vet & Mars, 1999) to build the concept structure. It is possible to apply some templates (e.g. "product function template", "organizational template", "conflict types template", etc.) to clarify the concepts. These templates act as the contend-based skeletons for organizing the external information that stakeholders may share with others.

When stakeholders propose new concepts, the concept structure is updated and is used to systematically organize these concepts and their relationships. Since a stakeholder should first consider whether there are same or similar concepts in the structure, only the novel concepts can be specified and added. The concepts involved within the collaboration are classified into two types. Shared concepts are those that have been well-defined from previous projects. They have widely accepted meaning shared among the stakeholders (e.g., in Figure 3, "Function Requirements", "Product", and "Organization" etc. are shared concepts). Private concepts are perceived only by some particular stakeholders. Their names or meanings are not expressed around the group. If a group of people have a shared purpose toward a concept, everyone will be asked to view it. After the concepts are identified, the dependencies among these concepts can be further clarified by stakeholders.

The second step is to generate the perspective model. A perspective model is the special information representing the status of a stakeholder's perspective at a certain time. A perspective model consists of the purpose (i.e. the intention to conduct certain actions), context (i.e. the circumstances in which one's action occurs), and content (i.e. what one knows and understands) that the stakeholder uses to access the external knowledge and to expose the internal knowledge. In information systems, perspective model can be depicted as a data format relating to other information entities.

Our research develops a format of representing perspectives and a procedure to capture, generate and analyze perspective models. Given the well-organized structure of concepts, it is feasible to ask the stakeholders to build the perspective model state diagrams (PMSD) at a certain time. A stakeholder's PMSD attempts to depict the explicit relationships among his/her concepts (include the shared concepts and private concepts) and his/her purpose, content, and context information. The concepts listed in the PMSD are categories of perspective contents. Using the concept structure to generate the PMSD provides a structured way for us to systematically compare and examine the perspective differences among stakeholders.

Each concept of the concept model can be associated with a stakeholder by a set of purposes, contexts, and contents. The operation is to ask the stakeholders to:

First, relate this concept to their purposes. A stakeholder is able to specify his/her purpose within the project for a given concept. There might be more than one purpose involved. For an abstract concept, the purpose could be more general. For a specific concept, the purpose could be detail.

Second, specify the relationships of this concept with other concepts based on his/her context. If there is a new concept generated, add it to the PMSD architecture and set it as a private concept.

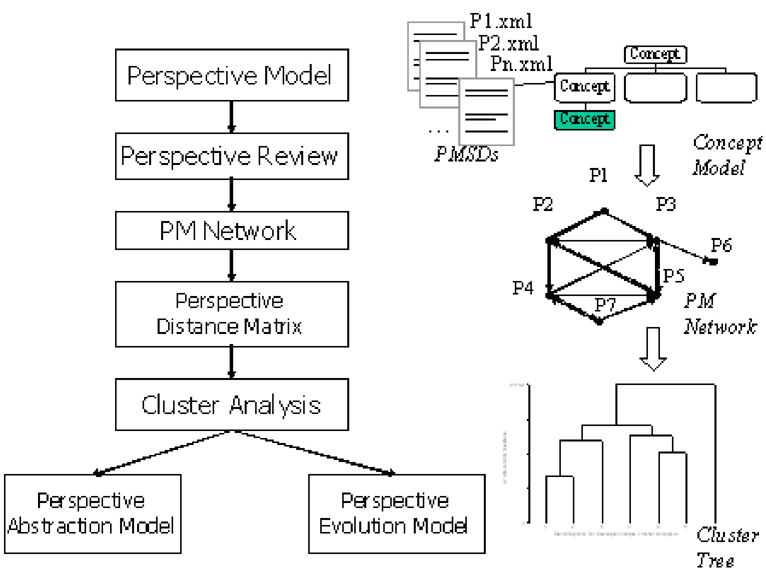
For each concept, declare or relate his/her own knowledge, document, and data about that concept and put them as the elements of the content associated with that concept.

Therefore, a PMSD is the picture that depicts a snapshot of a stakeholder's perception of concepts. It embodies his/her related purposes, context, and content. In a collaboration support system, a PMSD is represented as XML formats to facilitate analysis.

The third step is to conduct the perspective analysis. By comparing and analyzing stakeholders' perspective models it is possible to determine the degree of agreement among their opinions during their interaction. As shown in Figure 4, given the PMSDs for certain stakeholders, we can ask them to review others' perspective models. The review information is used to compare the perspective models and determine the similarity of two stakeholders' perspectives toward a shared concept. We can also aggregate multiple stakeholders' perspective models and compare their general attitudes at different levels of abstraction. Furthermore, we can track the evolution of the perspective model based on the clustering analysis results. The procedure is called perspective analysis (Figure 4).

The first step is to determine the inconsistency (i.e. the "distance") among a group of perspective models. There are two approaches: the intuitive approach and the analytical approach. The intuitive approach relies on the insights of the stakeholders. The analytical approach uses mathematical algorithms to derive the distance through "positional analysis", which is based on a formal method used in social network analysis (Wasserman & Faust, 1994). This approach views the perspective models of a group of stakeholders toward a single concept as a network of opinions associated with each other. In this network, a stakeholder, who possesses a perspective model, has relationships with others' perspective models. We define these relationships as their perceptional attitudes toward each other. A group of perspective models towards a given concept are placed as a graph (i.e., a PM network). Two perspective models are compatible (or similar) if they are in the same "position" in the network structure. In the social network analysis, "position" refers to a collection of individuals who are similarly embedded in networks of relations. If two perspective models are structurally equivalent (i.e., their relationships with other perspective models are the same), we assume that they are purely compatible and there are no detectable differences. That implies that they have the same perception towards others and others have same perception towards them.

Figure 4. The perspective analysis procedure



A distance matrix is derived for each PM network. It represents the situation of perspective compatibility among a group of stakeholders for a given concept. We can also compare stakeholders' perspective models for multiple concepts by measuring the structural equivalence across the collection of perspective model networks. Perspective distance matrices serve as the basis for cluster analysis. Hierarchical clustering is a data analysis technique that is suited for partitioning the perspective models into sub-classes. It groups entities into subsets so that entities within a subset are relatively similar to each other. Hierarchical clustering generates a tree structure (or a dendrogram), which shows the grouping of the perspective models. It illustrates that the perspective models are grouped together at different levels of abstraction (Figure 4).

The cluster tree exposes interesting characteristics of the social interactions. Within a collaborative project, the participants of the organization cooperate and build the shared reality (i.e. the common understanding of the stakeholders towards certain concepts) in the social interaction process (Berger & Luckman, 1966). Understanding the process of building shared realities is the key to managing social interactions. The shared reality can be represented by the abstraction of close perspective models among a group of stakeholders. As a matter of fact, the cluster tree depicts the structures of the shared reality, since a branch of the clustering tree at certain level implies an abstract perspective model with certain granularity. The height of the branch indicates the compatibility of the leaf perspective models. A cluster tree with simple structure and fewer levels implies that all of the perspective models have similar attitudes (or positions) toward others.

While the perspective models are changing, the clustering analysis can be used as a systematic way to depict the transformation of the perspective models. The change of the cluster trees at different stages of collaboration reveals the characteristics of perspective evolution. Investigating the changes of the topological patterns of the clustering trees leads to ways to interfere in the perspective evolutions.

Conflict Management

Given the condition that the social interactions are analytically measured, control mechanisms can be derived to manage the evolutions of the perspective models and therefore to support collaboration. Theses mechanisms could be selected and used by the group managers or coordinators to control conflicts. They can be classified into the following strategies.

- Process control
  The perspective analysis can be performed for all of the stakeholders who might act or influence a task. By evaluating their perspective compatibility and the execution feasibility of future tasks, which are in the plan but have not be conducted yet, we can prevent some conflicts by noticing their potential existence earlier. By providing certain information to stakeholders, it is possible to change the perception matrix and therefore to increase the perspective consistency of a task. It is possible to directly adjust the sequences and dependencies among the tasks to maintain the integrity of the opinions of stakeholders.
- Perspective control and ontology control
  First, it is possible to directly influence stakeholders' perspectives (their content, purpose, and context) to maintain the integrity and compatibility of the opinions toward a certain concept or task. Analyzing social interactions will identify the perspective models with low similarities and reveal the conflicts clearly. Thus, we can focus on the stakeholders who have singular perspectives and understand their rationale. Second, communication channels can be built to increase the interaction opportunities among

stakeholders with different perspective models. The group can manipulate the concept structure through clarifying the meanings and definitions of critical concepts so that people have shared understanding. It is also feasible to serve stakeholders with different concepts to isolate their perspectives. An opposite way is to use conflicting perspectives as means to enhancing brainstorming and innovation. Third, strategies can be derived to manage the conflicts through influencing stakeholders' information access and comprehension. Possible solutions include providing suitable trainings based on their perspectives and the job requirements, assisting the critical stakeholder to review the relevant information during certain conflicting tasks, and recording the discussions about the shared concept for future reuse.

- Organization control

  The clustering tree shows the grouping features of stakeholders' perspectives. Using different organizational structures will change the communication channels and the perception distances. If two stakeholders are separated into different groups, the possibility of interaction will decrease. We can change the task assignment or modify stakeholder' roles to affect their contexts. It is even possible to add or remove stakeholders associated with a certain task to avoid the conflicting situation or to move the stakeholders with similar perspectives together.
- Data and information control

  This control mechanism is to affect the conflicts through appropriately providing and handling external data and information, which will be accessed by the stakeholders. Examples are to use consistent checking and version control mechanisms to maintain the product data integrity, to track the changes of shared data and information by referencing to the perspective changing, and to map the shared data and information to perspective models so that the system realizes the specific impact of the conflicts towards the working results.

BUILDING ELECTRONIC COLLABORATION SUPPORT SYSTEMS USING THE PERSPECTIVE MODELING APPROACH

The perspective modeling and analyzing methodology provides a theoretical basis for building new knowledge management systems. The STARS system is a prototype system to support collaboration over the Internet. It is also developed as an experimental apparatus for testing the research. The system implements the process modeling, perspective modeling, and socio-technical analysis methodologies. On the other hand, it collects process and perspective data once stakeholders use it as a collaboration tool. By investigating the collected experimental data, we can determine the effectiveness of the approach and therefore improve it.

STARS system provides a Web-based environment that supports the collaboration process representation, conflict management, and knowledge integration within a project team. Stakeholders declare, share, and modify their perspective models on the Web. The perspectives models are analyzed in the system and stakeholders' roles in the collaboration tasks are depicted. The system implements the functional modules (e.g. perspective management, process management, conflict management, etc.) by using J2EE1.4 and Web Services technologies (Figure 5). It provides methods to detect, analyze, and track the conflicts during collaboration. It also supports the business-to-business process communications through SOAP and UDDI.

Figure 5. STARS system architecture

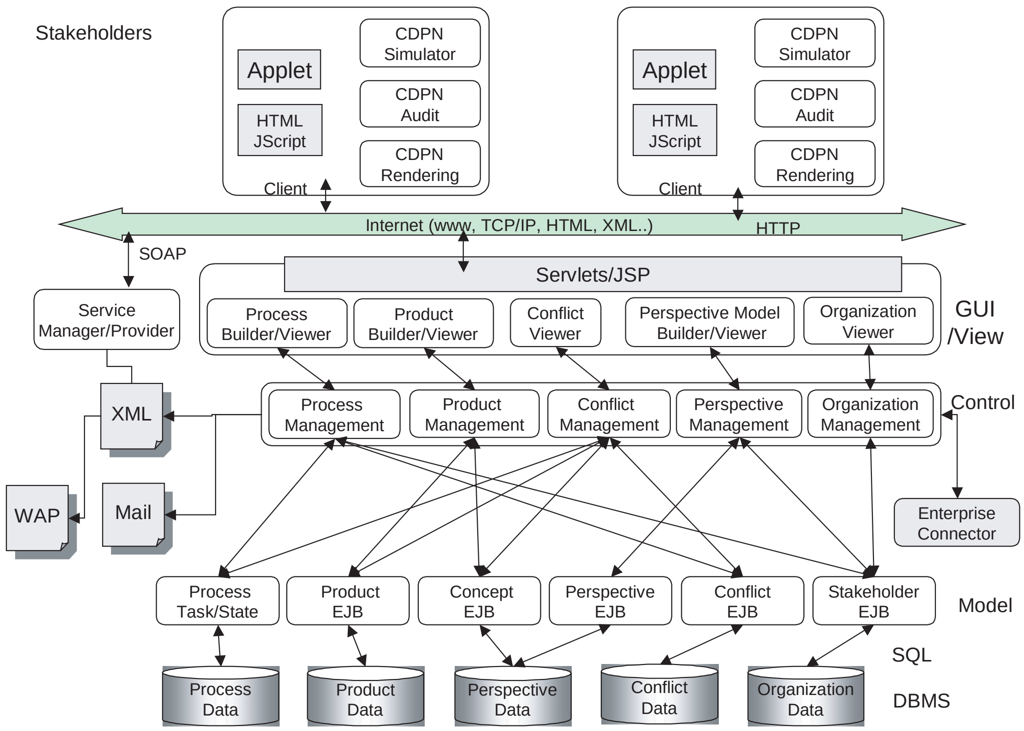


Figure 6 shows the knowledge perspective management module that allows stakeholders to declare and review their perspective information according to a concept structure tree. The system can analyze the perspective models, detect and predict conflicts, and suggest possible control strategies. The process management system of STARS uses a XML based process modeling tool for process planning, scheduling, simulation, and execution. It helps the stakeholders notice what is happening and who is doing what at any time. Stakeholders declare their perspectives during each step of the process. The system determines the conflict ratio of each tasks based on the perspective analysis.

Groups of designers, business analysts, and consultants working in a U.S. national construction research institute have been using STARS in their small projects. Feasibility and computability of the analysis algorithms were proved. Figure 7 depicts an example of using STARS to solve the conflict problem through perspective analysis. Before using STARS, similar cases described as below often happened in one design team:

"Within a design project, at the first meeting, the client's design consultant stated that the building was to be placed at a location on the site. The architect listened to the client's reasoning but noted that this location is not ideal from either an aesthetic or a functional point of view, since it would be too close to a major road intersection."

STARS perspective analyzing functions helped users notice the dependencies and differences of views among the stakeholders. The

Figure 6. The perspective management and conflict management modules of STARS

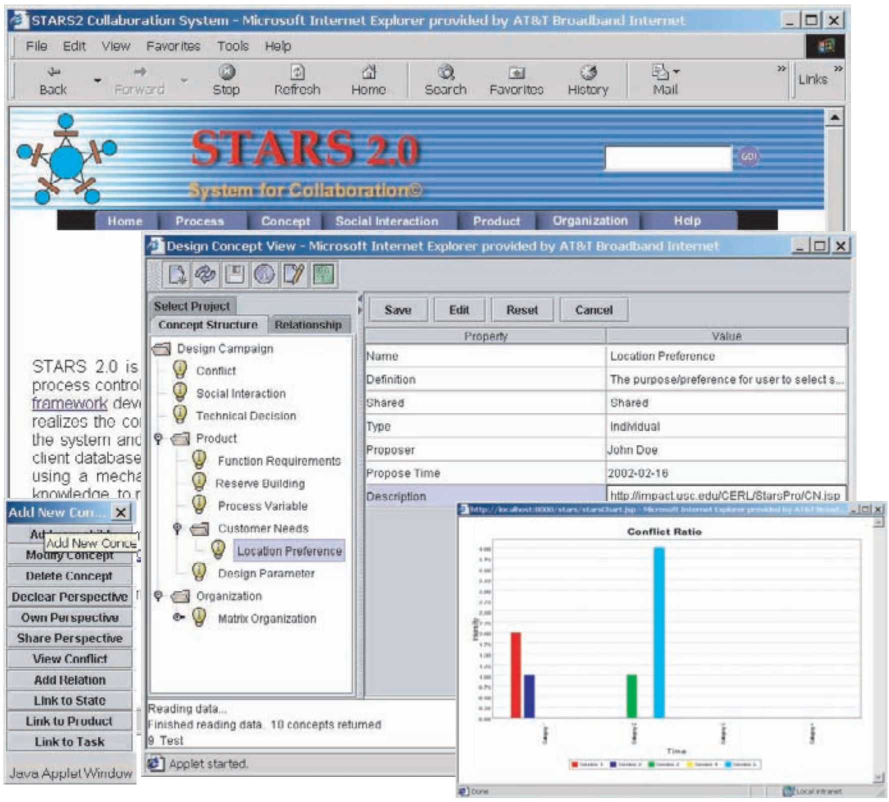
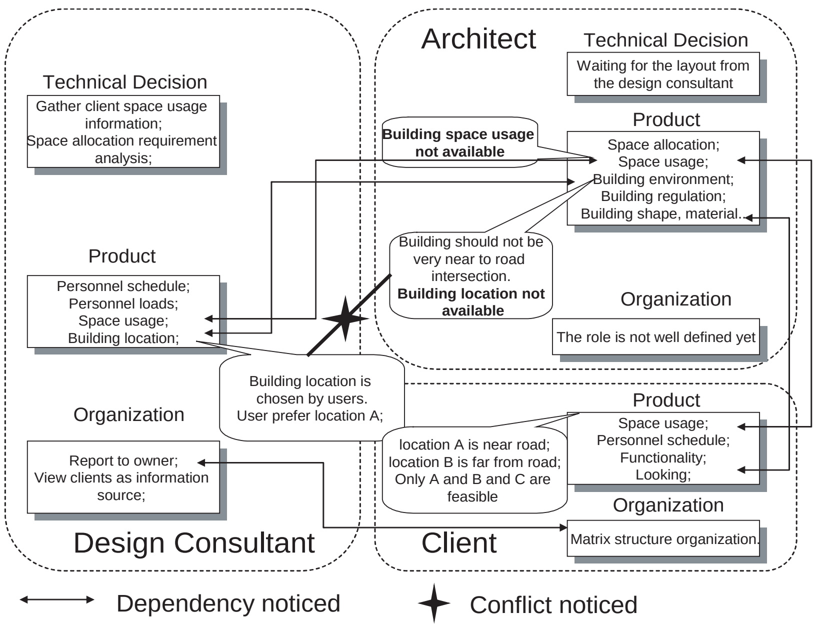


Figure 7. An example of detecting conflicts from perspective analysis



conflict was detected by tracking and mapping the "perspective models" of the three stakeholders. STARS compared the perspective models at early stage of the design. Although there was no direct meeting between the design consultant and the architect, the system detected a potential conflict during the design process.

The stakeholders who participated in the experiment considered that using the perspective modeling methodologies could accelerate their learning process and detect conflicts earlier in their collaborative projects. The causes of breakdowns of collaboration are more comprehensible when applying the analysis methodologies.

CONCLUSION

This paper presents a systematic methodology to supporting knowledge management by modeling and analyzing stakeholders' perspectives and their social interactions within collaborative processes. This approach provides methods for capturing perspectives and understanding their relationships to facilitate the control of the evolution of the shared insights. It avails knowledge management and conflict management by systematically facilitating the manipulation of the process, the perspectives, the organizational structure, and the shard data and information. The STARS system was built to improve the coordination among stakeholders. Its perspective modeling function provides an efficient way for stakeholders to understand the meanings and improve coordination during their collaboration over the Internet.

This research has some limitations. First, the closed-loop perspective management methodology requires stakeholders to be actively involved in the building and updating of perspective models. This might be overkill when the group is already very efficient and stable. Second, using the perspective analysis requires the computing tool and thus introduces a higher level of complexity. The system users have to be able to honestly and clearly specify their understandings toward the concepts and others' perspectives. In the future, the perspective analysis model can be improved by applying advanced statistics and econometrics techniques. It is also important to generate dynamic modeling methods to define the relationships between the evolution of perspective models and the quality of online collaboration.

REFERENCES

Alavi, M. & Leidner, D.E. (2001). Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *MIS Quarterly*, *25(1)*, 105-136.

Arias, E.G., Eden, H., Fischer, G., Gorman, A. & Scharff, E. (2000). Transcending the individual human mind-creating shared understanding through collaborative design. *ACM Transactions on Computer-Human Interaction*, *7(1)*, 84-113.

Becerra-Fernanaez, I. & Sabherwal, R. (2001). Organizational knowledge management: a contingency perspective. *Journal of Management Information Systems*, *18(1)*, 23-55.

Berger, P. & Luckman, T. (1966). The social construction of reality a treatise in the sociology of knowledge. New York: Doubleday.

Briggs, R.O., Vreede, G-J. & Nunamaker Jr., J.F., (2003). Collaboration engineering with thinkLets to pursue sustained success with group support systems. *Journal of Management Information Systems*, *19(1)*, 31-64.

Carley, K.M. & Prietula, M.J. (1994). ACTS theory: extending the model of bounded rationality, *Computational Organization Theory*, 55-88, UK: Lawrence Erlbaum Associates.

Chung, C-W., Kim, C-R. & Dao, S. (1999). Knowledge and object-oriented approach for interoperability of heterogenous information management systems. *Journal of Database Management, 10(3)*, 13-25.

Clancey, W.J. (1993). Guidon-manage revisited: a socio-technical systems approach. *Journal of Artificial Intelligence in Education 4(1)*, 5-34.

Clancey, W.J. (1997). The conceptual nature of knowledge, situations, and activity, in Feltovich, P., Hoffman, R. and Ford, K., Eds. *Human and Machine Expertise in Context*, 247-291, AAAI Press, CA.

Dym, C.L. & Levitt, R.E. (1991). Toward the integration of knowledge for engineering modeling and computation. *Engineering with Computers, 7(1)*, 209-224.

Earl, M.J. (2001). Knowledge management strategies: toward a taxonomy, *Journal of Management Information Systems. 18(1)*, 215–233.

Easley, R.F., Sarv, D. & Crant, J.M. (2003). Relating collaborative technology use to teamwork quality and performance: an empirical analysis *Journal of Management Information Systems, 19(4)*, 247-268.

Erickson, T. & Kellogg, W.A. (2000). Social translucence: an approach to designing systems that support social processes *ACM Transactions on Computer-Human Interactions, 7(1)*, 59-83.

Hanson, M., Nohira, N. & Tierney, T. (1999). What is your strategy for managing knowledge? *Harvard Business Review*, March-Aprial, 106-116.

Hardjono, T.W. & van Marrewijk, M. (2001). The social dimensions of business excellence. *Corporate Environmental Strategy, 8(3)*, 223-233

Huhns, M.N. & Stephens, L.M. (1999). Personal ontologies. *IEEE Internet Computing, 3(5)*, 85 –87.

Kannapan, S. & Taylor, D. (1994). The interplay of context, process, and conflict in concurrent engineering, *Journal of Concurrent Engineering Research and Applications, 2(1)*, 183-196.

Kwan, M.M. & Balasubramanian, P. (2003). Process-oriented knowledge management: a case study, *Journal of Operational Research Society, 54(1)*, 204-211.

Lee, H. & Choi B. (2003). Knowledge management enablers, processes, and organizational performance: an integrative view and empirical examination, *Journal of Management Information Systems* , 20(1), 179-228.

Lu, S. C-Y. & Cai, J., (2001). A collaborative design process model in the sociotechnical engineering design framework. *Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 15(1)*, 3-20.

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company*. New York: Oxford University Press,.

Nonaka, I., Reinmoeller, P. & Senoo D. (1998). The 'ART' of knowledge: systems to capitalize on market knowledge. *European Management Journal*, 16(6), 673-684.

O'Leary D. E. (1998). Enterprise knowledge management, *IEEE Computer*, March, 54-61.

Preece, A., Flett, A. & Sleeman, D. (2001). Better knowledge management through knowledge engineering. *IEEE Intelligent Systems*, January/ February, 36-43

Reimer, U., Margelisch, A. & Staudt, M. (2000). EULE: A knowledge-based system to support business processes. *Knowledge-Based Systems*,13, 261-269

Rouse, W.B. (2001). Need to know—information, knowledge, and decision making. *IEEE Transactions on Systems, Man, and Cybernetics Part C: Applications and Reviews*, 32(4), 282-292.

Shaw D., Ackermann, F. & Eden C. (2003). Approaches to sharing knowledge in group problem structuring. *Journal of the Operational Research Society*, 54, 936–948

Siau, K. (1999). Information modeling and method engineering: a psychological perspective. *Journal of Database Management*, 10(4), 44-50.

Sowa, J.F. & Zachman, J.A. (1992). Extending and formalizing the framework for information systems architecture. *IBM System Journal*, *31(3)*, 590-616.

Spender, J.C., (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal*, *17*, 45–62.

Staab, S., Schnurr, H-P., Studer, R. & Sure, Y. (2001). Knowledge processes and ontologies. *IEEE Intelligent Systems*, January/February, 26-34

Vet, P. E. & Mars, N.J. (1998). Bottom-up construction of ontologies. *IEEE Transaction on Knowledge and Data Engineering*, 10(4), 513-526

Wasserman, S. & Faust, K. (1994). *Social Network Analysis: Methods and Applications*. New York: Cambridge University Press.

Zack, M.H. (1999). Managing Codified Knowledge. *Sloan Management Review*, 40(4), 45-58.

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Chapter 3.14
Web-Based Knowledge Management Model

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INTRODUCTION

Knowledge is a limitless resource in the knowledge-based economy; therefore, organizations should learn, store, transfer and apply knowledge to add value or gain competitive advantage (Sveiby, 1997). Knowledge management (KM) refers to identifying and leveraging the collective knowledge within the organization for competitive advantage (von Krogh, 1998). However, it is usually discussed and implemented in high-tech industries (e.g., TI, TSMC and Winbond) and the software industry (e.g., Microsoft and Oracle). In Taiwan, the upstream firms or suppliers of the electronics industry (e.g., Winbond and UMC) implement KM in their organizations. As well as the suppliers, the downstream firms or manufacturers (e.g., Quanta and ASUS) also put KM into practice. However, in the intermediaries or distributors, only a meager number of firms really implement KM in their companies. Therefore, we have neglected whether KM is still suitable to implement in the distribution industry.

The IC distributors in Taiwan evolved from partnerships or intra-family enterprises into the overall arrangement in Asia, with output value in 2004 beyond $38.7 billion (United States dollars). IC distribution industry outsiders may consider that distributors just transact business, but don't have their own products, even though the scale of IC distributors has expanded. So an inaccurate notion exists that it isn't necessary to innovate or put KM into practice therein. In fact, IC distributors have to face not only the rapidly changing upstream firms, but also the variable requirements of downstream customers. Therefore, distributors have to adapt and learn even faster than their suppliers and customers to face the drastically changing and intensely competitive environment.

LITERATURE REVIEW

Knowledge Management

KM consists of the creation, storage, arrangement, retrieval and distribution of an organization's knowledge (Demarest, 1997; Saffady, 2000). Alavi and Leidner (2001) classified the processes of KM into four steps: knowledge creation, knowledge storage/retrieval, knowledge transfer and knowledge application, representing a detailed process view of organizational KM with a focus on the role of information technology. This systematic framework is shown as Figure 1, and each process will be illustrated in the following subsections.

Knowledge Creation

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge (Pentland, 1995). New knowledge is a necessary raw material for innovation and the creation of knowledge, both closely tied to new products and services (Hauschild, Licht, & Stein, 2001). When a firm starts to develop new products or services, or when organizational knowledge is antiquated or insufficient, a firm should create new knowledge through organizational learning activities.

Knowledge Storage/Retrieval

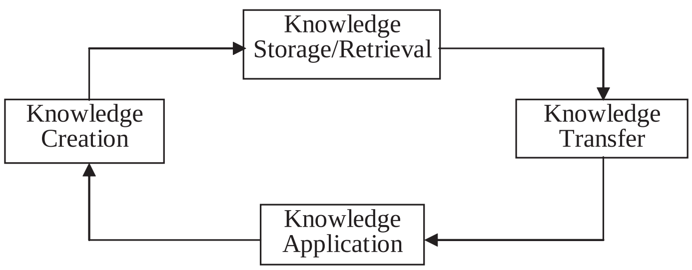
While new knowledge is developed by individuals, organizations play a critical role in articulating and amplifying that knowledge (Nonaka, 1994). Actually, the storage, organization and retrieval of organizational knowledge are referred to as organizational memory (Stein & Zwass, 1995; Malhotra, 2000). An organizational memory includes knowledge residing in various component forms, including structured information stored in electronic databases, written documentation, expert systems, documented organizational procedures and processes, and tacit knowledge acquired by individuals and networks of individuals (Tan, Teo, Tan, & Wei, 1999).

Knowledge Transfer

The distribution and transfer of knowledge is an important process in knowledge management (Alavi & Leidner, 2001; Huber, 1991). Knowledge should be shared and generalized within the organization; generalization occurs not only when single ideas are moved, but also when the entire process of moving ideas becomes institutionalized within an organization (Yeung, Ulrich, Nason, & von Glinow, 1999).

For shared knowledge to be meaningfully used, it needs to be coupled with mechanisms

Figure 1. Four processes of KM (modified from Alavi & Leidner, 2001)



for organization, retention, maintenance, search and retrieval of the information (Stein & Zwass, 1995). Such mechanisms are often computer-based, ranging from simple keyword organizers to complex intelligent agents and neural networks that grow with the growth of knowledge repositories (Ellis, Gibbs, & Rein, 1991; Johansen, 1988; Maes, 1994). Collaborative technologies (CT) application is fundamental to virtual teams. One CT, known as a virtual workplace, should at least be able to record the process of the group, an agenda and libraries of solutions and practices, as well as provide different forms of interaction, meta-information and shared information storage, access and retrieval (Ellis, Gibbs, & Rein, 1991; Ishii, Kobayashi, & Arita, 1994; Kling, 1991; Nunamaker, Briggs, & Mittleman, 1995; Romano, Nunamaker, Briggs, & Vogel, 1998; Thornton & Lockhart, 1994). For knowledge sharing and reuse with CTs, however, they must include mechanisms for exchange (such as e-mail) and access the knowledge repository (Majchrzak, Rice, King, Malhotra, & Ba, 1999).

In newly implemented IT-enabled communications environments, individual media choice was found to be overwhelmingly informed by so-called socialcultural determinants of how these technologies might most adequately and effectively be used (Webster & Trevino, 1995; Fulk & Boyd, 1991). Therefore, management may influence participation in the technologies of choice.

Knowledge Application

Knowledge application means making knowledge more active and relevant for firms in creating value through applying organizational knowledge to a company's products, processes and services (Bhatt, 2001; Demarest, 1997). Employees use all available resources, including the corporate knowledge base, to improve their chance of reaching the goals of the organization (Hauschild, Licht, & Stein, 2001). As stated by Prokesch (1997), using knowledge more powerfully than your competitors is key in the global information era. Knowledge should be applied to create suitable, real value for the company.

CASE STUDY: WORLDPEACE

Company Overview

Worldpeace Group, established in Taipei, Taiwan in 1981, became an OTC-listed company in 1987 and a TSE-listed company in June 2000. Its capital was $0.97 billion in 2004, and its group sales in 2003 were one $160 million. It is the largest and leading electronic component distributor in the Asia Pacific region; moreover, in 2003 it was ranked the sixth-largest among top global semiconductor distributors worldwide by EBN (a dedicated semiconductor Web site). Its suppliers include 60 world-famous firms, like Intel, TI, Philips, Hynix, Vishay and so forth.

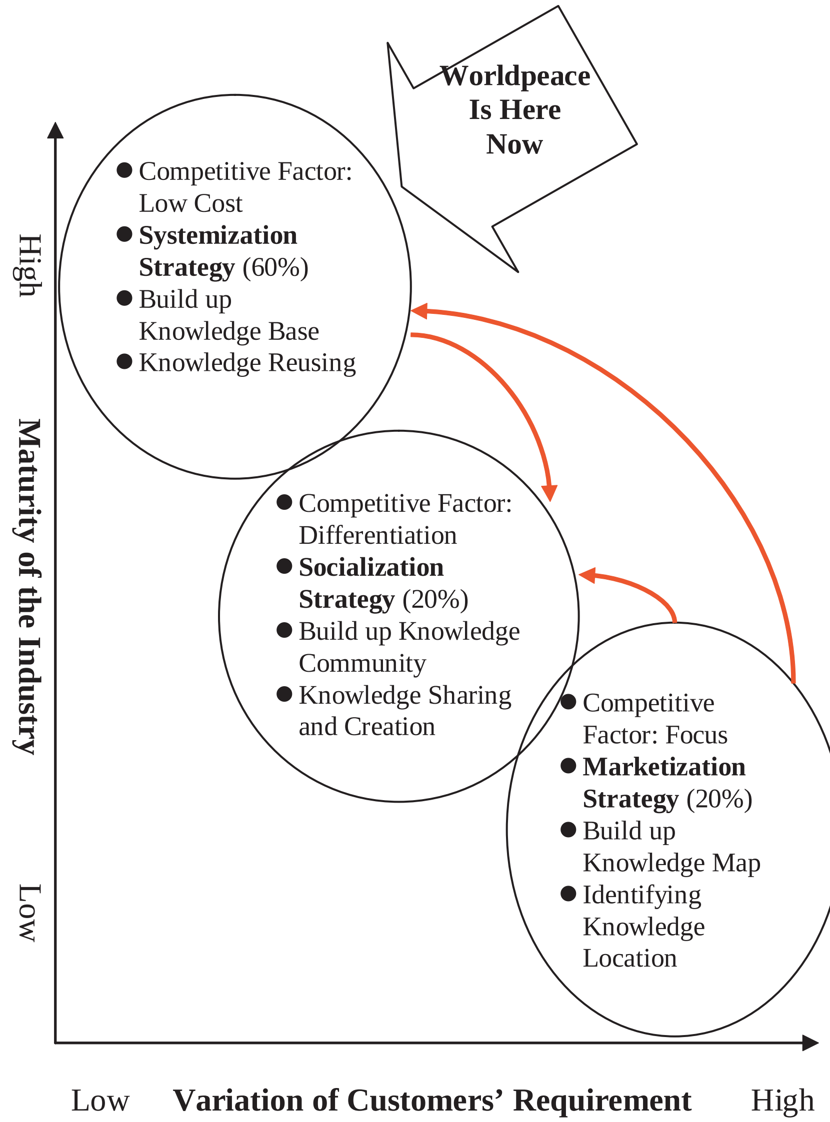
Worldpeace's department of KM was founded to facilitate the implementation of KM. Worldpeace invested positively in the information technologies and systems that help them to gain competitive advantage. They stored and transferred their knowledge, information, order status and market conditions in their self-developed information system named Enterprise Internal Portal (EIP).

KM Strategies

The implementation of KM in Worldpeace was guided according to three weighted strategies (see Figure 2) as follows:

- Marketization strategy: To find the knowledge within the organization, marketization strategy was applied to build up the knowledge map (IP map) to record the locations of knowledge owners, providers or experts. Most knowledge in Worldpeace is explicit,

Figure 2. Three strategies for the implementation of KM in Worldpeace (from Worldpeace, modified from Yu, 2001)



so they just put 20% weight on marketization efforts.

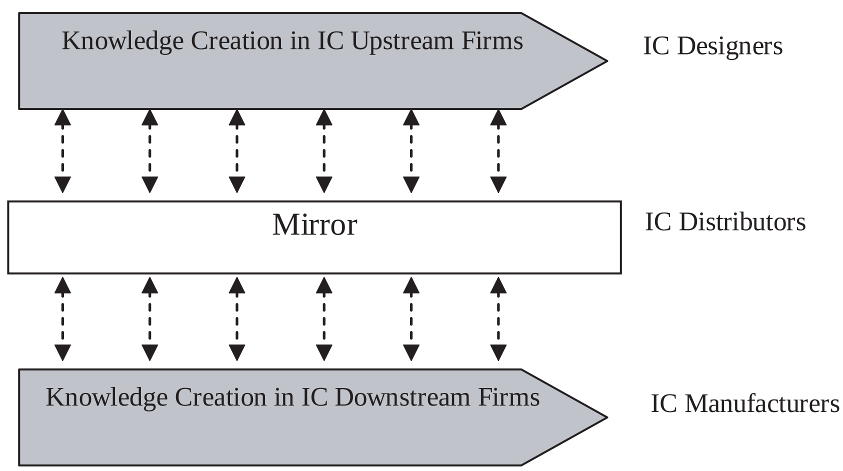
- Systemization strategy: Being in a mature industry and being the largest distributor in Asia, Worldpeace need not provide different products for customers, but rather focus on "low cost" instead. Worldpeace emphasizes the storage of knowledge within the organization. Therefore, Worldpeace put 60% weight on systemization strategy when putting KM into practice. For effective knowledge sharing and optimum users' understanding, knowledge in Worldpeace should be standardized. Hence, a "standard knowledge" mechanism was implemented before storing knowledge or information in the knowledge base. The associate vice president of corporate marketing and communication and assistant manager of knowledge management of Worldpeace announced the "standard knowledge" mechanism, and educated their engineers and employees to write standard documents to store standardized knowledge for months before they implemented KM.

- Socialization strategy: To encourage employees to share knowledge spontaneously and actively, a socialization strategy was implemented to build a "knowledge community." This strategy focuses on conversations (especially for tacit knowledge) among the members of Worldpeace, and knowledge creation through this knowledge community. However, most knowledge in IC distribution industry is explicit knowledge; therefore, they only put 20% weight on socialization strategy.

KM Practice

- Knowledge Creation: In the IC distribution industry, firms have to keep their knowledge consistent with their supply chain; that is, when their upstream firms or suppliers innovate or create new knowledge about IC products, the distributors must get that new knowledge instantly. As many innovations occur and much new knowledge is created in the IC design industry, distributors have to work hard to keep up with suppliers. Worldpeace keeps knowledge consistent with suppliers by being a two-way mirror of the knowledge creation of their suppliers, which means knowledge will be transferred from the IC designer to the distributor as it was created or devised. The distributor plays the same role as the designer in knowledge creation by acquiring knowledge about new requirements from customers or information about market demand. Besides acquiring the knowledge from suppliers and customers, Worldpeace plays an important role in transferring knowledge between upstream and downstream firms whenever knowledge is created (see Figure 3).
- Knowledge Storage/Retrieval: As distributors, they make a profit by managing knowledge and information about products. In

Figure 3. Knowledge creation with suppliers and customers—"mirror"



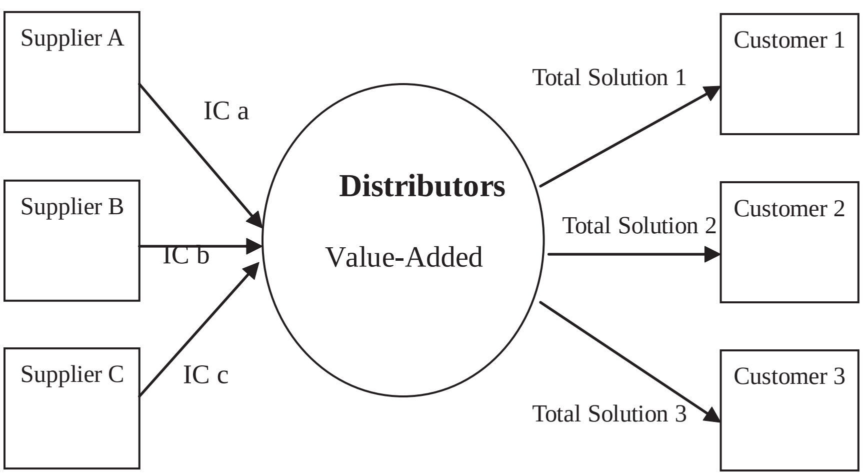
Worldpeace, knowledge and information are stored well in their database, and employees can access it via intranet. Worldpeace has become a distributor for business-to-business (B2B) e-commerce based on the knowledge management platform of its self-developed EIP information system. It established e-service for Customer Relation Management (CRM) to greatly improve the transaction process. The information on order status, accounts receivable and customers is recorded in EIP.

A report must be completed when any project closes. The new knowledge, findings, specifics and experiences in the case must be recorded and stored following a "standard knowledge" mechanism for effective knowledge sharing and understanding. All employees of Worldpeace are educated to write a standard document when they store knowledge, as the policy of "standardized knowledge" is critical when implementing KM.

- Knowledge Transfer: Two approaches were applied in Worldpeace to transfer knowledge. Explicit knowledge is stored in the EIP system in the standard format. Managers, engineers, salesmen and employees could access the knowledge that they need. Worldpeace has a solid Asia-Pacific service network, with more than 20 sales offices around the greater China and Asia Pacific region. Employees everywhere can access the EIP system via Internet. This EIP system is divided into four sections presented in four colors: blue, green, red and orange. The colors represent the Taiwan headquarters, branches in Taiwan, branches in China and branches in ASEAN, respectively. Thus, employees can store and access the information and knowledge within the same color section.

The second approach is for tacit knowledge transfer. In the distribution industry, tacit knowledge could be the experience of sealing a business deal. The salesmen or managers, who are masters in making deals or marketing, are invited to speak to other employees. Besides, some special cases will be studied to discover their characteristics,

Figure 4. The total solutions provided by integrating different IC chips in distributors



called "Worldpeace DNA." The associate vice president of corporate marketing and communication decides which cases are worth publicizing. The case study will proceed, and the assistant manager of knowledge management will have interviews with the salesman or manager to complete this case study. After it is completed, it will be stored in the EIP system for members in the virtual community.

- Knowledge Application: There are three knowledge domains in the distribution industry: first, knowledge about the nature of IC chips; second, knowledge about the purpose, function and application of the products; and third, knowledge about how to integrate IC chips in a module or system. Therefore, distributors build the knowledge base of products first, then understand how and where to apply them. Finally, they try to discover how to integrate different IC chips in a module. Being distributors, they do not design IC nor produce IC chips. They create value for customers by integrating chips from different suppliers in a module and providing total solutions, adding value for their customers (see Figure 4).

DISCUSSION AND INSIGHTS

With stiff global competition, high-tech companies face the challenge of a shorter product life cycle, the rapid depreciation of tangible assets and the transience of employees, especially marketing employees and salesmen in the distribution industry. The most knowledge in the distribution industry is explicit; therefore, it is suitable to put KM into practice through the intranet. Based on the literature and case study of Worldpeace, three insights are provided.

- Insight 1: In order to increase the efficiency of knowledge sharing and understanding among the members of virtual community, a "standard knowledge" mechanism should be implemented first. The standardized knowledge records will increase the readability and help members of virtual communities to understand their meaning. Besides, this "standard knowledge" mechanism also contributes to the storage of knowledge within organizations. Therefore, we suggest that firms set up this mechanism before building virtual communities.
- Insight 2: KM could be implemented in the distribution industry through a Web-based system to help firms strategically apply knowledge and keep robust relationships with their suppliers and customers. A supply chain could profit and grow by implementing KM and applying knowledge efficiently in every link of the chain.
- Insight 3: The critical information technology in Worldpeace's implementation of KM is a self-developed system and virtual community named EIP. Worldpeace invested significant budget to develop this system to help in daily access, storage and transfer of knowledge. According to Worldpeace's associate vice president of corporate marketing and communication, the company invested very generously in technologies that may be the basis of competition or contribute to their market edge. Therefore, we propose that more emphasis on investment in IT may result in a more effective outcome from KM.

CONCLUSION AND SUGGESTIONS

In this article, Worldpeace, the largest and leading electronic component distributor in the Asia Pacific region, was studied to reveal the real practice of how an IC distributor implements KM in a Web-Based Knowledge Management Model. Findings indicate that firms should set up this mechanism before building a virtual community. Furthermore, findings in this study also reveal that emphases on investment in IT and support from executives have the potential to improve the efficiency and favorability in implementation of KM.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Bhatt, G.D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-75.

Demarest, M. (1997). Understanding knowledge management. *Long Range Planning, 30*(3), 374-384.

di Norcia, V. (2002). The knowledge economy and moral community. *Journal of Business Ethics, 38*(1/2), 167-177.

Ellis, C.A., Gibbs, S.J., & Rein, G. (1991). Groupware: Some issues and experiences. *Communications of the ACM, 34*(1), 39-58.

Fulk, J., & Boyd, B. (1991). Emerging theories of communication in organizations. *Journal of Management, 17*(2), 407-446.

Hauschild, S., Licht, T., & Stein, W. (2001). Creating a knowledge culture. *The McKinsey Quarterly,* (1), 74-81.

Hellstrom, T., & Husted, K. (2004). Mapping knowledge and intellectual capital in academic environments: A focus group study. *Journal of Intellectual Capital, 5*(1), 165-180.

Huber, G. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Ishii, H., Kobayashi, M., & Arita, K. (1994). Iterative design of seamless collaboration media. *Communications of the ACM, 37*(8), 83-97.

Johansen, R. (1988). Groupware: Computer support for business teams. New York: Free Press.

Kling, R. (1991). Cooperation, coordination, and control in computer-supported work. *Communications of the ACM, 34*(12), 83-88.

Maes, P. (1994). Agents that reduce work and information overload. *Communications of the ACM, 35*(11), 30-40.

Majchrzak, A., Rice, R.E., King, N., Malhotra, A., & Ba, S. (1999). Computer-mediated interorganizational knowledge-sharing: Insights from a virtual team innovating using a collaborative tool. *Information Resources Management Journal, 13*(1), 44-53.

Malhotra, Y. (2000). Knowledge management & new organization forms: A framework for business model innovation. *Information Resources Management Journal, 13*(1), 5-14.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nunamaker, J., Briggs, R., & Mittleman, D. (1995). Electronic meeting systems: Ten years of lessons learned. In D. Coleman & R. Khanna (Eds.), *Groupware: Technology and applications* (pp. 149-193). Englewood Cliffs, NJ: Prentice-Hall.

Pentland, B.T. (1995). Information systems and organizational learning: The social epistemology of organizational knowledge systems. *Account, Management and Information Technologies, 5*(1), 1-21.

Prokesch, S.E. (1997). Unleashing the power of learning: An interview with British Petroleum's John Browne. *Harvard Business Review, 75*(5), 5-19.

Romano, N. Jr., Nunamaker, J., Briggs, R., & Vogel, D. (1998). Architecture, design, and development of an HTML/Javascript Web-based group support system. *Journal of the American Society for Information Science*, *49*(7), 649-667.

Saffady, W. (2000). Knowledge management: An overview. *Information Management Journal*, *34*(3), 4-8.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research*, *6*(2), 85-117.

Sveiby, K.E. (1997). *The new organizational wealth: Managing & measuring knowledge-based assets.* San Francisco, CA: Berrett-Koehler Publishers.

Tan, S.S., Teo, H.H., Tan, B.C., & Wei, K.K. (1999). Developing a preliminary framework for knowledge management in organizations. In E. Hoadley & I. Benbasat (Eds.), *Proceedings of the Fourth Americas Conference on Information Systems* (pp. 629-631).

Thornton, C., & Lockhart, E. (1994). Groupware or electronic brainstorming. *Journal of Systems Management*, *45*(10), 10-12.

von Krogh, G. (1998). Care in knowledge creation. *California Management Review, 40*(3), 133-153.

Webster, J., & Trevino, L.K. (1995). Rational and social theories as complementary explanations of communication media choices: Two policy-capturing studies. *Academy of Management Journal*, *38*(6), 1544-1572.

Yeung, A.K., Ulrich, D.O., Nason, S.W., & von Ginow, M.A. (1999). *Organizational learning capability.* New York: Oxford University Press.

Yu, K.C. (2001). *Knowledge management and innovation*. Taipei, Taiwan: Commonwealth Press.

Chapter 3.15
Knowledge Management Ontology

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INTRODUCTION

Many definitions of ontology are posited in the literature (see Guarino, 2004). Here, we adopt Gruber's (1995) view which defines ontologies as simplified and explicit specification of a phenomenon. In this article, we posit an ontology that explicates the components of knowledge management (KM) phenomena. This explicit characterization of knowledge management can help in systematically understanding or modeling KM phenomenon.

In the past decade, KM has received significant attention within the information systems community, however, the community has not provided a well-integrated framework to help unify this sub-discipline. Therefore, in an effort to provide a comprehensive and unified view of KM, we introduce a formal characterization of a KM ontology collaboratively developed with an international panel of KM practitioners and researchers. Prior articles have either detailed various portions of this ontology and described panelists' piecewise evaluations of them (Holsapple & Joshi, 2000, 2001, 2002c) or outlined a more definitional and axiomatic version of this ontology (Holsapple & Joshi, 2004). Here, however, we provide a concise integrated view of the whole ontology.

Several methodologies for designing and developing ontologies have been proposed in the literature for many domains and for various objectives. For instance, Noy and McGuinness (2001) have posited seven steps for developing a basic ontology, whereas others, such as Guarino (retrieved 2004), have discussed the application of ontological principles in various context. Our ontololgy development process, although unique in certain aspects, incorporates many of the principles recommended in the literature.

BACKGROUND

The ontology was developed through a process of four phases including the preparatory, anchoring, collaborative, and application phases (Holsapple & Joshi, 2002a). In the preparatory phase, standards and criteria for ontology development and evaluation were created. In the anchoring phase, an initial ontology by consolidating, synthesizing, organizing, and integrating concepts from the past literature was developed. During the third phase, a panel of 31 KM practitioners and researchers collaborated in two Delphi rounds to further refine, modify, and evaluate the initial ontology. The last phase involved illustrating the application and utility of the developed ontology.

KNOWLEDGE MANAGEMENT ONTOLOGY

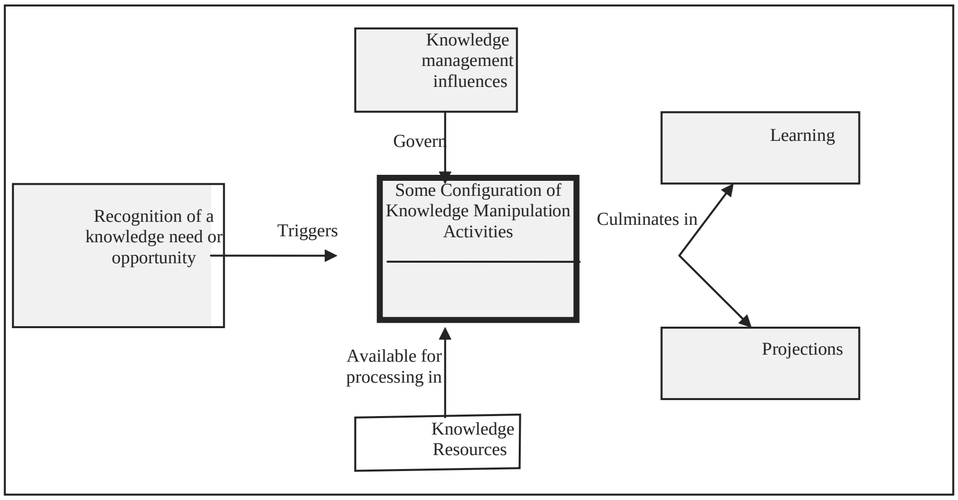
This ontology defines knowledge management as an entity's (such as an individual, group, organization, community, nation) deliberate and organized efforts to expand, cultivate, and apply available knowledge in ways that add value to the entity, in the sense of positive results in accomplishing its objectives or fulfilling its purpose (Holsapple & Joshi, 2004).

Many definitions of knowledge can be found in the literature (see Nonaka, 1994; Alavi & Leidner, 2001; Marshall & Brady 2001; Randall, Hughes, O'Brien, Rouncefield, & Tolmie, 2001; Sutton, 2001). The objective of the Delphi process was to characterize knowledge management behaviors that can accommodate various perspectives on the nature of knowledge. Therefore, no single definition of knowledge was developed or adopted. Knowledge can be represented in mental, behavioral, symbolic, digital, visual, audio, and other sensory patterns that may occur in various object and process formats. Knowledge has a variety of attributes including mode (tacit vs. explicit), type (descriptive vs. procedural vs. reasoning), orientation (domain vs. relational vs. self), applicability (local vs. global), accessibility (public vs. private), immediacy (latent vs. currently actionable), perishability (shelf-life), and so forth. More complete and detailed listings of attribute dimensions for characterizing knowledge have been advanced but are beyond the scope of this article (Holsapple & Joshi, 2001; Holsapple, 2003a) In the interest of being generic, the ontology is neutral on these differential views.

This ontology adopts an episodic view to knowledge work. In other words, an entity's knowledge management work is viewed as a collection of episodes. These episodes, which vary in structure, function, and purpose, unfold in various settings to accomplish a range of different tasks. This ontology characterizes a knowledge management episode (KME) (see Figure 1) as a configuration of knowledge manipulation activities, by a collection of knowledge processors, operating on available knowledge resources, subject to knowledge management influences, and yielding learning and/or projections (Holsapple & Joshi, 2004). Knowledge management episodes are triggered to satisfy a knowledge need or opportunity; it concludes when that need/opportunity is satisfied or terminated. Some examples of KME include decision-making, problem-solving, and brainstorming episodes.

KME is considered to have a learning outcome when the state of an entity's knowledge resources is altered. On the other hand, projection outcomes are expressions or manifestations—in the form of knowledge, material, capital, or behavior—of an entity's KME that are released into its environment. The resulting alteration in the state of the entity's knowledge base or environment due to learning or projection can be functional or dysfunctional in nature. The three primary components that drive the execution of a KME are the knowledge manipulation activities, knowledge resources, and knowledge management influences.

Figure 1. Architecture of a KM episode (adapted from Holsapple & Joshi, 2004)



Knowledge Manipulation Activities Component

Knowledge manipulation refers to the processing of usable knowledge representations embedded within an entity's knowledge resources. Knowledge processors that possess skills for performing knowledge manipulations activities can be human participants or computer-based parts in an entity. Numerous classifications of knowledge manipulation activities have been forwarded by KM researchers (see Alavi & Leidner, 2001; Holsapple & Joshi, 2002c). However, they often fail to provide a unifying view due to the use of differing terminology and varying levels of manipulation activities. This ontology provides a relatively comprehensive, unifying, elemental characterization of the major knowledge manipulation activities that occur during knowledge work.

As illustrated in Table 1, the Delphi process uncovered elemental knowledge manipulation activities, their sub-activities, and their interrelationships. The five types of basic knowledge manipulation activities that can occur during knowledge work include knowledge acquisition, knowledge selection, knowledge generation, knowledge assimilation, and knowledge emission.

The knowledge resulting from the execution of a knowledge manipulation activity by a processor can be transferred for further processing to other instances of knowledge manipulation activities. In other words, knowledge flows into and out of knowledge manipulation activities. A knowledge flow can be initiated through a pull or a push mechanism. So, a processor performing an instance of an activity could push that resulting knowledge to another instance of an activity or it could transfer that knowledge to satisfy the knowledge request from some other activity instance. In order to establish, coordinate, and control the knowledge flows among activity instances, processors also transfer ancillary messages to the interacting instances. These ancillary messages provide feedback, clarification, and evaluation of actual knowledge flow.

The ontology's five elemental knowledge manipulation activities that resulted from the Delphi

Table 1. The ontology's knowledge manipulation activity component (Adapted from Holsapple and Joshi, 2004)

Knowledge Manipulation Activity	Sub-Activities Within This Activity	Knowledge Flows into This Activity from	Knowledge Flows Released from This Activity to
Acquisition	Identification, Capturing, Organizing, Transferring	Entity's Environment	Assimilation, Generation, Emission
Selection	Identification, Capturing, Organizing, Transferring	Entity's Knowledge Resources	Acquisition, Assimilation, Generation, Emission
Generation	Monitoring, Evaluating, Producing, Transferring	Acquisition, Selection	Assimilation, Emission
Assimilation	Assessing/Valuing, Targeting, Structuring, Transferring	Acquisition, Selection, Generation	Entity's Knowledge Resources
Emission	Targeting, Producing, Transferring	Acquisition, Selection, Generation	Entity's Environment

process are characterized as follows (see Holsapple & Joshi, 2004 for a more formal discussion of these activities).

A knowledge acquisition activity involves identification of knowledge from the entity's environment and making it available in a suitable representation to an appropriate activity. The knowledge selection activity is similar to knowledge acquisition with one difference: Knowledge selection identifies knowledge from within an entity's knowledge resources as opposed to from the entity's environment. A knowledge generation activity derives or discovers knowledge in the context of existing knowledge. A knowledge assimilation activity culminates in learning by altering an entity's knowledge resources. A knowledge emission activity applies the existing knowledge to produce projections for release into the environment. The knowledge assimilation and emission activity involves usage and application of entity's existing knowledge to create knowledge.

Each of the five knowledge manipulation activities are comprised of sub-activities. Next, we will describe the sub-activities as well as the incoming and outgoing knowledge flows for each of the knowledge manipulation activities.

Knowledge acquisition (knowledge selection) is accomplished through a set of sub-activities which include identification of appropriate knowledge from the external sources (within the entity's existing resources), capturing the identified knowledge, organizing captured knowledge, and transferring the organized knowledge to an appropriate activity. A knowledge acquisition activity receives knowledge flows from an entity's environment and delivers the acquired knowledge to an activity that immediately uses the knowledge and/or to one that assimilates it within the entity for subsequent use. A knowledge selection activity receives knowledge flows from an entity's knowledge resources and delivers the selected knowledge to the acquisition, use, and/or assimilation activities.

The generation of knowledge entails monitoring the entity's knowledge resources and the external environment and attaining required knowledge (via selection or acquisition), evaluating the obtained knowledge in terms of its utility and validity for the production of knowledge, producing knowledge by creating, synthesizing, analyzing, and constructing knowledge from a base of existing knowledge, and transferring the produced knowledge to an appropriate activity. A knowledge generation activity receives knowledge flows from knowledge selection or acquisition activities and delivers the generated knowledge to assimilation and/or emission activities.

Knowledge assimilation involves assessing and valuing knowledge to be assimilated, targeting knowledge resources where knowledge would be situated, structuring knowledge into forms appropriate for the targets, and transferring the knowledge representations as targeted. A knowledge assimilation activity receives knowledge flows from knowledge acquisition, selection, or generation activities and produces knowledge flows that are transferred/embedded into the entity's knowledge resources.

The emission activity involves targeting elements of the environment to determine what projections need to be produced, producing projections for the target, and transferring the projections to targets which involves packaging and delivery. A knowledge emission activity receives knowledge flows from knowledge selection, acquisition, and/or generation activities and delivers the packaged knowledge (i.e., projections) to targets in the environment.

Knowledge assimilation and emitting activities, which result in learning and projection respectively, are very critical to effective knowledge work. These activities, if executed effectively, can add value to an entity in terms of enhanced knowledge, profits, and performance. The knowledge processed by the knowledge manipulation activities are embedded within different types of knowledge resources that are characterized below.

Knowledge Resource Component

An organizational resource is a source of value, revenue, wealth, or rent to an organization (Holsapple & Joshi, 2004). Traditionally, organizations have recognized and effectively managed three types of resources: financial, human, and material. However, knowledge assets are recognized as crucial organizational resources (Drucker, 1993) for creating and maintaining a competitive advantage (Holsapple & Singh, 2001). More organizations are attempting to manage knowledge resources with a degree of systematic, deliberate, or explicit effort devoted to managing the other three resources. Knowledge resources are entities where organizational knowledge is embedded and can be manipulated by an organization in ways that yield value. A taxonomy characterizing knowledge resources, a component of our knowledge management ontology, which was developed through the Delphi process is described next.

Some classes of knowledge resources exist independent of an entity's existence whereas the others depend on the existence of an entity. The resources that exist independent of an entity are called content knowledge resources. The resources that are dependent on the existence of an entity are called schematic resources. Schematic knowledge is embedded within the behaviors that manifests in an organization. The four kinds of schematic resources include culture, infrastructure, strategy, and purpose. An organization's cultural knowledge resource holds organizational values, principles, norms, traditions, unwritten rules, and informal procedures. An organization's infrastructure structures an organization's participants in terms of the roles that have been defined for participants to fill, the relationships among those roles, and regulations that govern the use of roles and relationships (Holsapple & Luo, 1996). An organization's strategy consists of planning knowledge for utilizing organization's infrastructure, culture, knowledge artifacts, and participants' knowledge (as well as other organizational resources). An organization's purpose consists of directional knowledge used to align entity's strategy, infrastructure, and culture.

The two types of content knowledge resources include participants' knowledge and knowledge embedded within artifacts. These resources can exist without an entity that host, own or create these resources. Knowledge artifacts are objects without any processing skills, but have knowledge embedded within them that can be processed by human or computer processors. Participants' knowledge is the knowledge possessed by knowledge processors that participate in an organization.

The last class of knowledge resources that is accessible to an entity are the resources in its environment. The environment's knowledge resources are a crucial source for replenishing and augmenting an organization's knowledge resources.

Knowledge Management Influences Component

Knowledge influences are factors that shape and govern the execution of knowledge manipulation activities during a KM episode. The Delphi methods revealed three classes of KM influences, including managerial influences, resources influences, and environmental influences. Managerial influences incorporate administrative activities established and executed by an entity that affect its knowledge work. Resource influences are comprised of organizational resources that are employed to carry out entity's knowledge work. Environmental influences are factors external to an entity (i.e., in its environment) that affect its conduct of knowledge management.

The managerial influences include knowledge leadership, knowledge coordination, knowledge control, and knowledge measurement. Leadership facilitates fruitful knowledge work. Knowledge coordination involves management of dependencies among knowledge manipulation activities, knowledge resources, knowledge processors, and knowledge management episodes. Knowledge control involves ensuring that needed knowledge resources and processors are available in sufficient quality and quantity, subject to required security. Knowledge measurement involves assessing and valuing knowledge resources, knowledge processors, knowledge manipulation activities, managerial influences, knowledge management episodes, and overall conduct of knowledge management.

The ontology recognizes an entity's resources as influences on how a KM episode unfolds. This includes not just its knowledge resources, but also the other more traditional resources such as financial, material, and human. The third class of influence includes an entity's environment. Unlike managerial influences (and, to a considerable extent, resource influences), environmental influences are factors over which an entity typically has limited (or no) control. These factors may operate as constraints, impediments, or facilitators of the entity's knowledge management efforts. The Delphi process yielded six major classes of environmental influences: competition, fashion, markets, technology, time, and the GEPSE (governmental, economic, political, social, and educational) climate.

FUTURE TRENDS

This article provides a general purpose ontology that is very generic in nature and applicable to various knowledge contexts. Although, on one hand the ontology's general nature broadens its applicability, it also limits it from capturing the nuances of a specific knowledge context. Therefore, by adopting this ontology as its foundation, future research needs to develop context-specific ontologies that focus on characterizing a specific KM episode in a more detailed fashion. For instance, in order to better understand how the knowledge management conduct unfolds during an information system development (ISD) process, it is crucial to explicate and characterize the KM conduct in the context of an ISD process. Such an effort could entail enumeration of knowledge manipulation activities and its relationships specific to this task, identification of knowledge resources involved in this type of knowledge work, and uncovering influences that facilitate or constrain knowledge processing in an ISD process.

This ontology provides concepts and components associated with KM episodes. However, it does not offer measures for these constructs. Future research needs to create measurement scales that operationalize the ontology's constructs for measuring and testing the execution of KM episodes within organizations.

Future research and practice needs to continually test and examine this ontology's utility and applicability and develop it further through improvements, refinements, and modifications.

CONCLUSION

The posited ontology identifies and characterizes major elements of KM in a unified and relatively comprehensive manner. It provides a characterization of KM episodes that consists of three components: knowledge manipulation activities, knowledge resources, and knowledge influences. Moreover, it provides a taxonomy for an entity's knowledge resources where knowledge may be stored, embedded, and/or represented. It identifies and relates knowledge manipulation activities that operate on those resources. It recognizes factors that influence the conduct of KM in an organization.

The ontology in its current form provides a foundation for systematic KM research, study, and practice. It provides researchers with a unified and comprehensive view of KM that is crucial for studying KM (e.g., Holsapple & Singh, 2000; Holsapple & Singh, 2001; Massey, Montoya-Weiss, & O'Driscoll, 2002; Holsapple & Jones, 2003). It gives practitioners a frame of reference for evaluating KM practices and identifying KM opportunities. It forwards a structure and content for developing a formal KM curriculum (e.g., Holsapple, 2003b, 2003c; Weidner, 2003).

This ontology is an initial step toward initiating conceptual development in the KM field. This ontology can be developed further through added breath and depth. It can be extended in a normative direction by adding elements that prescribe methods and technologies for the conduct of KM.

REFERENCES

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Drucker, P. (1993). *Post-capitalist society*. New York: Harper Collins.

Gruber, T.R. (1995). Toward principles for the design of ontologies used for knowledge sharing. *International Journal of Human and Computer Studies, 43*(5/6), 907-928.

Guarino, N. (2004). *Understanding, building, and using ontologies*. Retrieved 2004, from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/guarino/guarino.html

Holsapple, C., & Luo, W. (1996). A framework for studying computer support of organizational infrastructure. *Information and Management, 31*(1), 13-24.

Holsapple, C., & Singh, M. (2000, March 31-April 2). The knowledge chain. *Proceedings of the Annual Conference of the Southern Association on Information Systems.*

Holsapple, C., & Singh, M. (2001). The knowledge chain model: Activities for competitiveness. *Expert Systems with Applications, 20*(1), 77-98.

Holsapple, C.W., & Joshi, K.D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information System, 9*(2-3), 235-261.

Holsapple, C.W., & Joshi, K.D. (2001). Organizational knowledge resources. *Decision Support Systems, 31*(4), 39-54.

Holsapple, C.W., & Joshi, K.D. (2002a). A collaborative approach to ontology design. *Communications of the ACM, 44*(2), 42-47.

Holsapple, C.W., & Joshi, K.D. (2002c). Knowledge manipulation activities: Results of a Delphi study. *Information and Management, 39*(6), 477-490.

Holsapple C. (2003a). Knowledge and its attributes. In C. Holsapple (Ed.), *Handbook on knowledge management: Knowledge matters* (pp. 165-188). Berlin: Springer-Verlag.

Holsapple, C. (Ed.) (2003b). *Handbook on knowledge management: Knowledge matters*. Berlin: Springer-Verlag.

Holsapple, C.W., & Jones, K. (2003, August 4-5). Toward an elaboration of the knowledge chain model. *Proceedings of the Americas Conference on Information Systems*, Tampa, FL.

Holsapple, C.W., & Joshi, K.D. (2004). A collaboratively designed ontology of knowledge management. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Marshall N., & Brady, T. (2001). Knowledge management and the politics of knowledge: Illustrations from complex products and systems. *European Journal of Information Systems, 10*(2), 99-112.

Massey, A.P., Montoya-Weiss, M.M., & O'Driscoll, T.M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Noy, N.F., & McGuinness, D.L. (2001). *Ontology development 101: A guide to creating your first ontology*. SMI technical report SMI-2001-0880.

Randall, D., Hughes, J., O'Brien, J., Rouncefield, M., & Tolmie P. (2001). Memories are made of this: Explicating organisational knowledge and memory. *European Journal of Information Systems, 10*(2), 113-121.

Sutton D.C. (2001). What is knowledge and can it be managed? *European Journal of Information Systems, 10*(2), 80-88.

Weidner, D. (2003) Book review. In *thought and practice, 2*(1). Retrieved from www.kmpro.org/journal/Book_Review/Handbook_on_Knowledge_Management.cfm

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Chapter 3.16
Discovering Implicit Knowledge from Data Warehouses

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INTRODUCTION

Today, every corporation faces the problem of how to acquire, store, and share information. Knowledge management (KM) has been introduced to accomplish these tasks (Adams, 2004; Barquin, 2000; Frappaolo & Wilson, 2004). Fundamental to KM is the realization that knowledge exists in two basic forms: explicit and tacit (Adams, 2004; Barquin, 2000; Frappaolo & Wilson, 2004; Orr, 2004). Organizations have data, in the form of operational databases and/or data warehouses, which contain implicit knowledge. Some knowledge believed to be tacit (experiential and intuitive) can be transformed into explicit knowledge. Getting to implicit knowledge requires taking a look at tacit knowledge resources (i.e., domain experts or data warehouses) to determine whether that knowledge could be codified if it were subjected to some type of mining and translation process. Then, it requires implementing that mining/translation process. The majority of an organization's knowledge is presumed to be tacit. Yet, the majority of the KM applications seem to focus on the explicit knowledge base: working on existing corporate knowledge or making individuals more effective at sharing explicit knowledge (Frappaolo & Wilson, 2004). Efforts have been put in creating an organized explicit knowledge repository, called data warehousing (Bischoff & Alexander, 1997) that is continuously fed and leveraged. Knowledge management is not truly possible without data warehousing (Barquin, 2000). It is the real-time access to an enterprise's integrated data stores through data warehousing that complements an individual's tacit knowledge of how something is done.

Knowledge discovery is defined as the nontrivial extraction of implicit, previously unknown, and potentially useful information from data (Adriaans & Zantinge, 1996; Agrawal, Imielinski & Swami, 1993; Brachman et al., 1996; Fayyad, 1996; Inmon, 1996). The automatic knowledge acquisition in a nondata warehouse environment has been on the operational databases which contain the most recent data about the organizations.

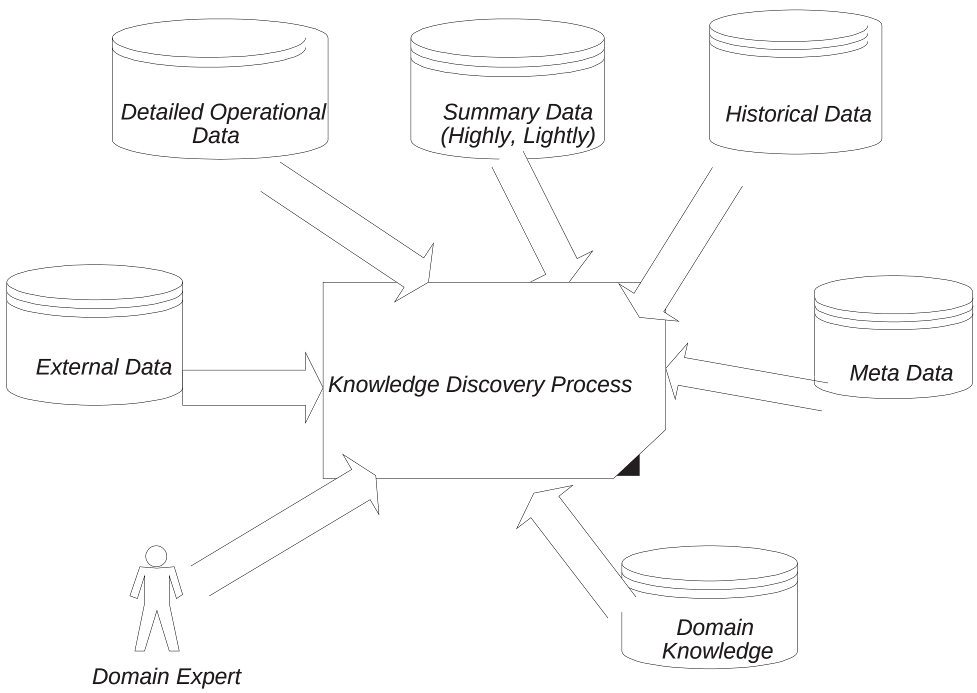
Summary and historical data, which are essential for accurate and complete knowledge discovery, are generally absent in the operational databases. A data warehouse is an ideal environment for rule discovery since it contains the cleaned, integrated, detailed, summarized, historical, and metadata (Bischoff & Alexander, 1997; Inmon, 1996; Meredith & Khader, 1996; Parsaye, 1996).

In this article, we are looking at the discovery of implicit knowledge from the data warehouses. Most of the success of knowledge discovery resides in the ability of the system to elicit the right level of detail as well as accuracy from the data warehouse which has the implicit data. We look at the knowledge discovery process on detailed, summary, and historical data. Also, we show how the discovered knowledge from these data sources can complement and validate each other.

KNOWLEDGE DISCOVERY IN DATA WAREHOUSES

Knowledge discovery on operational relational databases could lead to inaccurate and incomplete discovered knowledge. Without first warehousing its data, an organization has lots of information that is not integrated and has little summary or history information. The effectiveness of knowledge discovery on such data is limited. A data warehouse environment integrates data from a variety of source databases into a target database that is optimally designed for decision support. A data warehouse includes integrated data, detailed and summary data, historical data, and metadata. Each of these elements enhances the knowledge discovery process (Adriaans & Zantinge, 1996; Barquin & Edelstein, 1997; Bischoff & Alexander, 1997; Meredith & Khader, 1996).

Figure 1. A framework for knowledge discovery in a data warehouse environment



There are several benefits in rule discovery in a data warehouse environment. First, in a data warehouse environment, the validation of the data is done in a more rigorous and systematic manner. Using metadata, many data redundancies from different application areas are identified and removed. The cleansing process will remove duplication and reconcile differences between various styles of data collection. Second, data warehouses are not concerned with the update anomalies since update of data is not done. This means that at the physical level of design, we can take liberties to optimize the access of data, particularly in dealing with the issues of normalization and physical denormalization. Universal relations can be built in the data warehouse environment for the purposes of rule discovery, which could minimize the chance of undetecting hidden patterns.

Figure 1 shows a general framework for knowledge discovery in a data warehouse environment. External data, domain knowledge (data that is not explicitly stored in the database, that is, male patient cannot be pregnant), and domain expert are other essential components to be added in order to provide an effective knowledge discovery process in a data warehouse environment.

KNOWLEDGE DISCOVERY FROM DETAILED DATA

Most of the knowledge discovery has been done on the operational relational databases. An operational database stores the most recent and detailed data. In addition, the goal of the relational databases are to provide a platform for querying data about uniquely identified objects. However, such uniqueness constraints are not desirable in a knowledge discovery environment. In fact, they are harmful since from the data mining point of view, we are interested in the frequency with which objects occur (Adriaans & Zantinge, 1996). In the following, we discuss two main problems associated with the knowledge discovery in the operational relational databases, namely, the possibility of discovering incorrect and incomplete knowledge.

INCORRECT KNOWLEDGE DISCOVERY FROM RELATIONAL DATABASES

In general, summary data (aggregation) is never found in the operational environment. Without discovery process on summary data, we may discover incorrect knowledge from detailed operational data. Discovering rules based just on current detail data may not depict the actual trends on data. The problem is that statistical significance is usually used in determining the interestingness of a pattern (Giarrantanto & Riley, 1989). Statistical significance alone is often insufficient to determine a pattern's degree of interest. A "5% increase in sales of product X in the Western region", for example, could be more interesting than a "50% increase of product X in the Eastern region". In the former case, it could be that the Western region has a larger sales volume than the Eastern region; thus its increase translates into greater income growth.

The following example (Matheus, Chan & Piatetsky-Shapiro, 1993) shows that we could discover incorrect knowledge if we only look at the detailed data. Consider Table 1, where the goal of discovery is to see if product color or store size has any effect on the profits. The data are not large, but they show the points.

Assume we are looking for patterns that tell us when profits are positive or negative. We should be careful when we process this table using discovery methods such as simple rules or decision trees. These methods are based on probabilities that make them inadequate for dealing with influence within aggregation (summary data). A discovery scheme based on probability may discover the following rules from Table 1:

Table 1. Sample sales data

Product	Product Color	Product Price	Store	Store Size	Profit
Jacket	Blue	200	S1	1000	-200
Jacket	Blue	200	S2	5000	-100
Jacket	Blue	200	S3	9000	7000
Hat	Green	70	S1	1000	300
Hat	Green	70	S2	5000	-1000
Hat	Green	70	S3	9000	-100
Glove	Green	50	S1	1000	2000
Glove	Blue	50	S2	5000	-300
Glove	Green	50	S3	9000	-200

- Rule 1: IF Product Color = Blue Then Profitable = No CF = 75%
- Rule 2: IF Product Color = Blue and Store Size > 5000 Then Profitable = Yes CF = 100%

The results indicate that blue products in larger stores are profitable; however, they do not tell us the amounts of the profits which can go one way or another. Now, consider the modified table, where the third row in Table 1 is changed for the Profit to be 100 instead of 7000. Rules 1 and 2 are also true in the modified table. That is, from a probability point of view, Table 1 and the modified one produce the same results.

However, this is not true when we look at the summary tables (product color = Blue, Profit = 6400, based on Table 1) and (product color = Blue, Profit = -500, based on modified Table 1). The former summary table tells us that Blue color product is profitable, and the latter summary table tells us it is not. That is, in the summary tables, the probability behavior of these detailed tables begins to diverge and thus produce different results. We should be careful when we analyze the summary tables since we may get conflicting results when the discovered patterns from the summary tables are compared with the discovered patterns from detailed tables. In general, the probabilities are not enough when discovering knowledge from detailed data. We need summary data as well.

INCOMPLETE KNOWLEDGE DISCOVERY FROM RELATIONAL DATABASES

The traditional database design method is based on the notions of functional dependencies and lossless decomposition of relations into third normal forms. However, this decomposition of relations is not useful with respect to knowledge discovery because it hides dependencies among attributes that might be of some interest. To provide maximum guarantee that potentially interesting statistical dependencies are preserved, knowledge discovery process should use the universal relation (Parsaye et al., 1991) as opposed to normalized relations in order to reveal all the interesting patterns.

Consider the relations Sales (Client Number, Zip Code, Product Purchased) and Region (Zip Code, City, Average House Price) (Adriaans & Zantinge, 1996) which are in third normal form. The relation Sales-Region (Client Number, Zip Code, City, Average House Price, Product Purchased) shows the universal relation which is the join of the two tables, Sales and Region. From the universal relation, Sales-Region, we may discover that there is a relationship between the Average Price of the House and the type of Products Purchased by people. Such relationship is not that obvious on the normalized relations.

One possible scheme for validating the completeness/incompleteness of the discovered knowledge is to analyze the discovered rules (known as statistical dependencies) with the available functional dependencies (known as domain knowledge). If new dependencies are generated that are not in the set of discovered rules, then we have an incomplete knowledge discovery. For example, processing the Sales relation, we may discover that if Zip Code = 11111, then Product Purchased = Wine with some confidence. We call this a statistical dependency that indicates that there is a correlation (with some confidence) between the Zip Code and the Product Purchased by people. Now, consider the Region relation, where the given dependencies are Zip Code —> City and City —> Average House Price which gives the derived new functional dependency Zip Code —> Average House Price due to the transitive dependency. By looking at the discovered statistical dependency and the new derived (or a given dependency in general), one may deduce that there is a relationship between the Average House Price and the Product Purchased (with some confidence). If our discovery process does not generate such a relationship, then we have an incomplete knowledge discovery that is the consequence of working on normalized relations as opposed to universal relations.

KNOWLEDGE DISCOVERY FROM SUMMARY DATA

In knowledge discovery, it is critical to use summary tables to discover patterns that could not be otherwise discovered from operational detailed databases. Summary tables have hidden patterns that can be discovered. For example, a summary table (Product Color, Profit) based on Table 1 tells us that Blue products are profitable. Likewise, a summary table (Product, Profit) based on Table 1 tells us that Hat products are not profitable. Such discovered patterns can complement the discoveries from the detailed data (as part of the validation of the discovered knowledge).

Accurate knowledge, however, cannot be discovered just by processing the summary tables. The problem is that the summarization of the same data set with two summarization methods may produce the same or different results. Therefore, it is extremely important that the users be able to access metadata that tells them exactly how each type of summarized data was derived so that they understand which dimensions have been summarized and to what level. Otherwise, we may discover inaccurate patterns from different summarized tables. For example, based on summary tables from Table 1, it is the Green Hat in small stores (Store Size <= 1000) that makes profit, and it is the Green Hat product in large stores (Store Size > 1000) that loses money. This fact can only be discovered by looking at all different summary tables and knowing how they are created (i.e., using the metadata).

VALIDATING POSSIBLE INCORRECT RULES

It is possible to use the patterns discovered from the summary tables to validate the discovered knowledge from the detailed tables. The following cases are identified for validating possible incorrect/correct discovered rules.

- Case 1: If the discovered pattern from the summary tables completely supports the discovered knowledge from the detailed tables, then we have more confidence in the accuracy of the discovered knowledge.

- Case 2: The patterns discovered from the detailed and summary tables support each other, but they have different confidence factors. Since the discovered patterns on the summary tables are based on the actual values, they represent more reliable information compared to the discovered patterns from the detailed tables which are based on the occurrences of the records. In such cases, we cannot say that the discovered pattern is incorrect, but rather it is not detailed enough to be considered as an interesting pattern. Perhaps, the hypothesis for discovering the pattern has to be expanded to include other attributes (i.e., Product or Store Size or both) in addition to the Product Color.
- Case 3: The patterns discovered from the detailed and summary tables contradict each other. The explanation is the same as the one provided for Case 2.
- Case 4: There are cases where the discovered knowledge from summary tables is based on statistical significance. If the discovered knowledge from detailed and summary tables support each other with a different confidence factor, then additional information from other sources (perhaps from domain expert, if possible) is needed to verify the accuracy of the discovered knowledge.

KNOWLEDGE DISCOVERY FROM HISTORICAL DATA

Knowledge discovery from operational/detailed or summary data alone may not reveal trends and long-term patterns in data. Historical data should be an essential part of any discovery system in order to discover patterns that are correct over data gathered for a number of years as well as the current data. For example, we may discover from current data a pattern indicating an increase in students' enrollment in the universities in the Washington, DC area (perhaps due to good Economy). Such pattern may not be true when we look at the last 5 years of data.

Using Historical Data for Knowledge Discovery

There are several schemes that could be identified in using historical data in order to detect undiscovered patterns from detailed and summary data and to validate the consistency/accuracy/completeness of the discovered patterns from the detailed/summary data.

1. Validate discovered knowledge from detailed/summary data against historical data

We can apply the discovered rules from detailed and/or summary data to the historical data to see if they hold. If the rules are strong enough, they should hold on the historical data. A discovered rule is inconsistent with the database if examples exist in the database that satisfy the condition part of the rule, but not the conclusion part (Giarranttanto & Riley, 1989). A knowledge base (i.e., set of discovered rules from detailed and summary data) is inconsistent with the database if there is an inconsistent rule in the knowledge base. A knowledge base is incomplete with respect to the database if examples exist in the database that do not satisfy the condition part of any consistent rule.

If there are inconsistent rules, that means we have some historical data that contradict the rules discovered from detailed/summary data. It means we may have anomalies in some of the historical data. This is the case where any knowledge from external data, domain expert, and/or domain knowledge could be used to verify the inconsistencies. Similarly, if we have incomplete knowledge base, then there are some historical data that could represent new patterns or some anomalies. Again, additional information (i.e., domain expert) is necessary to verify that.

2. Compare the rules discovered from detailed/summary data with the ones from historical data

We perform the knowledge discovery on the historical data and compare the rules discovered from the historical data (call it H_RuleSet) with the ones discovered from detailed/summary data (call it DS_RuleSet). There are several possibilities:

a. If H_RuleSet ∩ DS_RuleSet = Æ Then, none of the rules discovered from detailed/summary data hold on the historical data.
b. If H_RuleSet ∩ DS_RuleSet = X Then
   - If DS_RuleSet - X = Æ Then, all of the rules discovered from detailed/summary data hold on the historical data.
   - If X Ì DS_RuleSet Then, there are some rules discovered from detailed/summary data that do not hold on the historical data (i.e, N_RuleSet - X). We can find the data in the historical data that do not support the rules discovered from the detailed/summary data by finding the data that support the rules in N-RuleSet and subtract it from the entire historical data. This data can then be analyzed for anomalies.
c. If H_RuleSet - DS_RuleSet != Æ (or DS_RuleSet Ì X) Then, there are some rules discovered from historical data that are not in the set of rules discovered from the detailed/summary data. This means we discovered some new patterns.

CONCLUSION AND FUTURE TRENDS

Current research in knowledge management involves the tools and techniques to acquire the tacit knowledge from the domain experts. We presented an approach for the automatic acquisition of some tacit knowledge from the implied knowledge that may be presented in the organizations' data warehouses. There are several issues/concerns that need to be addressed before we could have an effective knowledge discovery process. One major issue is the size of the data warehouses. The larger a warehouse, the richer its patterns would be. However, after a point, if we analyze too large a portion of a warehouse, patterns from different data segments begin to dilute each other, and the number of useful patterns begins to decrease (Parsaye, 1996). We could select segment(s) (i.e., a particular medication for a disease) from data that fits a particular discovery objective. Alternatively, data sampling can be used to foster data analysis. However, we lose information because we throw away data not knowing what we keep and what we ignore. Summarization may be used to reduce data sizes; although, it can cause problem too, as we noted.

In automatic discovering of implied knowledge from data warehouses, there is definitely some tacit knowledge that can be discovered and verified by experts. However, we may find some implied knowledge that may not be verifiable, as even the experts do not know the truth of the discovered knowledge. The significance and interestingness of such knowledge may become apparent in the future after the discovered knowledge is actually used in the organization.

REFERENCES

Adams, K. C. (2004). Information architecture translate KM theory into practice. *KM World*

Magazine Archives. Retrieved June 10, 2005, from http://www.kmworld.com/publications/maxine/index. cfm

Adriaans, P., & Zantinge, D. (1996). *Data mining*. Reading, MA: Addison-Wesley.

Agrawal, R., Imielinski, T., & Swami, A. (1993). Database mining: A performance perspective. *IEEE Transactions on Knowledge and Data Engineering, 5*(6), 914-925.

Barquin, C. R. (2000). *Knowledge management in the public sector*. Performance & Results, Management Concepts, Inc. Retrieved June 10, 2005, from http://www.barquin.com/documents/km-public-sector.pdf

Barquin, C. R., & Edelstein, H. A. (1997). *Building, using, and managing the data warehouse*. Upper Saddle River, NJ: Prentice Hall PTR.

Bischoff, J., & Alexander, T. (1997). *Data warehouse: Practical advise from the expert*. Upper Saddle River, NJ: Prentice Hall.

Brachman, R. J., Khabaza, T., Kloesgen, W., Piatetsky-Shapiro, G., & Simoudis, E. (1996). Mining business databases. *Communications of the ACM, 39*, 42-28.

Fayyad, U. (1996). Data mining and knowledge discovery: Making sense out of data. *IEEE Expert, 11*, 20-25.

Frappaolo, C., & Wilson, L. T. (2004). *After the gold rush: Harvesting corporate knowledge resources*. Retrieved June 10, 2005, from http://www.intelligent km.com/feature/feat1.jhtml?-requestid=387284

Giarrantanto, J., & Riley, G. (1989). *Expert systems: Principles and programming*. Boston, MA: PWS-Kent.

Inmon, W. H. (1996). The data warehouse and data mining. *CACM, 39*, 49-50.

Matheus, C. J., Chan, P. K., & Piatetsky-Shapiro, G. (1993). Systems for knowledge discovery in databases. *IEEE Transactions on Knowledge and Data Engineering, 5*(6), 903-913.

Meredith, M. E., & Khader, A. (1996). Designing large warehouses. *Database programming design, 9*(6), 26-30.

Orr, K. (2004). *Ken Orr Institute*. Retrieved June 10, 2005, from http://www.kenorrinst.com

Parsaye, K. (1996). Data mines for data warehouses. *Supplement to Database Programming & Design, 9*, S6-S11.

Parsaye, K., Chignell, M., Khoshafian, S., & Wong, H. (1991). Intelligent data base and automatic discovery. In B. Soucek (Ed.), *Neural and intelligent systems integration*. New York: John Wiley & Sons.

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Chapter 3.17
Strategically-Focused Enterprise Knowledge Management

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INTRODUCTION

Many of the knowledge management systems, such as the ones described in this entry, were originally computer information systems to which were added knowledge expertise that complemented the information and data communicated. As use of the Internet expanded and intranets within companies were developed, many new knowledge expertise exchange systems were established. As seen in the following discussions, many knowledge systems are therefore mixed, that is, integrated with traditional information and decision support systems, as at the consulting firm, while many, such as Xerox's, focus specifically on expertise knowledge storage and transfer and so can be designated focused knowledge management systems. Expert knowledge-based systems generally are pure knowledge systems (Mockler, 1992; Mockler & Dologite, 1992).

BACKGROUND

Narrowly defined, knowledge refers to practical skills or expertise gained from actual experience. In practice, however, knowledge management generally refers to the process of identifying and generating, systematically gathering, organizing and providing access to, and putting to use anything and everything that might be useful to know when performing some specified business activity. The knowledge management process is designed to increase profitability and competitive advantage in the marketplace.

As seen in the Key Terms section at the end of this article, since the knowledge management process involves keeping informed about and getting to know anything useful to doing a business task, the process can encompass data, information, and knowledge. Further, the knowledge management process can involve employing any useful and practical means of communication and storage, manual or electronic. Useful manual means might include: service manuals; professional publications; personal correspondence and conversations; special studies and reports; client correspondence and summaries; competitor role-playing; sales force feedback; current news; supplier feedback; and the like. Useful computer-based electronic technologies might include: e-mail; hierarchical, network, and relational databases and data warehouses; group decision support systems; Lotus Notes; intranets and Internet Web sites; browsers and search engines; expert and knowledge-based systems; and the like.

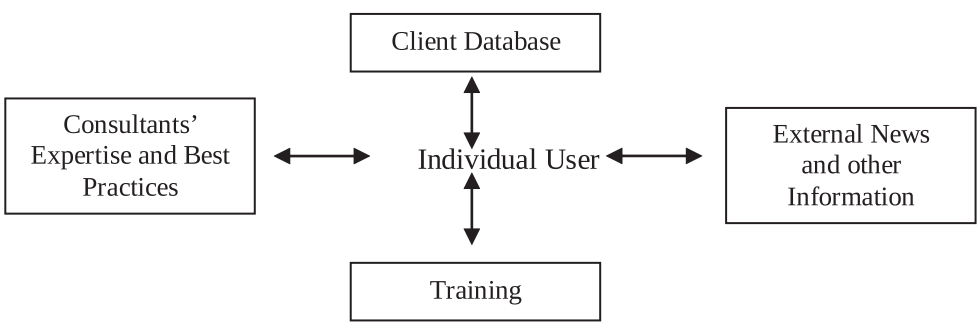
Because of the wide range of concepts and activities involved, the term knowledge management can more easily be understood by examples. Figure 1 outlines the knowledge management system (KMS) at a large consulting firm (Engoron, 1998).

The strategic focus is the individual consultant who needs access to data, information, and knowledge in order to do his/her job. Since consulting is its business, the system is strategic. The system provides this access in large part electronically.

At the top of Figure 1 is a large computer database of information about clients, covering past assignments, consultants who worked on the assigned projects, outcomes, organized data on the company involved, and contacts who can provide further information. On the right, there is a system incorporating expert knowledge-based systems that scans news media and library resources daily and daily directs relevant intelligence material to different consultants. On the left is a database of consultants' expertise or knowledge including that acquired from experience during past assignments. This includes written summaries of what was learned from the assignments, videos in which consultants describe the highlights of their experiences or general knowledge, and contingent best practices guidelines in different areas (such as strategic alliances, all marketing and production areas, human resources management, and the like). At the bottom, there is available a bank of online training programs, which a consultant can make use of (privately) to sharpen skills needed to improve job performance.

On any given day that a consultant receives a new assignment, he/she could immediately review current relevant information in the media (intelligence) about the client and project area, gather information quickly about the client and past assignments involving the client, review the related knowledge expertise of other consultants, and brush up on needed skills. At the same time, the consultant would make use of any relevant personal knowledge sources. The system is a good

Figure 1. Knowledge management system at a major consulting firm



example of using a knowledge system to strategically manage resources; that is, of a strategic management knowledge system.

Not all knowledge management systems are that complex or that multidimensional in scope. Some are narrowly focused on single activities. For example, Xerox in 1996 developed Eureka, an intranet communication system linked with a traditional corporate computer database that helps service representatives share repair tips; that is, knowledge. To date, more than 500 tips have been entered by Xerox technicians, and this practical knowledge is available to all via their laptops. For employees scattered around the world who travel often, the ability to share such know-how means they do not have to miss out on the kind of knowledge typically exchanged at the water cooler (Hickens, 1999).

A number of key characteristics of knowledge management can be identified from company experiences. These can apply to strategic and operational knowledge systems. First, the types of knowledge management systems vary considerably depending on the company situation requirements, a contingency perspective. Second, knowledge generation involves identifying knowledge relevant to strategic business activities, as well as its source and the way it is used or exploited. Third, structuring refers to designing knowledge management systems to capture and deliver the knowledge generated; such structures can range from simple ones involving individual business process areas, as at Xerox, to multidimensional complex enterprise-wide ones, as at the consulting firm. Their content can involve any company activity/business process or combination of them. Fourth, diffusing or communicating any type of relevant data, information, or knowledge involves transferring and absorbing knowledge to put it to work. In the company experiences studied, the main means of diffusion was electronic and audio/video tools. Knowledge is also very often continually transferred and absorbed informally through personal interaction.

Due to the complexity of knowledge management systems, they are best defined by a description of their characteristics, as discussed previously.

ENTERPRISE-WIDE KNOWLEDGE MANAGEMENT SYSTEMS

This section begins by describing a range of systems in use by businesses followed by a discussion of the contingent situation requirement factors of knowledge management systems. This section then continues with discussing the impact of these factors and others on KMS developments as well as their implementation and use in such areas as: knowledge generation and selecting or developing strategic structure, content, and design of the system

Company Examples

The Ford Motor Company case provides an example of how at a large firm the company-wide strategic knowledge systems are closely linked to and dependent on computer information systems (Austin, 1997, 1999). As part of an integration program in the early 1990s, computer information systems at Ford were standardized across the company, which enabled installation of an external Internet network – extranet – with appropriate Web sites linking Ford with its suppliers and with its customers. Most of these were used initially for communication of information on available models, prices and availability of supplies, and other information (that is, targeted organized data). It also enabled development of an internal company intranet system, which also focused mainly on information conveyance initially.

The system also, however, served as a basis upon which to develop broader, more strategic knowledge systems. For example, in the design area, as auto design and development facilities were more closely coordinated worldwide, knowledge about solving design problems and inconsistencies could now be resolved using the intranet, a knowledge exchange process based on experiential expertise. Knowledge about lessons learned from experience in other business process areas, such as manufacturing, could also now be exchanged, since a worldwide system with Web sites was in place.

Complex strategic knowledge management systems can also focus on critical business activity areas. For example, strategic alliances are extremely important to multinational companies today (Mockler, 1999; Sparks, 1999). They involve, however, complex human and business processes whose management requires in-depth expertise gained from experience. Capturing this developing knowledge base is a knowledge management activity. As a company undertakes alliances and begins learning from successes and failures, leaders in alliance management within a company emerge. These leaders, who are essentially gurus with experience and knowledge gained from experience, are the firm's initial imbedded alliance expertise capability. This initial experiential expert knowledge base in successful firms is extended in several ways. First, formal processes and procedures and a staff capable of managing alliance processes are developed. This is the initial knowledge depository for future use. The steps taken to collect, store, and disseminate this knowledge and to train people in order to further institutionalize alliance capabilities vary at different firms (Harbison & Pekar, 1997a, b, c).

Hewlett-Packard (H-P), for example, found that general seminars for managers on alliances were not enough. Managers needed H-P specific information on the best practices guidelines developed from H-P alliance experiences. A database of case histories, tools kits, checklists, and best practices was, therefore, developed and incorporated into training seminars. This database material was supplemented with studies of the best practices of other companies (Harbison & Pekar, 1997a, b, c).

In general, such a knowledge database would include a specific company's experiences with each of its alliance partners in each of the applicable best practices guidelines areas, areas that are outlined in alliance guidebooks (Mockler, 1999). These areas include strategic planning, negotiation, alliance structures and contracts, operational planning and management, and control. Companies such as Ford, IBM, and Dun & Bradstreet, are in various stages of creating such company-specific database repositories; most often these are mixed systems – using computers and other approaches, as for example at H-P. The alliance knowledge bases are Web sites that are accessible from laptop computers by consultants or service personnel at clients' offices (Harbison & Pekar, 1997a, b, c).

As part of their strategic knowledge management systems, dissemination of this knowledge is usually supplemented through seminars and workshops. BellSouth, for example, has offered a two-day alliance workshop for 150 senior managers, a major means of developing personal information networks to encourage ongoing knowledge dissemination. H-P has conducted 50 two-day seminars on alliances for its top 1000 executives prior to 1999 (Harbison & Pekar, 1997a, b, c).

Contingent Solution

As seen from the company experiences described, KM is a contingent process. While it is stimulating and useful to study the different approaches of other so-called models, the final solution will be the one that meets specific situation requirements factors, such as:

- The company's size and nature of its business.
- The company's competitive position.
- The type of business activity(ies) supported.
- The knowledge used for strategic aspects of the business activities targeted.

- The type of knowledge.
- The people involved.
- The state of the organization's culture.
- Available company resources.
- The technologies available and needed.

Knowledge Generation

Knowledge comes from inside and outside the organization. The main criteria are whether and how it is useful in making business activities and processes more effective and efficient (Moore, 1999). Its source – whether created from scratch or borrowed – is a secondary consideration. For example, some companies have an award for the best stolen idea! Five methods of generating knowledge can be identified: acquisition; dedicated resources; fusion; adaptation; and knowledge networking.

Knowledge can be acquired in many ways – for example, through strategic alliances, acquisitions of patents or other companies, engaging consultants, outsourcing research and development, and hiring experts. While each of these sources is useful, additional steps are needed to assimilate acquired knowledge into existing organizations.

Dedicated resources were established at H-P to preserve and transmit company knowledge about strategic alliances. H-P also set up a permanent knowledge system designed to preserve and transmit knowledge to targeted users in a systematic continuing way. This is referred to as institutionalizing or imbedding knowledge within a company.

Fusion involves bringing together people of different perspectives to create new synergies. Sometimes referred to as creative chaos, such interactive collaboration is often needed to create new knowledge. There are several guidelines that help make such brainstorming cross-fertilization work: identify key knowledge workers who might be brought together; provide the time and incentives to fuse knowledge; create specific projects and project goals that inculcate attitudes encouraging such working together; reinforce a sharing culture through incentives and leadership.

Adaptation often arises from competitive market pressures, such as when new technologies are invented, competitors introduce new products, and social changes occur. These pressures can drive knowledge generation. Knowledge is also generated by informal self-organizing networks or "webs" within organizations that may over time become more formalized. There exist communities of knowers within organizations, united by common interests or a common professional vocabulary, who talk with each other in person, by phone or through e-mail or groupware – to share knowledge and solve problems, in essence by word-of-mouth. This kind of knowledge is hard to capture systematically, though at times, such as at Xerox, it can be done. Such informal webs can be nurtured through creating common meeting places, allowing time for people to interact, and generally developing a corporate sharing climate.

Developing Strategic Structure, Content, and Design for the System

These initial decisions are dictated by strategic needs. For example, first the needs of strategic operations are identified – as in the consulting operation described earlier or in the strategic alliance area at H-P. Second, the sources of this knowledge – the people and data/information reservoirs – are identified; for example, the consulting firm's partners' experiences in former assignments, the alliance managers' experiences at H-P, and the repair workers' expertise at Xerox. Third, the form it is in and its suitability to available manual and electronic tools. Five different media were used, for example, at the consulting company: video and audio tools, databases, expert systems, e-mail, and personal interviewing. These were supplemented by personal interaction webs. H-P's system included a variety of electronic and manual approaches in their system, which combined training and computer techniques in a much different way. Fourth, not all knowledge is easily systematically stored, transmitted, and absorbed; for example, knowledge involving planning in rapidly changing markets often requires tacit intuitive knowledge that is not readily articulated and codified. For this segment of a KMS, personal networking or expert systems may be more useful. In contrast, repair procedures learned from experience can be codified, as at Xerox.

Davenport (1997) has described the structure of a KMS at Monsanto. Monsanto's knowledge management architecture system aimed to allow the firm's 30,000 employees to share knowledge and information. In making global knowledge locally available, Monsanto was mimicking GE's strategic posture: combining the knowledge benefits of a large firm (quantity and diversity) with the benefits of a small one (accessibility to knowledge).

As for the system's structure, in classifying existing knowledge and information a distinction was made between quantitative structured content and relatively unstructured qualitative content. Different tools were used to store and manipulate each kind: relational databases with desktop access through appropriate query software for structured material; Web pages and Lotus Notes for unstructured material. This avoided distortions arising from forcing unstructured material into an artificially rigid structure.

The system also provided definitions of key terms, such as "customer," "product" and "material," a necessary step in organizing intellectual material into a single system. Such common definitions were also necessary common ground for communicating and sharing knowledge across boundaries, but they had to be limited to only the most necessary terms, since some local truths and nuances can be lost during the standardization process. Gatekeepers were charged with continually refining this aspect of the system, as well as with organizing and identifying the most important aspects. A large body of material randomly assembled could be counterproductive; editing was needed, as were clearly defined paths to needed knowledge. All of the major systems examined have such gatekeepers and facilitators.

FUTURE OUTLOOK AND CONCLUSION

As discussed in this article, the current and future success of KMS is and will be highly dependent on the strategic fit of structure and content with strategic requirements or critical success factors in the situation. The success of knowledge management also depends and will continue to depend on the participation of people sharing their knowledge expertise with others, which in turn can depend on the way the system is designed, implemented, and managed (the operational fit), as well as on the degree to which a firm has a "learning" organization culture (Lucier & Torsilieri, 1997). Nurturing this sharing culture in the future will require very active leadership by a knowledge management champion, since very often people are reluctant to share their expertise (Manchester, 1999b).

REFERENCES

Austin, R.D. (1999). *Ford Motor Company: Supply chain strategy*. Boston: Harvard Business School.

Austin, R.D., & Coteleer, M. (1997). *Ford Motor Company: Maximizing the business value of Web technologies*. Boston: Harvard Business School.

Engoron, F. (1998). *Organization effectiveness and development*. PricewaterhouseCoopers, New York: New York University (Center for Research on Information Systems).

Glasser, P. (1998, December 15-January 1). The knowledge factor. *CIO,* 108-118.

Harbison, J.R., & Pekar, P. (1997a). *A practical guide to alliances: Leapfrogging the learning curve*. New York: Booz-Allen & Hamilton.

Harbison, J.R., & Pekar, P. (1997b). *Cross-border alliance in the age of collaboration*. New York: Booz-Allen & Hamilton.

Harbison, J.R., & Pekar, P. (1997c). *Institutionalizing alliance skills: Secrets of repeatable success.* New York: Booz-Allen & Hamilton.

Hickens, M. (1999, September). *Management Review,* 40-45.

Lucier, C.E., & Torsilieri, J.D. (1997). Why knowledge programs fail: A CEO's guide to managing learning. *Strategy & Business, 9,* 64-79.

Manchester, P. (1999a, November 10). A marriage of culture and technology. *Financial Times,* 1.

Manchester, P. (1999b, November 10). Fundamental dilemma over ownership of knowledge. *Financial Times*, 5.

Mockler, R.J. (1992). *Developing knowledge-based systems using an expert system: A guidebook for general business managers and computer information technicians*. Upper Saddle River, NJ: Prentice-Hall/Macmillan.

Mockler, R.J. (1999). *Multinational strategic alliances.* New York: John Wiley & Sons.

Mockler, R.J., & Dologite, D.G. (1992). *Expert systems: An introduction to knowledge-based systems*. Upper Saddle River, NJ: Prentice-Hall/Macmillan.

Sparks, D. (1999, October 25). Special report: Partners. *Business Week,* 106-134.

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Chapter 3.18
Mentoring Knowledge Workers

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INTRODUCTION

In an economic environment where organizations have been forced to take a step back and reevaluate their core competencies and ability to innovate, organizational knowledge has come to the forefront as a valuable strategic asset (Haghirian, 2003). While the concept of knowledge management (KM) is not new, the focus on knowledge management as a strategy has increased in recent times as organizations realize the importance of knowledge as an intangible asset contributing to the enhancement of competitive advantage (Bolloju, 2000). In the 21st century, it is believed that successful companies are those that effectively acquire, create, retain, deploy, and leverage knowledge (Cecez-Kecmanovic, 2000). Knowledge work is the ability to create an understanding of nature, organizations, and processes, and to apply this understanding as a means of generating wealth in the organization (Boland & Tenkasi, 1995). Evidently, the focus on knowledge management as a strategy has become central to organizations (Davenport & Prusak, 1998). Ichijo, Von Krogh, and Nonaka (1998) view knowledge as a resource that is unique and imperfectly imitable, allowing firms to sustain a competitive advantage. Additionally, knowledge management as a formalized organizational strategy is supported; it should not be left unintentional to become unsystematic and random (Ichijo et al.). This article provides an example of knowledge workers and experts collaborating to implement successful training and learning programmes to support knowledge-management activities in their organization. The authors hope that the case discussed will inform researchers of an appropriate model in designing an interactive learning environment that enables a positive knowledge-sharing environment and in turn contributes to the growth of an organization's memory.

BACKGROUND

The intensity of competition in the business market, advances in technology (Crossman, 1997), and a strong shift toward a knowledge-based economy have each contributed to the demand for Web-based mentoring systems (WBMSs). According to Emerson (1843), "There is no knowledge that is not power," and the organization (public or private) that can utilize its knowledge resources more effectively than its competitor will persevere (Laudon & Laudon, 1998). An effective mentoring system between knowledge workers and experts can provide an organization with a strategic advantage in the market (Benjamin & Blunt, 1993). Mentoring environments can help create and maintain skills and, therefore, the corporate knowledge base (Garvin, 1993). They both alleviate the strain on corporate resources and facilitate employees' changing training needs (Driscoll, 1998) through knowledge sharing. Therefore, the majority of organizations face the enormous challenge of supporting their employees' thirst for expanding their skill bases and corporate assets effectively as "[k]nowledge implies a knower; the rest is just information." In the case under consideration in this article, the organization implemented a successful mentoring system in order to develop employee skills and knowledge in both IT and managerial issues such as knowledge management. This article is focused on the development of a Web-based mentoring system to mentor workers and enhance learning (Neville, Adam, & McCormack, 2002). The case study indicates a strong requirement for the utilization of such an environment to both increase support for and collaboration between the knowledge workers.

MAIN FOCUS OF THE ARTICLE

Mentoring is a traditional method of teaching that strengthens the concept and objectives of learning and training (Benton, Elder, & Thornbury, 1995). The Oxford dictionary defines the word mentor as a "wise counselor, who tutors the learner in intellectual subjects..." When this model is applied to a learning network, the student is called a teleapprentice who studies using appropriate methods (Levin, 1990). The teleapprentice reads messages, answers questions, participates in discussions, and conducts research online to master his or her subject. Mentorship is a method of teaching that has been used for hundreds of years; this design is incorporated into learning and knowledge networks to develop more effective learning and collaborating practices (Eisenstadt & Vincent, 1998), and to provide additional support and mediation to the learners and workers (Alexander, 1995). Access to experts is one of the many advantages provided through learning networks (Harasim, 1995). Networks are, in fact, modeled on this method (Harasim, Hiltz, Teles, & Turoff, 1995). Therefore, WBMSs allow students and workers to communicate with experts in a field and collaborate with their peers (Crossman, 1997; Dick & Reiser, 1989). WBMSs can be described as learning delivery environments in which the World Wide Web (WWW) is its medium of delivery (Crossman, 1992; Driscoll, 1998; Neville et al., 2002). The possibilities of WBMSs are limited only by constraints imposed by the university or organization in question, such as technological or managerial support (Neville, 2000). Innovative companies and universities are using this implementation for a number of reasons, specifically to keep employees or students abreast of emerging technologies in their fields and to provide effective training to both staff and customers on new products and skills (Khan, 1997). Designing a WBMS requires a thorough investigation into the use of the Web as a medium for delivery (Driscoll; McCormack & Jones, 1997; Ritchie & Hoffman, 1996). The designer must be aware of the attributes of the WWW and the principles of instructional design to create a meaningful support environment (Driscoll; Gagne, Briggs,

& Wagner, 1988). The Web-based training room is viewed as an innovative approach to teaching (Relan & Gillani, 1997). The virtual training room, like the traditional method, requires careful planning to be both effective and beneficial (Dick & Reiser). As stated by McCormack and Jones, a Web-based classroom must do more than just distribute information. It should include resources such as discussion forums to support collaboration between learners and ultimately it should also support the needs of both the novice and advanced learner (Sherry, 1996; Willis, 1995). A WBMS is composed of a number of components that are integral to the effective operation of the environment (Banathy, 1992), for example, for the development of content and the use of multimedia, Internet tools, hardware, and software (Reeves, 1993). A developer must understand the capabilities of these components (search engines, feedback pages, and movie clips) as their use will determine the success or the failure of the learning environment (Driscoll). In this article, we provide an example of a WBMS to help illustrate the main elements, issues, components, and problems encountered through the implementation of learning systems to enhance knowledge management in organizations.

The WBMS (Figure 1) was constructed to support and develop knowledge sharing for personnel who seek to acquire and develop their knowledge-management skills. Training material is available online, but in addition, a discussion forum enables both learners and experts to exchange ideas and add to the environment. This allows learners to provide feedback (anonymously, if desired) to the experts. It also enables them to pose queries, which other participants or the experts can answer. All participants are able to see the initial queries and the discussion stream of answers from other participants and the instructors. This further extends the reach of the training material as employees can log on to the WBMS at home or at work and pose questions for which answers are available when they next log on. The facility also allows the learners to voice their satisfaction regarding the different elements of the environment. This provides the participants with the opportunity to take part in the ongoing design of the WBMS, and therefore increases user acceptance.

Figure 1. The Web-based mentoring system

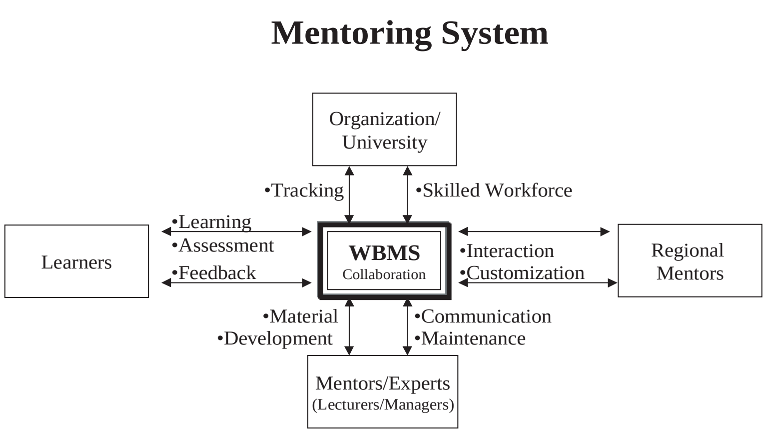

Figure 1 illustrates the opportunities available to the participants of the case. The system provides professional training to a range of employees including full-time staff at all levels and senior management. Its core aim is to further develop the knowledge and abilities of personnel so that they are increasingly aware of IT and management issues within the organization with a particular focus on capturing, storing, disseminating, and creating knowledge. The course is designed on a distance learning basis and is supported by a tutorial system. The main purpose of the tutorials is to facilitate the learning process, assist in the completion of interactive assignments, and encourage team playing within the group. Learners are presented with written modules, which act as the lecture, and the expert plays the role of the facilitator, enabling the students to combine the written materials with their own experiences. Feedback from the students identified the need to provide additional learning support through an online environment. The WBMS has provided an improved learning process and has enabled enhanced collaboration among employees. This article focuses on the development of these requirements through an interactive learning environment for employees, and on the fact that the WBMS is designed or customized for the requirements of the individual learner. This approach accounts for the varying learning abilities of students and overcomes the limitations of traditional training environments that are restricted to rules in order to adequately facilitate the group. The educator or expert instructs a class, but the level of collaboration and the development of problem-solving skills can be directly correlated to class sizes. The greater the size of the group, the less attention individual learners gain or the more intimidated a student is to participate in discussions, thus reducing collaboration. The WBMS, when adequately designed, can reduce the limitations of the classroom and allow the learner to work at his or her own pace with structured support from both the educators and the other learners.

DESIGN CONSIDERATIONS

Web-based learning is regarded as a silver-bullet solution to training issues faced by organizations, therefore it is essential to define the characteristics of interactive education that can be achieved through the WWW and to expand the Web-based mentoring concept to promote learning. The identification of these characteristics is necessary to implement such a concept. Thus, this section reviews 10 dimensions proposed by Reeves and Reeves (1993) for interactive training and collaboration: (a) the educational philosophy, (b) the learning theory, (c) the goal orientation, (d) the task orientation, (e) the source of motivation, (f) the role of the teacher, (g) metacognitive support, (h) collaborative learning, (i) cultural sensitivity, and (j) structural flexibility. The dimensions are proposed to describe the characteristics of a WBMS. Each of the dimensions identified is outlined in the following paragraphs:

1. Educational philosophy emphasizes the belief that learners build their cognitive strategies on previous knowledge and on the learning environment. Therefore, a rich and stimulating environment is required to train different adult learners. Thus, direct instruction is also replaced with challenging tasks.
2. The design of the environment should be based on researched learning theories. The two dominant theories identified in the design of training environments are behavioral and cognitive psychology. Behaviorists believe that the most important factors that should be taken into consideration are the arrangement of stimuli, responses, feedback, and reinforcement to shape the desirable behavior of the learners. By contrast, cognitive psychologists place more emphasis on internal mental states rather than on behavior. As a result, the WBMS design,

using cognitive theory, will be based on direct instruction and practice exercises.

3. The goals for a WBMS can vary from being sharply focused, where a specific environment is required, to a having a more general approach.
4. The orientation of tasks can range from being academic to authentic. As an example, an authentic design for adult education would require the learners to tackle job-related exercises or cases (tacit knowledge). The design orientation of a WBMS should support the transfer of skills to the learners.
5. Motivation is the main factor for the success of any learning environment. The source of motivation ranges from two extremes: from the extrinsic (outside the learning environment) to the intrinsic (a part of the learning environment).
6. Lecturers and tutors fulfill different roles, from the traditional role of instructor (didactic) to the facilitative role.
7. Flavell (1979) described metacognition as the learner's ability to identify objectives, and plan and understand learning strategies. Thus, a WBMS can be designed to challenge the learner to solve course-related problems (Driscoll, 1998).
8. The collaborative learning dimension for a WBMS can also range from a lack of support to the inclusion of facilities to support it.
9. Reeves and Reeves (1993) argue that all training environments have cultural implications. However, the development of a WBMS cannot be designed to adjust to every rule. Therefore, a WBMS should be designed to be as culturally aware as possible.
10. Structural flexibility describes a WBMS as either asynchronous or synchronous (Driscoll, 1998). Open or asynchronous environments refer to the use of such an environment at any particular time or from any location. However, synchronous environments refer to fixed environments that can only be used in the training room of an organization. The WWW provides educators and students alike with the opportunity to avail of resources from more open environments through which students are supported or mentored in the acquisition of both tacit and explicit knowledge.

The dimensions were used as an aid in the production of the generic WBMS (see Figure 1). Both the study of the different dimensions and the factors necessary for the collaboration and structure of learning provide valuable information and steps for the analysis, and therefore the development, of the solutions.

FUTURE TRENDS

Knowledge workers have praised the hands-on approach provided through this expert-driven system. As knowledge sharing has increasingly become a key organizational objective, this type of environment provides an extensive communication channel leveraging technology to support a wide variety of knowledge-sharing activities. It also enables the experts and learners to collaborate, therefore providing 24-hour online support. This case is a prime example of a successful KM-support tool that can and will continue to avail of technological advances to ensure ongoing success. Further research exploring the various pedagogy and technology mixes to produce a set of options, which would identify the integration of a particular pedagogy with an appropriate technology, would prove beneficial if WBMSs are to meet their full potential. Additionally, the WBMS illustrated in this article is primarily concerned with the downstream development process that incorporates key design and development considerations. Therefore, further research exploring the upstream development process would be worthwhile. This would involve exploring some of the development options that were identified in the development of off-the-shelf packages, and exploring the open-source development option for WBMSs. These further studies may yield interesting results and therefore increase the level of understanding of the development of effective WBMSs.

CONCLUSION

After an in-depth analysis, it was apparent that learners lacked an efficient online support system that would complement alternative communication channels such as face-to-face encounters and traditional training classes as a means of knowledge sharing. An effective KM training-support system can provide an organization with a strategic advantage in the market. Learning environments can help create and maintain skills and therefore increase the corporate knowledge base. They both alleviate the strain on corporate resources and facilitate employees' changing training needs. This article focuses on the design of a suitable environment to support knowledge workers and encourage collaboration. The research outlines the factors necessary for the successful implementation and use of the system. It also highlights the potential of the system to overcome the physical barriers of traditional knowledge-sharing and learning channels. Interactive learning environments can, when properly mediated and structured, facilitate cooperation and enhanced learning practices, reduce conflict, and avail of all of the benefits that technology can provide.

REFERENCES

Alexander, S. (1995). *Teaching and learning on the World Wide Web*. Retrieved from http://www.scu.edu.au/ausweb95/chapters/education2/alexnder/

Banathy, B. H. (1992). *A systems view of education: A journey to create the future*. Englewood Cliffs, NJ: Educational Technology Publications.

Benjamin, R. I., & Blunt, J. (1992). Critical IT issues: The next ten years. *Sloan Management Review, Summer,* 7-19.

Benton, V., Elder, M., & Thornbury, H. (1995). *Early experiences of mentoring: Design and use of multimedia material for teaching OR/MS* (Working Paper No. 95/5). Department of Management Science, University of Strathcycle.

Bolland, R., & Tenkasi, R. (1995). Perspective making and perspective taking in communities of knowing. *Organizational Science, 2,* 40-57.

Bolloju, N., & Khalifa, M. (2000). A framework for integrating decision support and knowledge management in enterprise-wide decision making environments. *Proceedings of IFIP TC8/WG8.3 International Conference on Decision Support through Knowledge Management*, Stockholm, Sweden.

Cecez-Kecmanovic, D. (1999). Understanding knowledge sharing in organizational decision making supported by CMC. *Proceedings of IFIP TC8/WG8.3 International Conference on Decision Support through Knowledge Management,* Stockholm, Sweden.

Crossman, D.M. (1997). The evolution of the World Wide Web as an emerging instructional technology tool. In B.H. Khan (Ed.), *Web-based instruction* (pp. 19-23). Englewood Cliffs, NJ: Educational Technology Publications.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dick, W., & Reiser, R. (1989). *Planning effective instruction*. Englewood Cliffs, NJ: Prentice-Hall.

Driscoll, M. (1998). *Web-based training: Using technology to design adult learning experiences*. San Francisco, CA: Jossey-Bass/Pfeiffer.

Eisenstadt, M., & Vincent, T. (1998). *The knowledge Web: Learning and collaborating on the Net*. London: Kogan Page Ltd.

Emerson, R.W. (1843). *Quotes by Ralph Waldo Emerson*. *Quotations Book*. Retrieved 2004 from http://www.quotationsbook.com/quotes/31653/view

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of psychological inquiry. *American Psychologist, 34,* 906-911.

Gagne, R. M., Briggs, L. J., & Wagner, W. W. (1988). *Principles of instructional design* (3rd Ed.). New York: Holt Reinbank Winston.

Garvin, D. A. (1993). Building a learning organization. *Harvard Business Review.*

Haghirian, P. (2003). Does culture really matter? Cultural influences on the knowledge transfer process within multinational corporations. *European Journal of Information Systems.*

Harasim, L., Hiltz, S. R., Teles, L., & Turoff, M. (1995). *Learning networks: A field guide to teaching and learning online*. Cambridge, MA: The MIT Press.

Ichijo, K., Von Krogh, G., & Nonaka, I. (1998). *Knowledge enablers. Knowing firms: Understanding, managing and measuring knowledge*. London: Sage Publications.

Khan, B. (1997). *Web-based instruction*. Englewood Cliffs, NJ: Educational Technology Publications.

Laudon, K. C., & Laudon, J. P. (1998). *Management information systems: Organization and technology in the networked enterprise* (6th Ed.). Upper Saddle River, NJ: Prentice Hall International Editors.

Levin, J. (1990). *Teleapprenticeships on globally distributed electronic networks.* Paper presented at the Meeting of the American Educational Research Association.

McCormack, C., & Jones, D. (1997). *Building a Web-based education system*. New York: Wiley.

Neville, K. (2000). A Web-based training (WBT) system development framework: A case study. *Proceedings of Business Information Technology Management (BIT) 2000: 10th Annual Conference,* Manchester, UK.

Neville, K., Adam, F., & McCormack, C. (2002). Mentoring distance learners: An action research study. *Proceedings of the 10th European Conference on Information Systems,* Gdañsk, Poland.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review, 69,* 96-104.

Oxford English Dictionary. (1989). Oxford: Oxford University Press.

Reeves, T. C. (1993). Research support for interactive multimedia: Existing foundations and future directions. In C. Latchem, J. Williamson, & L. Henderson-Lancett (Eds.), *Interactive multimedia: Practice and promise* (pp. 79-96). London: Kogan Page.

Reeves, T.C., & Reeves, P.M. (1997). Effective dimensions of interactive learning on the World Wide Web. In B.H. Khan (Ed.), *Web-based instruction* (pp. 59-66). Englewood Cliffs, NJ: Educational Technology Publications, Inc.

Relan, A., & Gillani, B. (1997). Web-based information and the traditional classroom. In C. M. Reigeluth & R. J. Garfinkle (Eds.), *Systemic change in education*. Englewood Cliffs, NJ: Educational Technology Publications.

Ritchie, D. C., & Hoffman, B. (1996). Incorporating instructional design principles with the World Wide Web. In B.H. Khan (Ed.), *Web-based* *instruction* (pp. 135-138). Englewood Cliffs, NJ: Educational Technology Publications.

Sherry, L. (1996). Raising the prestige of online articles. Intercom, *The Society for Technical Communication Magazine, 43*(7), 24-25, 43.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. Oxford: Oxford University Press.

Willis, J. (1995). A recursive, reflective, instructional design model based on constructivist-interpretivist theory. *Educational Technology, 35*(6), 5-23.

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Chapter 3.19
RDF and OWL

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INTRODUCTION

As Web-based content becomes an increasingly important knowledge management resource, Web-based technologies are developing to help harness that resource in a more effective way.

The current state of these Web-based technology—the "first generation" or "syntactic" Web—gives rise to well-known, serious problems when trying to accomplish in a non-trivial way essential management tasks like indexing, searching, extracting, maintaining, and generating information. These tasks would, in fact, require some sort of "deep understanding" of the information dealt with: In a "syntactic" Web context, on the contrary, computers are only used as tools for posting and rendering information by brute force. Faced with this situation, Berners-Lee first proposed a sort of "Semantic Web" where the access to information is based mainly on the processing of the semantic properties of this information: "… the Semantic Web is an extension of the current Web in which information is given well-defined meaning [emphasis added], better enabling computers and people to work in co-operation" (Berners-Lee, Hendler, & Lassila, 2001, p. 35). The Semantic Web's challenge consists then in being able to manage information on the Web by "understanding" its proper semantic content (its meaning), and not simply by matching some keywords.

BACKGROUND

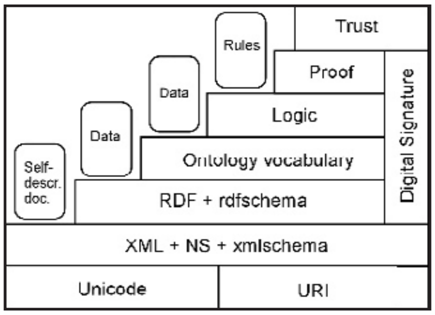
The architecture proposed by Berners-Lee for the Semantic Web is reproduced in Figure 1. "Unicode" and "URI" make up the basis of this hierarchy. The Unicode Standard provides a unique numerical code for every character that can be found in documents produced according to any possible language, no matter what the hardware and software used to deal with such documents. Uniform Resource Identifier (URI) represents a generalization of the well-known Uniform Resource Locator (URL) that is used to identify a "Web resource" (e.g., a particular page) by denoting its primary access mechanism (essentially, its "location" on the network). URI has been created to allow recording information about all those "notions" that, unlike Web pages, do not have network locations or URLs, but that need to be referred to in an RDF statement. These notions include network-accessible things, such as an electronic document or an image, things that are not network-accessible, such as human beings, corporations, and bound books in a library, or abstract concepts like the concept of a "creator."

XML (eXtensible markup language) (see Bray, Paoli, Sperberg-McQueen, Maler, & Yergeau, 2004) has been created to overcome some difficulties proper to hypertext markup language (HTML); this last suffers from a number of limitations, from its lack of efficiency in handling the complex client/server communication of today's applications to the impossibility of defining new tags to customize exactly the user's needs. XML is called "extensible" because, at the difference of HTML, it is not characterized by a fixed format, but it lets the user design its own customized markup languages (a specific DTD, document type description) for limitless different types of documents; XML is a "content-oriented" markup tool. Basically, the syntactic structure of XML is very simple. Its markup elements are normally identified by an opening and a closing tag, like <employees> and </employees>, and may contain other elements or text; the elements must be properly nested and every XML document must have exactly one root element. Markup elements can be specialized by adding attribute/value pairs inside the opening tag of the element, like <person name="Jane">; taking into account the nesting constraint, a very simple fragment of XML document could then be represented as: "<employees> <person name="Jane"> <id>99276</id> </person> </employees>". To allow a computer interpreting correctly a fragment like this, it is necessary, however, to specify the semantics of the markup elements and tags used to make it; a simple way of doing this is to make use of a DTD. A DTD is a formal description in XML Declaration Syntax of a particular type of document: for example, a DTD may specify that every person markup element must have a name attribute, and that it can have an offspring element called id whose content must be text. There are many sorts of DTDs ready to be used in all kinds of areas (e.g., www.w3.org/QA/2002/04/valid-dtd-list.html#full) that can be downloaded and used freely: some of them are MathML (for mathematical expressions), Sync Multimedia Integration Language (SMIL), Chemical Markup Language (CML), Open Software Description (OSD), Electronic Data Interchange (EDI) , Platform for Internet Content Selection (PICS), and so forth. A more complete way of specifying the semantics of a set of XML markup elements is to make use of XML Schema (as mentioned in Figure 1): XML Schema (Thompson, Beech, Maloney, & Mendelsohn, 2001; Biron & Malhotra, 2001) supplies a more complete grammar for specifying the structure of the elements allowing, for example, to define the cardinality of the offspring elements, default values, and so forth.

MAIN FOCUS OF THE ARTICLE: RDF AND OWL

Moving up in the structure of Figure 1, we find now Resource Description Framework (RDF), an example of "metadata" language (metadata = data about data) used to describe generic "things" ("resources," according to the RDF jargon) on the Web. An RDF document is basically a list of statements under the form of triples having the classical format: <object, property, value>, where the elements of the triples can be Universal Resource Identifiers (URIs), literals (mainly, free text), and variables. To follow a well-known RDF example (Manola & Miller, 2004), let us suppose we want to represent a situation where someone named John Smith has created a particular Web page. We will then make use of the RDF triple:

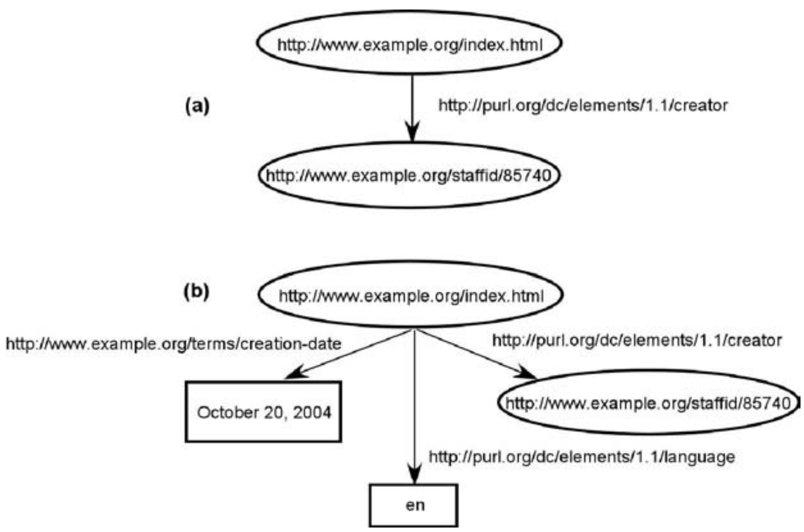
Figure 1. Semantic Web architecture according to Tim Berners-Lee



<http://www.example.org/index.html (object), creator (property), john_smith (value)>. Adding additional information about the situation, by stating, for example, that the Web page was created October 20, 2004, and that the language in which the page is written is English, amounts to add two additional statements: <http://www.example.org/index.html (object), creation_date (property), October 20, 2004 (value)> and <http://www.example.org/index.html (object), language (property), English (value)>. Note that RDF uses a particular terminology for denoting the three elements of the triples, calling then "subject," "predicate," and "object," respectively, the "object," "property," and "value" elements of the triples; this decision is really questionable because it introduces an undue confusion with well-defined and totally different linguistic categories.

RDF triples can be represented as directed labeled graphs, by denoting resources as ovals, properties (predicates) as arrows, and literal values like October 20, 2004 or English within boxes. Figure 2a represents under graph form the original statement: "John Smith has created a Web page"; the addition of information about date and language gives rise to the graph of Figure 2b, given that groups of statements are represented by corresponding groups of nodes and arcs. Note that, to simulate the actual conditions of utilization of RDF, the properties creator, creation_date and language in Figure 2 have been replaced, respectively, by http://pur1.org/dc/elements/1.1/creator, http://www.example.org/terms/creation-date,

Figure 2. RDF statements represented in graph format



and http://pur1.org/dc/elements/1.1/language; analogously, john_smith has been replaced by http://www.example.org/staffid/85740. All these "http://…" terms are URIs that identify in an unambiguous way specific RDF entities; more exactly, they refer to the ontologies/metadata repositories/lists of reserved domain names where these entities are defined. For example, "http://pur1.org/dc/…" refers to the collection of metadata terms maintained by the Dublin Core Metadata Initiative (Dekkers & Weibel, 2003); in this collection, http://pur1.org/dc/elements/1.1/creator is defined as: "An entity primarily responsible for making the content of the resource." The literal en (Unicode characters) is an international standard two-letter code for English, see http://purl.org/dc/elements/1.1/language; the example.org Internet domain name is reserved for documentation purposes.

From what expounded until now, RDF seems to be nothing more than a Internet-oriented, downgraded form of Semantic Networks as they were used in the artificial intelligence domain at the beginning of the 1970s. Its significance in a Semantic Web context becomes more evident when we examine the way of writing RDF statement into XML format – the so-called "RDF/XML syntax" (Beckett, 2004), that is, when RDF is seen as a sort of additional DTD of XML. Table 1 reproduces then the simple example of Figure 2b making use of the RDF/XML syntax.

The first line of the code, <?xml version="1.0"?> is the "XML declaration," which states that what follows consists of XML, and which specifies the version used. In the second line, we find an XML markup element that starts with the tag <rdf:RDF – this tag specifies that all the following XML code, until the </rdf:RDF> tag of the last line, is intended to represent RDF statements – and ends with the '>' symbol at the right limit of line 4. Within this markup element we find three "XML attributes" of the opening <rdf:RDF tag; all these attributes (xmlns attributes) have as values the declarations of the namespaces to be used within the RDF/XML code. An attribute like xmlns:rdf means that, according to the "value" associated with this attribute (after the '=' symbol), all the terms/tags included in this RDF/XML content and prefixed with rdf: are part of the namespace identified with the URI: http://www.w3.org/1999/02/22-rdf-syntax-ns#; analogously for the xmlns:dc (Dublin Core terms) and xmlns:exterms (example terms) attributes.

After these preliminary, "housekeeping" declarations, lines 5 to 9 represent the core of the RDF/XML representation of the example. The rdf:Description start-tag of line 5 indicates that we are now introducing the "description" of a resource; this resource, http://www.example.org/index.html, is identified as the value of the

Table 1. The RDF/XML syntax

```
<?xml version="1.0"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:dc="http://purl.org/dc/elements/1.1/"
    xmlns:exterms="http://www.example.org/terms/">
  <rdf:Description rdf:about="http://www.example.org/index.html">
    <exterms:creation-date>October 20, 2004</exterms:creation-date>
    <dc:language>en</dc:language>
    <dc:creator rdf:resource="http://www.example.org/staffid/85740"/>
  </rdf:Description>
</rdf:RDF>
```

rdf:about attribute of the start-tag. The three following lines, 6 to 8, are examples of use of "property element" constructions. In these lines, the tags are built up according to the XML Qname (Qname = Qualified name) convention, which allows shortening the writing of full RDF triples by introducing abbreviations for the URI references. A Qname tag contains, in fact, a "prefix" that denotes a given namespace (e.g., exterms in line 6) followed, after a "colon," by a "local name" (creation-date, i.e., the name of the property); a full URI reference is then created by appending the local name to the URI of the namespace identified by the first part of the Qname. For lines 6 to 8, the full URIs become then http://www.example.org/terms/creation-date, http://purl.org/dc/elements/1.1/Language, and http://purl.org/dc/elements/1.1/creator. Note that the values of the properties corresponding to literals (lines 6 to 7) are directly included within opening and closing Qname tags; for the property of line 8, which corresponds to a resource, the value corresponds to the value of the rdf:resource attribute of the dc:creator Qname tag. The description of the resource introduced in line 5 ends with the closing tag of line 9.

To conclude about RDF, we will note that RDF Schema (RDFS) (Brickley & Guha, 2004) provides a mechanism for constructing specialized RDF vocabularies through the description of domain-specific properties. This is obtained mainly by describing the properties in terms of the classes of resource to which they apply: for example, we could define the creator property saying that it has the resource document as "domain" (document is the value or "object" of this property) and the resource person as "range" (this property must always be associated with a resource person, its "subject"). Other basic modeling primitives of RDFS are used to set up hierarchies, both hierarchies of concepts (i.e., ontologies) thanks to the use of "class" and "subclass-of" statements, and hierarchies of properties thanks to the use of "property" and "subproperty-of" statements. Instances of a specific class (of a specific concept) can be declared making use of the "type" statement.

Passing to the next stage of the structure of Figure 1, "ontologies," we can make three general remarks:

- the basic "nature" of ontologies as described in the article "Knowledge Representation" in this encyclopedia does not change fundamentally in a Semantic Web context: They are still formed by hierarchies (DAGs) of concepts defined through properties and values;
- for their practical implementation, however, these Semantic Web ontologies make a large use of the RDF/XML syntactic/semantic constructs;
- taking also into account that the level that follows "Ontology vocabulary" in the pyramid of Figure 1 is "Logic," the Semantic Web ontologies evidence a very strong logic influence.

On February 10, 2004, the W3C published an official "recommendation" concerning OWL, the Web Ontology Language (Bechhofer et al., 2004); W3C—the World Wide Web Consortium, coordinated by MIT (USA), ERCIM, the European Research Consortium for Informatics and Mathematics, and the Keio University (Japan)—includes all the main bodies on earth interested in the developments of Internet and the Web. At the beginning of this document is stated that: "The Web Ontology Language (OWL) is a semantic markup language for publishing and sharing ontologies on the World Wide Web. OWL is developed as a vocabulary extension of the Resource Description Framework (RDF) and is derived from the DAML+OIL Web Ontology Language…An OWL ontology is an RDF graph, which is in turn a set of RDF triples." The mention of DAML+OIL (McGuinness, Fikes, Hendler, & Stein, 2002) explains the strong logic orientation of OWL, given that Ontology Inference Layer (OIL), the "European" component of DAML+OIL (DAML is the Darpa Agent Markup Language) was implemented in Description Logics (DL) terms—DL (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2002) have been created to offer, among other things, a formal foundation for frame-based systems.

OWL consists of three subsets (three specific sub-languages) characterized by an increasing level of complexity and expressiveness, OWL Lite, OWL DL (DL stands for Description Logics), and OWL Full.

OWL Lite is the syntactically simplest sub-language; it includes only a reduced subset of the OWL language constructors and has a lower formal complexity than the other OWL versions. It is meant mainly to allow: (1) the implementation of simple classification hierarchies; (2) the familiarization with the OWL approach; (3) the possibility of a quick migration path for existing thesauri/taxonomies and other conceptually simple hierarchies. It employs all the features already introduced by RDFS, making use of the same tags—like rdfs:subclassOf, rdfs:subPropertyOf, rdfs:domain, rdfs:range—with the same semantics. Note that rdfs:subclassOf is the fundamental constructor that is used to set up taxonomies/ontologies in OWL. It relates, in fact, a more specific class (concept) to a more general one; if X is a sub-class of Y, then every instance of X is also an instance of Y. The relation rdfs: subclassOf is transitive: If X is a sub-class of Y and Y is a sub-class of Z, then X is a sub-class of Z. With respect to RDFS, OWL Lite includes several new features:

- Constructors for equality and inequality, for example,owl:equivalentClass,owl: equivalent Property, owl:sameAs (two individuals may be stated to be the same), owl:differentFrom, owl:AllDifferent.
- Constructors used to provide specific information about properties and their values, like owl:inverseOf—for example, stating that the property hasChild is the inverse of the property hasParent, and stating that Mary is endowed with the property (hasParent Lucy), allows then an OWL reasoner to deduce that Lucy is endowed with the property (hasChild Mary)—owl:TransitiveProperty and owl: Symmetric Property.
- Constructors used to impose constraints on the way properties can be used by the instances of a class (concept). They are owl: allValuesFrom and owl:someValuesFrom. For example, owl:allValuesFrom introduces a range restriction, imposing, for example, that the property hasDaughter of the class Person is restricted to obtaining all its values (allValuesFrom) from the class Woman. This allows a reasoner to deduce that, if an individual Lucy is related by the property hasDaughter with the individual Mary, Mary must be an instance of the class Woman.
- Constructors, for example, owl:minCardinality and owl:maxCardinality, used to introduce a limited form of cardinality restrictions, stated on the properties of a particular class, and to be intended as constraints on the cardinality of that property when used in the instances of that class. Note that, for algorithmic efficiency reasons, OWL Lite allows using only the integers 0 and 1 to express the cardinality constraints; this restriction is removed in OWL DL.
- OWL Lite includes a (restricted form) of intersection constructor, owl:intersectionOf, allowing, for example, to state that the class EmployedPerson is the intersectionOf the classes Person and EmployedThings.

OWL DL is much more expressive than OWL Lite and is totally based on Description Logics—this is denoted by the suffix DL. OWL DL makes use of the full set of the OWL constructors, but it also introduces some constraints on their use to give rise to systems that are "complete" (all the possible deductions are computable) and "decidable" (all the computations will be executed in finite time). Mainly, OWL DL implements what is called "type separation," which means that a class (concept) also cannot be an individual or a property, and that a property also cannot be an individual or a class. This restriction is removed in OWL Full. OWL DL adds to the OWL Lite list of constructors some new constructors like owl:oneOf (classes may be described by enumeration of the individuals that make up the class), owl:hasValue (a property is required to have a given individual as value), owl:disjointWith (classes can be described as disjoint from each other, see the classes Man and Woman), owl:unionOf, owl:complementOf, owl:intersectionOf (Boolean combinations of classes), and so forth.

OWL Full is the most expressive of the OWL sub-languages, and should be used in situations where very high expressiveness is particularly important. It is similar to OWL DL but, in the OWL Full case, all the constraints have been suppressed—for example, a class (concept) can be simultaneously treated as a collection of instances (individuals) and as an individual in itself. This can lead to the implementation of systems that are, at least partly, "incomplete" and/or "undecidable": this means that it is not possible to perform automated reasoning on OWL Full hierarchies. Currently, no complete implementation of OWL Full exists.

To give at least a partial picture of the representation of an ontology in OWL format, we reproduce in Table 2 a small fragment of the OWL version of the "wine" ontology, an ontology often used for exemplification's purposes in the Semantic Web milieus (see McGuinness, Fikes, Hendler, & Sten, 2002; Smith, Welty, & McGuinness, 2004). The code in this table can be considered indifferently as OWL Lite, OWL DL, or OWL Full. Note that for simplicity's sake, we have not reproduced in Table 2 and the following the "housekeeping" declarations (see Table 1) that are necessary to identify all the XML namespaces associated with the wine ontology.

In the first line of Table 2, the class Wine is introduced making use of an rdf:ID attribute. At the difference of the rdf:about attribute used in Table 1, rdf:ID introduces as its value only a "fragment identifier" (here Wine) that represents an abbreviation of the complete reference to the URI of the resource being described. The full URI reference is formed by taking the base URI of the wine ontology, for example, http://www.w3.org/TR/2004/REC-owl-guide-20040210/wine, and appending the character # (to indicate that what follows is a fragment identifier) and then Wine to it, giving then the absolute URI reference:

Table 2. A fragment of the OWL wine ontology

```
<owl:Class rdf:ID="Wine">
 <rdfs:subClassOf rdf:resource="#PotableLiquid"/>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#madeFromGrape"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 ...
</owl:Class>
```

http://www.w3.org/TR/2004/REC-owl-guide-20040210/wine#Wine. Note that the Wine class can now be referred to by using #Wine; for example, rdf:resource="#Wine" is a well-formed OWL statement. As already stated, the fundamental taxonomic constructor is rdfs:subClassOf; the second line of the code of Table 2 allows the insertion of the class Wine into the global ontology by asserting that it is a specialisation of the class (concept) PotableLiquid (liquid suitable for drinking)—which can be defined, in turn, as a specialisation of the class ConsumableThing.

The third line of the code warns that the class Wine is also a specialisation of a second class: This last is an "anonymous" class, whose definition is included within the opening owl:Restriction markup element in line 4 and ends with the closing /owl:Restriction markup element in line 7. In OWL, in fact, a property restriction on a class is a special kind of class description, that of the anonymous class including all the individuals that satisfy the given restriction. In line 5, the owl:onProperty constructor introduces the name of the property, madeFromGrape, to associate with the class Wine; line 6 specifies that the cardinality of this property is 1. The insertion of this restriction in the definition of Wine states, globally, that every specific wine also must be characterized by at least one madeFromGrape relation. Note that (1) the &xsd;nonNegativeInteger datatype used to introduce the literal 1 in the owl:minCardinality restriction of line 6 is part of the built-in XML Schema datatypes (Biron and Malhotra, 2001): Their use is strongly recommended in an OWL context; (2) the value 1 conforms to the OWL Lite restrictions.

Following (Smith et al., 2004, pp. 11-13), we can now supply, in the upper part of Table 3, the definition of the Vintage class—vintage is a particular wine made in a specific year. The lower part of Table 3 shows how the property vintageOf ties a Vintage to a Wine; the rdfs:domain and rdfs:range features indicate, respectively, that the property vintageOf can only be associated with terms of the Vintage type (e.g., RomaneeConti1998), and that the values of this property can only be specific terms of the Wine hierarchy (e.g., RomaneeConti).

To conclude about OWL, we reproduce in Table 4 another fragment of the wine ontology that makes use of constructors proper to the DL version of the language. The code fragment of Table 4 defines the class RedWine as the precise intersection (logical conjunction, "and") of the

Table 3. Vintage class and vintage of property

```
<owl:Class rdf:ID="Vintage">
 <rdfs:subClassOf>
   <owl:Restriction>
     <owl:onProperty rdf:resource="#vintageOf"/>
     <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:minCardinality>
   </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="vintageOf">
 <rdfs:domain rdf:resource="#Vintage" />
 <rdfs:range rdf:resource="#Wine" />>
</owl:ObjectProperty>
```

Table 4. Use of OWL DL constructors in the context of the wine ontology

```
<owl:Class rdf:about="#RedWine">
 <owl:intersectionOf rdf:parseType="Collection">
  <owl:Class rdf:about="#Wine" />
  <owl:Restriction>
   <owl:onProperty rdf:resource="#hasColor" />
   <owl:hasValue rdf:resource="#Red" />
  </owl:Restriction>
 </owl:intersectionOf>
</owl:Class>
```

class Wine and the set of things that are red in color (anonymous class). The presence of the attribute rdf:parseType="Collection" is mandatory for this type of construction. Note the use of the DL constructor owl:hasValue to impose the value "Red" on the property hasColor of the anonymous class.

FUTURE TRENDS, AND THE IMPLICATIONS FOR KNOWLEDGE MANAGEMENT

Rules—self-contained knowledge units that entail some form of reasoning—are explicitly mentioned in the upper level of the architecture of Figure 1 and are, obviously, an essential prerequisite for a practical utilization of the RDF/OWL data structures. However, rules have not been included in the OWL standard, and they are still a hot topic of discussion in the Semantic Web and W3C milieus.

In RuleML (see Boley, Tabet, & Wagner, 2001), the inferential properties of Prolog/Datalog are associated with an XML/RDF-based rule format—for an introduction to Prolog/Datalog and to their logical support, Horn clauses, see, e.g., Bertino, Catania, and (Zarri, 2001, pp. 112-121, 170-207). The main categories of rules considered in RuleML are the "derivation rules" (i.e., rules used to automatically defining derived concepts), "integrity rules" (constraints on the state space), "reaction rules" (for specifying the reactive behavior of a given system in response to specific events), "production rules" (if-then rules according to the classical expert systems paradigm) and "transformation rules" (used to implement translators between different versions of RuleML, and between RuleML and other rule languages like Jess).

TRIPLE, see (Sintek & Decker, 2002), is a rule language that also follows the logic programming paradigm; its core is based on Horn logic clauses, and it has been syntactically extended to support RDF primitives like namespaces, resources, and RDF triples—these last have given TRIPLE its name. Rules expressed in this core language can be compiled into Horn logic programs and then executed by Prolog inference engines like XSB.

SWRL is a proposal (see Horrocks et al., 2004) based on a combination of OWL DL with the Datalog sub-language of RuleML. Concretely, the proposal extends the set of the OWL axioms to include Horn-like rules, enabling then these rules to be combined with an OWL knowledge base. The rules have the form of an implication between an antecedent (body) and a consequent (head); their meaning corresponds to say that, whenever the conditions specified in the antecedent hold, then the conditions specified in the consequent also hold. Both the antecedent and the consequent consist of zero or more atoms; atoms can be in the form of C(x), P(x, y), sameAs(x, y) or differentFrom(x, y), where C is an OWL description, P is an OWL property, and x, y are either variables, OWL individuals or OWL data values. An XML- and an RDF-based syntax for the rules also have been defined.

Another "hot topic" in a Semantic Web context concerns Semantic Web services. A "normal" Web service can be defined as a Web site that does not simply supply static information, but that also allows the automatic execution of some "actions" (services), like the sale of a product or the control of a physical device; an increasing number of Web services are accessible on the Web, developed by independent operators or large companies such as Amazon and Google. To carry out their tasks, Web services must provide interoperability among diverse applications, using platform and language independent interfaces for a smooth integration of heterogeneous systems. This has led to a standardization of the Web service descriptions, discovery, and invocation, making use of XML-based standards like WSDL (Christensen, Curbera, Meredith, & Weerawarana, 2001), a description protocol, and SOAP (Mitra, 2003), a messaging protocol. However, these standards, in their present form, are characterized by a low level of semantic expressiveness: For example, WSDL can be used to describe the interface of the different services, and how these services are deployed via SOAP, but it is very limited in its ability to express what the overall competences of this service are. Semantic Web services are then Web services that can specify not only their interfaces, but also describe in full their capabilities and the prerequisites and consequences of their use.

OWL-S (Semantic Markup for Web Services) (Ankolekar et al., 2002)—formerly DAML-S—is a specification, in the form of an OWL-based ontology, that describes different Semantic Web services features. It should enable Web users and software agents to automatically discover, invoke, select, compose, and monitor Web-based services. The ontology is structured into three main parts: (1) The "profile" component supplies a general description of a particular Web service by specifying the input and output types, the preconditions, and (3) the effects. (2) The "process model" component describes how the Web service works and the Web service interaction protocol; each service is either an atomic process that can be executed directly or a combination of several processes. An example of atomic process can be a service that returns a postal code, or the longitude and latitude when supplied with an address. A complex service often requires some form of interaction with the user, who can make choices and provide information conditionally: an example can be that of a personal shopping agent, that can assist the user in finding and buying many different sorts of items, requiring, in case, credit card and mailing information. (3) The "grounding" component specifies how the atomic processes defined in the process model can be mapped into WSDL descriptions, able to directly call up the described (atomic) service.

The ODE SWS framework, (see Gómez-Pérez, González-Cabrero, & Lama, 2004) proposes both an ontology to describe Semantic Web services and an environment to support their graphical development. A characteristic of this framework is the use of Problem-Solving Methods to describe these services at the "knowledge level" (see the "Knowledge Representation" article in this encyclopedia), that is, independently of the language in which they will be actually expressed. The ODE SWS ontology reproduces the upper level concepts of OWL-S, with the exception of the concepts associated with the "process model" component that are substituted by method descriptions. The ODE SWS environment is composed of three main layers: (1) The "data source" layer is devoted to the integration of external applications; (2) the "domain" layer includes the main modules of the environment, as the SWSOntologiesManager, the

SWSInstanceCreator—this module creates, from the graphical description of a particular service, the corresponding instance of a concept pertaining to the OWL-S ontology—and the SWSTranslator, which translates the general model of the service into a Semantic Web language description; (3) the "presentation" layer consists of a SWSDesigner module, that is, a user-friendly graphical interface that the user employs to describe a service – according to the authors, this graphically oriented process is more simple and less error prone than manipulating directly instance of the internal OWL-S ontology.

Implications for knowledge management of what expounded in this section and in the previous ones could be very important. There is general agreement that, from a very concrete point of view, the notion of knowledge management amounts, practically, to the set up and management of large corporate memories. These last can be defined (van Heijst, 1966) as the indexing and persistent storing of strategic knowledge about a given organization to facilitate its access, sharing, and reuse by the members of the organization in their individual and collective work. Taking into account the fact that ontologies provide a shared and common understanding of a domain, which can be communicated across people and application systems, corporate memories can, in turn, be materialized as a "Corporate Semantic Web," this last consisting both of ontologies and of Web-stored documents annotated with ontological tools. In this context, all the Semantic Web conceptual tools mentioned in this article, from XML to Semantic Web services, can then contribute—at least in principle, see the next section—to make knowledge management a tangible reality.

CONCLUSION

In spite of the heavy W3C support, the Semantic Web vision outlined in this article has not fully reached the status of "inescapable" standard.

First of all, the intrinsic "binary" nature—based on an "attribute value" approach—of tools like RDF and OWL makes it extremely difficult to use them for dealing with complex "narrative" documents particularly important from a knowledge management point of view, like memos, policy statements, reports, minutes, news stories, normative and legal texts, medical records, many intelligence messages, and so forth. This point is developed in depth in the "Representation Languages for Narrative Documents" article in this encyclopedia.

Moreover, Berners-Lee's architecture has been criticized from the beginning, in particular because it ignores some fundamental components of computer science today, from database technology (the whole world economy runs on SQL) to Unified Modeling Language (UML): UML is the standard modeling language in software engineering and, at the difference of RDF, OWL, and so forth, has received wide attention not only in academia but also in the professional milieus. Note, however, that some researchers are actually investigating the possibility of defining a mapping between UML and OWL-like languages. UML has, in fact, a type hierarchy comparable with OWL and a class diagrams facility that can be compared to a frame-based language (see, in this context, the comparison between UML and DAML in Baclawski et al., 2001). A general discussion about the proposals for defining transformations between UML and the Semantic Web ontology languages can be found in Falkovych, Sabou, and Stuckenschmidt, (2003).

In the context of the Semantic Web architecture, the choice of OWL as paradigmatic language to be used for ontological work also has raised some criticisms, and several knowledge representation specialists have challenged as hastily the endorsement of OWL by the W3C—for the relationships between Semantic Web, artificial intelligence and knowledge representation (see Schwartz, 2003). Apart from the "binary flaw" already mentioned before, criticisms range from the use of a particularly cumbersome syntax, inherited from RDF/XML, to the availability of an expressive power that, from a strict knowledge representation point of view, does not seem to improve so much with respect to "traditional" frame systems like Protégé-2000 (see the article "Knowledge Representation" in this encyclopedia). We can, however, remark, in this context, that an "OWL plugin" for Protégé has been recently implemented (see Horridge, 2004 and http://protege.stanford.edu/plugins/owl/); it allows loading and saving OWL and RDF ontologies, editing and visualizing OWL classes and their properties and, mainly, supporting reasoners such as the description logics classifiers.

Note that, according to OWL's supporters, it is precisely this last characteristic that "makes all the difference" between a simple frame system that utilize pragmatically based inference procedures, and an OWL-based reasoning tool—see, for example, RACER (Haarslev & Möller, 2003)—that employs sound and complete inferencing algorithms supported by the description logics theory. Unfortunately, description logics have been, in turn, criticized in spite (or because) their (too) rigorous formal framework, associated, inter alia, with a reduced expressiveness of their main reasoning component, the automatic classification mechanism. To give only an example, nearly a printed page is needed in McGuinness et al. (2002) to demonstrate that, using the DAML+OIL definitions (DAML+OIL is the ancestor of OWL), we can infer that "Red" can be considered as a sort of "WineColor." A plea for the use, in a Semantic Web context, of knowledge representation languages more "meaningful" than those based on a description logics approach can be found in Zarri (2002).

In spite of all the criticisms, Semantic Web techniques have really represented a quantum leap in the "knowledge management" domain, in the widest meaning of these words, and are surely here to stay.

REFERENCES

Ankolekar, A., Burstein, M., Hobbs, J., Lassila, O., Martin, D., McDermott, D., McIlraith, S., Narayanan, S., Paolucci, M., Payne, T., & Sycara, K. (2002). DAML-S: Web service description for the Semantic Web. In *Proceedings of the 1st International Semantic Web Conference—ISWC 2002 (LNCS 2342)*. Heidelberg: Springer-Verlag.

Baader, F., Calvanese, D., McGuinness, D., Nardi, D., & Patel-Schneider, P.F. (Eds.) (2002). *The description logic handbook: Theory, implementation and applications*. Cambridge, MA: University Press.

Baclawski, K., Kokar, M.K., Kogut, P.A., Hart, L., Smith, J., Holmes, W.S., Letkowski, J., & Aronson, M.L. (2001). Extending UML to support ontology engineering for the Semantic Web. In *Proceedings of the 4th International Conference on the Unified Modeling Language—UML 2001 (LNCS vol. 2185)*. Heidelberg: Springer-Verlag.

Bechhofer, S., van Harmelen, F., Hendler, J., Horrocks, I., McGuinness, D.L., Patel-Schneider, P.F., & Stein, L.A. (Eds.) (2004). *OWL Web ontology language reference—W3C recommendation—W3C*. Retrieved February 10, 2004, from www.w3.org/TR/owl-ref/

Beckett, D. (Ed.) (2004). *RDF/XML syntax specification (Revised)—W3C recommendation*. Retrieved February 10, 2004, from www.w3.org/TR/rdf-syntax-grammar/

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic Web. *Scientific American, 284*(5), 34-43.

Bertino, E., Catania, B., & Zarri, G.P. (2001). *Intelligent database systems*. London: Addison-Wesley and ACM Press.

Biron, P.V., & Malhotra, A. (Eds.) (2001). *XML schema part 2: Datatypes—W3C recommenda-*

tion. Retrieved May 2, 2001, from www.w3.org/TR/xmlschema-2/

Boley, H., Tabet, S., & Wagner, G. (2001). Design rationale of RuleML: A markup language for Semantic Web rules. In *Proceedings of SWWS'01—The 1st Semantic Web Working Symposium*. Stanford: Stanford University.

Bray, T., Paoli, J., Sperberg-McQueen, C.M., Maler, E., & Yergeau, F. (Eds.) (2004). *Extensible markup language (XML) 1.0* (3rd ed.)—W3C recommendation. Retrieved February 4, 2004, from www.w3.org/TR/REC-xml/

Brickley, D., & Guha, R.V. (Eds.) (2004). *RDF vocabulary description language 1.0: RDF Schema—W3C recommendation*. Retrieved February 10, 2004, from www.w3.org/TR/rdf-schema/

Christensen, E., Curbera, F., Meredith, G., & Weerawarana, S. (2001). *Web services description language (WSDL) 1.1—W3C Note.* Retrieved March 15, 2001, from www.w3.org/TR/wsdl

Dekkers, M., & Weibel, S. (2003). State of the Dublin Core Initiative, April 2003. *D-Lib Magazine 9*(4). Retrieved from www.dlib.org/dlib/april03/weibel/04weibel.html

Falkovych, K., Sabou, & Stuckenschmidt, H. (2003). UML for the Semantic Web: Transformation-based approaches. In B. Omelayenko & M. Klein (Eds.), *Knowledge transformation for the Semantic Web.* Amsterdam: IOS Press.

Gómez-Pérez, A., González-Cabrero, R., & Lama, M. (2004). ODE SWS: A framework for designing and composing Semantic Web services. *IEEE Intelligent Systems 19*(4), 24-31.

Haarslev, V., & Möller, R. (2003). Racer: A core inference engine for the Semantic Web. In *Proceedings of the 2nd International Workshop on Evaluation of Ontology Tools (EON2003)*, October 20, Sanibel Island, FL.

Horridge, M. (2004). *A practical guide to building OWL ontologies with the Protégé-OWL Plugin* (Edition 1.0). Manchester: The University of Manchester.

Horrocks, I., Patel-Schneider, P.F., Boley, H., Tabet, S., Grosof, B., & Dean, M. (2004). *SWRL: A Semantic Web rule language combining OWL and RuleML—W3C member submission*. Retrieved May 21, 2004, from www.w3.org/Submission/SWRL/

Manola, F., & Miller, E. (2004). *RDF primer—W3C recommendation*. Retrieved February 10, 2004, from www.w3.org/TR/rdf-primer/

McGuinness, D.L., Fikes, R., Hendler, J., & Stein, L.A. (2002). DAML+OIL: An ontology language for the Semantic Web. *IEEE Intelligent Systems, 17*(5), 72-80.

Mitra, N. (Ed.) (2003). *SOAP version 1.2 Part 0: Primer—W3C recommendation*. Retrieved June 24, 2003, from www.w3.org/TR/soap12-part0

Schwartz, D.G. (2003). From open IS semantics to the semantic Web: The road ahead. *IEEE Intelligent Systems, 18*(3), 52-58.

Sintek, M., & Decker, S. (2002). TRIPLE: A query, inference, and transformation language for the semantic Web. In *Proceedings of the 1st International Semantic Web Conference—ISWC 2002 (LNCS 2342).* Heidelberg: Springer-Verlag.

Smith, M.K., Welty, C., & McGuinness, D.L. (Eds.) (2004). *OWL Web ontology language guide—W3C recommendation*. Retrieved February 10, 2004, from www.w3.org/TR/owl-guide

Thompson, H.S., Beech, D., Maloney, M., & Mendelsohn, N. (Eds.) (2001). *XML schema part 1: Structures—W3C recommendation*. Retrieved May 2, 2001, from www.w3.org/TR/xmlschema-1/

van Heijst, G., van der Spek, R., & Kruizinga, E. (1996). Organizing corporate memories. In B.R.

Gaines & M. Musen (Eds.), *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop,* Calgary: Department of Computer Science of the University.

Zarri, G.P. (2002). Semantic Web and knowledge representation. Database and expert systems applications. In *Proceedings of the 13th International Conference, DEXA'02*. Los Alamitos, CA: IEEE Computer Society Press.

Chapter 3.20
Interactive Information Retrieval as a Step Towards Effective Knowledge Management in Healthcare

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ABSTRACT

The chapter shows how modern information retrieval methodologies can open up new possibilities to support knowledge management in healthcare. Recent advances in hospital information systems lead to the acquisition of huge quantities of data, often characterized by a high proportion of free narrative text embedded in the electronic health record. We point out how text mining techniques augmented by novel algorithms that combine artificial neural networks for the semantic organization of non-crisp data and hyperbolic geometry for an intuitive navigation in huge data sets can offer efficient tools to make medical knowledge in such data collections more accessible to the medical expert by providing context information and links to knowledge buried in medical literature databases.

INTRODUCTION

During the last years the development of electronic products has lead to a steadily increasing penetration of computerized devices into our society. Personal computers, mobile computing platforms, and personal digital assistants are becoming omnipresent. With the advance of network aware medical devices and the wireless transmission of health monitoring systems pervasive computing has entered the healthcare domain (Bergeron, 2002).

Consequently, large amounts of electronic data are being gathered and become available online. In order to cope with the sheer quantity, data warehousing systems have been built to store and organize all imaginable kinds of clinical data (Smith & Nelson, 1999).

In addition to numerical or otherwise measurable information, clinical management involves administrative documents, technical documentation regarding diagnosis, surgical procedure, or care. Furthermore, vast amounts of documentation on drugs and their interactions, descriptions of clinical trials or practice guidelines plus a plethora of biomedical research literature are accumulated in various databases (Tange, Hasman, de Vries, Pieter, & Schouten, 1997; Mc Cray & Ide, 2000).

The storage of this exponentially growing amount of data is easy enough: From 1965—when Gordon Moore first formulated his law of exponential growth of transistors per integrated circuit—to today: "Moore's Law" is still valid. Since his law generalizes well to memory technologies, we up to now have been able to cope with the surge of data in terms of storage capacity quite well. The retrieval of data however, is inherently harder to solve. For structured data such as the computer-based patient record, tools for online analytical processing are becoming available. But when searching for medical information in freely formatted text documents, healthcare professionals easily drown in the wealth of information: When using standard search engine technologies to acquire new knowledge, thousands of "relevant" hits to the query string might turn up, whereas only a few ones are valuable within the individual context of the searcher. Efficient searching of literature is therefore a key skill for the practice of evidence-based medicine (Doig & Simpson, 2003).

Consequently, the main objective of this chapter is to discuss recent approaches and current trends of modern information retrieval, how to search very large databases effectively. To this end, we first take a look at the different sources of information a healthcare professional has access to. Since unstructured text documents introduce the most challenges for knowledge acquisition, we will go into more detail on properties of text databases considering MEDLINE as the premier example. We will show how machine learning techniques based on artificial neural networks with their inherent ability for dealing with vague data can be used to create structure on unstructured databases, therefore allowing a more natural way to interact with artificially context-enriched data.

SOURCES OF INFORMATION IN HEALTHCARE

The advance of affordable mass storage devices encourages the accumulation of a vast amount of healthcare related information. From a technical point of view, medical data can be coarsely divided into structured and unstructured data, which will be illustrated in the following sections.

Data Warehouses and Clinical Information Systems

One major driving force for the development of information processing systems in healthcare is the goal to establish the computer-based patient record (CPR). Associated with the CPR are patient registration information, such as name, gender, age or lab reports such as blood cell counts, just to name a few. This kind of data is commonly stored in relational databases that impose a high degree of structure on the stored information. Therefore, we call such data "structured." For evidence based medicine the access to clinical information is vital. Therefore, a lot of effort has been put into the goal to establish the computer-based patient record (CPR) as a standard technology in healthcare. In the USA, the Institute of Medicine (1991) defined the CPR as "an electronic patient record that resides in a system specifically designed to support users by providing accessibility to complete and accurate data, alerts, reminders, clinical decision support systems, links to medical knowledge, and other aids." However, as Sensmeier (2003) states, "this goal remains a vision [...] and the high expectations of these visionaries remain largely unfulfilled." One of the main reasons why "we are not there yet" is a general lack of integration.

A recent study by Microsoft1 identified as much as 300 isolated data islands within a medical center. The unique requirements of different departments such as laboratory, cardiology, or oncology and the historical context within the hospital often results in the implementation of independent, specialized clinical information systems (CIS) which are difficult to connect (McDonald, 1997). Consequently, main research thrusts are strategies to build data warehouses and clinical data repositories (CDR) from disjoint "islands of information" (Smith & Nelson, 1999). The integration of the separated data sources involves a number of central issues:

1. Clinical departments are often physically separated. A network infrastructure is necessary to connect the disparate sites. Internet and Intranet tools are regarded as standard solutions.
2. Due to the varying needs of different departments, they store their data in various formats such as numerical laboratory values, nominal patient data or higher dimensional CT data. Middleware solutions are required to translate these into a consistent format that permits interchange and sharing.
3. In the real world, many data records are not suitable for further processing. Missing values or inconsistencies have to be treated: Some fields such as blood cell counts are not always available or data was entered by many different persons, and is thus often furnished with a "personal touch." Cleaning and consistency checks are most commonly handled by rule-based transformations.
4. Departmental workflow should not be strained by data copying tasks. Automated script utilities should take care of the data migration process and copy the data "silently in the background."

None of the steps above is trivial and certainly it requires a strong management to bring autonomous departments together and to motivate them to invest their working power for a centralized data warehouse. But once such a centralized repository of highly structured data is available it is a very valuable ground for retrospective analysis, aggregation and reporting. Online analytical processing (OLAP) tools can be used to perform customized queries on the data while providing "drill downs" at various levels of aggregation. A study with an interactive visualization framework has shown that it can massively support the identification of cost issues within a clinical environment (Bito, Kero, Matsuo, Shintani, & Silver, 2001). Silver, Sakata, Su, Herman, Dolins, and O'Shea (2001) have demonstrated that data mining "helped to turn data into knowledge." They applied a patient rule induction method and discovered a small subgroup of inpatients on the DRG level which was responsible for more than 50 percent of revenue loss for that specific DRG (diagnoses related group). The authors describe a "repeatable methodology" which they used to discover their findings: By using statistical tools they identified regions and patterns in the data, which significantly differentiated them from standard cases. In order to establish the reason for increased costs in those regions, they found it necessary that a human expert further analyzes the automatically encircled data patterns. Therefore, a closed loop between clinical data warehouse, OLAP tool and human expert is necessary to gain the maximum of knowledge from the available data.

A recently proposed data mart by Arnrich, Walter, Albert, Ennker, and Ritter (2004) targets in the same direction: Various data sources are integrated into a single data repository. Results from statistical procedures are then displayed in condensed form and can be further transformed into new medical knowledge by a human expert.

UNSTRUCTURED DATA IN BIOMEDICAL DATABASES

As the discussion on hospital information systems shows, interactive data processing tools form a large potential to extract hidden knowledge from large structured data repositories. A yet more challenging domain for knowledge acquisition tasks is the field of unstructured data. In the following we will briefly present the two premier sources of unstructured data available to the healthcare professional.

Narrative Clinical Data

Many hospitals do not only store numerical patient data such as laboratory test results, but also highly unstructured data such as narrative text, surgical reports, admission notes, or anamneses. Narrative text is able to capture human-interpretable nuances that numbers and codes cannot (Fisk, Mutalik, Levin, Erdos, Taylor, & Nadkarni, 2003). However, due to the absence of a simple machine-parsable structure of free text, it is a challenging task to design information systems allowing the exchange of such kind of information.

In order to address the interoperability within and between healthcare organizations widely accepted standards for Electronic Health Records (EHR) are important. Health Level 7 (HL7)—an ANSI accredited organization, and the European CEN organization both develop standards addressing this problem. The HL7 Clinical Document Architecture (CDA) framework "stems from the desire to unlock a considerable clinical content currently stored in free-text clinical notes and to enable comparison of content from documents created on information systems of widely varying characteristics." (Dolin, Alschuler, Beebe, Biron, Boyer, Essin, Kimber, Lincoln, & Mattison,, 2001). The emerging new standard based on HL7 version 3 is purely based on XML and therefore greatly enhances the interoperability of clinical information systems by embedding the unstructured narrative text in a highly structured XML framework. Machine-readable semantic content is added by the so-called HL7 Reference Information Model (RIM). The RIM is an all-encompassing look at the entire scope of healthcare containing more than 100 classes with more than 800 attributes. Similar to HL7 v3, the European ENV 13606 standard as defined by the TC 251 group of the CEN addresses document architecture, object models and information messages. For a more detailed discussion on healthcare information standards see Spyrou, Bamidis, Chouvarda, Gogou, Tryfon, and Maglaveras (2002).

Another approach to imprint structure on free text is the application of ontologies to explicitly formalize logical and semantic relationships. The W3C consortium has recently (as of May 2004) recommended the Web Ontology Language (OWL) as a standard to represent semantic content of web information and can therefore be seen as a major step towards the "semantic Web" (Berners-Lee, Hendler, & Lassila, 2001). In the medical domain, the Unified Medical Language System (UMLS) uses a similar technology to represent biomedical knowledge within a semantic network (Kashyap, 2003). Once an ontology for a certain domain is available, it can be used as a template to transfer the therein contained explicit knowledge to corresponding terms of free text from that domain. For example, the term "blepharitis" is defined as "inflammation of the eyelids" in the UMLS. If a medic professional would search for the term "eyelid" within the hospital's EHRs, documents containing the word "blepharitis" would not show up. However with knowledge from the UMLS, these documents could be marked as relevant to the query. However, the tagging of free text with matching counterparts from an ontology is either a cost intensive human labor or requires advanced natural language processing methods. We shall see below, how computational approaches could address the problem of adding semantics to free narrative text.

Biomedical Publications

For most of the time in human history, the majority of knowledge acquired by mankind was passed on by the means of the written word. It is a natural scientific process to formulate new insights and findings and pass them to the community by publishing. Consequently, scientific literature is constantly expanding. It is not only expanding at growing speed, but also increasing in diversification, resulting in highly specialized domains of expertise.

The MEDLINE database at the U.S. National Library of Medicine (NLM) has become the standard bibliographic database covering the fields of medicine, nursing, veterinary medicine, dentistry, pharmacology, the healthcare system, and the preclinical sciences. The majority of publications in MEDLINE are regular journals and a small number of newspapers and magazines. The database is updated on a regular daily basis from Tuesdays to Saturdays and on an irregular basis in November and December. At the time of this writing, MEDLINE contains approximately 12 million references to articles from over 37,000 international journals dating back to 1966. In 1980 there were about 100,000 articles added to the database, and in 2002 the number increased to over 470,000 newly added entries. That means, currently over 50 new biomedical articles are published on an hourly basis. Clearly, no human is able to digest one scientific article per minute 24 hours a day, seven days a week. But the access to the knowledge within is lively important nonetheless: "The race to a new gene or drug is now increasingly dependent on how quickly a scientist can keep track of the voluminous information online to capture the relevant picture … hidden within the latest research articles" (Ng & Wong, 1999).

Not surprisingly, a whole discipline has emerged which covers the field of "information retrieval" from unstructured document collections, which takes us to the next section.

COMPUTATIONAL APPROACHES TO HANDLE TEXT DATABASES

The area of information retrieval (IR) is as old as man uses libraries to store and retrieve books. Until recently, IR was seen as a narrow discipline mainly for librarians. With the advent of the World Wide Web, the desire to find relevant and useful information grew to a public need. Consequently, the difficulties to localize the desired information "have attracted renewed interest in IR and its techniques as promising solutions. As a result, almost overnight, IR has gained a place with other technologies at the center of the stage" (Baeza-Yates & Ribeiro-Neto, 1999).

Several approaches have shown that advanced information retrieval techniques can be used to significantly alleviate the cumbersome literature research and sometimes even discover previously unknown knowledge (Mack & Hehenberger, 2002). Swanson and Smalheiser (1997) for example designed the ARROWSMITH system which analyses journal titles on a keyword level to detect hidden links between literature from different specialized areas of research. Other approaches utilize MeSH headings (Srinivasan & Rindflesch, 2002) or natural language parsing (Libbus & Rindflesch, 2002) to extract knowledge from literature. Rzhetsky, Iossifov, Koike, Krauthammer, Kra, Morris, Yu, Duboue, Weng, Wilbur, Hatzivassiloglou, and Friedman (2004) have recently proposed an integrated system which visualizes molecular interaction pathways and therefore has the ability to make published knowledge literally visible.

In the following sections we go into more detail and look how computational methods can deal with text.

Representing Text

The most common way to represent text data in numerical form such that it can be further processed by computational means is the so-called "bag of words" or "vector space" model. To this end a standard practice composed of two complementary steps has emerged (Baeza-Yates & Ribeiro-Neto, 1999):

1. Indexing: Each document is represented by a high-dimensional feature vector in which each component corresponds to a term from a dictionary and holds the occurrence count of that term in the document. The dictionary is compiled from all documents in the database and contains all unique words appearing throughout the collection. In order to reduce the dimensionality of the problem, generally only word stems are considered (i.e., the words "computer", "compute", and "computing" are reduced to "comput"). Additionally, very frequently appearing words (like "the" & "and") are regarded as stop words and are removed from the dictionary, because they do not contribute to the distinguishability of the documents.
2. Weighting: Similarities between documents an then be measured by the Euclidean distance or the angle between their corresponding feature vectors. However, this ignores the fact that certain words carry more information content than others. The so-called tf-idf weighting scheme (Salton & Buckley, 1988) has been found a suitable means to deal with this problem: Here the term frequencies (tf) in the document vector are weighted with the inverse document frequency idfi = log(N/sdi), where N is the number of documents in the collection, and sdi denotes the number of times the word stem si occurs in document d.

Although the "bag of words" model completely discards the order of the words in a document, it performs surprisingly well to capture its content. A major drawback is the very high dimensionality of the feature vectors from which some computational algorithms suffer. Additionally, the distance measure typically does not take polysemy (one word has several meanings) and synonymy (several words have the same meaning) into account.

Evaluating Retrieval Performance

In order to evaluate an IR system, we need some sort of quality measure for its retrieval performance. The most common and intuitively accessible measures are precision and recall. Consider the following situation: We have a collection of C documents and a query Q requesting some information from that set. Let R be the set of relevant documents in the database to that query, and A be the set of documents delivered by the IR system as answers to the given query Q. The precision and recall are then define by

$$precision = \frac{|R \cap A|}{|R|} \text{ and } recall = \frac{|R \cap A|}{|R|} ,$$

where R∩A is the intersection of the relevant and the answer set, that is, the set of found relevant documents. The ultimate goal is to achieve a precision and recall value of one, that is, to find only the relevant documents, and all of them. A user will generally not inspect the whole answer set A returned by an IR system—who would want to click through all of the thousands of hits typically returned by a web search? Therefore, a much better performance description is given by the so-called precision-recall-curve. Here, the documents in A are sorted according to some ranking criterion and the precision is plotted against the recall values obtained when truncating the sorted answer set after a given rank—which is varied between one and the full size of A. The particular point on the curve where the precision equals the recall is called break even point and is frequently used to characterize an IR system's performance with a single value.

Therefore, the quality of a search engine which generates hit lists is strongly dependent on its ranking algorithm. A famous example is PageRank, which is part of the algorithm used by Google. In essence, each document (or page) is weighted with the number of hyperlinks it receives from other web pages. At the same time the links themselves are weighed by the importance of the linking page (Brin & Page, 1998). The higher a page is weighted, the higher it gets within the hit list. The analogue to hyperlinks in the scientific literature are citations, that is, the more often an article is cited, the more important it is (Lawrence, Giles & Bollacker, 1999).

The Role of Context

So, we can handle unstructured text and measure how good an IR system works, but a critical question was not answered yet: How do we determine, which documents from a large collection are actually relevant to a given query? To answer this question, we have to address the role of context.

User Context

Consider the following example: A user enters the query "Give me all information about jaguars." The set of relevant documents will be heavily dependent on the context in which the user phrases this query: A motor sports enthusiast is probably interested in news about the "Jaguar Racing" Formula 1 racing stable, a biologist probably wants to know more about the animal. So, the context—in the sense of the situation in which the user is immersed—plays a major role (Johnson, 2003; Lawrence, 2000).

Budzik, Hammond and Birnbaum (2001) discuss two common approaches to handle different user contexts:

1. Relevance feedback: The user begins with a query and then evaluates the answer set. By providing positive or negative feedback to the IR system, this can modify the original query by adding positive or negative search terms to it. In an iterative dialogue with the IR system, the answer set is then gradually narrowed down to the relevant result set. However, as studies (Hearst, 1999) have shown, users are generally reluctant to give exhaustive feedback to the system.
2. Building user profiles: Similar to the relevance feedback, the IR system builds up a user profile across multiple retrieval sessions, that is, with each document the user selects for viewing, the profile is adapted. Unfortunately, such a system does not take account of "false positives", that is, when a user follows a link that turned out to be of no value when inspecting it closer. Additionally, such systems integrate short term user interests into accumulated context profiles, and tend to inhibit highly specialized queries which the user is currently interested in.

Budzik, Hammond & Birnbaum (2001) presented a system that tries to guess the user context from open documents currently edited or browsed on the work space. Their system constitutes an "Information Management Assistant [which] observes user interactions with everyday applications and anticipates information needs […] in the context of the user's task." Another system developed by Finkelstein and Gabrilovich (2002) analyzes the context in the immediate vicinity of a user-selected text, therefore making the context more focused. In an evaluation of their system both achieved consistently better results than standard search engines are able to achieve without context.

Document Context

Context can also be seen from another point of view: Instead of worrying about the user's intent and the context in which a query is embedded, an information retrieval system could make the context in which retrieved documents are embedded more explicit. If each document's context is immediately visible to the information seeker, the relevant context might be quickly picked out. Additionally, the user might discover a context he had not in mind when formulating the query and thus find links between his intended and an unanticipated context. In the following we describe several approaches that aim in this direction.

Augmenting Document Sets with Context

Text Categorization

One way to add context to a document is by assigning a meaningful label to it (Le & Thoma, 2003). This constitutes a task of text categorization and there exist numerous algorithms that can be applied. The general approach is to select a training set of documents that are already labelled. Based on the "bag of words" representation, machine learning methods learn the association of category labels to documents. For an in depth review of statistical approaches (such as naives Bayes or decision trees) see Yang (1999). Computationally more advanced methods utilize artificial neural network architectures such as the support vector machine which have achieved break even values close to 0.9 for the labelling of news wire articles (Joachims, 1998; Lodhi, 2001).

However, in the medical domain, 100 categories are seldom adequate to describe the context of a text. In case of the MEDLINE database, the National Library of Medicine has developed a highly standardized vocabulary, the Medical Subject Headings (MeSH) (Lowe & Barnett, 1994). They consist of more than 35,000 categories that are hierarchically organized and constitute the basis for searching the database. To guarantee satisfactory search results of constant quality, reproducible labels are an important prerequisite. However, the cost of human indexing of the biomedical literature is high: according to Humphrey (1992) it takes one year to train an expert the task of document labelling. Additionally, the labelling process lacks a high degree of reproducibility. Funk, Reid, and McGoogan (1983) have reported a mean agreement in index terms ranging from 74 percent down to as low as 33 percent for different experts. Because the improvement of index consistency is such demanding, assistance systems are considered to be a substantial benefit. Recently, Aronson, Bodenreider, Chang, Humphrey, Mork, Nelson, Rindflesh, and Wilbur (2000) have presented a highly tuned and sophisticated system which yields very promising results. Additionally to the bag of words model their system utilizes a semantic network describing a rich ontology of biomedical knowledge (Kashyap, 2003).

Unfortunately, the high complexity of the MeSH terms makes it hard to incorporate a MeSH-based categorization into a user interface. When navigating the results of a hierarchically ordered answer set it can be a time-consuming and frustrating process: Items which are hidden deep within the hierarchy can often only be obtained by descending a tree with numerous mouse-clicks. Selection of a wrong branch requires backing up and trying a neighboring branch. Since screen space is a limited resource only a small area of context is visible and requires internal "recalibration" each time a new branch is selected. To overcome this problem, focus and context techniques are considered to be of high value. These are discussed in more detail below.

The Cluster Hypothesis

An often cited statement is the cluster hypothesis, which states that documents which are similar in their bag of words feature space tend to be relevant to the same request (van Rijsbergen, 1979). Leuski (2001) has conducted an experiment where an agglomerative clustering method was used to group the documents returned by a search engine query. He presented the user not with a ranked list of retrieved documents, but with a list of clusters, where each cluster in turn was arranged as a list of documents. The experiment showed, that this procedure "can be much more helpful in locating the relevant information than the traditional ranked list." He could even show that the clustering can be as effective as the relevance feedback methods based on query expansion. Other experiments also validated the cluster hypothesis on several occasions (Hearst & Pedersen, 1996; Zamir & Etzioni, 1999). Recently the vivisimo2 search engine has drawn attention by utilizing an online clustering of retrieval sets, which also includes an interface to PubMed / MEDLINE.

Visualizing Context

Another way to create context in line with the spirit of the cluster hypothesis is by embedding the document space in a visual display. By making the relationship between documents visually more explicit, such that the user can actually see inter-document similarities, the user gets (i) an overview of the whole collection, and (ii) once a relevant document has been found, it is easier to locate others, as these tend to be grouped within the surrounding context of already identified valuable items. Fabrikant and Buttenfield (2001) provide a more theoretical framework for the concept of "spatialization" with relation to cognitive aspects and knowledge acquisitions: Research on the cognition of geographic information has been identified as being important in decision making, planning and other areas involving human-related activities in space.

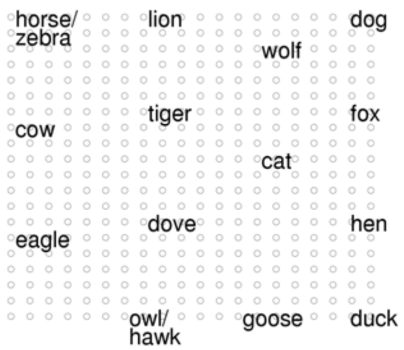
In order to make use of "spatialization", that is, to use cognitive concepts such as "nearness" we need to apply some sort of transformation to project the documents from their high-dimensional (typically several thousands) bag-of-words space onto a two dimensional canvas suitable for familiar inspection and interaction. The class of algorithms performing such a projection is called multi dimensional scaling (MDS). A large number of MDS methods such as Sammon mapping, spring models, projection pursuit or local linear embeddings have been proposed over the years. Skuping and Fabrikant (2003) provide an excellent discussion of the most common MDS variants in relation to spatialized information visualization.

Self-Organizing Maps

The notion of the self-organizing map (SOM) has been introduced by Kohonen (1982) more than 20 years ago. Since then is has become a well-accepted tool for exploratory data analysis and classification. While applications of the SOM are extremely wide spread—ranging from medical imaging, classification of power consumption profiles, or bank fraud detection—the majority of uses still follows its original motivation: to use a deformable template to translate data similarities into spatial relations.

The following example uses a simple toy dataset to demonstrate the properties of the SOM algorithm. Consider a 13-dimensional dataset describing animals with properties such as small, medium, big, two legs, hair, hooves, can fly, can swim, and so on. When displaying the data as a large table, it is quite cumbersome to see the interrelationship between the items, that is, animals. The map shown in Figure 1 depicts a trained SOM

Figure 1. A map of animals



with neurons placed on a 20x20 regular grid. After the training process, each animal is "presented" to the map, and the neuron with the highest activity gets labelled with the corresponding name. As can be seen in the figure the SOM achieves a semantically reasonable mapping of the data to a two-dimensional "landscape": birds and non-birds are well separated and animals with identical features get mapped to identical nodes.

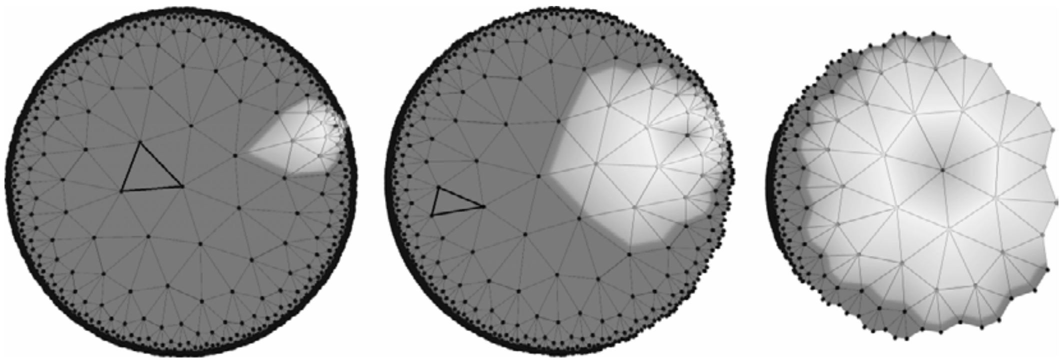
There have been several approaches to use the SOM to visualize large text databases and relations of documents therein. The most prominent example is the WEBSOM project. Kohonen, Kaski and Lagus, (2000) performed the mapping of 7 million patent abstracts and obtained a semantic landscape of the corresponding patent information. However, screen size is a very limited resource, and as the example with 400 neurons above suggests, a network with more than one million nodes—2500 times that size—becomes hard to visualize: When displaying the map as a whole, annotations will not be readable, and when displaying a legible subset, important surrounding context will be lost. Wise (1999) has impressively demonstrated the usefulness of compressed, map-like representations of large text collections: His ThemeView reflects major topics in a given area, and a zoom function provides a means to magnify selected portions of the map—unfortunately without a coarser view to the surrounding context.

Focus & Context Techniques

The limiting factor is the two dimensional Euclidean space we use as a data display: The neighborhood that "fits" around a point is rather restricted: namely by the square of the distance to that point. An interesting loophole is offered by hyperbolic space: it is characterized by uniform negative curvature and results in a geometry, where the neighborhood around a point increases exponentially with the distance. This exponential behavior was firstly exploited (and patented) by the "hyperbolic tree browser" from Lamandpng & Rao (1994), followed by a Web content viewer by Munzner (1998). Studies by Pirolli, Card and van der Wege (2001) showed that the particular focus & context property offered by hyperbolic space can significantly accelerate "information foraging".

Naturally, it becomes apparent to combine the SOM algorithm with the favorable properties of hyperbolic space (Ritter, 1999). The core idea of the hyperbolic self-organizing map (HSOM) is to employ a grid of nodes in the hyperbolic plane H2. For H2 there exists an infinite number of tessellations with congruent polygons such that each grid point is surrounded by the same number of neighbors (Magnus, 1974). As stated above, an intuitive navigation and interaction methodology is a crucial element for a well-fitted visualization framework. By utilizing the Poincaré projection and the set of Möbius transformations (Coxeter, 1957) a "fish-eye" fovea can be positioned on the HSOM grid allowing an intuitive interaction methodology. Nodes within the fovea are displayed with high resolution, whereas the surrounding context is still visible in a coarser view. For further technical details of the HSOM see (Ritter, 1999; Ontrup & Ritter, 2001). An example for the application of the fish-eye view is given in Figure 2. It shows a navigation sequence where the focus

Figure 2. Navigation snapshot showing isometric transformation of HSOM tessellation. The three images were acquired while moving the focus from the center of the map to the highlighted region at the outer perimeter. Note the "fish-eye" effect: All triangles are congruent, but appear smaller as further they are away from the focus.



was moved towards the highlighted region of interest. Note, that from the left to the right details in the target area get increasingly magnified, as the highlighted region occupies more and more display space. In contrast to standard zoom operations, the current surrounding context is not clipped, but remains gradually compressed at the periphery of the field of view. Since all operations are continuous, the focus can be positioned in a smooth and natural way.

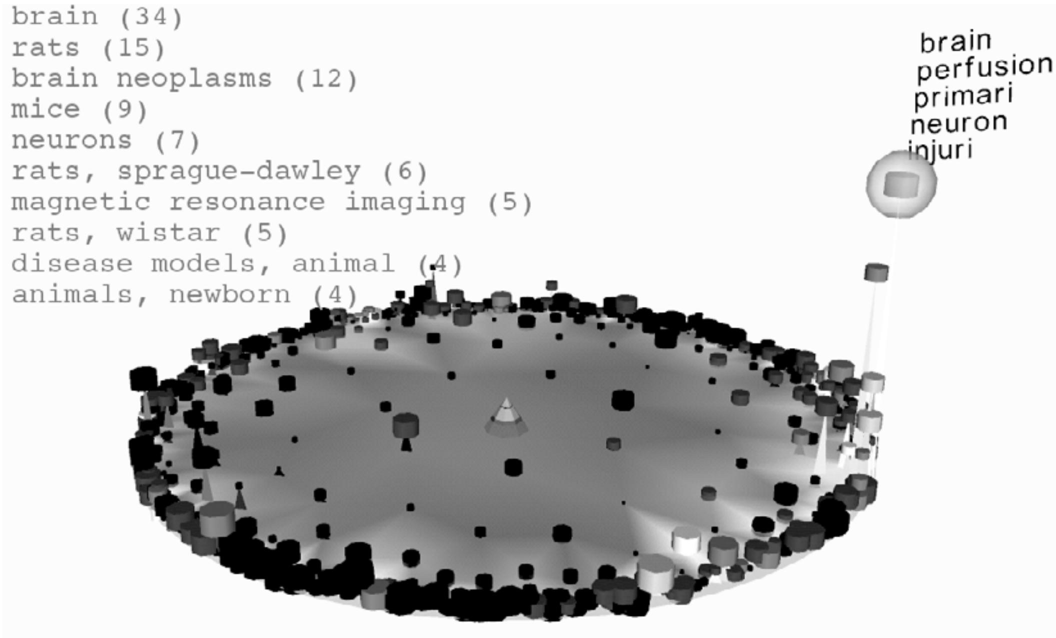
Browsing MEDLINE in Hyperbolic Space

The following example presents a HSOM framework that combines the aspects of information retrieval, context enrichment and intuitive navigation into a single application. The following images show a two dimensional HSOM, where the nodes are arranged on a regular grid consisting of triangles similar to those in Figure 2. The HSOM's neurons can be regarded as "containers" holding those documents for which the corresponding neuron is "firing" with the highest rate. These containers are visualized as cylinders embedded in the hyperbolic plane. We can then use visual attributes of these containers and the plane to reflect document properties and make context information explicit:

- The container sizes reflect the number of documents situated in the corresponding neuron.
- A color scale reflects the number of documents which are labelled with terms from the Anatomy hierarchy of MeSH terms, i.e. the brighter a container is rendered, the more articles labelled with Anatomy MeSH entries reside within that node.
- The color of the ground plane reflects the average distance to neighboring nodes in the semantic bag-of-words space. This allows the identification of thematic clusters within the map.

Figure 3 shows a HSOM that was trained with approximately 25,000 abstracts from MEDLINE. The interface is split into two components: the

Figure 3. MEDLINE articles mapped with the HSOM. The user submitted the query string "brain" and the corresponding results are highlighted by the system.

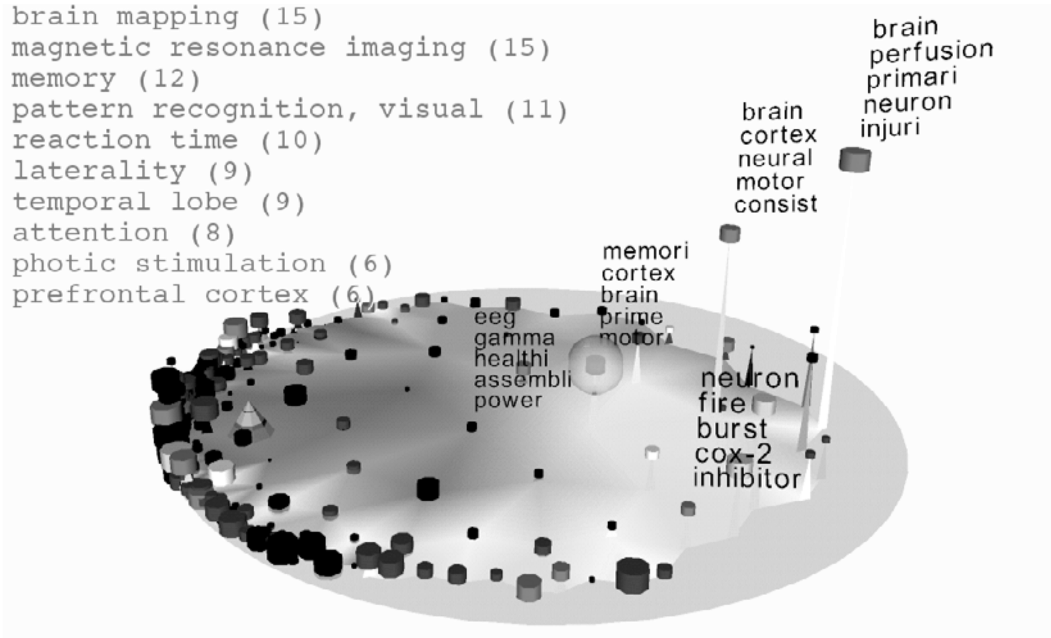


graphical map depicted below and a user interface for formulating queries (not shown here). In the image below, the user has entered the search string "brain". Subsequent to the query submission, the system highlights all nodes belonging to abstracts containing the word "brain" by elevating their corresponding nodes. Additionally the HSOM prototype vectors—which were autonomously organized by the system during a training phase—are used to generate a key word list which annotate and semantically describe the node with the highest hit rate. To this end, the words corresponding to the five largest components of the reference vector are selected. In our example these are: brain, perfusion, primari, neuron, and injuri. In the top left the most prominent MeSH terms are displayed, that is, 34 articles are tagged with the medical subject heading "brain", 15 are tagged with "rats", and so on.

The map immediately shows that there are several clusters of brain-related articles in the right part of the map. Moving the focus into this area leads to the situation shown in Figure 4. By selecting single neurons with the mouse, the user can selectively retrieve key words of individual containers. Additionally, the MeSH terms of the selected node are displayed. As can be seen from the keyword distribution, all nodes share semantically related characteristics. The two leftmost labelled nodes do not contain key words like "brain" or "neuron", but the labelling with "cord", "spinal", "eeg", and "gamma", respectively, indicates a close relation to the selected "brain-area".

The drill-down process to the document level combines the strengths of the graphical and the textual display: After zooming-in on a promising region, the titles of documents pertaining to a particular node can be displayed by a double

Figure 4. The user has moved the focus into the target area and can now inspect the context enriched data more closely.



mouse click. Note, that due to the ordering process of the SOM algorithm these documents are typically very similar to each other—and in the sense of the clustering hypothesis therefore might all provide an answer to the same query. A further double click on a document title then displays the selected abstract on the screen. In this way, the hyperbolic self-organizing map can provide a seamless interface offering rapid overview of large document collections while allowing at the same time the drill down to single texts.

BENEFITS FOR A HOSPITAL INFORMATION SYSTEM

In the framework of a hospital information system, such a context enriched interactive document retrieval system might be of great benefit to the clinical personal. According to Chu and Cesnik (2001) a hospital may generate up to five terabytes of data a year, where 20 to 30 percent of such data are stored as free text reports such as medical history, assessment and progress notes, surgical reports or discharge letters. Free text fields in medical records are considered of invaluable importance for medical relevance (Stein, Nadkarni, Erdos, & Miller, 2000). By using document standards like the CDA as briefly discussed in Section 2.2, the clinician is able to browse and retrieve the data according to the structure provided by the document framework. However, many existing information systems do not yet take advantage of the complex CDA or the even more substantial Reference Information Model—because it is a very time consuming task to transfer documents to the new standards and to fit the enormous mass of model objects to free text data.

Nevertheless, these systems store valuable information—just in a format which cannot be directly analyzed by structured methods. In order to provide access by content, the aforementioned Information Retrieval methodologies can significantly contribute to facilitate these tasks: a self-organizing map creates structure and context purely on the statistical word distributions of free text and thus allows a semantic browsing of clinical documents. This in turn offers the possibility to gain a problem orientated perspective on health records stored in information systems, that is, as Lovis et al (2000) have noted: "intelligent browsing of documents, together with natural language emerging techniques, are regarded as key points, as it appears to be the only pertinent way to link internal knowledge of the patient to general knowledge in medicine."

CONCLUSION

Recent advances in hospital information systems have shown that the creation of organization-wide clinical data repositories (CDR) plays a key role for the support of knowledge acquisition from raw data. Currently, many case studies are published which emphasize that data mining techniques provide efficient means to detect significant patterns in medical records. Interactive OLAP tools support best practice and allow for informed real time decision-making and therefore build the solid foundation for further improvements in patient care.

The next step to further broaden the knowledge base in healthcare environments will be the integration of unstructured data, predominantly free narrative text documents. The nature of this type of data will demand for new approaches to deal with the inherently vague information contained in these documents. We have shown how artificial neural networks with their ability for self-organization of non-crisp data provide an almost natural link between the hard computational world and the soft-computing of the human brain. We believe that interactive information retrieval methodologies that account for the rich context of natural language will significantly contribute to knowledge acquisition through text analysis.

REFERENCES

Arnrich, B., Walter, J., Albert, A., Ennker, J. & Ritter, H. (2004). Data mart based research in heart surgery: Challenges and benefit. *Proceedings of the MEDINFO 2004,* San Francisco.

Aronson, A.R., Bodenreider, O., Chang, H.F., Humphrey, S.M., Mork, J.G., Nelson, S.J., Rindflesh, T.C. & Wilbur, W.J. (2000). The NLM indexing initiative. *Proceedings of the Annual AMIA Symposium* (pp. 17-21).

Baeza-Yates, R. & Ribeiro-Neto, B. (1999). *Modern information retrieval.* New York: ACM Press/Addison-Wesley.

Bergeron, B.P. (2002). Enterprise digital assistants: The progression of wireless clinical computing. *Journal of Medical Practice Management, 17*(5), 229-233.

Berners-Lee, T., Hendler, J. & Lassila, O. (2001). The Semantic Web. *Scientific American* (May), 35-43.

Bito, Y., Kero, R., Matsuo, H., Shintani, Y. & Silver, M. (2001). Interactively visualizing data warehouses. *Journal of Healthcare Information Management, 15*(2), 133-142.

Brin, S. & Page, L. (1998). The anatomy of a large-scale hypertextual web search engine. *Proceedings of the 7th International WWW Conference*, Brisbane, Australia.

Budzik, J., Hammond, K.J. & Birnbaum, L. (2001). Information access in context. *Knowledge-Based Systems, 14*(1-2), 37-53.

Chu, S. & Cesnik, B. (2001). Knowledge representation and retrieval using conceptual graphs and free text document self-organisation techniques. *International Journal of Medical Informatics, 62*(2-3), 121-133.

Coxeter, H.S.M. (1957). *Non Euclidean geometry*. Toronto: University of Toronto Press.

Doig, G.S. & Simpson, F. (2003). Efficient literature searching: A core skill for the practice of evidence-based medicine. *Intensive Care Medicine*, *29*(12), 2109-11.

Dolin, R.H., Alschuler, L., Beebe, C., Biron, P.V., Boyer, S.L., Essin, D., Kimber, E., Lincoln, T. & Mattison, J.E. (2001). The HL7 clinical document architecture. *Journal of the American Medical Informatics Association, 8*(6), 552-69.

Fabrikant, S.I. & Buttenfield, B.P. (2001). Formalizing semantic spaces for information access. *Annals of the Association of American Geographers, 91*, 263-280.

Finkelstein, L. & Gabrilovich, E. (2002). Placing search in context: the concept revisited. *ACM Transactions on Information Systems, 20*(1), 116-131.

Fisk, J.M., Mutalik, P.G., Levin, F.W., Erdos, J., Taylor, C. & Nadkarni, P.M. (2003). Integrating query of relational and textual data in clinical databases: A case study. *Journal of the American Medical Informatics Association*, *10*(1), 21-38.

Funk, M.E., Reid, C.A. & McGoogan, L.S. (1983). Indexing consistency in MEDLINE. *Bulletin of the Medical Library Association*, *2*(71), 176-183.

Hearst, M.A. (1999). User interfaces and visualization. In R. Beaza-Yates & B. Ribeiro-Neto. *Modern information retrieval*. New York: ACM Press/Addison-Wesley.

Hearst, M.A. & Pedersen, J.O. (1996). Reexamining the cluster hypothesis: scatter/gather on retrieval results. *Proceedings of 19th ACM International Conference on Research and Development in Information Retrieval* (pp. 76-84).

Humphrey, S.M. (1992). Indexing biomedical documents: From thesaural to knowledge-based retrieval systems. *Artificial Intelligence in Medicine, 4*(5), 343-371.

Institute of Medicine. (1991). *The computer-based patient record: An essential technology for healthcare*. Washington, DC: National Academy Press.

Joachims, T. (1998). Text categorization with support vector machines: Learning with many relevant features. *Proceedings of 10th European Conference on Machine Learning (ECML)* (pp. 137-142).

Johnson, J.D. (2003). On contexts of information seeking. *Information Processing and Management*, *39*(5), 735-760.

Kashyap, V. (2003). The UMLS semantic network and the Semantic Web. *Annual Conference of the American Medical Informatics Association (AMIA)* (pp. 351-355).

Kohonen, T. (1982). Self-organized formation of topologically correct feature maps. *Biological Cybernetics, 43,* 59-69.

Kohonen, T., Kaski, S. & Lagus, K. (2000). Organization of a massive document collection. *IEEE Transactions on Neural Networks. Special Issue on Neural Networks for Data Mining and Knowledge Discovery*, 574-585.

Lamping, J. & Rao, R. (1994). Laying out and visualizing large trees using a hyperbolic space. *ACM Symposium on User Interface Software and Technology,* 13-14.

Lawrence, S. (2000). Context in Web search. *IEEE Data Engineering Bulletin*, *23*(2), 25-32.

Lawrence, S., Giles, C.L. & Bollacker, K. (1999). Digital libraries and autonomous citation indexing. *IEEE Computer, 32*(6), 67-71.

Le, D.X. & Thoma, G.R. (2003). Automated document labeling for Web-based online medical journals. *Proceedings of the 7th World Multiconference on Systemics, Cybernetics and Informatics*, July (pp. 411-415).

Leuski, A. (2001). Evaluating document clustering for interactive information retrieval. *Conference on Information and Knowledge Management (CIKM)* (pp. 33-40).

Libbus, B. & Rindflesch, T.C. (2002). NLP-based information extraction for managing the molecular biology literature. *Annual Conference of the American Medical Informatics Association (AMIA),* 445-449.

Lodhi, H., Shawe-Taylor, J., Christianini, N. & Watkins, C. (2001). Text classification using string kernels. *Advances in Neural Information Processing Systems (NIPS)*, 13, 563-569.

Lovis, C., Baud, R.H., & Planche, P. (2000). Power of expression in the electronic patient record: Structured data or narrative text? *International Journal of Medical Informatics*, 101-110.

Lowe, H.J. & Barnett, G.O. (1994). Understanding and using the medical subject headings (MeSH) vocabulary to perform literature searches. *Journal of the American Medical Association, 27*1(4), 1103-1108.

Mack, R. & Hehenberger, M. (2002). Text-based knowledge discovery: search and mining of life-sciences documents. *Drug Discovery Today, 7*(11), 89-98.

Magnus, W. (1974). *Noneuclidean tesselations and their groups.* London: Academic Press.

McCray, A.T. & Ide, N.C. (2000). Design and implementation of a national clinical trials registry. *Journal of the American Medical Informatics Association, 7,* 313-23.

McDonald, C. (1997). The barriers to electronic medical record systems and how to overcome them. *Journal of the American Medical Informatics Association, 4,* 213-221.

Munzner, T. (1998). Exploring large graphs in 3D hyperbolic space. *IEEE Computer Graphics and Applications*, *18*(4), 18-23.

Ng, S.K. & Wong, M. (1999). Towards routine automatic pathway discovery from on-line scientific text abstracts. *Genome Informatics*, *10*, 104-112.

Ontrup, J. & Ritter, H. (2001). Hyperbolic self-organizing maps for semantic navigation. *Advances in Neural Information Processing Systems (NIPS), 14*, 1417-1424.

Pirolli, P., Card, S.K. & van der Wege, M.M. (2001). Visual information foraging in a focus + context visualization. *ACM Conference on Human Factors in Computing Systems* (pp. 506-513).

Ritter, H. (1999). Self-organizing maps in non-euclidean spaces. In E. Oja & S. Kaski (Eds.), *Kohonen maps* (pp. 97-110). Amer Elsevir.

Rzhetsky, A., Iossifov, I., Koike, T., Krauthammer, M., Kra, P., Morris, M., Yu, H., Duboue, P.A., Weng, W., Wilbur, W.J., Hatzivassiloglou, V. & Friedman, C. (2004). GeneWays: A system for extracting, analyzing, visualizing, and integrating molecular pathway data. *Journal of Biomedical Informatics*, *37*(1), 43-53.

Salton, G. & Buckley, C. (1988). Term-weighting approaches in automatic text retrieval. *Information Processing and Management*, *24*(5), 513-523.

Sensmeier, J. (2003). Advancing the state of data integration in healthcare. *Journal of Healthcare Information Management, 17*(4), 58-61.

Silver, M., Sakata, T., Su, H.C., Herman, C., Dolins, S.B. & O'Shea, M.J. (2001). Case study: How to apply data mining techniques in a healthcare data warehouse. *Journal of Healthcare Information Management, 15*(2), 155-164.

Skupin, A. & Fabrikant, S.I. (2003). Spatialization methods: A cartographic research agenda for non-geographic information visualization. *Cartography and Geographic Information Science*, *30*(2), 95-119.

Smith, A. & Nelson, M. (1999). Data warehouses and clinical data repositories. In M.J. Ball, J.V. Douglas & D. Garets (Eds.). *Strategies and technologies for healthcare information* (pp. 17-31). New York: Springer Verlag.

Spyrou, S.S., Bamidis, P., Chouvarda, I., Gogou, G., Tryfon, S.M. & Maglaveras, N. (2002). Healthcare information standards. *Health Informatics Journal, 8*(1), 14-19.

Srinivasan, P. & Rindflesch, T.C. (2002). Exploring text mining from MEDLINE. *Annual Conference of the American Medical Informatics Association (AMIA).*

Stein, H.D., Nadkarni, P., Erdos, J. & Miller, P.L. (2000). Exploring the degree of concordance of coded and textual data in answering clinical queries from a clinical data repository. *Journal of the American Medical Informatics Association, 7*, 42-54.

Swanson, D.R., Smalheiser. N.R. & Sleeman, D.H. (1997). An interactive system for finding complementary literatures: A stimulus to scientific discovery. *Artificial Intelligence, 91*(2), 183-203.

Tange, H.J, Hasman, A., de Vries, R., Pieter, F. & Schouten, H. C. (1997). Medical narratives in electronic medical records. *International Journal of Medical Informatics, 46*(1), 7-29.

Van Rijsbergen, C.M. (1979). *Information retrieval*. London: Butterworths.

Wise, J. (1999). The ecological approach to text visualization. *Journal of the American Society for Information Science*, *50*(13), 1224-1233.

Yang, Y. (1999). An evaluation of statistical approaches to text categorization. *Information Retrieval*, *1*(2), 69-90.

Zamir, O. & Etzioni, O. (1999). Grouper: A dynamic clustering interface to Web search results. *Computer Networks*, *31*, 1361-1374.

ENDNOTES

1. http://www.microsoft.com/resources/casestudies/CaseStudy.asp? CaseStudyID=14967
2. http://vivisimo.com

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Chapter 3.21
Breaking the Knowledge Acquisition Bottleneck Through Conversational Knowledge Management

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ABSTRACT

Much of today's organizational knowledge still exists outside of formal information repositories and often only in people's heads. While organizations are eager to capture this knowledge, existing acquisition methods are not up to the task. Neither traditional artificial intelligence-based approaches nor more recent, less-structured knowledge management techniques have overcome the knowledge acquisition challenges. This article investigates knowledge acquisition bottlenecks and proposes the use of collaborative, conversational knowledge management to remove them. The article demonstrates the opportunity for more effective knowledge acquisition through the application of the principles of Bazaar style, open-source development. The article introduces wikis as software that enables this type of knowledge acquisition. It empirically analyzes the Wikipedia to produce evidence for the feasibility and effectiveness of the proposed approach.

INTRODUCTION

Ever since the development of artificial intelligence (AI) and expert systems, there has been the promise of capturing an organization's knowledge on a large scale and making it available to the entire organization. Unfortunately, these promises did not materialize (Buchanan & Smith, 1988; Ullman, 1989). While there have been several early success stories, such as American Express' Credit Advisor or Digital's Expert Configurer (XCON), attempts to acquire the broad knowledge of organizations have been less fruitful. More than a decade later, a decidedly optimistic survey by Frappaolo and Wilson (2003) found that no more than 32% of the knowledge was available in computerized form. Obviously, knowledge acquisition is a challenge. How can we extract more of the existing knowledge from organizational sources, especially from people? And how can we manage the maintenance so as to assure that the stored knowledge is accurate and up-to-date? Discovering answers to these questions is important for organizations as information work becomes knowledge work, thus requiring knowledge to support non-routine decision making (Drucker, 1993, 1999). It is similarly important for organizations whose corporate portals that were set up years ago increasingly are becoming dated and stale (Newcombe, 2000). Furthermore, it is important for organizations in the business of creating knowledge assets who are faced with increased costs of knowledge creation, shorter knowledge life cycles, and increased knowledge obsolescence.

Seeking a solution to the problems of organizational knowledge acquisition, the article makes the following argument. First, it introduces previous approaches to knowledge acquisition, identifies four limitations, and offers evidence for these limitations. The article then refers to Bazaar style (software) development (Raymond, 2001) as a potential direction for knowledge asset creation. It then explains the concept of conversational knowledge management and advocates wiki technology and the "wiki way" (Leuf & Cunningham, 2001) as a possible approach to using Bazaar-style methods in conversational knowledge management. An empirical analysis of the viability and effectiveness of the approach follows. The article ends with implications and conclusions about the future of conversational knowledge management.

KNOWLEDGE ACQUISITION

Approaches to Knowledge Acquisition

Organizations that try to acquire organizational knowledge formally (based on artificial intelligence methods) have relatively few available alternatives. For application areas with large amounts of transaction data, data mining can induce rules from that data. Data mining solutions work well for high-volume applications such as credit approval. Even then, the knowledge creation effort is highly resource-intensive (Lee, 2001). When insufficient data volumes thwart data mining efforts, the acquisition activity has to elicit knowledge directly from experts as rules and facts or similar formal representations. This should be done under the guidance of knowledge engineers trained in knowledge elicitation, formalization, and representation. Yet a knowledge engineer's productivity is limited to hundreds of rules per year for development and maintenance (Sviokla, 1990; Turban & Aronson, 2000). This productivity level may be acceptable for high value-added projects but limits the broad applicability of the approach. Smaller projects have attempted to rely on capturing knowledge without knowledge engineers, relying on end-user development. The latter has not been very successful (Wagner, 2000, 2003). Wagner found end-user expert systems often to be poorly structured, incomplete, highly coupled, and thus, difficult to maintain. Artificial intelligence-based methods thus are facing considerable applicability constraints. Consequently, organizational knowledge management efforts have sought to capture knowledge in less formal ways; for instance, by extending document management and groupware systems into knowledge management systems (Davenport & Prusak, 1998; Holsapple & Joshi, 2002) in part through better indexing, search engines, and linking.

Yet challenges remain. When organizations try to make sense out of large volumes of documents in their document management systems, they usually need search engines, text mining, and automatic indexing tools, resulting in an expensive solution with limited success (Bygstad, 2003). Furthermore, this approach is well suited only for relatively stable and centralized knowledge bases. Users of such knowledge bases often encounter information overload, irrelevant responses, or no response to queries. Alternatively, organizations might use expert reports and harvest expert knowledge to capture the methods used by domain experts (Snyder & Wilson, 1998). Again, this method often is limited to niche applications, requires considerable effort, and still faces knowledge maintenance difficulties (Malhotra, 2000). Other solutions, such as corporate controlled portals, can quickly suffer from outdated knowledge and lack of maintainability (Newcombe, 2000).

Knowledge Acquisition Bottleneck

In summary, we can describe the knowledge acquisition bottleneck as follows (Wagner, 2000; Waterman, 1986):

- Narrow bandwidth. The channels that exist to convert organizational knowledge from its source (either experts, documents, or transactions) are relatively narrow.
- Acquisition latency. The slow speed of acquisition frequently is accompanied by a delay between the time when knowledge (or the underlying data) is created and when the acquired knowledge becomes available to be shared.
- Knowledge inaccuracy. Experts make mistakes and so do data mining technologies (finding spurious relationships). Furthermore, maintenance can introduce inaccuracies or inconsistencies into previously correct knowledge bases.
- Maintenance trap. As the knowledge in the knowledge base grows, so does the requirement for maintenance. Furthermore, previous updates that were made with insufficient care and foresight (“hacks”) will accumulate and render future maintenance increasingly more difficult (Land, 2002).

Given these challenges, it appears that there are few opportunities for breaking the knowledge acquisition bottleneck. The next section will propose one possible remedy.

LEARNING FROM SOFTWARE DEVELOPMENT

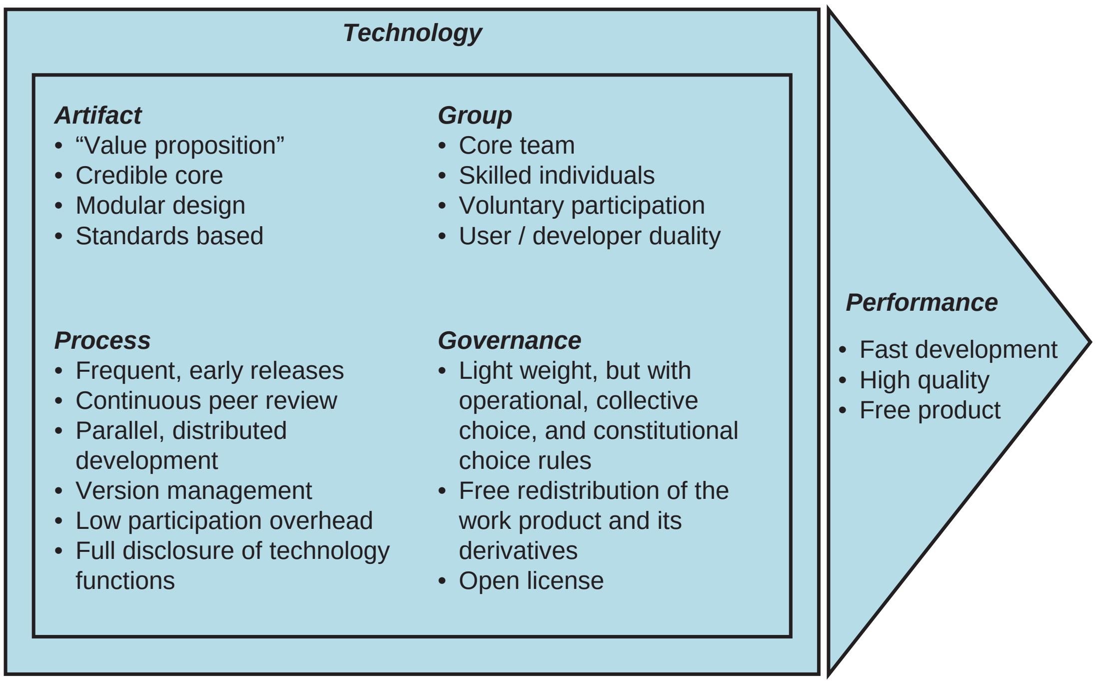
One area that has offered lessons for the successful creation of knowledge assets is software development, and specifically open source software development by distributed teams of volunteers. Open source projects engage software developers, wherever they may reside, and have them collaboratively develop the knowledge asset (the software). Surprisingly, this activity takes place with little centralized management. Raymond (2001) characterized this approach to software development as the Bazaar style in contrast to the traditional cathedral style of development. Cathedral is a metaphor for the development of a large monolithic artifact through a structured and lengthy development process. Fundamental to the cathedral style approach is that source code is only widely available at release dates with access restricted to a few developers between release dates. Bazaar style development, however, occurs over the Internet in constant public view. Raymond identified principles of this development style that challenge the assumption that large and complex software assets need to be built via an a priori, centralized approach. Overall, four themes guide this development approach, which can be characterized as follows: (1) design simplicity of the artifact, (2) team work, (3) frequent creation of a visible work product, and (4) development as an ongoing conversation. This section introduces a framework of open source (software) development, identifies its benefits, and derives lessons about the applicability for knowledge assets other than software.

Open Source Software Development

Open source software development, as described, for instance, by Raymond (2001), Benkler (2002), and Markus, et al. (2000), relies on several factors to achieve success (and thus, performance of the knowledge creation effort). Key success factors (see Figure 1) consist of a suitable artifact, a skilled and motivated team of volunteer users and developers, a lean and transparent development process, and lightweight but effective governance. Added to this is an enabling factor; namely, an appropriate technology infrastructure, which, for instance, permits frequent releases, accommodates voting mechanisms to govern the community, or enables fast and reliable version management, all with little overhead and few transaction costs. With these factors in place, open source software development promises faster development speed than proprietary approaches (including higher developer productivity) and a better quality product, which is also free.

Open source software development has had remarkable successes, creating software that appears to break long-standing rules of software evolution (Scacchi, 2004). For example, open source software size has been shown to grow super-linear (exponential) rather than linear or inverse-square (Mockus et al., 2002).

Figure 1. Framework for open source software development



Bazaar-Style Knowledge Management

Can Bazaar-style development be applied successfully to the creation of knowledge assets other than software? Several leaders of the open source community have hypothesized this, including Torvalds (Hamm, 2004). Yet Torvalds also acknowledged that not all knowledge assets are equally suitable, as the creation process may be too personal or too linear. Hence, in order to extend the lessons and benefits of Bazaar-style development, we should target applications where the core themes can be applied: (1) simplicity of design and frequent redesign (refactoring) to maintain simplicity, (2) teamwork (3) frequent creation of a small work product available for review and testing, and (4) development as conversation to facilitate back-up, clarity, and shared understanding. Applications of this kind exist within organizations, and among organizations and people. For example, companies could conceivably turn their traditional help desks into open help desks, where customers would openly share their problems with others, help each other, and free up company experts to tackle only the most difficult problems. Unfortunately, companies frequently do not want to relinquish control of their (closed) help desk. Open help desks exist on the Web, typically as discussion forums of questions and answers. While they embody teamwork and conversation, the resulting work product often is not simple and well-structured but lacks organization and is filled with repetition and inconsistencies.

Consequently, one necessary condition for this research was to find a knowledge asset that was highly amenable to the Bazaar-style development approach and that used a technology that facilitated this type of development. The selected asset was an online encyclopedia — Wikipedia (wikipedia.org) — that employs wiki technology and the "wiki way" of knowledge asset creation (Leuf & Cunningham, 2001). The article will provide more detail on the Wikipedia application, following a briefing on knowledge management with wiki technology and the wiki way.

CONVERSATIONAL KNOWLEDGE MANAGEMENT WITH WIKIS

Knowledge management with wikis has recently drawn media attention (Brown, 2004; Hof, 2004; Ripley, 2003) as a new, end user developed approach founded on collaboration and conversation. Collaborative knowledge management means that many people work together to create or acquire knowledge instead of a few individual experts. In other words, a community (of practice) will jointly create and maintain the knowledge. Research elsewhere (Cheung et al., 2005) suggests that conversational knowledge management is well suited for this challenge, whereby conversations (i.e., questions and answers) become the source of relevant knowledge.

Conversational knowledge management has become popular in communities that form around discussion boards. Leading solutions such as ezboard or Yahoo groups are now used by millions of communities1. Yet while discussion forums have been a simple and practical solution to share knowledge through conversation, they lack several useful knowledge representation and maintenance features. For example, discussion forum postings, even within a single thread, often do not build upon each other. As a result, the latest post may not be an incremental improvement of earlier ones. An alternative technology, which combines the most desirable features of other conversational technologies, is the wiki. This section discusses wiki technology and its suitability for knowledge management.

Wiki Structure and Principles

A wiki is a set of linked Web pages created through the incremental development by a group of collaborating users (Leuf & Cunningham, 2001) as well as the software used to manage the set of Web pages. Ward Cunningham developed the first wiki in 1995 as the PortlandPatternRepository in order to communicate specifications for software design within a large, heterogeneous community. The term wiki (from the Hawaiian wikiwiki, meaning fast) references the speed with which content can be created with a wiki. Wiki key characteristics are as follows:

- It enables Web documents to be authored collectively;
- It uses a simple markup scheme (usually a simplified version of HTML, although HTML frequently is permitted);
- Wiki content is not reviewed by any editor or coordinating body prior to its publication; and
- New Web pages are created when users navigate a hyperlink that points nowhere.

Underlying these characteristics are specific principles that have shaped wiki software as well as its use. They are intended to produce a development environment where multiple people easily can create and modify a set of jointly owned Web pages. Wiki pages are expected to be open, incrementally developed, and organic; require little markup; have consistent edit functions and clear naming, be heavily hyperlinked and easily observable (found). As a result, wiki pages are expected to change and improve incrementally.

Wikis in Use

Creating Wiki Pages

Creating and editing wiki pages is a simple activity. A wiki author will use a Web-enabled formfield to enter a comment he or she wishes to publish. Authors can use plain text or a simplified markup language. The system then automatically generates and publishes a Web page with a unique URL that can be indexed and linked to. Hence, users with virtually no Web publishing knowledge can create Web content about as quickly as they can write a text document.

Linking Wiki Pages

A fundamental aspect of knowledge management with wikis is the use of simple hyperlinks. Hyperlinks link topics and create context. Wikis drastically simplify hyperlinking. To link pages within a wiki, users do not have to create and use URLs (although they can). Instead, they normally use CamelCase (multiple words capitalized and concatenated) or double parentheses around a term ([[term]]) in order to create a link. Links whose destination (page) does not exist are depicted as question marks (or similar) as if the author were asking a question. Another author (or the original creator) then can respond by clicking on the question mark, thus navigating the hyperlink to a new page and invoking an editor to write that page. Upon completion of the edit, the question mark automatically will be rendered as a regular hyperlink (now underlined text) pointing to the new page.

Versioning

As multi-user systems, wikis enable every user to modify any other user's Web pages (unless explicitly forbidden by access right settings). This creates challenges in version management. Wikis solve them by keeping prior versions of any Web page in memory, and enabling rollback, comparison, difference identification, and similar capabilities, if so desired. Wikis also track the history of prior changes with author, date, and related information.

Wikis and Open Source Principles

Knowledge management using wikis and the wiki way (see, for instance, "WhyWikiWorks" at http://c2.com/cgi/wiki?WhyWikiWorks) appear to bear considerable resemblance to open source software development, described in part by the following traits:

- Sense of responsibility in contributing to a common good;
- Openness to change and modification by anyone;
- Meritocracy (anyone can play, but only good players last);
- Self-governance of the developer team;
- Task decomposition and incremental development;
- Use of technology for communication and coordination, as well as norms for their use, including objectivity (neutral point of view); and
- Ease of use for knowledge creation and maintenance.

Thus, as an enabling technology, wikis establish an environment to develop the right artifact, to use a Bazaar-style process, to engage teams in voluntary collaboration, and to govern the effort with a lightweight structure (Figure 1), thus offering the potential for open source knowledge management. In open source software development, the corresponding results are ultimately lower error rates (compared to closed source); fast(er) development speed; and the ability to develop large(r) applications, accelerated development, and high(er) maintainability of the source code (Mockus et al., 2002). Whether these same benefits accrue in wiki-enabled open source knowledge management must be determined empirically.

ASSESSING CONVERSATIONAL KNOWLEDGE MANAGEMENT

Can principles of Bazaar-style development be applied to knowledge management, and if so, will they improve knowledge acquisition effectiveness? To begin to answer these questions, the research analyzed a single case of wiki-enabled knowledge asset creation — Wikipedia.

Knowledge Asset: Wiki-Based Encyclopedia

Encyclopedias reasonably can be characterized as knowledge assets. While one may debate how much of their content is information instead of knowledge, encyclopedias contain insights (factual), rules (inferential), principles (inferential), and so forth. They also fit the definition of information in context (Davenport &Prusak, 1998), since they frequently link concepts to other concepts (cross-referencing). By design, encyclopedias also are relatively loosely coupled knowledge assets, whose components (articles) can exist independently. Encyclopedias frequently are compiled from the work of a group of authors who know little about each other or each other's work. Encyclopedia articles have common structural elements, since all articles are definitions. They typically also follow some standards for articles of a similar type (e.g., all biographies are structured similarly and different from city descriptions).

The majority of digital encyclopedias, such as Britannica, Encarta, Compton, or Grolier, is closed source. They are compiled by a relatively small group of commissioned writers and editors. The result of their work only becomes available to the readership once the entire edit process has been completed and the new encyclopedia version is released. Yet, because of their loosely structured nature, encyclopedias (and other, similar knowledge assets) also can be created in Bazaar style, given certain conditions. The work product cannot be an off-line product such as a book or a CD; the technology in general has to be amenable to Bazaar-style knowledge acquisition and representation, and the organization creating the encyclopedia has to formulate procedures and methods that enable this type of knowledge acquisition. Bazaar-style knowledge acquisition, therefore, becomes a possibility when the asset is created following the wiki way. Hence, Wikipedia, the online encyclopedia developed as a wiki, was used as the knowledge asset to be analyzed for this research. Wikipedia is one of several knowledge products developed over the last few years with wiki technology and the wiki way of development. Other applications include Wikitravel and Wikibooks. Development of Wikipedia began in 2001. As of May 2004, less than three and a half years later, the (English) Wikipedia contains about 280,000 articles.

Wikipedia, applying wiki principles, appears to enable its developers to use a Bazaar-style approach. Specifically, writers can make incremental changes and then commit and publish them immediately. Also, articles can be written by numerous writers as joint authors, thus building on the work of others or correcting mistakes. Furthermore, Wikipedia rules stress an authoring etiquette that incorporates rules of article design and redesign targeted toward simple and clear articles. In other words, it is possible for Wikipedia authors to follow the main themes of Bazaar-style development. Whether authors do so and whether the outcome of their efforts is consistent in its effectiveness with Bazaar-style software development needs to be determined empirically.

Research Questions

The research sought to address two questions through empirical analysis.

1. Is conversational knowledge management, as demonstrated in Wikipedia, consistent with Bazaar-style knowledge asset creation?
2. Is conversational knowledge management, as illustrated by Wikipedia, able to achieve the benefits of Bazaar-style development?

The research thus needed to determine whether "Wikipedians" would follow Bazaar-style knowledge acquisition and whether the effect would be improved knowledge acquisition. Based on the criteria in Figure 1, numerous questions would have to be addressed. Yet, as Table 2 illustrates, compliance with the majority of criteria was confirmed from Wikipedia information (Wikipedia Web site and Wikimedia Meta-Wiki), leaving four core questions to be answered.

Thus, the research questions focused on the incremental nature of the knowledge acquisition effort, the multi-person effort, and the effect on the growth and quality of the work product, as described in the following subsections.

Incremental Development with Frequent Releases

Incremental development and frequent releases are fundamental to Bazaar-style development. Would Wikipedians follow this approach, or instead would they prefer to write an authoritative article in an effort burst with few revisions in the process and even fewer thereafter?

To answer this question, the research explored (1) the frequency of article edits and (2) the change in article size. If the effort were non-incremental, one would expect a relatively short development period of high activity (since an article is typically a few hundred to a few thousand words long) followed by little editing activity thereafter, possibly with some maintenance and some extensions. An incremental effort, in contrast, would result in a high level of activity with many edits during an extended development period followed by a much-extended maintenance period with lower yet still considerable update efforts. To operationalize the assumption, the research adopted the Pareto rule, thus hypothesizing that if Wikipedia articles were written in a non-incremental effort, then 80% of

Table 2. Wikipedia fit with Bazaar-style development criteria

Dimension	Bazaar Style Development	Wikipedia Adaptation
Artifact	"Value Proposition"	Yes – create free and open encyclopedia
	Credible Core	Yes/No – not a ***content*** core, but a developer group core
	Modular Design	Yes – loosely coupled articles
	Standards Based	Yes – article structures
Group	Core Team	***? - Is Wikipedia development a team effort?***
	Skilled Individuals	Yes/No – participants from the Nupedia initiative were all PhDs, but no control over new participants
	Voluntary Participation	Yes – only one paid "chief editor", Larry Sanger (until 2002)
	User / Developer Duality	Yes – author and users
Process	Frequent, early releases	***? – Are Wikipedia articles developed through an incremental approach with continuous releases?***
	Continuous peer review	
	Parallel, distributed development	Yes – 7,000 authors worldwide
	Version management	Yes – through wiki technology
	Low participation overhead	Yes – through wiki technology
	Full disclosure of (technology) functions	Yes – through wiki technology
Governance	Light weight, operational, collective choice	Yes – Wikimedia organization with meritocracy as governing structure
	Free re-distribution of the work product	Yes – GPL license
	Open License	
Performance	Fast Development	***? – Does conversational knowledge management result in linear or better growth of knowledge assets***
	High quality	***? – Does conversational knowledge management result in improved knowledge asset quality?***
	Free product	Yes – GPL license

their size growth and 80% of the edit efforts should occur during the first 20% of their existence:

H1: Wikipedia articles are the outcome of an incremental development, and therefore, their growth and edit pattern does not follow the 80-20 Pareto rule.

Multi-Person Effort

There is little doubt that Wikipedia is a multi-person effort with presently more than 7,000 people contributing to it and more than 500 people making more than 100 contributions each per month (see Wikistats at http://www.wikipedia.org/wikistats/EN/TablesWikipediaEN.htm). However, according to the principles of Bazaar-style development, one would expect Wikipedia development to be a team effort at a more detailed level with multiple authors working on each article in order to extend it and possibly to correct mistakes. This would reflect one of the key themes of open source, also called Linus' [Torvalds] Law; namely, that "given enough eyeballs, all bugs become shallow." Hence, the research sought to determine whether enough eyeballs were scrutinizing each article, at least more than two. Hence, the analysis focused on whether article publication and maintenance was a multi-person effort.

H2: Knowledge acquisition and maintenance in individual Wikipedia articles is a multi-person effort.

Effectiveness

The research sought to determine whether encyclopedia development adopting the wiki way would be effective. In this exploratory study, effectiveness was measured through two variables; namely, (1) growth of the knowledge asset and (2) quality improvement efforts. Growth of the knowledge asset was determined, based on the increase in the number of articles in the Wikipedia over time. In line with other open source successes (Mockus et al., 2002), the expectation was that growth would be linear or better (super-linear).

H3: Wikipedia growth in terms of number of articles will be linear or super-linear.

Unable to assess the overall quality of the Wikipedia objectively vis-à-vis other encyclopedias, the research focused on process quality and specifically quality improvement efforts. These efforts were operationalized by the ratio of edit efforts vs. the growth of Wikipedia articles. In other words, the research tested whether editing efforts were devoted to increasing the size of articles or to refining existing articles. The assumption was that refinements (without significant increase in size) would improve overall quality, for instance, through an increase in presentation quality, content quality, or the inclusion of more viewpoints (diversity).

Hence, we computed a words-per-edit ratio based on the number of words (per article) written and the number of edits it took to create the article version. This ratio was calculated for articles in their early stages (20% of development effort) and at their present state. Decreasing ratios would indicate more effort being spent over time on article refinement. To exclude insignificant edits, the research only considered non-minor changes (counted separately in Wikipedia). The expectation was that, over time, more effort would be devoted to increased article quality. It is a stated Wikipedia goal to increase quality as articles mature (see, for instance, the reply to objections concerning Wikipedia, which discusses quality and growth issues, at http://en.wikipedia.org/wiki/Wikipedia:Replies_to_common_objections).

The corresponding hypothesis concerning quality improvement was as follows:

H4: Edit effort targeted at quality improvements for individual Wikipedia articles will increase over time, demonstrated by reduced article growth per edit.

Data Source

Wikipedia is an open encyclopedia in many ways. In addition to articles being freely accessible, so is the history of their creation, including dates, content of each version, and author information. Hence, it was possible to trace changes, change frequencies, and author contributions. To address the first two questions, 80 articles were randomly selected with the one qualification that 40 of them had to be created originally in 2001 and 2002. More recent articles were ignored because of their short history. To determine knowledge asset growth, Wikipedia summary statistics were accessed, which logged the number of articles written each month from the start of Wikipedia.

Results

Incremental Development (Release Early and Often)

This analysis focused on two samples of 40 articles from 2001 and 2002. For both of these samples, the edit efforts for the first 20% of each article's existence (up to the measurement point in March 2004) were compared against the entire development effort. The results do not support the notion

Table 3. Wiki development activity

	20% Avg. Actual	**Avg. Expected (80-20 Rule)**	**t (df = 39)**	**Significance p**
2001 Articles, *Size (Words)*	793	1,855	6.468	.0000
2001 Articles, *Edits*	17	230	8.841	.0000
2002 Articles, *Size (Words)*	811	1,795	4.212	.0000
2002 Articles, *Edits*	24	133	6.820	.0000

Table 4. Wikipedia article author statistics

	Min. No. Authors	**Max. No. Authors**	**Avg. No. Authors**	**t-Statistic**	**Significance p**
2001 Articles	33	285	121.4	10.33	.0000
2002 Articles	18	268	70.8	7.870	.0000
All Articles	18	285	96.1	12.21	.0000

of a short effort burst but one of incremental development, as shown in Table 3.

For articles started in 2001, the first 20% of an average article's existence accounted for about 34% of the article's size (793 words out of 2,319) and less than 6% of its edits (17 out of 288). For the 2002 articles, the first 20% accounted for about 36% of article size and 15% of article edits. Overall, this was considerably less than expected according to the Pareto rule. All results are highly significant ($p < 0.0001$). Hence, size grew relatively incrementally with a somewhat larger upfront effort (about 35% of size produced in 20% of the time). Wikipedia edits were even more incremental with a disproportionately small number during the early existence of an article (15% or less of the edits in 20% of the time).

Multi-Person Effort

Each of the 80 articles in the two samples also was evaluated according to the number of authors. None of the articles in the sample was co-authored by fewer than 18 people, and the maximum number of authors for any article was 285. On average, more than 96 authors worked on an article (Table 4).

Given these results, what is the likelihood that articles overall were predominantly single-authored? Virtually none. A t-test showed very significant differences between the actual author numbers and the possibility of single authorship. This is a strong result, yet the reader is reminded that the sample articles were old articles. More than half of the Wikipedia articles were less than 12 months old (as of June 2004) and will have been edited by fewer people. An additional sample of 40 randomly selected articles started in 2003, though, still corroborated the results (average of 48 authors, $t = 7.164$, $p = 0.0000$). In other words, as time progresses, Wikipedia articles are scrutinized by "many eyeballs".

Wikipedia Growth

Data points concerning the growth of Wikipedia illustrate dramatic growth. Although Wikipedia has existed since 2001, more than half of its approximately 280,000 articles (English articles as of May 2004) were written since June 2003. (See http://www.wikipedia.org/wikistats/EN/TablesWikipediaEN.htm).

To explore the growth pattern further, the analysis targeted the numbers of new articles created each month. Three different time series were compared: number of articles, log of number of articles, and square root of number of articles. For each series, the fit was computed to determine which one best predicted Wikipedia growth. As Table 5 illustrates, Wikipedia growth is best explained by a quadratic function (R2 = 0.988, highest). In other words, Wikipedia article growth is most likely quadratic and, thus, super-linear, which is an aggressive growth pattern. Quadratic growth also best explained the increase in the number of Wikipedians and in the number of edits (changes) made to Wikipedia.

Quality Improvement

The second effectiveness measure, the allocation of effort to quality improvement, suggested a shift toward more quality as Wikipedia articles aged. Table 6 illustrates that during the first 20% of an article's existence, each edit resulted in about 60 additional words vs. 11 or fewer words for the remaining 80% of the article's life (up to the measurement date in March 2004).

The differences in the means of these ratios were highly significant, confirming that later effort is an investment in article quality rather than article length.

Discussion

Results of the exploratory study confirm what has been expected. Hypotheses H1, H2, H3, and H4 were all confirmed. Knowledge acquisition efforts apparently can successfully adopt Bazaar-style development with multi-user involvement, incremental changes, and quick releases in an environment that enables conversational knowledge acquisition. In the case of Wikipedia, this was possible for several reasons. First, Wikipedia was able to draw a large and quadratically growing developer group (approximately 7,000 as of May 2004).

Second, Wikipedia pages are highly decoupled from each other so that new authors can write with little concern for the current content of other pages. When an author breaks a hyperlink or negatively affects content, it becomes quickly

Table 5. Growth in Wikipedia articles (articles official count, March 2004)

Relationship	**R^2**	**p**
Linear	.932	.0000
Exponential (log)	.819	.0000
Quadratic (square root)	.988	.0000

Table 6. Words per edit by article age

	20% - Avg. Words / Edit	**80% - Avg. Words / Edit**	**t (df = 39)**	**Significance p**
2001 Articles	57.8	6.7	5.848	.0000
2002 Articles	64.4	10.7	4.239	.0001

apparent, and other Wikipedians will fix the problem. Third, when authors make a contribution, whether writing a new page or changing an existing article, the result is immediately visible to the entire community, thus enabling quick releases with minimal latency and multi-user quality assurance. Therefore, the transaction cost of making a contribution is low, much lower than in any peer-reviewed or closed source authoring environment (Ciffolilli, 2003). Fourth, there is no individual ownership of Wikipedia pages, which are developed by volunteers; thus, everyone works to improve everyone's contributions. Quality is everyone's responsibility. Fifth, Wikipedia has strong editing guidelines that are motivated by the refactoring rules of software development and principles of objectivity. This ensures that articles, which might have suffered in readability from the disjointed work of multiple contributors and commentator, ultimately become very readable again.

As a result, in three and a half years of existence, Wikipedia has challenged the otherwise largest but closed authorship Encyclopedia Britannica (Britannica Online) for leadership in content (Britannica has self-reportedly about 100,000 entries, although with a larger word count per article). Other wiki-supported knowledge assets, such as Wikitravel, for instance, may be able to achieve similar leadership roles in their knowledge domain. The open, multi-user model also appears to scale well by interesting an increasingly larger user population to contribute their efforts, thus keeping the article latency at about 10 days for old articles (initially created in 2001) and less than two days for newer articles (i.e., 2003). However, since wiki technology is relatively new and contrary to many organizations' cultures, we should not expect this approach to become predominant soon. In fact, the successes are few at present. However, one should expect an increasing number of wiki software products to emerge in the future and an increasing number of communities to replace their inferior conversational technologies with wikis.

CONCLUSION

The challenge of capturing and maintaining exponentially growing volumes of knowledge requires new ways of knowledge acquisition; namely, on approaches that rely on the contributions of many rather than the expertise of a few. Wiki technology and the wiki way of collaboration show a feasible model for knowledge acquisition and maintenance. Wikipedia offers an illustration of the effectiveness of this approach. The research demonstrates that users of a wiki-based knowledge asset (i.e., Wikipedia) apply Bazaar-style methods and techniques in their conversational knowledge asset creation. The research also suggests that knowledge acquisition through collaboration and conversation can lead to super-linear knowledge asset growth and continuous quality improvement.

Not surprisingly, there are several caveats. For instance, knowledge quality cannot be measured or managed easily. The quality of Wikipedia articles, for instance, remains a source of arguments. Therefore, future research will need to investigate the quality of the resulting knowledge based on content. In addition, knowledge creation with wikis relies on a strong and positive social contract among its contributors and on subject matters that are not controversial. These conditions are not always present. Wikipedia does have guidelines in place to handle disorderly participants and to maintain a neutral point of view (NPOV) in articles. But Wikipedia clearly relies on the social capital within its community. Studies of less strong communities will have to be part of the future research in order to determine knowledge losses due to lack of social capital. Furthermore, Bazaar-style knowledge management relies on volunteers who are genuinely interested in the cause. This may not be a paradigm for organizations where knowledge assets are not free. Future research will need to explore the applicability of open source knowledge management when the intellectual property is at least partially proprietary. Finally, the discussed approach to knowledge management appears to work, partly because it can engage increasing numbers of participants to deal with a growing task domain. One has to wonder about the limits of growth of this scenario. Considering both the positive findings and the challenging questions, it appears that Bazaar-style knowledge acquisition using wikis will be a promising application for the practice of knowledge management as well as a rich source of interesting research questions.

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REFERENCES

Benkler, Y. (2002). Coase's Penguin, or, Linux and the nature of the firm. *The Yale Law Journal, 112*(3), 369-446.

Brown, E. (2004). Veni, vidi ...Wiki? *Forbes, 173*(13), 062a.

Buchanan, B., & Smith, R. (1988). Fundamentals of expert systems. *Annual Review of Computer Science, 3*(7), 23-58.

Bygstad, B. (2003). The implementation puzzle of CRM systems in knowledge-based organizations. Information *Resources Management Journal, 16*(4), 33-45.

Cheung, K. S. K., Lee, F. S. L., Ip, R. K. F., & Wagner, C. (2005). The development of successful on-line communities. *International Journal of the Computer, the Internet and Management, 13*(1).

Ciffolilli, A. (2003). Phantom authority, self-selective recruitment and retention of members in virtual communities: The case of Wikipedia. *First Monday, 8*(12). Retrieved from http://firstmonday.org/issues/issue8_12/ciffolilli/index.html

Davenport, T., & Prusak, L. (1998). *Working knowledge. How Organizations Manage What They Know.* Harvard Business School Press.

Drucker, P. (1993). *Post-capitalist society.* New York: Harper Business.

Drucker, P. (1999). *Management challenges for the 21st century.* New York: Harper Business.

Frappaolo, C., & Wilson, L. T. (2003). *After the gold rush: Harvesting corporate knowledge resources. intelligentKM.* Retrieved from http://www.intelligentkm.com/feature/feat1.shtml

Hamm, S. (2004, August 18). Linus Torvalds' benevolent dictatorship. *Business Week Online.* Retrieved from http://businessweek.com/technology/content/aug2004/tc20040818_1593.htm

Hof, R. D. (2004, June 7). Something wiki this way comes: They're Web sites anyone can edit — And they could transform corporate *America. Business Week*, 128.

Holsapple, C. W., & Joshi, K. D. (2002). Knowledge management: A threefold framework. *The Information Society, 18,* 47-64.

Jones, C. (1996). *Patterns of software systems failure and success.* Boston, MA: International Thomson Computer Press.

Land, R. (2002). Software deterioration and maintainability: A model proposal. In *Proceedings of the Second Conference on Software Engineering Research and Practice in Sweden (SERPS),* Karlskrona, Sweden.

Lee, W. A. (2001). Experian and fair, isaac tweak subprime scoring. *American Banker, 167*(247), 7.

Leuf, B., & Cunningham, W. (2001). *The wiki way: Collaboration and sharing on the Internet.* Reading, MA: Addison-Wesley.

Malhotra, Y. (2000). From information management to knowledge management: Beyond the "hi-tech hidebound" systems. In K. Srikantaiah, & M. E. D. Koenig (Eds.), *Knowledge management for the information professional* (pp. 37-61). Medford, NJ: Information Today Inc.

Markus, M. L., Manville, B., & Agres, C. (2000). What makes a virtual organization work — Lessons from the open source world. *Sloan Management Review*, *42*(1), 13-26.

Mayfield, R. (2002, November 19). *Occupational spam*. Ross Mayfield's Weblog: Markets, Technology and Musings. Retrieved from http://radio.weblogs.com/0114726/2002/11/19.html

Mockus, A., Fielding, R. T., & Herbsleb, J. D. (2002). Two case studies of open source software development: Apache and mozilla. *ACM Transactions on Software Engineering Methodology*, *11*(8), 309-346.

Newcombe, T. (2000). *Opening the knowledge portal*. *Government Technology*. Retrieved from http://www.govtech.net/magazine/gt/2000/sept/knowledge/portal.phtml

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, *5*(1), 14-37.

Raymond, E. S. (2001). The cathedral and the bazaar. *First Monday, 3*(3). Retrieved from http://www.firstmonday.dk/issues/issue3_3/raymond/

Scacchi (2004). Understanding free/open source software evolution: Applying, breaking and rethinking the laws of software evolution. In N. H. Madhavji, M. M. Lehman, J. F. Ramil, & D. Perry. (Eds.), *Software evolution*. New York: John Wiley and Sons.

Snyder, C. A., & Wilson, L. T. (1998). The process of knowledge harvesting: A key to knowledge management. In *Proceedings of the 8th Annual BIT Conference*, Manchester, UK.

Sviokla, J. J. (1990). An examination of the impact of expert systems on the firm: The case of XCON. *MIS Quarterly*, *14*(2), 127-140.

Turban, E., & Aronson, J. (2000). *Decision support and intelligent systems* (6th ed.). Prentice Hall.

Ullman, H. (1989, July 17). *Machine dreams: Future shock for fun and profit.* The New Republic.

Wagner, C. (2000). End-users as expert system developers. *Journal of End User Computing, 12*(3), 3-13.

Wagner, C. (2003). Knowledge management through end user developed expert systems: Potential and limitations. In M. A. Mahmood (Ed.), *Advanced topics in end user computing, Volume 2* (pp. 148-172). Hershey, PA: Idea Group Publishing.

Waterman, D. A. (1986). *A guide to expert systems.* Reading, PA: Addison-Wesley.

ENDNOTE

[1] ezboard.com announced that it had hosted more than 1 million communities on March 1, 2002, and claims 14 million registered users as of June 2004.

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Chapter 3.22
Technical Aspects of Knowledge Management:
A Methodology for Commercial Knowledge Management Tool Selection

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ABSTRACT

One of the repercussions of the ever-rising popularity of knowledge management is a sudden increase in the number and range of knowledge management tools available on the software market. This can present a problem for organisations that are required to sift through the vast number of tools in the hope of finding one that meets their requirements. Moreover, guidelines describing how to go about selecting a commercial knowledge management tool do not currently exist. Therefore, the aim of this chapter is to present a set of guidelines to aid the evaluation and selection of a commercial knowledge management tool. In order to achieve this, a methodology is proposed that outlines factors and issues that could be taken into consideration during the selection of a knowledge management tool. Furthermore, an overview of criteria specific to knowledge management tools that can be used to evaluate and ascertain the features present in a knowledge management tool are also suggested.

INTRODUCTION

Knowledge management has attracted a great deal of interest in the past few years. However, this appears to have focused on the organisational and human aspects (Davenport, 1996). The technical aspect of knowledge management has been acknowledged, but few academic studies have ventured beyond this point. While research efforts have been centred on the organisational and human issues of knowledge management, software vendors have been busy bombarding the market with various knowledge management tools. Consequently, an overwhelming number of knowledge management tools exist on the software market (Angus et al., 1998; Davenport and Prusak, 1998; Silver, 2000). This is not immediately perceived as being problematic since the greater the choice, the more competitive and dynamic the market. However, the overwhelming alternatives can make it difficult for organisations to select a suitable knowledge management tool that adequately meets their requirements. This is further complicated by the fact that, while some of these tools have been designed specifically as knowledge management tools, others have been re-packaged, re-labelled and re-marketed as knowledge management tools (Angus et al., 1998). Other disciplines and even areas within information systems and computing have overcome this problem by creating a set of guidelines that aid the selection of suitable software tools. In light of this, it appears feasible to provide a similar facility for knowledge management tools.

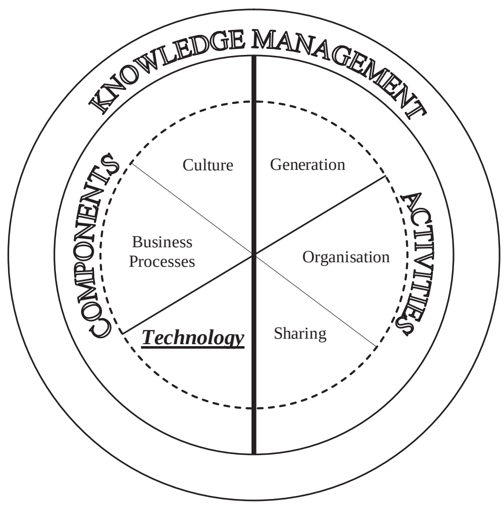
Therefore, the motivation for this research stems from the lack of guidelines available for the selection of knowledge management tools. The purpose of this chapter is to demonstrate a methodology that has been designed to aid the selection of a commercial knowledge management tool. The chapter begins by demonstrating how knowledge management tools fit into the broader context of knowledge management. Following this is an illustration of the methodology and a description of how it was designed. A part of the methodology involves the evaluation of candidate knowledge management tools. Therefore, an evaluation framework that could be used to achieve this is also described. The chapter concludes by reflecting on the methodology and discussing further work in this area.

KNOWLEDGE MANAGEMENT TOOLS IN CONTEXT

The area of knowledge management has been subjected to a great deal of controversy with regards to the lack of a common definition or concept. However, there does appear to be some consistency in relation to the components and the activities, often referred to as processes, which constitute knowledge management. This research can be classified under the ‘Technology’ component of knowledge management which is illustrated in Figure 1.

Figure 1 shows that knowledge management consists of two areas —knowledge management activities and knowledge management components. The former, knowledge management activities, is divided into the three areas of knowledge generation, knowledge organisation and knowledge sharing. These represent the primary activities that can take place, either in

Figure 1. Knowledge management activities and components



isolation or in various combinations, during a knowledge management deployment. The latter components of knowledge management consist of culture, business processes and technology. These reflect the aspects of an organisation that must be taken into consideration for a knowledge management effort to be successful. Unlike the activities, the components must not exist in isolation as part of a knowledge management exercise. In fact, all three components should receive equal, and combined, attention (Borghoff and Pareschi, 1997; Davenport, 1997; Davenport and Prusak, 1998; Milton et al., 1999; Trauth, 1999; Vaas, 1999, Duffy, 2001). Therefore, as mentioned in the previous section, the research specified within this chapter focuses on the technology component of knowledge management. However, prior to addressing knowledge management technology the remainder of this section describes the knowledge activities and components in more detail, in order to provide some background information and to clarify the context of this research.

Knowledge Management Activities

Knowledge management activities refer to the phases that take place in order to achieve knowledge management. Table 1 describes the knowledge management activities specified by various authors. In general, knowledge management activities range from between three and five categories. Although the terms used are very similar, there appears to be some variance in the meanings. For instance, Angus and Patel (1998) claim that knowledge gathering refers to the bringing in of information and data. However, according to Kramer (1998) knowledge gathering entails the process of collecting knowledge. The subtle difference here is reference to what is being gathered. Angus and Patel (1998) are collating information and data whereas Kramer (1998) is gathering knowledge.

Essentially, it appears that the knowledge management activities involve obtaining knowledge in the first place, organising it so that it can be easily accessed at a later date and ensuring that the collated knowledge is exploited by sharing it with the people who require it. A number of authors have sub-divided each of the knowledge management activities further by associating various actions that refer to the way the activity is achieved. For example, Angus and Patel (1998) claim that knowledge can be gathered through pulling, searching, Optical Character Recognition (OCR) or voice input.

Knowledge Management Components

The other aspect of knowledge management that appears to contain some consistency is related to the areas that must be addressed during a knowl-

Table 1. Knowledge management activities according to various authors

AUTHORS	KNOWLEDGE MANAGEMENT ACTIVITIES				
Ruggles (1997)	Generation	Codification	Transfer		
Angus and Patel (1998)	Gathering	Organising	Refining	Disseminating	
Kramer (1998)	Gathering	Organising	Distributing	Collaboration	
Ferran-Urdaneta (1999)	Creation	Legitimisation	Sharing		
Jackson (1999)	Gathering	Synthesis	Storage	Communication	Dissemination
Macintosh (1999)	Developing	Preserving	Using	Sharing	

edge management deployment. These include: culture, business processes and technology (Borghoff and Pareschi, 1997; Davenport, 1997; Davenport and Prusak, 1998; Milton et al., 1999; Trauth, 1999; Vaas, 1999, Duffy, 2001). The cultural aspect of knowledge management is often considered as one of the most difficult obstacles to overcome (Bicknell, 1999). This is attributed to traditional business practices of hoarding knowledge (Hibbard and Carillo, 1998). Previously, knowledge was perceived as an individual's power and secured their position, and in some cases led to promotion, within an organisation. However, the repercussions of the knowledge age mean that in order to create a knowledge sharing environment, it is necessary for employees to change their way of thinking. Nevertheless, theory is very different from practice. Many suggestions have been made in order to improve the cultural environment, ranging from story telling (Reilly et al., 1999) to ensuring that employees feel confident that they will still be a valuable asset to the organisation if they share their knowledge (Angus et al., 1998; Hibbard and Carillo, 1998). Unfortunately, the cultural branch remains a major hindrance to the success of many knowledge management deployments.

A number of theorists believe that the key to creating a knowledge sharing environment is to re-design business processes (Angus and Patel, 1998; Hibbard and Carillo, 1998; Klamma and Schlaphof, 2000). This involves the radical re-design of business processes that exist within an organisation without allowing current practices to influence the resulting design (Davenport, 1993; Hammer and Champy, 1993; Robson and Ullah, 1996). Consequently, business processes are re-designed in order to accommodate a knowledge sharing environment. Furthermore, the resulting business processes should also consider, and support, the chosen knowledge management strategy. For instance, an organisation's strategy may consist of capturing information from consultants while they are working at a client site on a project. However, in order to achieve this, it is necessary for the consultants to keep a record of certain activities. This should be taken into consideration, and time to do this should be allocated within the re-designed business processes. Knowledge management strategies are a separate research area altogether and are out of the scope of this research and therefore are not covered in any detail.

According to Ruggles (1997) technology and culture are connected by the condition that technology is compromised if the appropriate knowledge sharing culture is not adopted. Technology, in the form of knowledge management tools, is used to facilitate the knowledge management activities. As described in the previous section (Knowledge Management Activities), these consist of knowledge generation, organisation and sharing (Ruggles, 1997; Angus and Patel, 1998; Davenport and Prusak, 1998; Kramer, 1998; Ferran-Urdaneta, 1999; Jackson, 1999; Macintosh, 1999). One example of a knowledge generation tool is software that creates user profiles according to the parts of a web site a user has navigated. The knowledge collated is exploited during the user's subsequent visits. For instance, if during the initial visit the user shows an interest in the sports sections of the web site, they would be presented with various links connected to sport on their next visit. If during this particular visit they only read the football articles, then the site would prioritise football articles. Each time the user visits the site, more knowledge is collected about them and, it is believed, the better their requirements are understood. Knowledge generation tools appear to vary quite considerably in where knowledge is obtained from and how it is generated. Some tools generate new knowledge by combining knowledge that already exists within an organisation. Others search the Internet to obtain the relevant knowledge.

Knowledge organisation tools are used to store and organise knowledge so that it is quick and easy to access by the people who need it. Although

Table 2. Knowledge management tools

	KNOWLEDGE MANAGEMENT TOOLS						
	GENERATION			ORGANISATION		SHARING	
KM TOOLS	**Capture**	**Discovery**	**Retrieval**	**Storage**	**Monitor**	**Collaboration**	**Transfer**
ARS Remedy			8	8	8		
Netmeeting						8	8
Synera		8	8	8			
80-20 Product Suite		8	8				
Assistum		8					
Correlate K-Map		8	8				
Engenia			8			8	8
Eureka		8		8			
Groove						8	8
Orbis Intelliware	8		8		8		
C-business Server	8	8		8		8	8
Hummingbird EIP	8			8		8	
Plumtree Portal	8			8		8	
Active Knowledge	8	8	8		8		
AskMe Enterprise	8		8	8		8	
Authorete		8	8				
Autonomy Update		8			8		
BackWeb			8		8		
Collectively Sharper			8				
Communispace	8		8			8	8
Deskartes		8	8				
DocSmart			8	8			
Docushare		8	8	8			
Global Network	8		8			8	
Hyperwave	8		8	8		8	8
InfoImage Freedom		8				8	8
ISYS:web	8	8	8	8		8	
Kanisa		8	8				
KM Studio			8				
Knowledge XChanger	8		8			8	
KnowledgeMail		8			8		
myLivelink			8	8		8	
Net Perceptions		8	8				
Portal-in-a-Box	8	8	8		8	8	
Practicity			8	8		8	
RetrievalWare	8	8	8				
SageMaker			8				
Semio Map		8	8				8
Semio Taxonomy		8		8			
STRATEGY!			8				
Thinkmap		8					
work2gether			8	8			
ZyIMAGE		8	8				8

not immediately obvious, there are various ways that knowledge can be stored and organised. For instance, the method of cataloguing knowledge may be achieved automatically by the tool using a predefined set of criteria. Alternatively, it may be necessary for somebody, often referred to as a knowledge librarian, to organise the knowledge manually.

Davenport and Prusak (1998) claim that knowledge sharing tools are the most valuable of the three. The main aim of knowledge sharing tools is to disseminate knowledge to the relevant people efficiently and effectively. This may be achieved by using utilities such as conferencing, bulletin boards, messaging and file transfer. A conferencing facility would enable a group of people to work together although they may be located in a dispersed fashion. Tools of this calibre allow the use of features such as chat, whiteboard and application sharing so that all group members are able to see and understand what is being demonstrated. Furthermore, an item can be worked on collaboratively, with everyone present being able to view the same information. Table 2 displays a list of knowledge management tools and the functions associated with each. Furthermore, the relationship between the functions and knowledge management activities are also demonstrated.

This is only a small selection of the types of knowledge management tools available, and the list is constantly growing at a rapid pace. Furthermore, the lack of any formal techniques for knowledge management tool selection means that the process of choosing one is the responsibility of the purchasing organisation. This entails time, money and effort to be invested that could be utilised elsewhere, if some form of guidelines were available. It would be possible to use one of the numerous generic techniques that exist (Curry and Bonner, 1983; Martin and McClure, 1983; Lynch, 1985; Breslin, 1986; Klein and Beck, 1987; Anderson, 1990; Le Blanc and Jelassi, 1991; Sharland, 1991; Montazemi et al., 1996). However, these would need to be adapted to accommodate characteristics present in knowledge management tools. Furthermore, other disciplines including education (Berryman et al., 1994; Buckleitner, 1999), the health service (McDonald, 1996) and the military (Parnas et al., 1990; Dupuy and Leveson, 2000) can make use of such guidelines designed specifically for their areas. Therefore, a methodology that aids the selection of a commercial knowledge management tool has been designed and is presented in the following sections.

METHODOLOGY FOR KNOWLEDGE MANAGEMENT TOOL SELECTION

A methodology was designed that illustrates the factors and issues that can be taken into consideration during the selection of a knowledge management tool. It is important to note that the methodology is not intended as a rigid structure that must be followed without any deviation, as is often the associated meaning where the term 'methodology' is concerned. In fact the opposite is true: the methodology is intended as a guideline and aid that can be adapted according to the requirements of the individual organisation. The remainder of this chapter describes the resultant methodology that was designed for the purpose of knowledge management tool selection.

Designing the Methodology

The information used for designing the methodology was obtained predominantly from three different sources. The first resulted from conducting interviews with people involved with knowledge management tools. Prior to conducting the interviews, questionnaires were used in order to obtain a general understanding of the knowledge management tool and the context in which it was being used. Furthermore, this enabled the questions that needed to be asked during the follow-up interviews to be highlighted. Therefore, in total 58 questionnaires were distributed and follow-up interviews were conducted. The questions used in both, questionnaire and interview, were predominantly of an open-ended nature, and the format of the interviews were unstructured.

The second source of information was from existing methodologies designed for the selection of software. These include two different types: 1) generic methodologies (Curry and Bonner, 1983; Martin and McClure, 1983; Lynch, 1985; Breslin, 1986; Klein and Beck, 1987; Anderson, 1990; Le Blanc and Jelassi, 1991; Sharland, 1991; Montazemi et al., 1996) that can be used for the selection of any software tool and 2) specific methodologies intended for the selection of discipline specific tools. An example of the latter is a methodology that is designed specifically for the selection of educational tools and therefore considers educational requirements (Berryman et al., 1994; Buckleitner, 1999). Discipline-oriented methodologies were investigated to establish how the task of designing a discipline-specific methodology is undertaken and how issues that need to be addressed, with regards to the particular area, were obtained. Furthermore, methodologies designed for areas already existing within the discipline of information systems and computing such as simulation (Hlupic, 1997; Nikoukaran et al., 1998) and computer-aided software engineering (Forte, 1992; Mosley, 1992), were also analysed. The reason underlying this was that, being classified under the same discipline parts of the methodology may also apply to knowledge management tool selection.

The third and final source of information was obtained by consulting the literature related to knowledge management. The purpose of this was to identify the factors specific to knowledge management tools that need to be taken into consideration during the selection process. The results from the three different avenues of information were collated and combined in order to create a methodology for knowledge management tool selection.

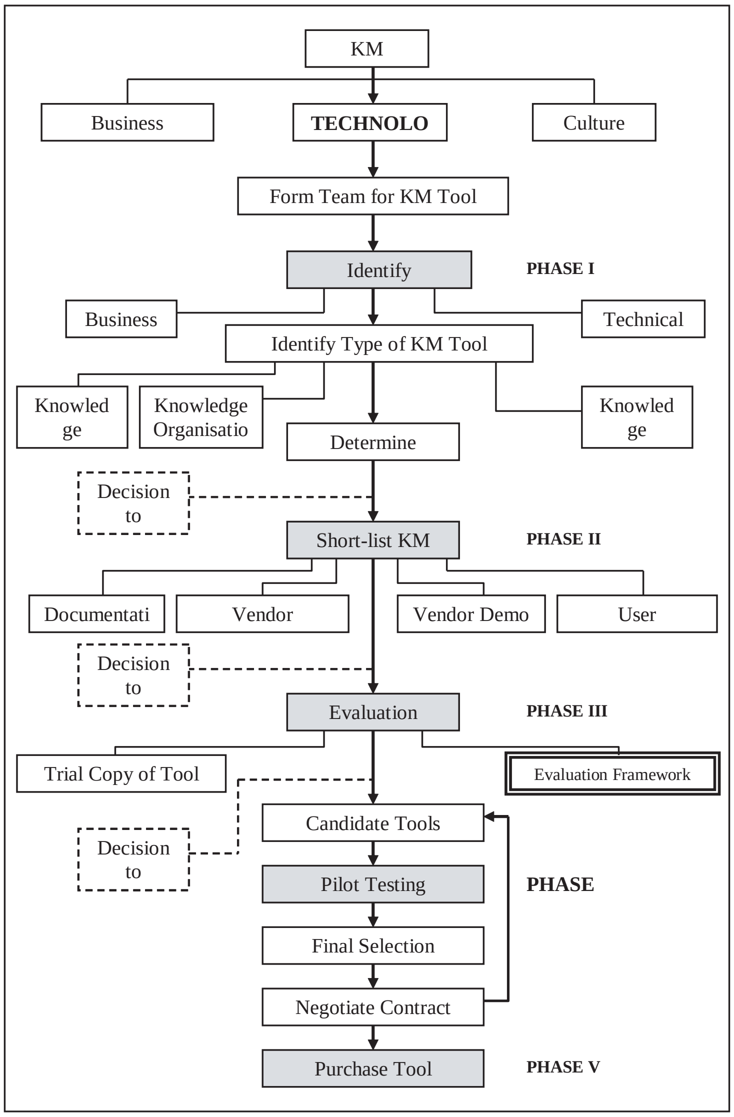
The Methodology

The methodology, illustrated in Figure 2, has been designed to aid the selection of knowledge management tools and can be classified under the 'Technology' component of knowledge management. However, Figure 2 demonstrates that the 'Business Processes' and 'Culture' components have also been included within the methodology. The justification for this is to further substantiate the theory that a knowledge management deployment must take into consideration the three components, in combination, as opposed to one in isolation (Davenport and Prusak, 1998; Milton et al., 1999; Trauth, 1999; Vaas, 1999, Duffy, 2001). The methodology consists of five main phases, each of which requires several intermediate stages to be undertaken. In essence, the methodology involves: identifying requirements, creating a short-list of suitable knowledge management tools, evaluating the tools, conducting pilot tests and finally purchasing a tool. The following sections provide a detailed account of each of the five phases and the associated intermediary steps.

Phase I

In order to achieve Phase I, Identify Requirements, it is necessary for a selection team to be formed. The team should consist of a variety of representatives from all levels of an organisation (McDonald, 1996). Ideally this would include: a chief knowledge officer (CKO), technical staff, managers, knowledge librarians, and potential users. The chief knowledge officer, or equivalent, should be a part of the team because their role is to ensure that the knowledge that exists within an organisation is captured and utilised to its maximum potential (Bonner, 2000). The purpose of technical staff being present on the selection team is twofold. Firstly, they need to ensure that the tool that is eventually selected is compatible with the existing infrastructure. Secondly, since they are the ones that will be supporting the tool,

Figure 2. Methodology for knowledge management tool selection



their input and advice is vital. The involvement of managers within the selection team is crucial since they have a global view of the particular area that they manage, enabling them to specify broader requirements for the tool in question. It is also important to identify and include, in the selection team, the people that will be maintaining the knowledge once the tool is installed, usually referred to as knowledge librarians. Finally, a number of users should figure in the selection team since, ultimately, they are the ones who will be using the tool on a day-to-day basis (Montazemi et al., 1996).

Once a satisfactory team has been formed, their first task is to identify both business and technical requirements (Curry and Bonner, 1983). The former entails specifying the business objectives that need to be achieved, the manner in which each will be addressed and a description of the role of the tool that is to be purchased. For instance, a business objective for an organisation may be to improve customer service. A possible way of addressing this is to reduce the time taken for the Help desk to resolve a query. This could be accomplished by having a system whereby the solutions to queries that have previously been resolved can be easily accessed and used, omitting the need for the same query to be solved time and time again. In light of this, the knowledge management tool required needs to facilitate the storage and retrieval of Help desk queries and their respective solutions.

The identification of the technical requirements consists of establishing what hardware and software currently exists in order to ensure that the purchased knowledge management tool is compatible (Martin and McClure, 1983; Mosley, 1992). Another decision that needs to be considered at this point is if a commercial knowledge management tool would be purchased if it required adapting in order to meet the organisation's requirements. If tools that require adapting are not to be considered, then these need to be discarded from the list of potential tools whenever such a tool is identified. There is no one single point in the methodology that facilitates this consideration since the necessity to adapt may be evident at any number of stages. If the purchasing organisation is prepared to adapt a commercial knowledge management tool, then a number of issues need to be taken into consideration. These include the party responsible for adapting the tool (the vendor or the purchasing organisation), the amount of adaptation required, etc. (Martin and McClure, 1983). If the purchasing organisation is relying on the vendor to adapt the tool, then it needs to be confirmed that the vendor is capable and prepared to do this. If the purchasing organisation has decided to adapt the tool themselves, then they need to ensure that they have the resources and expertise in order to achieve this.

Once the requirements have been established, the next stage involves identifying which of the knowledge management activities need to be supported by the tool. This may include one, two or all three of the knowledge management activities. For instance, referring back to the Help desk example, the knowledge management activities that would be involved are knowledge organisation and knowledge sharing. The former activity will need to be facilitated by the tool in order to store and allow the manipulation of queries and their respective solutions. The latter activity needs to be catered for by the tool so that the knowledge about the queries and respective solutions can be shared between Help desk staff. Having identified the knowledge management activities that the tool is required to facilitate, it is necessary to determine the budget available for purchasing the tool.

In the process of considering this, it is also important to establish whether or not the budget, in addition to the cost of purchasing the tool, will include costs for training, installation, licences, etc. (Mosley, 1992). Once the requirements, the type of tool required, and the budget have been identified, the software market needs to be scoured in order to identify knowledge management tools that meet these criteria. Therefore, prior to preceding to Phase II, a list of all of the knowledge management tools that could potentially be purchased should be created. At this stage it may be indicative that the software market does not provide a knowledge management tool that meets the criteria specified within Phase I. Therefore, it may be decided that the most appropriate option would be to pursue the development angle (Martin and McClure, 1983). This may involve developing the knowledge management tool internally if the expertise and resources are available. Alternatively, a software development company may be utilised to create the required knowledge management tool. Following this route entails a separate study and therefore is not included within this methodology. The boxes in Figure 2 representing the decision to develop are denoted using a dotted line.

Phase II

The aim of Phase II is to take the list created as a result of Phase I of the methodology and produce a streamlined short-list of knowledge management tools. This is achieved by carrying out a sequence of four steps, the objective being to refine the short-list of knowledge management tools with each additional step. The first step involves obtaining an overview and a general idea of the features provided by each of the tools in the short-list. In order to accomplish this documentation, brochures, user manuals and reviews should be gathered and carefully analysed (Sharland, 1991). The tools that are considered unsuitable should be discarded from the list and the remaining tools should be further investigated.

The second step consists of collating information about the actual vendors of the tools. The main aim of this is to ensure, as much as it is possible, that the vendors are reputable and have a stable position within the software market (Martin and McClure, 1983). The level of information gathered during this step depends on the circumstances of the installation and support required for the tool. For instance, if the tool is to be installed, maintained and supported by the purchasing organisation, then the role of the vendor is limited and therefore basic information about the vendor will suffice. However, if the vendor is required to have a major contribution subsequent to the tool being purchased, then a more thorough investigation is required. There are a variety of areas for which information can be collated about the vendor, including the background of the company, contact information and quality of service.

It is important to have some general knowledge about the vendor's background and current stance within the industry to ensure that the vendor is stable and in a position to provide a high-quality service. This may involve gathering information, such as when the vendor was established, whether it is part of another company and a current list of clients. The list of clients can be extremely indicative of the vendor since an association with reputable customers implies the ability to provide a good service (Martin and McClure, 1983). However, it is important to emphasise that the decision of selecting a vendor should not solely be based on the client list. Another way of determining the quality of the vendor by using the client list is to actually contact the vendor's clients and gather their views on the tool and the vendor.

Contact details for the company includes where the vendor is based and the person whom is the main point of reference. The location of the vendor may be important if training is to be conducted at the vendor's site. Consequently the costs of sending employees for training need to be taken into consideration and budgeted for. If possible, it is important to communicate with the same person representing the vendor since this gives the two companies an opportunity to establish rapport. Moreover, the vendor's representative can form a clear idea about the purchasing organisation's requirements (Curry and Bonner, 1983).

The quality of the service provided by the vendor should be continuously recorded, as it is crucial that the purchasing organisation is satisfied and comfortable with dealing with the vendor. Another useful method, recommended by Curry and Bonner (1983), of separating the stronger vendors from the weaker ones is to request the vendor to write a proposal detailing how their particular tool and company can address the purchasing organisation's requirements. According to Curry and Bonner (1983), high-quality and experienced vendors are accustomed to responding to requests for proposals and should do so within a given timeframe (specified by the purchasing organisation). Those that do not respond can be discarded from the short-list.

The third step involves taking the further refined short-list and visiting the vendors of each of the knowledge management tools in order to view a demonstration. Ideally, the demonstration should take place at the vendor site since this provides the purchasing organisation with the opportunity to obtain further insight about the vendor (Curry and Bonner, 1983). During the demonstration of the tool, it is important to ask the vendor to illustrate how to perform functions similar to the ones that the tool is intended to be used for. The responses to these requests can assist the purchasing organisation with determining whether the tool is able to support their needs and how competent the vendor is with the tool. As a result of this step, the tools that appear inappropriate or the vendor that seems weak should be discarded from the short-list.

The final step within Phase II involves contacting actual users of the tools using the clients list that should have been obtained as a part of the second step. The clients should be questioned about the quality of service provided by the vendor and details of any problems encountered. They should also be asked for their opinions with regards to the actual knowledge management tool, and Martin and McClure (1983) suggest approaching the users for their views on how the tool could be improved. After taking all of the information gathered during this step into consideration, a final short-list of knowledge management tools should be drawn up, ready for evaluation. As with the previous phase, the result of this phase may indicate that a suitable knowledge management tool does not currently exist in the software market. Therefore, the option to develop a knowledge management tool may be considered.

Phase III

Phase III of the methodology is concerned with obtaining a trial copy of the tool and conducting evaluation (McDonald, 1996). Therefore, each of the vendors associated with the knowledge management tools contained in the short-list should be contacted and a trial copy obtained. These are usually based on a variation of a limited period of time with access to all features or no time limit but restriction placed on certain features. Once the tool has been installed, it can be explored and experimented with. Trial copies usually come with a tutorial, therefore this is a good place to start becoming accustomed to the tool. Once a certain level of confidence is achieved, a structured and systematic evaluation of the tool should be conducted. For comparison purposes it is advisable to use a framework against which each of the knowledge management tools can be evaluated. An evaluation framework was designed as a broader part of this research and an earlier version of which is published in Patel and Hlupic (2000). The framework is designed to evaluate all aspects of purchasing a commercial knowledge management tool, including areas applicable across all software tools, e.g., costs, training, interface, etc. However, Table 3 demonstrates a small section of the evaluation framework that is applicable to knowledge management tools to enable the understanding of the criteria relevant to this area.

The framework was designed using a similar procedure for data collection as that described in the section about designing the methodology. However, users of knowledge management tools were also interviewed in order to obtain information about criteria that could make up the framework. Furthermore, several knowledge management tools such as those presented in Table 2 were empirically investigated to identify further criteria. As previously mentioned knowledge management tools appear to be designed in

Table 3. Framework for evaluating knowledge management tools

CATEGORY	CRITERIA		DESCRIPTION
General Criteria			
Type	o Generate knowledge o Organise knowledge o Share knowledge		Which of the knowledge management activities does the tool accommodate?
Purpose	o General o Specific		Has the tool been designed for a specific area? E.g. helpdesk
Type of knowledge	o Structured o Unstructured		What type of knowledge does the tool facilitate?
Format of data	o Numeric o Text o Graphics	o Audio o Visual	What format(s) of data does the tool facilitate?
Criteria for Knowledge Generation Tools			
Method	o Acquisition o Synthesis o Creation o Search o User profiling o Agents o Clustering	o Data entry o OCR o Voice input o Analysis o Web spiders o Data mining o Email	What method(s) is used to generate knowledge?
Criteria for Knowledge Organisation Tools			
Method	o Auditing o Categorisation o Manual Cataloguing o Auto Cataloguing o Filtering o App Integration o Portal User Interface o Full text search o Linking	o Indexing o Contextualising o Compacting o Visualisation o Channels o Doc Management o Image/Video search o Structured search o Unstructured search	What method(s) is used to organise knowledge?
Import facility	o Provided o Not provided		Is an import facility provided?
Loading formats	o Text files o Databases	o Spreadsheets o HTML	If an import facility is provided, what types of files can be loaded into the knowledge base?
Criteria for Knowledge Sharing Tools			
Method	o Flow o Push o Communities o App Sharing o Conferencing o Bulletin Boards o Messaging	o Publishing o Notification o Collaboration o Group decisions o Chat o Virtual Teams o File Transfer	What method(s) is used to share knowledge?

order to support one or more of the knowledge management activities. Therefore, the resultant framework was designed to reflect this and consists of four main parts. The first part labelled 'General Criteria' consists of criteria that can be applied to any knowledge management tool regardless of which of the knowledge management activities it has been designed to support. The remaining three parts represent each of the knowledge management activities: knowledge generation, organisation and sharing. The framework can be used in a similar manner to a checklist during the evaluation of the trial copy of the knowledge management tool. This forms a base for the tools to be compared quickly and easily. However, it is important to note that the criteria contained within the evaluation framework are by no means exhaustive and therefore would need updating on a regular basis, particularly considering the frequency of new knowledge management tools appearing on the software market.

Once each of the tools contained in the short-list has been evaluated using the framework, those tools that are considered inappropriate should be discarded. The remaining tools should be listed according to the order of preference. The short-list now becomes a list of 'Candidate Tools' as demonstrated in Figure 2.

Phase IV

This phase involves taking the knowledge management tool positioned at the top from the list of candidate tools and conducting a pilot test (McDonald, 1983). This involves installing the tool in the environment the purchased tool is intended to be used. A selection of users should use the tool for a period of time determined by the purchasing organisation, as though it is a replacement for the existing system. It is probably best, whenever a pilot test is being conducted, to use old data from the existing system so as not to have a negative impact. However, it is important to note that while pilot testing is being undertaken, the old system should continue to support the organisation. In many cases the installation of a knowledge management tool will be a completely new initiative. Under these circumstances the tool should be installed and used by people who intend to use the tool that is finally purchased. If the data for the tool does not exist or is unavailable, then representative test data needs to be created.

Once the time limit for the pilot test is reached, then the users must be questioned about their views and opinions on the tool (McDonald, 1983). If the outcome is positive then the final selection can be made. However, if the outcome of the pilot test is negative then it is necessary to consult the candidate list of tools created as a result of Phase III and the next tool on the list should be pilot tested. If the results from the pilot test indicate an equally divided outcome, then it may be worth extending the testing period and perhaps involving a few more users in the evaluation. This process should be repeated until a suitable tool is identified and a final selection can be made.

Having selected a tool that is approved by both selection team and users, it is possible to approach the vendor to negotiate a contract. Martin and McClure (1983) provide a detailed discussion of what factors to consider when drawing up a contract. In summary, the contract should cover issues such as support, warranties, licences, etc. Furthermore, the contract is likely to be biased towards the vendor. Therefore, it is important to negotiate new terms that favour both parties (Martin and McClure, 1983). If the vendor disagrees to drawing up a new contract, then the purchasing organisation should re-consider carefully another vendor or tool, or both, if necessary. If another suitable vendor that supports the required tool cannot be found, or suitable terms and conditions agreed, then another tool will have to be considered. This involves selecting the next tool from the candidate list produced during Phase III. Once an appropriate knowledge management vendor and contract have been achieved, the tool can be purchased, which is the final phase, Phase V, of the methodology.

Phase V

Purchasing the knowledge management tool is the objective of this methodology and once this is achieved, the procedure concludes. However, at this stage an entirely new procedure begins for the organisation. This involves adapting the tool, if necessary, installing and integrating it into the organisation. This may be done by the organisation itself or the tool vendor. Regardless of who the responsible party is, this can be a long, drawn-out process that may require numerous cycles of testing. Once the knowledge management tool has been integrated, it is necessary to monitor the tool and ensure that it is functioning in the desired manner. It is important to note that this is an extremely brief version of activities that may take place subsequent to the knowledge management tool being purchased. However, the aim of this chapter was to present a methodology for the selection of commercial knowledge management tools, therefore the discussion concludes here.

USABILITY OF THE METHODOLOGY

The methodology presented in Figure 2 can be useful to both industry and academia. The former will be able to use the methodology to facilitate the purchase of a knowledge management tool. This will save them from having to invest time and money developing their own methodology and investigating the knowledge management software market. The latter will benefit because the current literature related to the technical aspects of knowledge management is limited, and this will contribute and help to provide some clarification in the area. The methodology has been used for the evaluation and selection of knowledge management tools by members of the Brunel Centre for Knowledge and Business Process Management (KBM, 2001). Furthermore, companies involved in participating in the interviews in order to share their experiences of evaluating and selecting a knowledge management tool have expressed that had such a methodology been available when they were embarking on purchasing a suitable knowledge management tool, they would have found it very useful.

CONCLUSIONS

In summary, the constant increase in interest in knowledge management has resulted in an overwhelming number of knowledge management tools available in the software market. This presents a problem for purchasing organisations that are required to sift through a vast number of tools. Furthermore, some form of guideline for the selection of knowledge management tools is lacking from the literature. Therefore, the purpose of this chapter was to present a methodology to aid organisations with the selection of an appropriate knowledge management tool. In essence, the methodology aims to identify the organisation's requirements, which are used to select an initial list of knowledge management tools. This list is continually refined until a practical short-list is achieved. A detailed evaluation of each of the tools contained in the short-list is conducted using an evaluation framework. Subsequently, those tools that are considered suitable are ordered according to preference and in turn pilot tested with users. Once the users are satisfied with a tool and a contract negotiated with the vendor, the knowledge management tool can be purchased.

In conclusion, the plethora of knowledge management tools makes a set of guidelines for tool selection essential. The methodology and evaluation framework presented in this chapter achieves this, particularly since no other guidelines for knowledge management tools exist. Furthermore, indications from companies have shown that such a facility would be useful and would be adopted to aid the evaluation and selection process.

REFERENCES

Anderson, E. E. (1990). Choice models for the evaluation and selection of software packages. *Journal of Management Information Systems, 6*(4), 123-138.

Angus, J. and Patel, J. (1998). Knowledge management cosmology. *Informationweek,* (March 16), 59.

Angus, J., Patel, J. and Harty, J. (1998) Knowledge management: Great concept…But what is it? *Informationweek*, (March 16), 58-70.

Berryman, R., Clark, G. and Ho, A. (1994). An exploration into practices and theories of software evaluation for educational use. *Computers in New Zealand Schools, 4*(1), 14-19.

Bicknell, D. (1999). Knowledge manager's don't work. *Computer Weekly*, (May 27), 26.

Bonner, D. (2000). Enter the chief knowledge officer. *Training and Development*, *54*(2), 36-40.

Borghoff, U. M. and Pareschi, R. (1997). Information technology for knowledge management. *Journal of Universal Computer Science. Special Issue on Information Technology for Knowledge Management, 3*(8), 835-842.

Breslin, J. (1986). *Selecting and Installing Software Packages.* New York: Quorum Books.

Buckleitner, W. (1999). The state of children's software evaluation: Yesterday, today and in the 21st century. *Information Technology in Childhood Education, 1,* 211-220.

Curry, J. W. and Bonner, D. M. (1983). *How to Find and Buy Good Software: A Guide for Business and Professional People.* Englewood Cliffs, NJ: Prentice-Hall.

Davenport, T. H. (1993). *Process Innovation: Reengineering Work Through Information Technology.* Boston, MA: Harvard Business School Press.

Davenport, T. H. (1996). We have the techknowledy: New tools for knowledge management. *CIO Magazine*, (September 15). Available: http://www.cio.com/archive/091596/dav.html.

Davenport, T. H. (1997). *Information Ecology: Mastering the Information and Knowledge Environment.* New York: Oxford University Press.

Davenport T. H. and Prusak, L. (1998). *Working Knowledge: How Organisations Manage What They Know.* Boston, MA: Harvard Business School Press.

Duffy, J. (2001). The tools and technologies needed for knowledge management. *Information Management Journal*, *35*(1), 64-67.

Dupuy, A. and Leveson, N. (2000). An empirical evaluation of the MC/DC coverage criterion on the HETE-2 satellite software. *Proceedings from DASC (Digital Aviation Systems Conference),* Philadelphia, October.

Ferran-Urdaneta, C. (1999). Teams or communities? Organisational structures for knowledge management. *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research*, 128-134.

Forte, G. (1992). Tools fair: Out of the lab, onto the shelf. *IEEE Software*, (May), 70-79.

Hammer, M. and Champy, J. (1993). *Re-Engineering the Corporation: A Manifesto for Business Revolution.* London: Nicholas Brearley.

Hibbard, J. and Carillo, K. M. (1998). Knowledge revolution: Getting employees to share what they know is no longer a technology challenge–It's a corporate culture challenge. *Informationweek*, (January 5), 663.

Hlupic, V. (1997). Simulation software selection using SimSelect. *Simulation*, *69*(4), 231-239.

Jackson, C. (1999). *Process to Product: Creating Tools for Knowledge Management.* Available: http://www.brint.com/members/online/120205/jackson/.

KBM. (2001). *Brunel Centre for Knowledge and Business Process Management.* Available: http://www.brunel.ac.uk/depts/cs/research/kbm/index.shtml.

Klamma, R. and Schlaphof, S. (2000). Rapid knowledge deployment in an organisational-memory-based workflow environment. In Hansen, H. R., Bichler, M. and Mahrer, H. (Eds.), *Proceedings of the 8th European Conference on Information Systems (ECIS 2000: A Cyberspace Odyssey), 1*, 364-371.

Klein, G. and Beck, P. O. (1987). A decision aid for selecting among information system alternatives. *MIS Quarterly, 11*(2), 177-185.

Kramer, M. (1998). Knowledge management becomes catch phrase but eludes easy definition. *PC Week*, (December 7), 95.

Le Blanc, L. A. and Jelassi, T. (1991). *An Empirical Assessment of Choice Models for Software Evaluation and Selection*. Working Paper, INSEAD No.91/24/TM.

Lennox, G. and McNairn, I. (1999) Making the connection between the mind and the database. *The Original Knowledge Management, 2*(4), 3-6.

Lynch, R. K. (1985). Nine pitfalls in implementing packaged applications software. *Journal of Information Systems Management*, *2*(2), 88-92.

Macintosh, A. (1999). *Knowledge Management.* Available: http://aiai.ed.ac.uk/~alm/kamlnks.html.

Martin, J. and McClure, C. (1983). Buying software off the rack. *Harvard Business Review, 61*(6), 32-47.

McDonald, T. (1996). Evaluating primary health care software packages. *ITCH '96 (A Conference Addressing Information Technology Issues in Community Health),* Victoria Conference Centre, Victoria, Canada, November 3-6.

Milton, N., Shadbolt, N., Cottam, H. and Hammersley, M. (1999). Towards a knowledge technology for knowledge management. *International Journal of Human-Computer Studies, 51*(3), 615-641.

Mosley, V. (1992). How to assess tools efficiently and quantitatively. *IEEE Software,* (May), 29-32.

Montazemi, A.R., Cameron, D. A. and Gupta, K. M. (1996). An empirical study of factors affecting software package selection. *Journal of Management Information Systems, 13*(1), 89-105.

Nikoukaran, J., Hlupic, V. and Paul, R. J. (1998). Criteria for simulation software evaluation. In Medeiros, D. J., Watson, E. F., Carson, J. S. and Manivannan, M. S. (Eds.), *Proceedings of the 1998 Winter Simulation Conference*, 399-406, Washington, DC, USA.

Parnas, D. L., John van Schouwen, A. and Po Kwan, S. (1990). Evaluation of safety-critical software. *Communications of the ACM, 33*(6), 636-648.

Patel, N. and Hlupic, V. (2000). The design of a framework for knowledge management tool evaluation. In Remenyi, D. (Ed.), *Proceedings of First European Conference on Knowledge Management*, 223-230, Bled School of Management, Bled, Slovenia. October 26-27.

Reilly, M., Matarazzo, T. and Ives, W. (1998/1999). Once upon a corporate time: The role of stories in organisational learning. *Knowledge Management, 2*(4), 7-12.

Robson, M. and Ullah, P. (1996). *A Practical Guide to Business Process Re-engineering.* Hampshire: Gower.

Ruggles, R. (1997). *Knowledge Tools: Using Technology to Manage Knowledge Better.* Available: http://www.cbi.cgey.com/pub/docs/KnowledgeTools.PDF.

Sharland R (1991). *Package Evaluation: A Practical Guide to Selecting Applications and Systems Software*. London: Avebury Technical.

Silver, C. A. (2000). Where technology and knowledge meet. *The Journal of Business Strategy, 21*(6), 28-33.

Trauth, E. M. (1999). Who owns my soul? The paradox of pursuing organisational knowledge in a work culture of individualism. *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research*, April 8-10, New Orleans, LA, USA.

Vaas, L. (1999). Brainstorming: Before opening the floodgates to new KM technologies, IT managers should make sure users are ready, willing and able to share what they know. *PC Week*, *16*(22), 65.

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Chapter 3.23
Knowledge Management in Safety-Critical Systems Analysis

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INTRODUCTION

Knowledge management in the design of safety-critical systems addresses the question of how designers can share, capitalize, and reuse knowledge in an effective and reliable way. Knowledge management is situated in groups, organizations, and communities, playing different roles in the design process. Design of safety-critical systems has specific properties, such as dealing with complexity, traceability, maturity of knowledge, interaction between experts, awareness of the status of information, and trust in knowledge. Documentation is of crucial importance in design processes, ensuring that these properties are taken care of in a proper and reliable way. However, writing is not an easy task for engineers, and support is needed. Several knowledge management solutions, both tools and organizational setups, are available to support design work, such as active notification of changes, personal and team workspaces, active design documents and knowledge portal solutions.

SITUATING KNOWLEDGE MANAGEMENT

Knowledge management (KM) has become an important research topic, as well as a crucial issue in industry today. People have always tried to organize themselves in order to capitalize, reuse, and transfer knowledge and skills among each other within groups. Poltrock and Grudin (2001) propose the triple distinction team-organization-community for groups. KM tools and organizational setups usually emerge from the requirements of one of these kinds of groups. Note that we do not dissociate a KM tool from the group that is likely to use it.

A team is a small group of persons that work closely with each other, but not necessarily in the same location. A leader often coordinates its work. Team participants typically fulfill different roles. They strongly need to communicate. The following groups are examples of teams: software development teams, proposal writing teams, conference program committees, and small operational groups such as customer support or research project teams. Support technologies include: buddy lists, instant messaging, chat, Groove (a peer-to-peer team collaboration environment), Quickplace (provides an instant virtual team room where information is managed), BSCW (both a product and a free service for managing information for self-organizing groups, Bentley, Horstmann, & Trevor, 1997), video conferencing, data conferencing, and eRoom (team workspaces with shared workspaces, calendars, and discussions through a Web browser).

The structure of an organization is typically hierarchical. Modern organizations are usually geographically distributed. They strongly need to be coordinated. The following groups are examples of organizations: companies, governments or government agencies, and non-profit organizations. Support technologies include: e-mail, calendars, workflow, Lotus Notes (an integrated collaboration environment), intranet applications and webs, document management systems, and broadcast video.

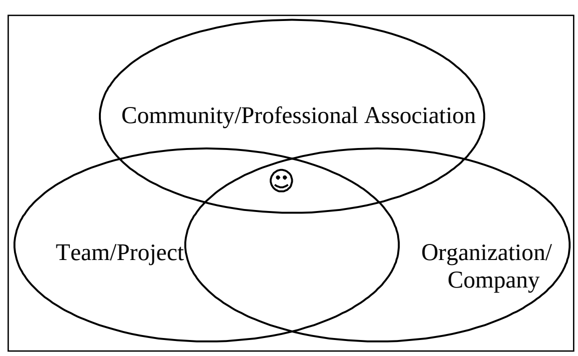
Communities share a common interest but no structure. They are usually geographically distributed and provide services to people (e.g., the European KM Forum, Amazon.com). The following groups are examples of communities: citizens of a city or neighborhood, special-purpose chat groups, virtual world citizens, auction participants, stamp collectors, and retired people. Support technologies include: Web sites, chat rooms, and virtual worlds.

In the field of safety-critical systems, teams, organizations, and communities inter-relate in order to insure quality on both products and processes. They are highly constrained. Usually teams are made to carry out projects and programs; they may be multi-national for example. Organizations are made to manage people within a consistent space, such as a national company that is more appropriate to handle social laws and customs of the country where it is chartered. Communities are made to help people who share the same kind of work practice to refer among each other, such as a community of electrical engineers. We summarize these distinctions in Figure 1.

A project team exists only during the time of the related project. A company may have several projects or programs that themselves may involve people from others companies. A company may become obsolete when the type of products it produces is no longer appropriate with the current market. Professional communities survive the obsolescence of both projects and companies. They actually may also become obsolete when either technology and/or the social world change.

In this article, we will present specific issues brought by the design of safety-critical systems, and human factors related to documentation generated and used in design processes. We will also focus on related current design issues. The specificity of safety-critical design knowledge will be presented. Several KM management solutions

Figure 1. An individual may belong to a project team, a company, and a professional association at the same time.



will be discussed. The article concludes with a discussion on the difficulties and challenges of KM in engineering.

The article is coming from several knowledge management projects performed in cooperation with groups of engineers in large aerospace and telecommunication companies. In particular, most recent findings come from the European Research and Development project WISE (IST-2000-29280; www.ist-wise.org). In WISE (Web-Enabled Information Services for Engineering), we study work-practices of engineers in large manufacturing companies, and we design practical methods to easily share and access essential knowledge and information for their tasks. These methods are supported by the development of an engineering knowledge portal application. The industrial partners involved in this project are Nokia and Airbus. Other partners are Cyberstream Interface SI, PACE, EURISCO International, Norwegian Computing Centre Helsinki University of Technology, and Technical University of Berlin.

Designing Safety-Critical Systems

Safety-critical systems have specific properties that directly affect the way knowledge management is carried out. Examples of safety-critical systems are aircraft, power plants, medical equipment, and telecommunication systems. They are basically complex, as complete as possible, and described by mature knowledge. Safety is not only a matter of end-user emotion, attention, and cognition; it is also a matter of organization and people involved in the whole lifecycle of related products. They involve experts that need to co-operate. For that matter, traceability of decisions is crucial.

Safety-Critical Systems Communities as Families

People working on safety-critical systems, in domains such as aerospace, nuclear power plants, and medicine, form strongly connected communities of practice that could be seen as families. They have their own meetings, workshops and conferences, even journals, where they can exchange experience, foster research, and improve knowledge on safety-critical systems in general. These communities work across organizations and teams. They tend to become references and initiate standards in the related field. They are recognized bodies for knowledge validation, providing principles for assessing knowledge maturity.

Dealing with Complexity

Even if the designers of safety-critical systems should always have in mind to design for simplicity, what they have to do is inherently complex. Systems are complex, and processes to design and develop these systems are complex. In the design process, designers rely on knowledge that is available in the form of handbooks, lessons learned, and best practices. Designers have to take into account the experiences with older systems, on which the new system is usually building, making sure that incidents and accidents that have happened are no longer possible in the new design. Designs are verified and validated in extensive, well-defined processes. In the end of the design process, certification by different authorities and certification bodies can also play a large role. In order to get a system certified, one has to be able to justify the choices that were made, to prove, as far as possible, that all knowledge about problems with similar systems has been taken care of, and that the system will function safely in all kinds of difficult and even disastrous scenarios.

Targeting Completeness in an Open World

Safety-critical systems require complete definition of their (cognitive) functions that they involve in terms of role, context of validity and use, and appropriate resources that they need to accomplish their functions (Boy, 1998). A cognitive function analysis is usually mandatory when we need to demonstrate that the system being designed satisfies a set of safety requirements. Completeness does not apply only to the mandatory kinds of functions, but also to the situations that end-users may encounter when they are using the systems. Completeness is difficult and often impossible to reach. This is why groups that design safety-critical systems use simulators in order to multiply the number of situations and cover a broader spectrum. They incrementally accumulate and articulate related knowledge by categorizing relevant situations.

Maturity of Knowledge and Maturity in Design

We claim that knowledge is constructed—let us say designed. The design of knowledge is incremental. Safety-critical systems are designed over time. They are tested, modified several times, and certified. Their use is carefully observed and documented. The resulting observation product, usually called experience feedback, is provided to designers who use it to modify their current understanding of the artifacts they have designed. Knowledge about these artifacts becomes progressively mature through this incremental process. There are short-loop design-knowledge validation processes that lead to official documents guiding the design process. There are also long-loop design-knowledge validation processes that involve experience feedback on already mature artifacts. In particular, engineers involved in safety analysis have an everyday need in using internal official documents. For example for a system safety analyst, requirements, courses, applicable documents, lessons learned (in-service experience), FAQs, lists of experts, previous similar deliverables, review results, validation and verification checklists/action lists, and system review action lists are crucial information that needs to be easily accessed.

Dealing with Drafts

Not all documents are finalized and approved at any time. Designers have to deal with draft documents, addressing questions such as how one can recognize that a document is ongoing, how versioning is taken into account, how revisions are managed. The validation of a document is related to the appropriate list of signatures. When a document is validated, it becomes "official." Each design rationale description should be appropriately contextualized. including its status (i.e., mainly the revision and approval dates) and background information (where it is coming from and who did it). In order to follow appropriate guidelines to edit and publish such a document, training may be necessary and guidelines should be easily available. From a broader standpoint, our investigations led to the distinction between private and public spaces of a document—that is, each technical document has a private space where it is invisible outside of a specific community, and a public space where it is visible by a wider community.

Awareness and Communication Between Experts

Situation awareness is a key issue in safety-critical systems. It is much studied at use time. However, it requires more attention at design and development times. People may make errors because they are not aware of the current situation or state of the art. Is Team 1 aware of current actions and productions of Team 2 at the right time? Is Team 1 aware of what Team 3 did a few years ago on the same topic or a similar one? How can we increase awareness? In some cases, it would be nice to have the appropriate information pushed to the front so potential users are aware of its existence.

In addition, efficient search mechanisms should provide the necessary means to pull appropriate information when needed. In both cases, context-sensitive algorithms, which may take the form of software agents, are necessary.

When designers know about a type of incident or accident that involved a piece of equipment that they are designing, they (at least try to) design artifacts in order to provide users with the necessary means to handle related situations in the best possible way. They are expert in their field (i.e., design). People who are likely to provide this "incident/accident" knowledge are human factors specialists, end-users themselves or experiences laid down in appropriate databases and knowledge bases. In any case, experts need to communicate either in a live way, such as using computer-supported cooperative work environments, or in a remote way, such as using knowledge bases. Space-time constraints usually impose choices in the way such communication would happen.

Traceability in Space and Time

One of us carried out an exhaustive study on traceability within a large aircraft manufacturing company (Boy, 2001). Traceability is not only information retrieval, it also deals with awareness that potential knowledge exists somewhere, and finally when this knowledge is found, it must be understood correctly. Whether they are project teams, corporate organizations, or professional communities, groups have difficulty providing clear explanations of why things were done in a certain way. This is due to the geographical spread-out of people composing these groups, speed of technology evolution, high turnover of personnel, and lack of documentation of the design process. We will see below that writing is a key issue that cannot be removed from the design activity. People need to know salient reasons that pushed other people to design artifacts they are currently responsible for. This remains true during the whole lifecycle of an artifact.

Trust in Knowledge

Whenever someone gets knowledge from someone else, a crucial issue is to figure out if it is reliable. Do I trust this knowledge without experiencing it? What are the processes that I would need to implement to believe that this knowledge is reliable? The use of Web technology opens our horizons to a wider spectrum of knowledge providers, but we are less sure that acquired knowledge might be trusted. The level of maturity needs to be clearly understood. Consequently, knowledge should come with contextual information that reinforces our understanding of its maturity and context if used.

In the study of Bonini, Jackson, and McDonald (2001), three dimensions of trust were found of importance: belief, dependence, and experience. If you have to trust the information coming from others, you have to be confident in the other and the information provided, you are dependent because you need the information, and you rely on the experience you have with this person and the information. In design processes, the designer is regularly in a dependent position, because preliminary versions are shared between group members and designs of other, related systems are often also in a not yet stable version (participatory design).

Especially in the design of safety-critical systems, one has to make sure that the knowledge that is shared is correct and can be trusted. For this reason extensive validation and document version management is in place in industries. One should avoid the risk of basing one's design on information that has not been verified, and designers should be aware what the latest version of a document is in order to use it.

DESIGN IS WRITING, AND WRITING IS DESIGN

Knowledge management for safety-critical systems mostly deals with documentation since everything should be traceable and formally validated. Consequently, the way things are written is crucial. However, writing is not always perceived as a key issue in engineering and design. Engineers are not scientists who base their careers on the number and quality of the papers they produce. A technical document may be generated the day before delivery just because it was planned to do so. Engineering culture is based on creativity and efficiency, based on very specific languages, often in the form of drawings and schematics that cannot be understood by an outsider. Engineers do not perceive the writing-for-all philosophy as relevant.

Two Separate Worlds: Engineering and Literature

The distinct worlds of engineering and literature barely met during the last century. The human-computer interaction (HCI) community has nicely introduced design "into the picture" since user interfaces require a subtle combination amount of technique and graphical art. There, science and arts met. In knowledge management, a deeper step is required. Designers need to step into literature. They need to write technical documents describing requirements, specifications, job orders, evaluation rationale, training and performance support, experience feedback, and a large variety of official documents. It has been observed that people who are already in senior positions in an organization know the benefit of good documentation, and tend to write more than younger employees who do not have as much experience. Document content should satisfy the objectives, thus answering the question: Why and for whom are we writing this document?

In addition, in international environments such as contemporary European multi-national companies, writing in English may be a difficult task for non-native English-speaking personnel. The result is that produced English-written documents may be difficult to understand

The Time-for-Writing Issue

Project deadlines are always very short and do not allow enough time for decent writing. In an engineering organization, the real job is design, not writing. People are usually awarded on design performance issues, not on documentation issues. Writing time should be clearly planned in a project schedule and given the same priority as other activities, so that when there is an extension in the duration of the project, writing is not the last item on the agenda when there is little time left to perform it, as is often the case.

What is Obvious for Someone (Expert) is Not Necessarily for Someone Else

There is no consensus whether writing has improved over the years, for example, in the aeronautics domain. However, some people think that most aerospace technical documents generated during the 1960s are remarkably precise. They were not ambiguous. Work was very well done. People had time and resources to write properly. Other people think that current engineers do not capitalized the necessary technical background to produce appropriate and sufficiently detailed technical documents. It is very important that a selected group of readers reviews all documents. If someone does not understand a technical document, then it should be modified and improved towards a better comprehension. We should apply to documents the same kind of usability testing and user-centered design procedures as for systems. Human factors principles are very similar. Sometimes we say "writing is design, and design is writing."

Redefining Prose Rules Using Multimedia

This statement claims that the quality of technical documentation contributes to the quality of design. We usually write for potential readers. In the same way, we design for potential users. Researchers know that several persons must review papers before being delivered outside. We also know that several persons must test artifacts before being delivered outside. The reader of a multimedia document has become a user of a software application. From this viewpoint, reading a physical note, report, or book has evolved towards interacting with a computer. Writing has also evolved towards design of interactive software. Writing words, phrases, paragraphs, and chapters has become designing objects and software agents. Static paper documents have become (inter)active documents.

The active part of a book (system) is the reader (user). In addition, the organization of the book (system), the way phrases (objects) are written (designed), style, and lexicon used suggest reader (user) activity. Sometimes, the reader (user) hardly understands what the author (designer) wanted to express. Instead of mobilizing the cognition of the reader (user) on interaction problems, the most important part of the cognitive activity of the reader (user) should be centered on the understanding and interpretation of (active) document content.

Toward Simplicity

Design documents are not only outputs of design processes, but also inputs—that is, formulating design rationale contributes to improving the design itself. There are two issues of simplicity: documenting to improve the simplicity of use of a system being developed, and reducing the difficulty of generating technical documents—that is, making it simpler. Simplest systems are best used. In most cases, when systems are too complicated, they are not used at all. This is true both for the system being developed and for its documentation.

Writing from Bottom-Up (Annotations) vs. Top-Down (Requirements)

People tend to write little notes either by using Post-Its, personal notebooks, page marks, and so on. They annotate what they do and use these notes in order to improve the capacities of their own short-term and long-term memories. If this kind of practice is very useful to people themselves, for a short term, interoperability becomes a problem when such knowledge needs to be exchanged with others or reused by the same person after a longer period of time. Annotations can be considered as pragmatic knowledge that needs to be structured if it is to be used by others. People cannot structure such knowledge in the first place because it is intrinsically situated—that is, it is captured in context to keep its full sense. This is why a mechanism that would support annotation generation and why structuring can be a powerful tool.

APPROPRIATE TOOLS AND ORGANIZATIONAL SETUPS

In industries that develop safety-critical systems, a variety of knowledge management tools are available. Also in R&D projects (including projects in the European Frameworks), many KM tools have been developed. It is clear that tools cannot be designed and used without appropriate organizational setups. People adapt to technology and groups, whether they are teams, organizations, or communities. However, adaptation can be limited by the constraints imposed by tools and socio-cultural habits of the people involved.

Active Notifications of Changes in Design

Designers of safety-critical systems are expected to be proactive people who manage information using available tools in their organizational setups. However, information technology is capable of augmenting their initial skills. Software agents may provide assistance in a variety of tasks that require routine, and usually boring, actions. Safety-critical technology always incrementally changes due to accidents and incidents, customer requirements and needs that continuously evolve, and refinement of the technology itself. There is always a discrepancy between these effective changes of technology and its related operational documentation. People need to be notified about changes in order to operate such technology in a safe way. When such notification is timely, it is usually passive and left to the expertise or intuition of the user; it may not be noticed. This is why a system that would provide proactive notification of changes would be tremendously useful. In the WISE environment, people can subscribe to documentation, indicating about which changes (updates, deletion, status changes, etc.) they want to be notified, by e-mail or in the active work environment.

Supporting the Writing Process

Above we have emphasized the importance of writing for the design process. Tools are available that can support engineers in documenting their work, and capture annotations during the design work, not just after the design is finished. An example of such a tool is the Computer Integrated Documentation (CID) system developed at NASA (Boy, 1991). Another example can be found in the IMAT (Integrating Manuals and Training) system developed for designing learning material (de Hoog et al., 2002). Also in the WISE workspace, the engineer is enabled to make annotations to all different kinds of knowledge objects and to choose whether to share them with team members or others.

Crisp and clearly understood design rationale is a good indicator of maturity in design. Formalisms have been developed to describe design rationale such as gIBIS (graphical Issue-Based Information System) (Conklin & Begeman, 1989) or QOC (Questions Options Criteria) (MacLean, Young, Bellotti, & Moran, 1991). They support the elicitation of design rationale and enable the documentation of design decisions, development plans, and systems that are effectively developed.

Organization of Personal and Team Workspaces

In current communication and cooperation software, very efficient search engines are available; bottlenecks are elsewhere. They are in the way people categorize incoming information with respect to what is already available on their desktop. This categorization is a strong condition for further retrieval and traceability. People organize their workspace in order to perform their tasks efficiently and manage time and content accordingly. They use Post-Its, bookmarks, document piles, proximity for urgent or frequent access, and so on. In any case, people do not stop to fine-tune their initial categorization to better fit their everyday needs. In the WISE project we have developed a environment in which users have a personal workspace in which they can organize the knowledge they need for their task, as well as a workspace for groups in which knowledge can be pre-structured and shared. The environment consists of a portal that gives access to the companies' documentations, databases, and tools, including search facilities on all knowledge objects thus available, of whatever format or location.

Active Design Documents

The concept of active design document (ADD) (Boy, 1997) was developed to support designers of safety-critical systems in knowledge management. Active documentation may take various forms and involve different kinds of content. An ADD is defined by four categories that organize a designer's workspace: interface objects, interaction descriptions, contextual links, and design rationale.

Interface objects (IOs) provide appropriate, useful, and natural illusions of designed artifacts. IOs have their own behavior reflecting the behavior of related artifacts. They enable users to test usefulness and usability of related artifacts. They provide concrete feeling and grasp of the use of an artifact, its learning requirements, its purpose hands-on, and so forth. Their progressive integration leads to a series of prototypes and, in the end, the final product.

Interaction descriptions (IDs) provide the specification of user-artifact dialogue. IDs may be expressed in either natural language, or a domain-specific technical language ranging from textual descriptions in simplified English (operational procedures for example) to a knowledge representation like the interaction blocks (Boy, 1998). A main advantage of using interaction blocks is to enable formal testing of interaction complexity, and expressing contexts and abnormal conditions of use explicitly.

A test user either follows IDs and produces an activity by using appropriate related IOs, or interacts directly with IOs and verifies the validity of related IDs. In both cases, he or she tests the links between IOs and IDs in context (i.e., in the context of the task being performed). The corresponding category is called contextual links (CLs). This is where usefulness and usability evaluations (sometimes annotations) are stored in the form of either free text or specific preformatted forms.

Design rationale (DR) provides the reasons why the IOs and IDs of an artifact have been designed the way they are, and design alternatives that were not chosen. DR is commonly implemented by using semi-formal languages such as gIBIS or QOC already mentioned.

ADDs are tools that support not only communication and mediation, but also prototyping and evaluation. They enable their users to store design knowledge according to a concrete and systematic formalism. Creation and maintenance of such ADDs enable an entire organization to maintain awareness of their design processes and products.

Interoperable Documents and the Portal Concept

Documents should be interoperable. This requirement induces two kinds of issues: standards and integrated environments. When people exchange documents across teams, organizations, and communities, they expect the others to be able to process what they provide. This is commonly a matter of standards. In a closed world where an organization can cope with an integrated environment in the form of intranet for example, people do not have to worry about standards. Nevertheless, standards progressively emerge from the extensive use of specific types of documents.

Designers require KM environments that are user-centered (easy to use and avoid overload) and integrated within their current tasks. They should have easy access to KM services at each design step. For example, in a safety assessment process, there should be information provided for performing safety analysis and related documents. In other words, the designer workspace should be (re)designed in such a way that he or she has easy access to experience feedback (e.g., not only a list of what is necessary to do and forbidden (checklists), but providing deep knowledge to foster preventive design actions and avoid later corrective actions) at any time. Having this knowledge available at the designer's desktop at all times can be realized by a KM portal. A portal means that it provides access to knowledge, wherever it is located, but does not contain this knowledge itself. In the KM portal developed in WISE, designers have access to knowledge available in, for example, databases with experience feedback, lessons learned, and best practices, to all kinds of relevant documents, and to people who can bring interesting knowledge and experience. Access to all these sources is provided in the same manner and with a single search facility.

CONCLUSION

The way knowledge is exchanged during the design and the further lifecycle of a safety-critical system induces several factors related to systems (complexity, completeness, maturity, traceability) and people (expertise, writing, simplicity, drafts, information credibility, uncertainty, and awareness).

Several actual developments influence the design processes of safety-critical systems: more people from different organizations (within the company or (sub)contractors) get involved, more procedures are in place (such as certification procedures, involving human factors in particular), and product development needs to be faster than before. These evolutions have a direct impact on the increase of both the number and content of documents. Information technology provides new means to generate, maintain, and use such documents. A main issue is to improve the use of such means.

Important questions remain to be answered: Does this technology change the job of engineers? Does it free up engineers from boring tasks? Or does it create new ones? Answers to these questions are complex. However, this article contributes by providing categories of KM solutions such as the organization of personal and team workspaces, active design documents, and knowledge portals. Usefulness and usability of such solutions need to be tested carefully in a real-world environment with a critical mass of people involved. This is very difficult to do since experts and specialists (e.g., designers of safety-critical systems) are always occupied, busy, and constrained into an already existing KM system, often very far from the solutions proposed. Transformations should be incremental, accepted by the people involved. Implementing a new KM system is also redefining a new philosophy of work, a new culture. This is hard to do and hard to implement! This is the main reason why the design of new KM systems must be human-centered—that is, team-centered, organization-centered, and community-centered. Each of these types of group has its own motivations, requirements, and constraints.

REFERENCES

Bentley, R., Horstmann, T., & Trevor, J. (1997). The World Wide Web as enabling technology for CSCW: The case of BSCW. *Computer-Supported Cooperative Work: Special Issue on CSCW and the Web, 6*.

Bonini, D., Jackson, A., & McDonald, N. (2001). Do I trust thee? An approach to understanding trust in the domain of air traffic control. *Proceedings of IEE People in Control, UMIST,* Manchester, UK.

Boy, G.A. (1991, December). Indexing hypertext documents in context. *Proceedings of the Hypertext'91 Conference,* San Antonio, TX.

Boy, G.A. (1997). Active design documents. *Proceedings of the ACM DIS'97 Conference.* New York: ACM Press.

Boy, G.A. (1998). *Cognitive function analysis.* Stamford, CT: Ablex.

Boy, G.A. (1999). *Traceability*. EURISCO-Airbus Report T-99-060-V3.

Conklin, E.J., & Begeman, M.L. (1989). gIBIS: A tool for all reasons. *Journal of the American Society for Information Science, 40,* 200-213. (This article describes a graphical support tool for IBIS.)

de Hoog, R., Kabel, S., Barnard, Y., Boy, G., DeLuca, P., Desmoulins, C., Riemersma, J., & Verstegen, D. (2002). Re-using technical manuals for instruction: Creating instructional material with the tools of the IMAT project. In Y. Barnard, M. Grnadbastien, R. de Hoog, & C. Desmoulins (Eds.), *Ingrating Technical and Training Documentation, Proceedings of the ITS2002 Workshop, 6th International Conference on Intelligent Tutoring Systems,* San Sebastian, Spain/Biarritz, France.

MacLean, A., Young, R.M., Bellotti, V.M.E., & Moran, T.P. (1991). Questions, options and criteria: Elements of design space analysis. *Human-Computer Interaction, 6*, 201-250. (This article describes the background for designing space analysis and the QOC notation. It explains how it can be used in the design process and to study reasoning in design. Other articles of interest on this topic also appear in this issue of the journal.)

Poltrock, S.E., & Grudin, J. (2001, July 9-13). Collaboration technology in teams, organizations, and communities. Tutorial. *Proceedings of the 8th IFIP TC13 IFIP INTERACT Conference on Human-Computer Interaction*, Tokyo, Japan.

Chapter 3.24
Metadata Management:
A Requirement for Web Warehousing and Knowledge Management

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ABSTRACT

This chapter introduces the need for the World Wide Web to provide a standard mechanism so individuals can readily obtain data, reports, research and knowledge about any topic posted to it. Individuals have been frustrated by this process since they are not able to access relevant data and current information. Much of the reason for this lies with metadata, the data about the data that are used in support of Web content. These metadata are non-existent, ill-defined, erroneously labeled, or, if well-defined, continue to be marked by other disparate metadata. With the ever-increasing demand for Web-enabled data mining, warehousing and management of knowledge, an organization has to address the multiple facets of process, standards, technology, data mining, and warehousing management. This requires approaches to provide an integrated interchange of quality metadata that enables individuals to access Web content with the most relevant, contemporary data, information, and knowledge that are both content-rich and practical for decision-making situations.

INTRODUCTION

Today, many of us use computers and the World Wide Web to communicate. We enter a Website name or address (www.informationbydesign.biz, www.ibm.com, www.tech.purdue.edu) into a browser on our desktop computer, where a unique numerical number replaces the words representing the Website name or address. It is analogous to a telephone number. We then are connected immediately to another computer assigned a numerical address somewhere on the World Wide Web. This allows us to access any document (Web page) on that computer. The Internet is capable of connecting us with any computer anywhere in the world. This computer sends the Web page we have requested from its Internet address to our desktop computer, where it is displayed using our browser. In most cases, the returned Web page is written in English and we are able to understand its content. But, if the Web page is written in another language, we would need an interpreter to understand its content. In a telephone analogy — if a person who responds to our telephone call speaks another language, then what is said may not have any meaning to the caller. If the information that describes the currency, content, and location of the Web page or telephone number is erroneous, it is of little value.

Now, in a different way, let's consider the reason why it is difficult for computer systems to communicate and to share data. First, the data often have been structured differently in one system than in another. This is particularly true with older application systems. Second, the data may not be stored in the same format (i.e., they are in a numerical format rather than in text format). Third, the name for the data may be different, causing a problem in identification or recognition of what they represent between systems. Last, the values of the data stored may be inconsistent between the systems. Technically, the programs in each system can be interconnected if they are designed, defined, and structured logically and physically for that purpose. But, each of the above items has to be evaluated for possible integration and sharing of the data between the systems if that is not the case.

One of the most common problems is that identical data are named differently in different systems. All too often, different names or terms refer to the same data that need to be shared. For example, a human resources system may use the term employee or candidate to refer to a person. An ordering system may refer to a person or an organization as a customer. In a sales system, the term may be prospect, client, or customer. Each system may use different terminology — a different language in a sense — to refer to similar or identical data. But if they use the wrong language, again, the systems cannot share the data to provide required information.

The problem can be even worse. Consider terms used in different parts of a business. Accountants use jargon — a technical language — that is difficult for non-accountants to understand. Similar terms used by individuals in engineering, production, sales, or in marketing may have different meanings. Likewise, managers may use another vocabulary. Each speaks a slightly different language and uses the same words in different ways. What is said may have no meaning without a common definition and so they cannot easily share common information. Each organization has its own internal language and jargon that becomes part of the subculture that evolves over time and is a key part of the way individuals communicate. In fact, in some organizations it is a miracle that people manage to communicate meaning at all!

As we saw above, there can be more than one language used in an organization. Metadata, the data about the data, identifies and uses their organization's own language. Where different terms refer to the same thing, a common term is agreed upon by all to use. Then people can communicate clearly. The same is true in the use of systems. Systems and programs intercommunicate when there is understanding and meaning between them. But without a clear definition and without common use of an organization's metadata, information cannot be shared effectively throughout the enterprise.

Previously we discussed how each part of an organization maintains its own version of customer, client, or prospect data. Each defines processes (a series of actions) — and assigns staff (persons) — to add new customers, clients or prospects to their own files and databases. When common details about customers, clients or prospects change, each redundant version of that data also has to be changed, requiring staff to make these changes. But, wait a minute, how about the metadata? They are also a consideration. Both the organizational and technical metadata may be affected and may also be redundant. This is the same rationale for reusable programs! These are all redundant processes that make use of redundant data and metadata. This is enormously expensive in both time and people — all quite unnecessary.

So, as metadata gains prominence, the process of managing metadata becomes critical since it becomes the common language used within an organization for people, systems and programs to communicate precisely. Confusion disappears. Common data are shared. Enormous cost savings can be made since it means that redundant processes (used to keep up-to-date redundant data) are eliminated as redundant data versions are integrated into a common version for all to share.

BACKGROUND

The mission statement of the Data Administration Management Association is to deliver the right data to the right person at the right time. This is a concept that has been around Information Resource Management (IRM) for years (Burk & Horton, Jr., 1988). Data are proclaimed to be an enterprise asset but little management of that asset has occurred. As a result, the world is made up of much disparate data and metadata, resulting in erroneous information being used in decision-making.

From a computing systems perspective, disparate data and metadata have also been around for years. It started with the early development of computing systems. Much of the data about data (their format and structure) was packaged within programming languages and their supporting technology. With the development of database management systems, these same technical metadata were incorporated into the database management system's catalog or dictionary. This content became known as metadata. They are needed by all systems.

Metadata is more than just a means for technological implementation. It is much broader in scope. Metadata embraces the fundamental data that are needed to define requirements. It is the information (metadata) that is used to design a product, understand business processes, provide information access, obtain data understanding, outline the rules applying to actions and data, and ultimately, make business decisions. In this context, metadata encompasses many aspects of an organization: its processes, organizational structure, technologies, motivations and, certainly, the format, structure, and context of data required to meet informational needs.

So, What are Metadata?

Let us examine the definition of metadata. This requires us to examine the meaning of data, information, and knowledge. These three terms need to be defined for the purpose of this discussion because of their key role in today's organizational environment.

- Data. Discrete facts that are represented in some symbolic way and are recorded in many different formats. By themselves, data may have little meaning or use.
- Information. Data being used and interpreted by a person. The data are relevant and have a purpose in influencing or altering a person's decisions or behavior.
- Knowledge. Personal or organizational experience, value and insight gained from an applied use of information. It is actionable information that is relevant information available in the right place, time, and context to the person using it in a decision-making situation.

Together, these terms (DIKs) are fundamental to every organization's daily existence. They work closely together to build the foundation for knowledge management (KM) and the use of Web mining.

So, what is metadata and where do they fit? There are definitional differences of metadata among authors (e.g., Devlin, 1997; Inmon, 1992; Kimball, 1998; Loshin, 2001; Marco, 2003; Tannenbaum, 2002). These definitions differ either in basic purpose (administrative, structural or descriptive), depth and richness, or in specificity for a particular situation. As such, metadata is our knowledge of data that we have interpreted as information in a particular decision-making situation. Therefore, it is a continuum between data (facts) and knowledge (experience) used in a personal or organizational context.

Where does metadata fit? Without naming, defining, structuring, categorizing, standardizing, and storing both the data and metadata, the utility of Web mining, warehousing and KM is suspect. Why? Because it is the semantic bridging mechanism (requirements and specification for semantic data models) that enables effective information access and exchange to occur both internally and externally for organizations. It requires management.

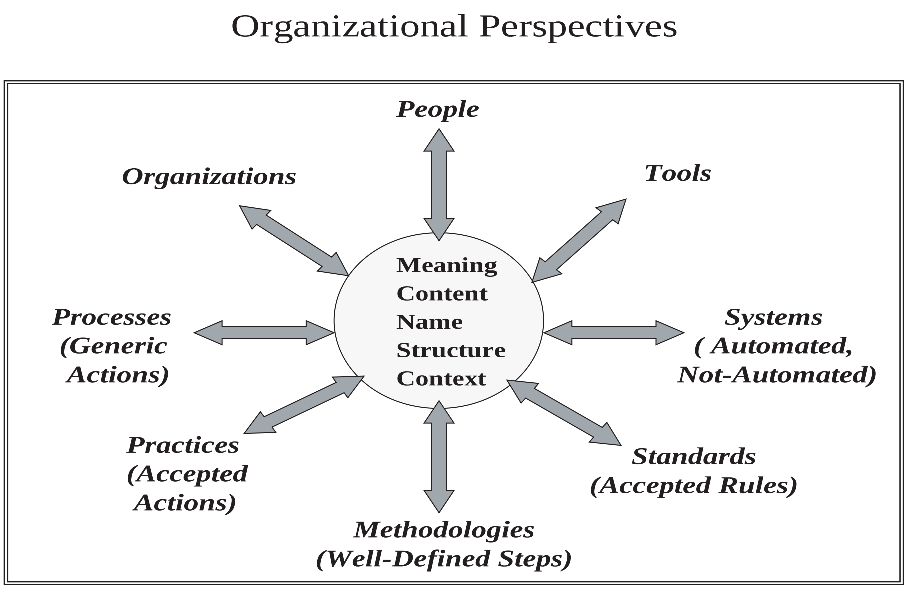
There is Management

In a sense, management takes action to produce a certain effect. Management is the activity that embodies four major functions: planning, organizing, leading, and controlling. Planning function is the selection and prioritization of goals and the ways to obtain them. Organizing function assigns the responsibilities to individuals to perform work or actions to produce something (product or service). Leading uses influence to effectively motivate individuals to attain the goals desired. In controlling, work activities or actions are monitored and corrected as required to meet stated goals. By focusing on doing the right things, the organization chooses the right goals to be effective, and by doing things right the organization is making the best use of its resources, including data.

Management is the art of getting things done by taking action and using people to achieve the goals of the organization. These goals are clearly communicated to all the individuals who are involved in their implementation by providing the reasons the actions are performed in an organizational context. Peter Drucker made the point of how management has changed with the use of information technology. He states: "So far, for 50 years, Information Technology has centered on DATA — their collection, storage, transmission, and presentation. It has focused on the 'T' in 'IT'. The new information revolutions focus on the 'I'. They ask, 'What is the MEANING of information and its PURPOSE?' And this is leading rapidly to redefining the tasks to be done with the help of information and, with it, to redefining the institutions that do these tasks" (Drucker, 1999, p. 82). The process of making a choice and taking action is a decision.

Management uses business processes that combine information technologies and people in attaining the goals of the organization. As they become more knowledge-based, individuals must take more personal responsibility for contributing to the whole organization by understanding the objectives, the values, the measurements, and the performance required. They must communicate effectively and efficiently with their peers and the other professional knowledge workers with whom they interact. The outcome is that "Every knowledge worker in modern organization is an executive [italics added] if, by virtue of his position or knowledge, he is responsible for a contribution that materially affects the capacity of the organization to perform and to obtain results" (Drucker, 1989, p. 44). Drucker (1999a) stated that the most valuable assets of the 21st century company are its knowledge and its knowledge workers. Knowledge workers face interesting challenges to use data,

Figure 1. Organizational perspectives cause different metadata to be captured



information, and knowledge more effectively and efficiently. The executives and leaders who manage have different organizational perspectives. Each piece of metadata has core elements of a name, meaning, descriptive content, structure and overall context. All of theses elements are essential to create metadata that are universally acceptable.

Each organizational perspective must ensure that effective communication of DIKs occurs. Each dimension provides different management perspectives and implications. People have different skills, talents, and needs. They are organized in a way to achieve some goal in a business process. Each process has a set of business practices that are executed in well-defined steps in accordance with internally or externally accepted rules or conventions. Many of these practices, steps, and tasks are part of organizational systems and in many instances may be automated in computerized software applications. In other cases, the basic tools (i.e., hardware or software) become instrumental parts of our daily work activities. An important implication of this environment is that each individual should have an understanding of the meaning, context, naming, structure, and content of data, information, and knowledge that are represented in each organizational situation.

The Purpose of Decision-Making

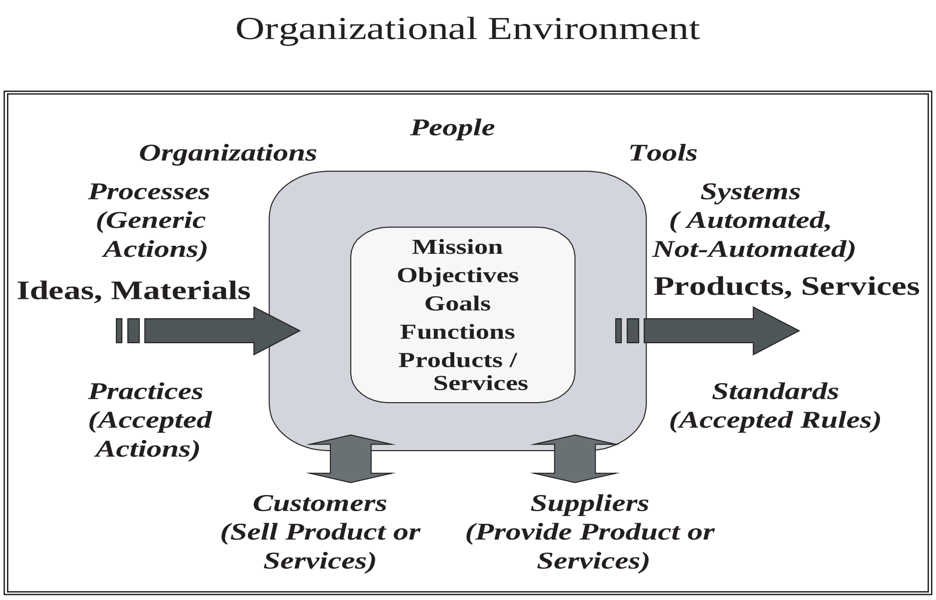
The purpose of delivering information and knowledge content through the Web is for one critical purpose: to help an individual gather DIKs for making a decision. Therefore, one has to question the various assumptions used in decision-making. What business are we in? What should it be? What changes are necessary to get it to the next level? These questions are contextually meaningful for decision-making. They set the stage for determining excellence and the priorities of processes, practices, and methods needed to implement the desired strategy to achieve the goals. Decision-making involves making choices in taking action and is an important ingredient in the overall process. Today's knowledge workers understand their contribution to achieving a result and must concentrate on opportunities that provide a competitive advantage in a systematic, purposeful, and organized manner for the welfare of the overall organization within its environment.

From an organizational perspective, an organization creates capital by combining ideas, materials or both and transforming them into some product(s) or service(s) that are marketed or sold to its customers, as shown in Figure 2.

The organization uses explicit or implicit mission statements, sets objectives, and outlines goals for the benefit of the owners of the organization. It structures itself along the lines of traditional business functions: accounting, finance, development, manufacturing, marketing, sales, and distribution of its final product(s) or services(s).

An assumption that underlies decision-making situations in any organizational environment is that data, information, and knowledge applicable to a particular situation provide a factual representation of the environment used by the decision-maker(s) in assessing the options available. Unfortunately, this premise does not hold true, as evidenced by documented studies about the low quality of data (English, 1999; see also Brackett, 1996, 2000; Loshin, 2001). Inaccurate data can be found in 1-5% of the time while impacting costs from 8-12% of revenue (Redman, 1998). Others have stated that data quality contributed to reducing the GNP by .5% in the year 2000 (Mandel, 1998). Thomas Redman described 15 ideal characteristics for data quality (Redman, 1992) and suggested groupings of these attributes into three areas: conceptual (level of detail, view consistency, composition, robustness and flexibility), data value (accuracy, completeness, currency, and value-consistency), and data representation

Figure 2. Transforming inputs into product(s) or services(s) in an organization

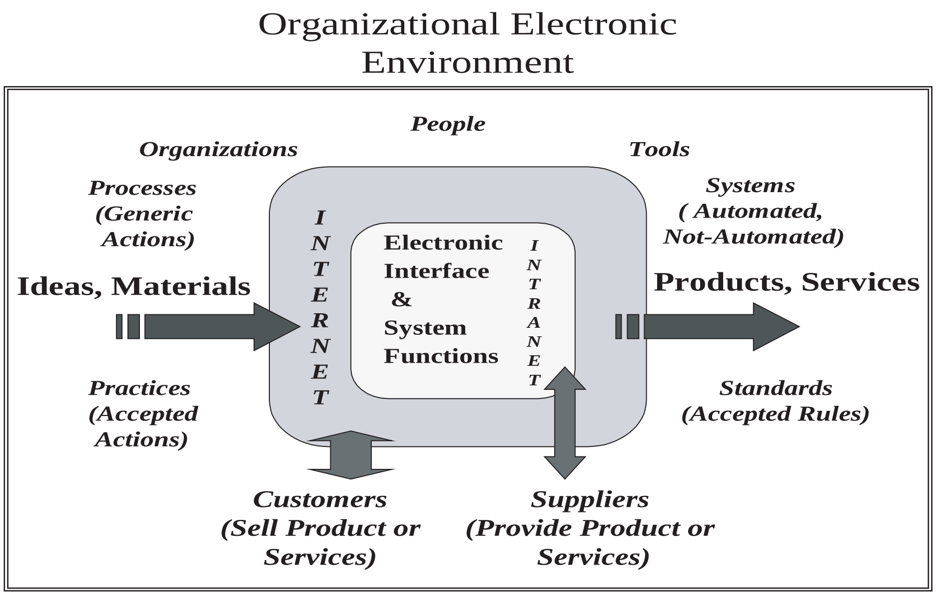


(appropriateness, interpretability, and portability) (Redman, 1996). By substituting the term metadata for data, the same characteristics are applicable in decision-making situations.

A human activity that is part of any leader or managerial role is decision-making. Henry Mintzberg (1971) described the characteristics of decision-making in a managerial role as an entrepreneur, disturbance handler, resource allocator, and negotiator. In each role, the use and quality of data, information, and knowledge are critical to understanding the problem, examining the options, and taking action. We use a decision rule or policy embedded in the world that we perceive from the data, information and knowledge that we have experienced. From a different perspective, Herbert Simon (1957) has best articulated the limits of human decision-making ability in his principle of bounded rationality, stating: "The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problem whose solution is required for objectively rational behavior in the real world or even for a reasonable approximation to such objective rationality" (p. 198). Faced with complexity in the real world and time pressures to make decisions, we fall back to habits, heuristics (rules of thumb), procedures or simple mental models to make a decision. This drives a critical requirement for quality data and information because it is paramount to producing the best possible results under the most stringent of time constraints and the critical need for high quality metadata. It has a tremendous impact on the processes used to collect, analyze, classify, standardize, translate, select, and distribute DIKs in a timely fashion to the organization and its collaborative parties.

With the introduction of the Internet and the World Wide Web, organizational boundaries have been significantly altered. This technology has enabled a global economy to develop in which

Figure 3. Organizational electronic environment increases scope of communications with Internet technologies



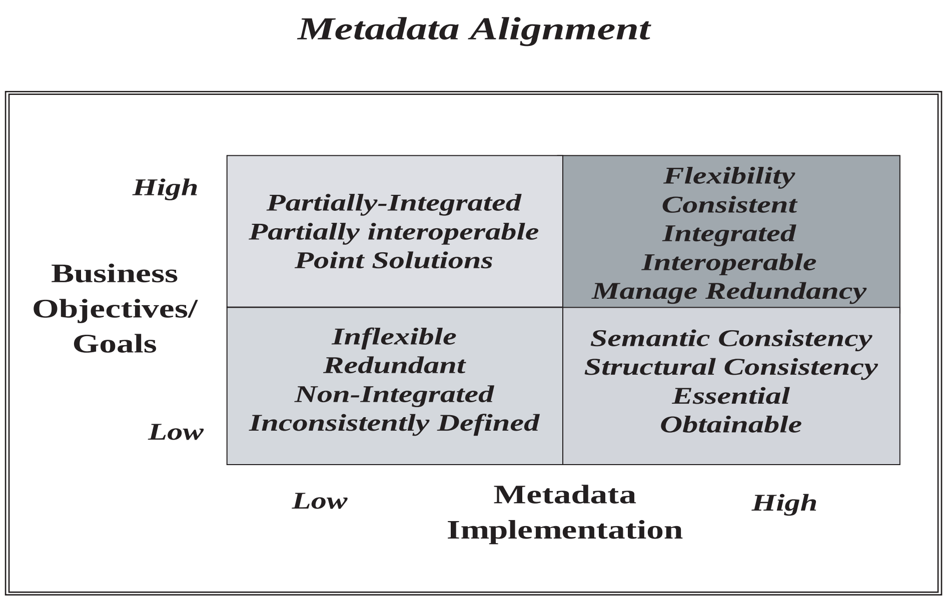
any organization with its accountants, distributors, financiers, customers, manufacturers, or suppliers can operate without regard to physical and geographical boundaries. In this environment, the digital transmission of all types of data, information, and knowledge, regardless of their form (numbers, words, graphs, photos, voice, video, etc.) is electronically moved throughout the world, as in Figure 3.

Within an organization, the application of the Internet's protocol (TCP/IP) is called an intranet. This is where an organization maintains proprietary, confidential, or intellectual property-based DIKs. Using both intra/Internet technologies can provide an immediate access to internal and external data, information and knowledge. This makes the management of the metadata critical for the decision-making process since knowledge workers can have access to too much information that may or may not be relevant to the decision-making situation. In cases in which various collaborative partnerships exist between organizations, electronic transactions exist between customers (B2C) and between other privileged organizations (B2B) that can access your DIKs. This further emphasizes the need for a mentality within an organization that data, information, and knowledge are an asset.

The Need for Asset Mentality

Realizing that data, information, and knowledge are so critical to an organization's overall success, why have we not seen a more strategic approach to managing DIKs in an organization? Should data and metadata be considered an asset? An asset is defined as "a useful desirable thing or quality" (Braham, 1998, p. 26). An intangible asset is something valuable which a company possesses which is not material, such as a good reputation or a patent (Merriam-Webster, 2003). Both definitions describe some factor or circum-

Figure 4. Impact of metadata alignment with business objectives



stance that benefits the possessor (advantage) or is considered a resource (source of information or expertise).

Dow Chemical Corporation in 1993 (Davenport, p. 85) started to manage data and metadata as an intangible asset and turned them into an asset by managing their company's patent database. Dow claims that they saved more than $1 million in patent maintenance fees within the first 18 months. This example also illustrates the concept of intellectual capital (such as documented patents in databases) tied to knowledge available in a managed environment.

Historically, organizations have set up programs, policies, and procedures to support managing data and information as an asset, but for the most part, "information and data are identified assets without an associated management process" (Metcalfe, 1988. p. 19). This is due largely to the diversity of technologies, differing organizational and management directives, incompatibility of data development and their implementations, lack of integrated solutions, and evolutionary standards. Figure 4 shows the implications of missed organizational opportunities from a business perspective since the relationships between business objectives/goals and metadata have to be aligned.

Metadata is a mediator in the DIKs environment. A higher degree of alignment between metadata and business objectives/goals results in a more flexible, consistent, integrated, interoperable environment for an organization. The tremendous payoff for Dow Chemical illustrates this point.

Need for Web Warehousing and Knowledge Management

Since data, information, and knowledge are so critical to an organization's overall operational success, Web mining, warehousing and KM are logical extensions of existing operational activities. In the quest for timely, accurate decisions, an essential element is to obtain the best DIKs possible to produce appropriate and effective courses of action.

The concept of Web warehousing originated with the development of data warehousing. W.H. Inmon (1992) defined data warehousing as a "subject-oriented, integrated, non-volatile, time variant collection of data in support of management's decisions" (p. 29). The only difference between data and Web warehousing is that in the latter, the underlying database is the entire World Wide Web. As a readily accessible resource, the Web is a huge data warehouse that contains volatile information that is gathered and extracted into something valuable for use in the organization situation. Using traditional data mining methodologies and techniques (TechReference, 2003), the Web mining is the process of extracting data from the Web and sorting them into identifiable patterns and relationships. Various data techniques of analysis determine:

- Association. A pattern exists in which one event is connected to another event
- Sequence or path analysis. A pattern exists in which one event leads to another later event
- Classification. A totally new pattern exists (develops a new structure)
- Clustering. Relates facts previously not known by finding and visually inspecting new groupings of data
- Forecasting. Predicting future conditions based on existing patterns in data

Given this sense of what Web mining is and warehousing is, what, then, is knowledge management (KM)?

Like metadata, knowledge management has multiple interpretations (Davenport, 1998; Firestone, 2003; Gates, 1999; Malhotra, 1998; Tiwana, 2001). Firestone (2003) provides a discussion of additional authors' treatment in the context of his definitions.

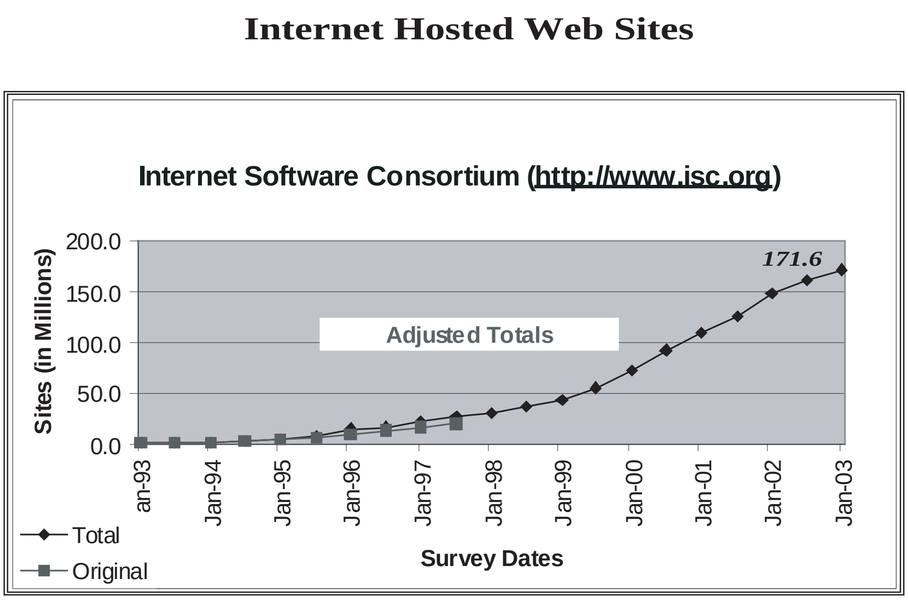
In this discussion, KM is the embodiment of all management activities (in the handling, directing, governing, controlling, coordinating, planning, organizing, disseminating of data, metadata, information, and knowledge) in a planned, directed, unified whole for the purpose of producing, maintaining, enhancing, acquiring, and transmitting the enterprise's DIKs assets to meet organizational objectives and goals. This definition is slightly different from Firestone's in that it encompasses data, metadata, information, and knowledge elements. The rationale for this distinction is the criticality of timely, accurate, quality-based information needed for organizational decision-making. In today's global market, maintaining an organization's knowledge base not only gives a competitive advantage, but is also necessary for its own survival. It is from this perspective that today's implementation of Web mining, warehousing and KM activities have to be closely aligned with management perspectives to ensure its success and the ultimate achievement of their goal.

With this New Environment

Without question, the development of Web technologies has been a great enabler to access data from worldwide sources. The growth of Internet hosted Websites continues to rise exponentially (Figure 5).

The Information and Research Division of InterGOV International indicated that online Web users in 2002 numbered 625 million, with an estimate that there will be 700 million in 2003 (InterGov, 2003). Currently hosted sites provide 3 billion Web pages (Sargent, 2003) with content. The Internet and its infrastructure can deliver a glut of information and data to a user. A million Web pages are added to the World Wide Web each day. If we also consider the volume of Intranet publications that occur each day, which

Figure 5. Internet hosted sites survey: An historical profile



is difficult to estimate, the Internet/intranet is a wonderful resource of useful DIKs to anyone accessing the Web.

ISSUES, CONTROVERSIES, PROBLEMS

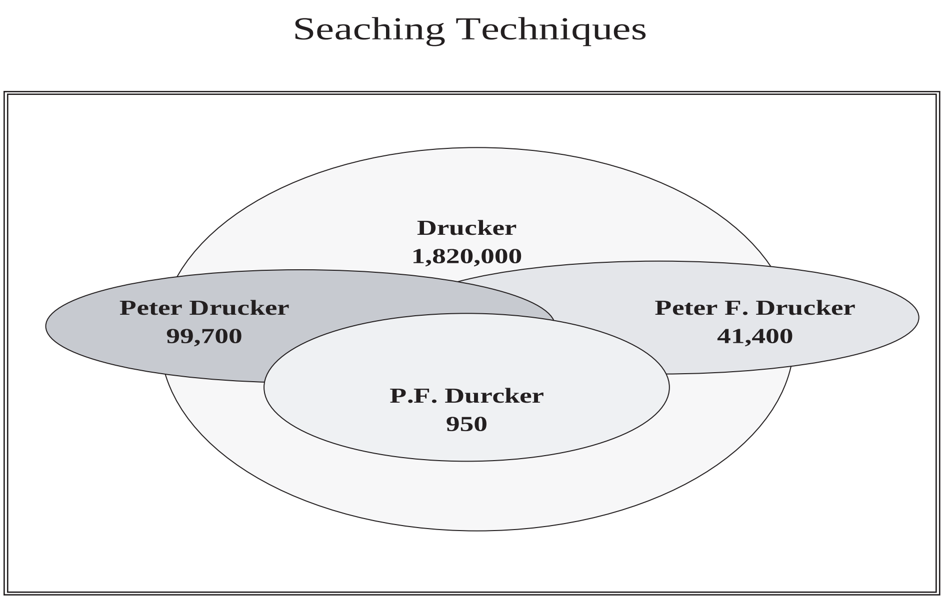
Internet/intranet Web page publications present some interesting issues, concerns and problems.

Ever-Increasing Proliferation of Redundant Data and their Disparate Metadata

Twenty years ago, if you needed certain information, you would drive to an excellent resource library. For example, you might ask the assistance of a highly skilled librarian for information on Peter F. Drucker's conclusions in his book: Managing for Results. Perhaps, in a couple of hours, you would receive the required information.

Today, using one of the Internet's most successful search engines, Google, you might formulate a search for information on "Peter Drucker". It returns a result with 99,700 possible Web pages to examine. If you refine your search to "Peter F. Drucker," the search gives 41,400 choices. Again, you might refine your search to "P.F. Drucker," resulting in 950 choices. If you just chose "Drucker," 1,820,000 referenced Web pages are returned. This illustrates the difficulty one has in assessing potential overlaps; currency of the content; material source generated whether from commercial, private, or foreign; or the possibility of mislabeled content. If you were interested in specific information from one of his books, Managing for Results, your next search would yield 20,700 possible references. This result allows you to get closer to your objective but still may not be sufficient since you might be interested in his

Figure 6. Search technique to access details on managing results by P.F. Drucker



chapter The Commitment (7,670 references) or finally, to his conclusion (2,870). The issue is the quality of the metadata that describe accurately the characteristics of the Web page. Even using a refined search process, it would take time and computing resources to get the required information sought. Much of the results from these searches might not contain what you require. This searching technique is illustrated in Figure 6.

Without standardized metadata, an ever-increasing proliferation of redundant data and their disparate metadata is a key inhibitor to successful data, information, and knowledge integration.

This brings up the next point.

Management of Metadata has not been a Key Part of Data Management Implementations

In a review of the implementation of Information Resource Management (IRM) or Data Administration (DA) organizations and practices, the predecessors of Web warehousing and KM, there is little external evidence that corporations have valued these practices. Very few public success stories have documented the value of data administration or data management in organizations, since these activities are not considered part of the value chain that directly contributes to the profit or bottom line of the organization. Only recently at an Information Quality conference was there a claim by attendees of savings of over one-half (1/2) a billion dollars (English, 2003). The U.S. government, however, through the Clinger-Cohen Act of 1996, has driven governmental organizations to be much more proactive in setting up and adopting IRM-based programs in the public sector.

In an attempt to standardize metadata, a meeting hosted by the Online Computer Library Center, Inc. (OCLC), in Dublin, Ohio set up standards for Web page metadata documentation elements. This is similar to a library's catalog card: title, subject, author, publisher, other agent, data, object type, form, identifier, language, relation and coverage. But this is only an initial step in the evolution of Web standards for metadata delivery. Will these developing standards be successful in the management of metadata and the software tools to manage them?

Software Solutions do not Address the Management of Metadata

Commercialization of software to support various business applications has increased dramatically. But the commercialization of software to assist in developing, cleaning, and relationship standardization of data has not been a key market item or a commercial success. What is the reason? Is it the quality of the software or is it the organization's lack of recognition for the need to manage the metadata? Why should there be thousands of ways to collect personal contact information? Likewise, why have software standards not addressed the uniformity and interchange of data? We are just beginning to see commercialization of this type of software.

Lack of Support to Manage Data and Metadata Inhibits Successful Implementation Efforts

By far, the profit motive drives most commercial organizations to focus on maximizing revenue while minimizing costs. In the service sector, generating a profit requires maximizing the services while minimizing the cost of resources to produce that service. The implication of this heuristic is that anything not directly related to the actual production of the product or service is non-essential. Thus, any resource (data, metadata, etc.) that is consumed in the process that does not directly contribute to the end product or service has little or no added value. This references a mentality that leads to redundant processes, redundant data and metadata that actually inhibit long-term solutions.

SOLUTIONS AND RECOMMENDATIONS

Explicit Recognition that Data and Metadata are Assets

Until an accepted norm for evaluating the value of data in the world of accounting and finance is established, the recognition and management of data and metadata will continue to be difficult. Although many engineering practices are accounted for in the manufacturing of a product, the same accounting practices (GAAP, taxes, etc.) have to be applied to data, metadata, information, and knowledge. The concept of intellectual capital has to encompass all activities used in the development of DIKs. This would mean a shift in the management of data and metadata, allowing for the adoption of a framework to manage these assets.

Adaptation of a Framework for Managing Data, Information and Knowledge

Using a Web-enabled metadata data warehouse with an Organization Search Assistant System (Scime, 2000) begins to provide a framework to access current, relevant DIKs and serves as a foundation for expanding enterprise KM. In order to become an effective enterprise resource, these metadata need to be managed with the same vigor and enthusiasm as data. The information glut must be overcome with contextual information and management practices that provide competitive advantage to those who are decisive about its practice. Two essential items have to be addressed from a communication perspective:

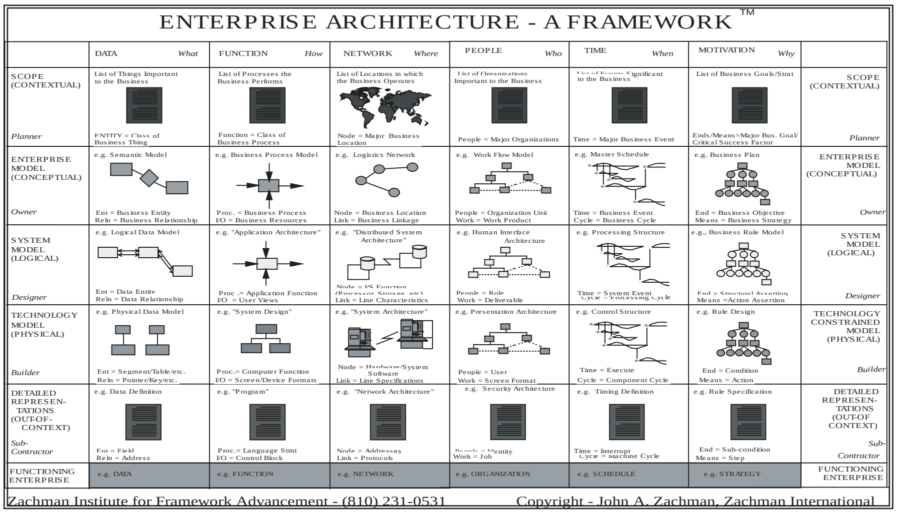
- Collaboration. A willingness to share, to cooperate, and to enhance subject DIKs
- Communities of Practice. A sociological grouping of people whose interests and experience complement the KM process

Foremost in the enterprise environment is a concerted effort to ensure that collaborating is rewarded. In a sense, declarative knowledge has much in common with explicit knowledge in that it consists of descriptions of what tasks, methods and procedures are used. Procedural knowledge describes how to do something, and strategic knowledge is knowing-when and knowing-why. Collaboration and communities of practice need all three forms of knowledge. An absence of organizational support, encouragement, and rewards often hinders the development of this practice. This inhibits the successful development of a process and practice, preventing it from becoming one of the basic beliefs of the organization. These values and beliefs need to be an integral part of development that requires declarative, procedural, and strategic knowledge.

Management provides an organization with a unifying framework for operating the organization. Much like Zachman's 1987 article, Framework for Information Systems Architecture, management needs a framework for DIKs. His framework contains 36 cells that represent the possible intersections of design perspectives and their aspects, from generic descriptions to specific details, in a consistent manner, as a way to support the organization's information systems requirement (O'Rouke, 2003). In a sense, these aspects provide the variety of perspectives needed to define requirements to implement an organization's need for an information-based solution (i.e., Web mining and KM). This framework requires one to address several key perspectives in answering the "why, who, when, where, what and how" to provide an insight into the motivations, initiatives, and expectations desired from Web mining, warehousing, and KM activities. Supporting processes address the following: knowledge cycle, program and project management, policies and procedures, methods and techniques, controls, and best practices. This framework is shown in Figure 7.

Figure 7. A framework for information systems architecture

Zachman Framework for Enterprise Architecture



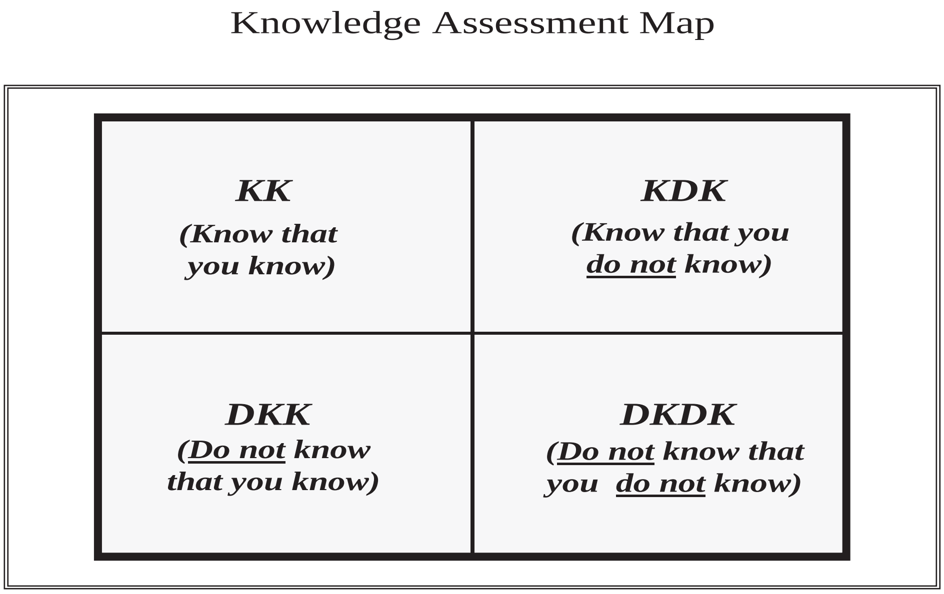
These processes provide the foundation for identifying, naming, defining, storing, documenting, authorizing, changing, securing, distributing, and deleting DIKs. They become the roadmap to successful implementation. From a different perspective, the underlying metadata supporting this taxonomy help to map the relationships to navigate across the 36 discrete cells of the Zachman Framework. Jeff Angus and Jeetu Patel in their InformationWeek article (1998, March 16) described the key KM processes to be gathering, organizing, refining, and disseminating DIKs. There is a significant need to develop tools and standards to ensure consistent semantic integrity of Web-delivered data to anyone who needs the DIKs.

Development of Web-Based Warehouse to House Consistent Data Definitions and Taxonomy to Ensure Semantic Consistency and Effective Communications

In the development of Web mining and warehousing, consistency of terminology becomes increasingly important in decision-making. Figure 8 shows a traditional matrix used to assess one's understanding in determining the current state of knowledge.

From the perspective of one who is accessing DIKs, each grid has different search criteria and different levels of DIKs that constrain the search requirements and impact the tools needed to support that request.

Figure 8. A knowledge assessment map



- In the KK quadrant, the requestor knows what he or she is looking for and where to get it. No additional investment is required in time or resources.
- In the KDK quadrant, the person realizes the DIK exists but does not have a means to access it. In this case, the person would use time and consume resources to determine how to access a DIK that exists.
- In the DKK quadrant, the DIKs are available but the person is not knowledgeable of the availability of the DIKs. In this case, the person would spend time and resources to determine if the DIK exists and later to determine how to access it if it does exist.
- In the final quadrant-DKDK, a person is totally unaware of the DIKs and any means to access them. In this case, the person may not even spend time and resources to determine if the DIK exists, since he or she is not aware of the possibility.

Consider the searching strategies we use on the Web and you can probably relate to the different scenarios above. How much time do we consume in search of quality information on the Web? Are the metadata critical to success or frustration with the Web's ability to retrieve something about which we are inquiring?

Metadata and basic terminology are critical to the access and use of DIKs. It is clear from the prior discussion that without metadata, it would be difficult to move from one grid to another. From that perspective, let's discuss the development of a data warehouse. The team that develops the data warehousing application has to understand all the required data from a business perspective. They must determine the best source of those data from various information systems and must inventory their associated technical (IT) metadata. This provides a profile of the data's current implementations. Design of the target data for implementation is required and becomes the basis for developing the Extraction-Translation-Load (ETL) rules; an automated process is set up to build the data warehouse. In implementing a data warehouse, the metadata that are collected and delivered as a part of this application are a critical part of the delivery of the warehouse for the organization's knowledge workers. The reason knowledge workers and information systems professionals develop a data warehouse together is that neither have the requisite knowledge to build the application independently. The knowledge workers (seekers of knowledge) understand the context of the required information required but do not have the insight and depth to organize it effectively. On the other hand, the information systems analyst has the knowledge of the DIKs and possible classification and structuring of the required DIKs, but does not have the contextual knowledge of its use from inside the organization.

Develop a Measurement to Assess Quality, Timeliness, and Accuracy of Web Content to Start to Minimize the Amount of Disparate Metadata

Given the acceptance of a financial recognition of the economic value of "intellectual capital," the assessment of the quality, timeliness, and accuracy of data, metadata and ultimately, Web content, has to be measured. Redman's grouping of characteristics, conceptual, data value and data representation would be an excellent starting point for measurement. Work currently being done to address data quality by MIT's Total Data Quality Management program is starting to address this issue from different perspectives (see Aerve, 2001; Kahn, 2002; Segev, 2001; Wang, 2003).

Management of Metadata has not been a Key Part of Data Management Implementations

Whenever information systems organizations design something new (i.e., applications, data, functions, systems, networks, or other key artifacts) for operating an organization, models are used. Models are descriptive or mathematical representations supporting a new design. It is significantly better to design models to communicate new requirements than it is to implement solutions without them. Because of the complexity in many of today's organizations, analysts develop various models (business model, business process, etc.) to portray a new design's requirements. In this process, an analyst gathers DIKs to build contextual representations of the new design requirements with his/her associated knowledge workers. The gathering of these DIKs is the metadata necessary to complete the modeling activity. Figure 9 shows one view of models that could be used in the process.

We perform various types of metamodel implementations in the development of information technology-based systems. Typical types of analysis associated with models include: clustering (combine, intersect, select), comparing (similar, different), inferring (seeing relationships between objects), ordering (by grouping or special sequence) and ranking (subjective evaluations) to provide recommendations.

With the implementation of repository (database) systems, we have an opportunity to perform some of the above analysis by modeling different relationships. The example in Figure 10 illustrates a transition in thinking which may require us to re-think the way we have done this process in the past.

Teaming concepts are critical to operational activities in delivering new ideas, concepts, approaches, and results. Organization dynamics often necessitate internal and external participation in cooperative efforts, so organizational objectives and goals need to be clearly understood by all. This process involves time and judgment in assessing the right content, experience, and knowledge that is applicable to the organization's requirement and operational activity. Supporting DIKs are involved in this process and are checked

Figure 9. Metamodel of models: A structure of models for relating metadata

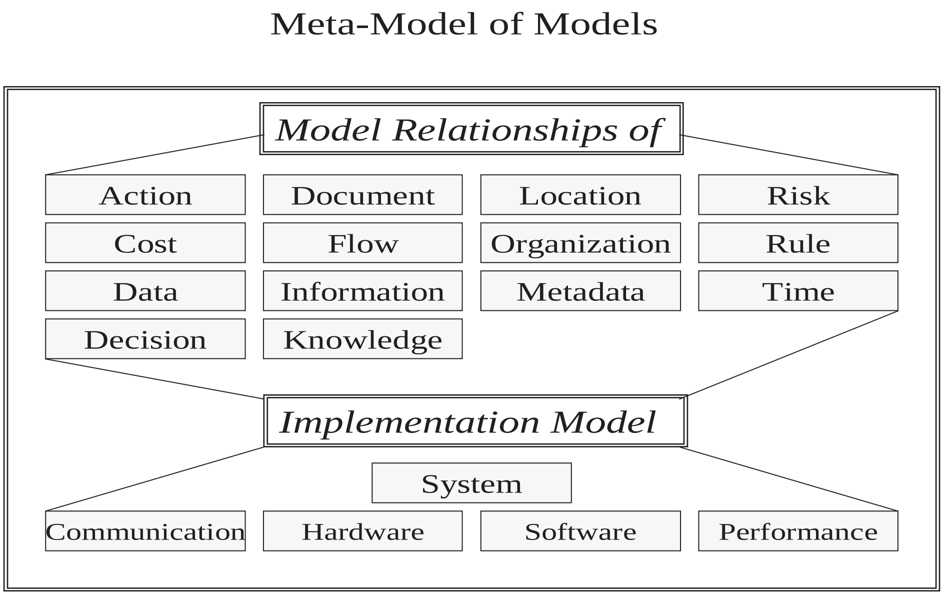
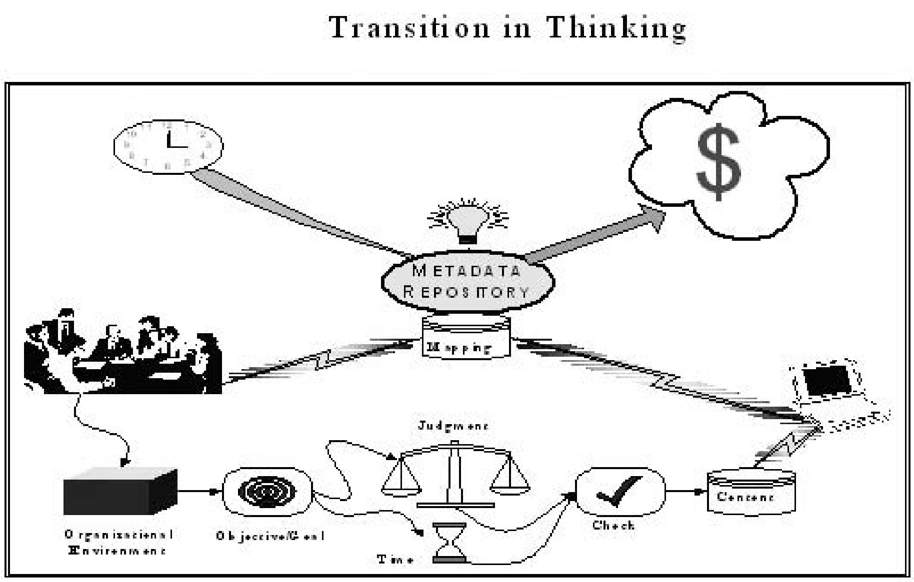


Figure 10. Transitional thinking: A repository structure for relating metadata



against the assumptions made and implemented in various systems. To assess the success of the decision, measurements are taken as part of the implementation of the system. Today, the critical factor is the necessity of timely decisions with sufficient return on investments in terms of implementation.

How does Web mining and KM fit into the picture? A central theme is that a metadata repository (database) provides the semantic mechanism and transitions necessary to deliver effective interchange of content appropriate to the operational activities. This is the beginning of the era of ever-increasing demand for automated DIKs. John F. Rockart and James Short (1989, p. 16) describe an increasing spiral of demand for information systems and technology in the business world, stating, Accessible, well-defined and a transparent network are, therefore, the keys to effective integration in the coming years. Developing these resources, however, is not easy. Excellence at investing in and deploying IT isn't sufficient to achieve superior business performance: companies must also excel at collecting, organizing and maintaining information, and at getting their people to embrace the right behaviors and values for working with information. In today's environment, it means that Web mining and KM are a large part of building and managing a new type of culture and infrastructure. Thus, organizations and their IT units must develop an architecture, establish standards, communicate the value of the infrastructure, and operate the increasingly complex infrastructure to deliver the content supporting this transition in thinking.

In an unpublished book in the 1990s, Ron Shelby wrote, "Senior management is sponsoring high-visibility initiatives to build common systems and databases to support their organization in the future. Increasingly, information resource management (IRM) organizations are asked to architect, integrate, and manage shared-data environments that will support the core of tomorrow's enterprise." In 1999, Shelby was cited in an InformationWeek article about data warehouses:

"One of the early reasons for data warehousing was to optimize your own business," says Ron Shelby, acting chief technology officer of General Motors Corp. "Sharing data with suppliers is an extension of that. To be more agile, we have to have a supplier base that's equally agile." The automotive giant is starting to use Internet technologies and data-analysis tools so it can share its data warehouse with suppliers and, in effect, treat them like other divisions. (Davis, 1999, June 28)

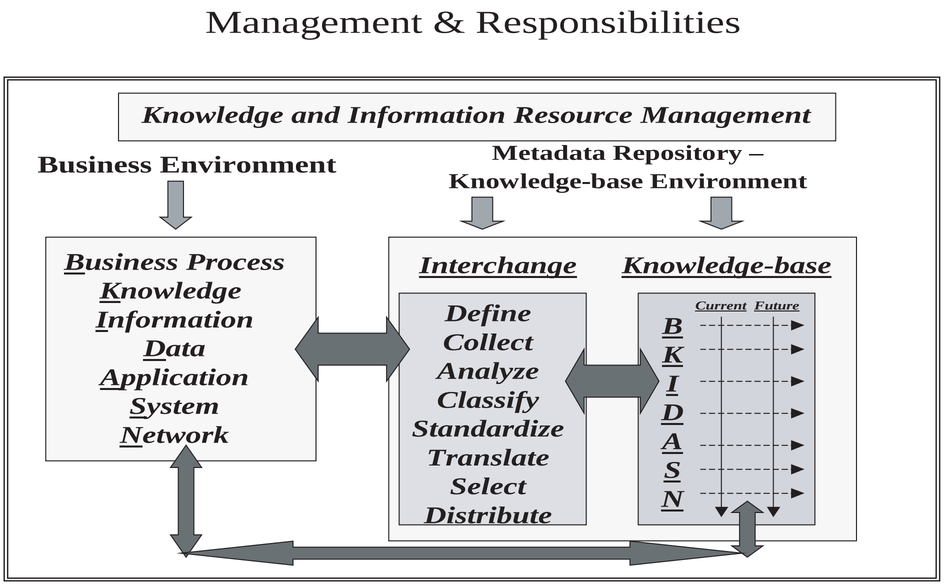
Since the 1999 articles, the likes of GM, GE and others have successfully implemented Internet technologies and data mining techniques, with significant dollar savings in supply chain logistics and marketing. For example, GM's Buy Power Website operates in 40 countries and, with other efficiencies, is saving the company $1.5 billion annually, with 9,900 GM suppliers linked in real time to the company (Riftin, 2002). A large part of the success of these implementations is based upon the management of data and metadata, a key proposition stated by Shelby and highlighted by Rockhart and Short.

Development of Software Standards and Measurements to Address Metadata Management Functionality

Given an organizational environment that addresses the objectives/goals, leadership is required to cultivate, motivate, and manage a knowledge and IRM initiative. Metadata, in combination with real-time data, provides immediate information for decision-making purposes in business systems. This is a valuable lesson since using metadata as an active participant in the management and control of this decision support system make the human-system interaction far more valued, flexible, and operationally successful as a knowledge-based information resource.

The premise of this 1986 integrated Business Information and Data (iBID) (Shields, 1986)

Figure 11. Management of an integrated business information architecture



architecture work, as shown in Figure 11, was to deliver a mechanism for a business to develop integrated, flexible, adaptive, and predictive information-based products and services.

This author included knowledge as a dimension in the business environment since it was an assumed element in the development of this architecture. A key part of this architecture was the collection, resolution, and dissemination of the business rules (Ross, 2003) that the organization currently operates, plans to operate, and analysis of gaps prior to their implementation. This type of simulation and forecasting of current business dynamics (Sherman, 2003) seeks to project the future environment prior to its implementation. This architectural representation provides a clear analogy to today's operating environment. Each organization or business environment has business models, business process management, data models, and data semantics. The organization performs a series of actions (broadly categorized as business processes) that effectively utilize data (internal or external) that have been created, updated, or deleted either by a business system (manual/semi-manual) or by an application of an information system. These business systems are networked internally, externally, or some combination of both to locations by some type of communications network.

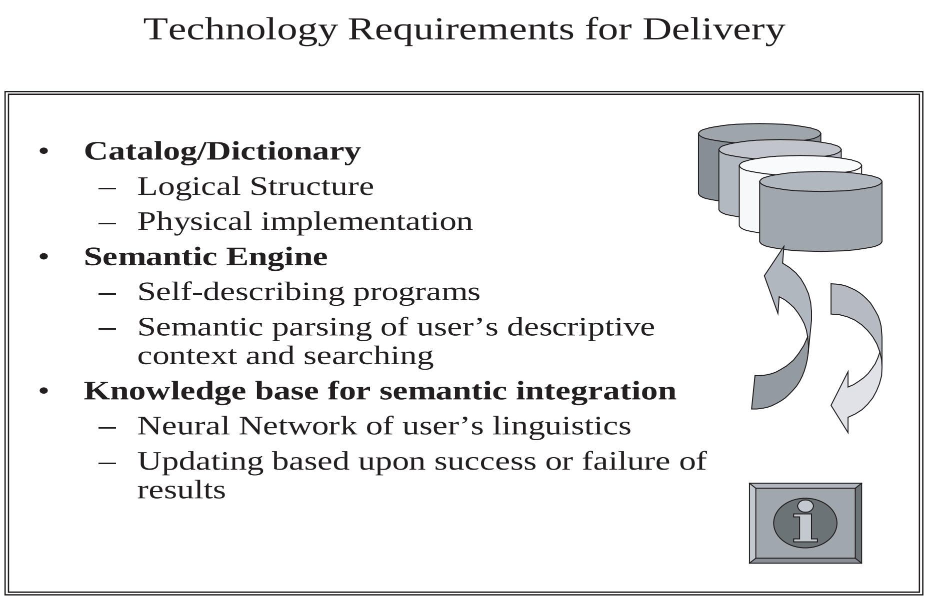
Within the knowledge base, two aspects are highlighted: the current (as-is) or the future state (to-be) across each dimension and is comparable to Zackman's use of interrogatives (who, what, where, when, how, and why) within each dimension. The main purpose is to understand current and future states to ensure transitional planning between the states so that they work. This transition between states is done effectively and efficiently because understanding the many interrelationships avoids errors in implementation.

The interchange mechanism enables and facilitates some of the services required (define, collect, analyze, classify, standardize, translate, select, distribute). Each service uses appropriate metadata that require management with a support system or tool in the delivery of repository services. Finally, the bi-direction arrows represent the system capability to access the knowledge-information resource repository from anywhere at any time, and for any purpose. Today, our mechanism to accomplish this is the intranet/Internet.

This knowledge base environment cannot be achieved without some critical considerations for the technology components that are required of such an environment. The focal point is the delivery of quality DIKs. Three essential components are required to be integrated, as shown in Figure 12 below.

The catalog/dictionary/thesaurus/repository system component is needed to provide the translation mechanism to bridge to various semantic questions that arise in the implementation of languages. A dictionary also would include relationships to other synonyms to ensure that content would be delivered properly to the requestor. Both logical and physical implementations should be available through the public domain. The semantic engine component provides a series of self-describing programs that hone in on the knowledge worker's descriptive model of context and searching needs. With a type of semantic matching (Rahm, 2003) and profile technique, this component would understand some of the context of the knowledge worker's characteristics to use as a means to extract and mine more meaningful results from the knowledge base. Based upon the overall experience in the knowledge base, it would develop fuzzy-set solutions. The semantic integrity component provides an artificial intelligence engine that dynamically adjusts a neural network of the results achieved from the knowledge worker's inquiries. This would improve the quality of the results from the inquiries based upon the various states from which the person may operate.

Figure 12. Technology requirements for delivery of KM environment



FUTURE TRENDS

Increasing Importance for an Organization to Adopt a Framework for Managing Information and Data

Because data and metadata will become an "asset" as part of the KM function, organizational leaders will be faced with competitive situations that will dictate their need for it. With distributed Web warehousing activities, the key role of DIKs is to become a new resource in an organization's environment. A centralized logical approach to develop and manage metadata content databases may be necessary. With centralized logical metadata that is indexed, searched, and processed by tools, it becomes an enabler for organizations to assess and use its knowledge. This IRM metadata repository and knowledge-based environment supports the overall mission and goals of the organization.

The implication of this change is that more robust analytical tools will be required. They will need to support automatic indexing, validation, searching, mapping of casual relationships, adaptive modeling, and fuzzy-set logic technologies to measure the metadata's utility in the context of organizational delivery and adaptation to their environment. Tools in many forms will develop: glossaries, dictionaries, subject taxonomies (generic-to-specific hierarchies), semantic maps (term/definition-to-homonym(s)-synonym(s)), visualization techniques to build relationship maps and new languages to support relationship structures.

This implies that managing metadata, data and information is clearly and explicitly linked to the organization's strategy with a real understanding of its knowledge advantage.

Assessing Organizational Context in a Systematic Approach for Adopting a Knowledge Management Practice

Because data and metadata are essential in the delivery of a robust Web mining and knowledge management solution, a systematic approach is needed to develop the organization's mission and requirements. Basic principles are the foundation for success in providing a systematic approach. They are: (1) to capture, codify, and share both information and knowledge; (2) to focus on the collaborative efforts among people and communities with an emphasis on learning and training; and (3) to prioritize the knowledge and expertise used in the everyday workplace. Remember, in the initial assessment of an organization's needs, one KM best practice may not work in another situation due to organizational culture and context (Glick, 2002). A plan can be put in place using this systematic approach and analysis, specific project goals, requirements, resources, and metrics. The essential design elements of the approach address several areas: content management, the knowledge chain and its dissemination, the infrastructure needs, and its components. In assessing the implementation of the knowledge chain, understanding the organizational context plays a significant part in delivering solutions that emphasize context, interaction and flows, the knowledge base with its content, and the acquisition strategy to be deployed. Knowledge delivery, services, and technology are a key part of the organization's infrastructural practices and culture. The evolution of an organization's knowledge management practice can move from short-term to longer-term projects to full acceptance based upon the success of each knowledge initiative within its proper context. This implies a compelling vision and architecture for your organization's KM mission and goal.

Emerging Standards to Address the Redundancy and Quality of Web-Based Content

The mapping of relationships between different objects in the meta-model of models is starting to play a key role in both organizational and industry standards. The development of various industry-based taxonomies (a class of objects and relationships that exist between them in a generic-to-specific structure) has started. The mapping of synonyms, homonyms, and data with definitional clarity becomes an essential ingredient to the interchange of DIKs. Ontologies (databases that contains the mapped relationships of one object to one or more objects) will be frequently used to provide the capability to infer new facts and observations. Concepts discussed in the InfoMap (Burk, 1988), especially those that focus on measuring cost and the retention practices for DIKs, will be of critical importance to the utility of the metadata knowledge base repository.

Information systems vendors and consultant organizations will support efforts to build these taxonomies and ontologies to provide hardware, software and consulting services that support their use. The implication is that if software products are developed to support these activities, the products may be proprietary in nature.

The American National Standards Institute (ANSI) is one of a number of member bodies that propose U.S. standards be accepted by the International Standards Organization (ISO). Each standards organization is made up of volunteers who develop, assess, and submit a standard for formal approval. There can be competing standards that are developed and some have to be reconciled. Due to the length of time, the level of detail and cost of participating in these standards, delays in the standards process often occur. This delay results in de facto standards being used and implemented prior to full acceptance as a standard. This could impact the development and transitional efforts needed to build robust taxonomies and ontologies. This implies a systematic approach for capturing explicit and implicit knowledge into a well-developed knowledge infrastructure.

Development of Tools and Standards to Assess Semantic Integrity of Web Delivered Pages

The efforts to develop a semantic Web by the W3C group will be key in development of standards. This effort from diverse participants will address a large opportunity to increase the utility of the Web. Various tools (agents) will be generated to assist in the functional services needed by the interchange architecture previously (define, collect, analyze, classify, standardize, translate, select, distribute). The most difficult service will be the semantic translation between a Web user's request and utility of the results. Products being developed for natural language, conversational, and parametric searching (Abrams, 2003) will be vital to their successful implementations.

Increasing Use of Intelligent Software to Enable Delivery of New Content to be Delivered into a Knowledge Base Under Users' Metadata Requirements

The efforts supporting the development of DARPA's Agent Markup Language (DAML) and Resource Definition Framework (RDF) are focused on the semantic integration, retrieval and utility of the Web's resources. A key effort is to have a unifying meta-model to store the metadata effectively in its knowledge-base repository for effective and efficient use in the organization. The success of the knowledge-based environment is predicated on linking multiple technologies and practices with critical focus on the quality of the data, information, and maintaining knowledge. This will be one of the biggest organizational challenges!

CONCLUSIONS

To create solutions for today's marketplace needs, the opportunity to build a quality knowledge base depends upon the following:

- The metadata management of DIKs as the major vehicle for the successful implementation of Web mining, warehousing and KM.
- The requirement that organizations adopt new methods/processes, organizational roles, standards and tooling.
- Addressing emerging standards in terms of redundancy and quality of DIKs being delivered through the Web warehousing of content and metadata.

Because of today's global marketplace, a KM system becomes necessary for economic survival. It enables an organization to assess internal and external content via World Wide Web resources and its own internal content-rich knowledgebase. To successfully develop that system, the enterprise has to establish an environment in which the system can succeed. This means integrating many processes and technologies in orchestrating a different environment. A significant hindrance has been the inability to access current, relevant DIKs. Much of the reason lies in the fact that the metadata used in support of the collection of DIKs' knowledge have been limited, or nonexistent, ill-defined, erroneously labeled, and disparate. With the ever-increasing demand for Web-enabled mining, the KM environment has to address multiple facets of process, technology, metadata Web mining and warehousing management approaches to provide an integrated content-rich and practical enterprise solution to assist in the delivery of Web warehousing and knowledge management.

REFERENCES

Abrams, C. (2003, March 9). *Metadata management: Crucial for the real-time enterprise*. Paper presented at the Gartner Symposium ITxpo. Retrieved April 16, 2003: http://symposium.gartner.com/docs/symposium/2003/spr4/documentation/spr4_02b.pdf.

Allen, T., Harris, W., Madnik, S., & Wang, R. (2003). *An information product approach to total information awareness*. Retrieved May 10, 2003: http://web.mit.edu/tdqm/www/publications.shtml.

American National Standards Institute. (2003). Retrieved May 10, 2003: http://www.ansi.org/.

Anguss, J., & Patel, J. (1988, March). Knowledge-management cosmology. *Information Week OnLine*. Retrieved May 10, 2003: http://www.informationweek.com/673/73olkn2.htm.

Au, W., & Chan, C. (2003, April). Mining fuzzy association rules in a bank-account database. *IEEE Transactions on Fuzzy Systems, 11*(2), 238-248.

Brackett, M. (1996). *The data warehouse challenge: Taming data chaos*. New York: John Wiley.

Brackett, M. (2000). *Data quality resource: Turning bad habits into good practices*. Boston, MA: Addison-Wesley.

Braham, C. (ed.). (1998). *School & office dictionary* (Rev. ed.). New York: Random House.

Burk, C., & Horton, F., Jr. (1988). *InfoMap: A complete guide to discovering corporate information resources*. Englewood Cliffs, NJ: Prentice Hall.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston, MA: Harvard Business School.

Davis, B. (1999, June 28). Data warehouses open up: Sharing information in your company's data warehouse with suppliers and partners can benefit everyone. *Information Week*. Retrieved May 10, 2003: http://www.informationweek.com/741/warehouse.htm.

Devlin, B. (1997). *Data warehousing: From architecture to implementation*. Boston, MA: Addison-Wesley.

Drucker, P.F. (1989). *The new realities*. New York: Harper Business.

Drucker, P.F. (1999a). Knowledge-worker productivity: The biggest challenge. *California Management Review, 41*(2), 79-85.

Drucker, P.F. (1999b). *Management challenges for the 21st century*. New York: Harper Business.

Drucker, P.F. (2000). *Knowledge-worker productivity: The biggest challenge*. *The knowledge management yearbook 2000–2001*. Woburn, MA: Butterworth-Heinemann.

English, L. (1999). *Improving data warehouse and business information quality*. New York: John Wiley.

English, L. (2003). How to save $576,295,000 through IQ management. *DMReview, 13*(6), 80.

Firestone, J. (2003). *Enterprise information portals and knowledge management* (p. 172). Burlington: Butterworth-Heinemann, an imprint of Elsevier Science.

Gates, B., & Hemingway, C. (1999). *Business @ the speed of thought: Using a digital nervous system*. New York: Warner Books.

Glick, W.H. (2002, April 5). Configurations of knowledge management practices: Three ideal types. Paper presented at the meeting of the *Third European Conference on Organizational Knowledge, Learning and Capabilities*, Athens, Greece.

Gruber, T.R. (1993). *Knowledge Acquisition, 5*(2), 199-220. Retrieved January 31, 2003: http://www-ksl.stanford.edu/kst/what-is-an-ontology.html.

Inmon, W. (1992). *Building the data warehouse*. New York: John Wiley.

InterGov International. (2003). *Latest Web statistics available from the InterGov International Website* [Data File]. Retrieved May 10, 2003: http://www.intergov.org/public_information/general_information/latest_web_stats.html.

International Standards Organization. Available: http://www.iso.ch/iso/en/ISOOnline. openerpage.

Kahn, B., Strong, D., & Yang, R. (2002). Information quality benchmarks: Product and service performance. *Communications of ACM, 45*(4), 188. Retrieved May 15, 2003: http://web.mit.edu/tdqm/www/publications.shtml.

Kimball, R., Reeves, L., Ross, M., & Thornthwaite, W. (1998). *The data warehouse lifecycle toolkit*. New York: John Wiley.

Knowledge Management Network, Brint Institute. Retrieved May 20, 2003: http://www.kmnetwork.com/.

Liu, J., & You, J. (2003, April). Smart shopper: An agent-based Web-mining approach to Internet shopping. *IEEE Transactions on Fuzzy Systems, 11*(2), 226-237.

Loshin, D. (2001). *Enterprise knowledge management: The data quality approach*. San Francisco, CA: Morgan Kaufmann.

Malhotra, Y. (2003). *World Wide Web virtual library on knowledge management*. Retrieved May 15, 2003: http://www.brint.com.

Mandel, M., Coy, P., & Judge, P. (1998, March 2). ZAP! How the Year 2000 bug will hurt the economy (It's worse than you think). *Business Week, 3567*, 47.

Marchand, D., Kettinger, W., & Rollins, J. (2000, Summer). Information orientation: People, technology and the bottom line. *Sloan Management Review, 41*(4), 69-80.

Marco, D. (2002). *Building and managing a meta data repository: A full lifecycle guide*. New York: John Wiley.

Merriam-Webster's collegiate on-line dictionary. Retrieved May 10, 2003: http://www.m-w.com/home.htm.

Metcalfe, J.T. (1998, December). *Information resource management – Data ownership, organization, roles and responsibilities*. Unpublished IBM Business Systems-Internal Publication. Norwalk, Connecticut, USA.

Mintzberg, H. (1971). Managerial work: Analysis from observation. *Management Science, 18*(2), 97-110.

Online Computer Library Center, Inc. Retrieved May 20, 2003: http://www.oclc.org/home/.

O'Rourke, C., Fishman, N., & Selkow, W. (2003). *Enterprise architecture: Using the Zachman framework*. Boston, MA: Thompson-Course Technology.

Rahm, E. (2003). *Metadata management for heterogeneous information systems.* Invited talk at the13th GI Workshop on Foundations of Database Systems (2001, June). Retrieved April 20, 2003: http://dbs.uni-leipzig.de/en/Research/meta.html.

Redman, T. (1992). *Data quality: Management and technology*. New York: Bantam.

Redman, T. (1996). *Data quality for the information age*. Boston, MA: Artech House.

Redman, T. (1998). The impact of poor data quality on the typical enterprise. *Communications of the ACM, 41*(2), 82.

Rifkin, G. (2002, October). GM's Internet overhaul. *MIT Technology Review, 105*(8), 66. Cambridge.

Rockart, J., & Short, J. (1989). IT in the 1990s: Managing organizational interdependence. *Sloan Management Review*, Winter, 7-17.

Ross, R. (2003, May). The business rule approach. *Computer, 36*(5), 85-87.

Scime, A. (2000). Learning from the World Wide Web: Using organizational profiles in information searches. *Informing Science, 3*(3), 136-173.

Segev, A., & Wang, R. (2001, November). *Data quality challenges in enabling eBusiness transformation*. Presentation at the Sixth International Conference on Information Quality (IQ-2001). Retrieved April 15, 2003: http://web.mit.edu/tdqm/www/iqc/past/.

Sergent, J. (2003, March 10). In Net vs. not: Which offers better shopping. *USA Today*. Retrieved March 10, 2003: http://www.usatoday.com/usatonline/20030310/4930922s.htm.

Shelby, R. (1992). *Information resource management's role in the 1990s.* Unpublished Auerbach book.

Shields, A., & Stein, P. (1989, September). *Requirements for a system to register and report on knowledge about the information used and needed by a business* (Document # 87-02-22). Unpublished IBM Business Systems-Internal Publication. Norwalk, CT.

Sterman, J. (2000). *Business dynamics: Systems thinking and modeling for a complex world*. New York: McGraw-Hill Irwin.

Tannenbaum, A. (2002). *Metadata solutions: Using metamodels, repositories, XML, and enterprise portals to generate information on demand*. Boston, MA: Addison-Wesley.

TechReference. Retrieved May 20, 2003: http://searchcrm.techtarget.com/.

Tiwana, A. (2001). *The essential guide to knowledge management: e-Business and CRM applications*. Upper Saddle River, NJ: Prentice Hall PTR.

U.S. Law. (1996, July). *Clinger-Cohen Act of 1996 introduced the concept and need for information resource management policies and practices*. Retrieved May 12, 2003: http://www.dau.mil/jdam/contents/clinger_cohen.htm.

Vaughn-Nichols, S. (2003, May). XML raises concerns as it gains prominence. *Computer, 36*(5), 14-16.

Wang, R., Allen, T., Harris, W., & Madnick, S. (2003, March). *An information product approach for total information awareness*. IEEE Aerospace Conference. Retrieved May 15, 2003: http://web.mit.edu/tdqm/www/publications.shtml.

Zachman, J. (1987). A framework for information systems architecture. *IBM Systems Journal, 26*(3), 276-92. Available: http://www.zifa.com/.

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Chapter 3.25
Multimedia Capture, Collaboration, and Knowledge Management

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ABSTRACT

This chapter presents methods and technologies from Siemens Corporate Research that can assist in the process of creating multimedia collaborative knowledge bases: capture, querying, visualization, archiving, and reusability of multimedia knowledge bases. A selection of Siemens products in the healthcare and communication domains are introduced, above which novel multimedia collaboration and knowledge management technologies have been developed by the authors. With examples, it is explained how in concert these technologies can contribute to streamlining the processes within healthcare enterprises, telemedicine environments and home healthcare practices.

INTRODUCTION AND MOTIVATION

The networked healthcare enterprise is providing unprecedented opportunities for healthcare workers to collaborate and make clinical decisions in an efficient manner. Significant progress has been made to enable healthcare personnel to obtain answers to simple clinical questions by using medical databases of evidence-based answers. This approach allows reuse and sharing of knowledge to help healthcare professionals to save time and effort and help patients in an efficient manner. For situations where healthcare workers have simple questions with simple answers, this approach is perhaps overkill. However, when the questions are of a more complex nature, by capturing and archiving complex answers in a rich multimedia form they can be exploited multiple in the future to explain solutions in a manner that can be easily digested by healthcare workers.

A contemporary healthcare enterprise involves complex media elements (images, videos, documents, etc.) and volumes of documentation both digital and on paper. The healthcare knowledge base should incorporate these media elements and easily allow users to search, extract, and reuse. Some of the modern knowledge management systems allow building of communities of practice around documents. But there is a need to move beyond regular office documents to address rich media and encompass specialized medical and clinical data.

The networked enterprise is also enabling a plethora of ways for healthcare personnel to communicate and collaborate. The next generation of communication technologies will bring converged voice and data solutions on a single network. This is helping integrate the healthcare IT (Information Technology) systems with Web-based communications. In recent years we have witnessed a proliferation of communication and data devices like GPRS cellular phones and PDAs, thus providing an opportunity for accessing clinical information anywhere/anytime and allowing users to collaborate over clinical information to reach decisions quickly.

The concept of presence and availability offered by various instant messaging tools is changing the manner in which people are communicating with each other. Presence enables a user to know who in their contact or buddy list is available or not at any given point in time. Availability options allow a user to signal whether they are available to be contacted and which form of communication they favor. Presence and availability information allow users to interact in various ways in offline, real-time or in near-real time modes. Mobile communication technologies are being developed that enables mobile location and presence. The integration of the healthcare enterprise content repository with a Web-based infrastructure and presence and availability represent the three pillars of modern unified, or converged, communication.

Although the potential for a rich communications and IT infrastructure is high, there remains a need to streamline the communications and collaborations between healthcare personnel to ensure that valuable knowledge gained from daily interactions between healthcare personnel is not lost. This chapter presents methods and technologies from Siemens Corporate Research that can assist in the process of creating multimedia collaborative knowledge bases: capture, querying, visualization, archiving, and reusability of multimedia knowledge bases. Throughout the chapter, a number of Web-based technologies are introduced that enable healthcare personnel to interact in a variety of modes regardless of whether they are mobile or sedentary.

BACKGROUND: STREAMLINING HEALTHCARE AND TELEHEALTH

Since the advent of Web-based workflows, there has been a growing emphasis in healthcare enterprises on methods to increase organizational efficiencies, reduce errors and focus on patient care. One such platform is Soarian (Siemens Soarian) from Siemens Medical (Siemens Medical) that offers an integrated workflow technology that can streamline the operational processes of healthcare. Soarian's infrastructure has been engineered based on clinical processes that enable physicians to focus less on administrative duties and more care by providing them with access to all clinical data in a single view. The goals being to offer actionable guidelines to clinicians based on best practices and to support them in reaching accurate, evidence-based decisions promptly.

A nascent area for which technology can be a significant enabler is that of telemedicine (Hibbert, Mair, May, Boland, O'Connor, Capewell, & Angus, 2004), where clinical needs are extended beyond the boundary of the hospital. A key requirement to facilitate a telehealth consultation is to have medical personnel in remote locations to communicate and collaborate with each other in a quick, efficient, and effective manner.

Some of the issues that an integrated communications and healthcare medical IT infrastructure can help address are:

- Reducing time and effort wasted in daily communications (paging, phone calls) between clinicians, nurses, and patients
- Reducing the communication pathways by a combined infrastructure can streamline how users can be reached at a given point in time
- Complex solutions to questions can be assembled in multimedia fashion to succinctly convey the message
- Knowledge exchanged and gained from daily interactions between people can captured and archived with high granularity
- Reuse, by querying and retrieving relevant segments from past collaborative activities, can avoid recreating the wheel when a recurrent problem reappears
- Reduce paper work by having one consolidated IT-communications infrastructure
- Reduce cost by managing a single converged voice and data network

Remote communications in contemporary telehealth systems allows users to collaborate in two different modes: store & forward and in real time. The asynchronous mode, or store & forward method, allows for the sharing of medical information in an offline mode, but the absence of human interactivity prevents healthcare personnel from augmenting this with personal comments, insight and knowledge. The real time collaboration mode requires the session to be scheduled in advance, and all participants must be dedicated to the collaboration session for the duration.

The current mode of document/data sharing involves all users within telehealth WAN (Wide Area Network) cluster to upload documents, data and code to a central repository from where other users can extract materials of interest. This mode of collaboration among users is not sufficient for many users to exchange complex ideas and viewpoints regarding various images and other documents in intricate detail. For example, medical researchers frequently need to locate and reference information that is not only physically distributed across the sites of their collaborators, but also in an array of formats (images, reports generated based on experiments, or code execution).

Often users collaborate by exchanging e-mail messages along with data/documents downloaded from a central Web server. Although this allows individuals to participate at their own pace, users invest much time typing descriptive text to discuss a particular topic, especially when expressing complex thoughts within context of a document or image. The problem becomes particularly acute when users are collaborating using document attachments. This mode leads to large documents being exchanged as attachments back and forth between users, with the potential for inconsistencies to arise between successive versions. Moreover, with clinicians collaborating across time zones on documents or images, a need has been observed for conveying complex information via rich multimedia.

To anticipate and streamline the future communication and IT needs of healthcare enterprises and burgeoning telehealth market, the various requirements were distilled:

- Communication: It is clear that there exists a need to combine communications within the healthcare processes to optimize the clinicians' time to manage better the inexorable stream of phone calls, paging, exchange of paper and digital documents. Presence-based communications enables the healthcare personnel to communicate in a very effective manner.

- Collaboration: The tools should provide a consistent manner to collaborate irrespective of the mode, all online in a real time conference, or a single user making her analysis and comments on an image in offline mode. By allowing users to collaborate in different modes within a browser-based environment on diverse medical data can facilitate a seamless collaboration workflow. These technologies can enhance typical telemedicine scenarios and also extend conventional doctor-patient interactions to include web-based interactions such as chronic care or follow-ups.
- Knowledge Management: There should also be a consistent way to archive the multimedia annotations made on such documents. This would not only allow researchers to collaborate based on their time and schedule, but also to search, retrieve and filter all comments and analysis made previously by collaborators on any multimedia document.

The remaining sections describe ongoing efforts at Siemens Corporate Research to develop technological solutions driven by these anticipated future needs.

TECHNOLOGICAL BUILDING BLOCKS

OpenScape (Siemens OpenScape) from Siemens Communications Networks (Siemens Information and Communications Networks) is a suite of communication applications designed to increase the productivity of information workers. It aims to control the panoply of communication applications and devices, on both fixed and wireless networks, connected via local and wide area networks. OpenScape addresses the fragmented nature of communication modalities and their separation and provides a unifying framework for integrating, managing and streamlining communication in the enterprise.

It obviates redundant communication sessions, where a person calls multiple phone numbers and/or leaves duplicate voice, email, and instant messages in an effort to communicate urgent issues. Hence, it is possible to avoid:

- Unnecessary cell phone intrusions into client meetings, work sessions or personal time;
- Wasted time setting up conference calls, communicating call-in information, sending and synchronizing documents, and establishing separate sessions for voice, Web and video collaboration; and
- The difficulty of mobilizing all key colleagues that may be equipped with different applications, or because setting up a collaborative session is too complex and time consuming.

It provides healthcare personnel the experience of a single, synchronized set of communication resources, sharing common controls and shared communication rules and intelligence. These capabilities can be accessed via a wide range of devices and interfaces to serve the constantly changing needs of mobile employees. OpenScape provides personal and workgroup communications portals for multiple healthcare domains. OpenScape makes extensive use of presence-based communication. There are different ways of showing presence and the user's status:

Device Presence: indicates the presence of an application or communications device. The user could be online or off-line. For example:

- Off hook/on hook status of an IP desk phone or mobile phone
- Instant Messaging (IM) application presence
- Collaboration application presence indicating whether an individual has signed on to the application or not

- On which terminal can the user be reached

User Presence: associates presence with an individual rather than the user's device

- The willingness of the user to be reached
- The activity that the user is currently engaged
- The location of the user—working remotely, out of office, and so on.
- Mood—happy, good or bad tempered or even annoyed

Device presence or terminal status will become less important as terminals become more advanced and intelligent, with the ability to handle a multitude of multimedia content adaptively. A mobile phone or PDA, for instance will be able to negotiate with the remote communication party the type of information it can support, for instance video, audio, and so on.

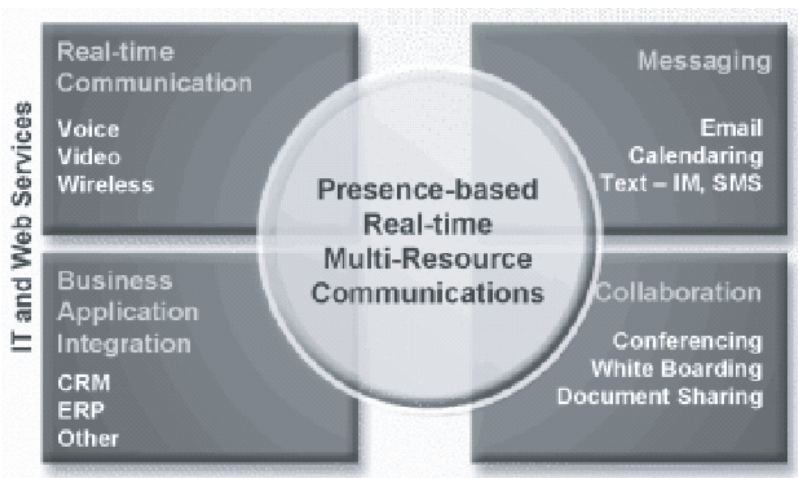
IMS (Siemens IMS) from Siemens Communications Mobile (http://www.siemens-mobile.com) provides new presence and communications platform for mobile devices and networks. The IMS platform was standardized for new multimedia applications and services that could be rapidly deployed by mobile network operators, such as audio/video conferencing, chat, and presence services over new mobile devices. Moreover, IMS is positioned to voice and multimedia communication. Different from the legacy circuit-switched voice/data communication in regular phone calls, IMS is based on IP technology that can control real-time and non-real-time services on the same IP network.

Together OpenScape, IMS and Soarian provide the core technological building blocks that enable the integration of the healthcare enterprise content repository with a Web-based infrastructure and presence and availability. Our research work is layered above these three pillars and the following sections illustrate the benefits of a converged communication healthcare enterprise.

ENRICHING COLLABORATIVE CONSULTATIONS

During a telehealth consultation between patient and clinician various medical documents might be

Figure 1. OpenScape: A way of communication



used including laboratory reports, photos of injury/skin lesions, x-rays, pathology slides, EKGs, MR/CT images, medical claim forms, prescriptions, clinical results, case reports, and other documents. Some of the documents like photos and images might have been captured using camera during patient visits, while other clinical (lab reports) or financial information (insurance claim) were gleaned from other information systems. Face-to-face video conferencing is commonly used in telemedicine not only for personalized remote communications, but also for regulatory reasons as evidence of a consultation the costs for which can subsequently be reimbursed.

It would be convenient if a clinician could combine, interface, convert, and extract disparate medical information such as those listed above from peripheral devices like photo cameras, video conferencing session, content management systems, PACS, and regular office documents into a Web-based composite document. Thereafter, it would be convenient if this composite document could be used as the basis for browser-based collaboration (whether it is offline or real time) between various participants. Such a composite document generated should combine all relevant information needed for a particular collaboration session into one seamless document so that effective offline or real time collaboration can occur.

Let us now look at some of the details involved in realizing our solution. A user could choose specific pages from document(s) stored locally and automatically have the selected pages converted to HTML format and hyperlinked with each other to form a composite document. Then, he or she could highlight important parts of the document and add personal comments with the help of voice and graphic annotations using our multimedia presentation software, called ShowMe (Sastry, Lewis, & Pizano, 1999). The multimedia annotation technology developed is unique as it not only captures the spatial nature but also the temporal aspects. For instance, the multimedia annotation on a document would capture a synchronized temporal voice, graphic and mouse pointer annotations. Finally, the user could save the composite document along with the annotations on the local web server, and this document is referred to as the collaboration document. Associated with this collaboration document is some metadata in the form of an XML schema that describes this document. This metadata is finally uploaded to the central server and its URL on this central server can then be sent to other participants.

Participants can view the collaboration document via the URL of the metadata stored on the central Web server using a lightweight Web-browser player. As the collaboration documents are stored locally, they are amenable to document management tasks, including deleting, moving, and so on. However, any such document management task must be accompanied by making an appropriate change in the metadata located at the central Web server. The above process allows various users to collaborate over documents quickly and easily by only sharing information relevant to the topic in question. In addition, there is increase in productivity as users can quickly exchange information without having to exchange e-mail to explain problem/solution.

Figures 2, 3, and 4 show a particular workflow implemented to demonstrate the spectrum of modes of browser-based collaboration using office documents and Web content. The components can be re-used in several other collaboration workflows and processes. As only specific parts of different documents might be needed for a particular collaborative session, participants are able to combine, on the fly, specific pages from several documents with different formats into one seamless Web-based composite document. Using synchronous voice and graphic annotations along with mouse as a pointer, a clinician can continuously narrate a patient's case history across the entire composite document while using the mouse to gesture or annotate on different parts of the aggregated document.

Figure 2. Multimedia Enhanced Store & Forward Collaboration: A clinician can quickly create one seamless web-based composite multimedia document by combining various medical information segments like images, photos, EKGs together. Synchronous voice, graphic and mouse annotations can then be easily added on top of the composite document before sending it via regular e-mail. The recipient needs only a web browser to view the composite document along with the voice and graphic annotations.

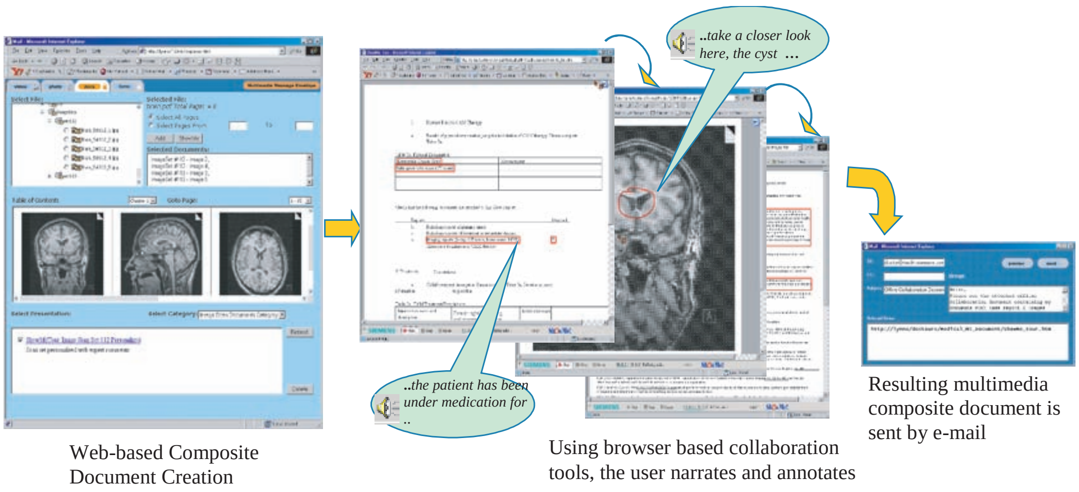


Figure 3. Instant Messaging Based Document Collaboration: This uses presence and availability of different participants to setup collaboration. Also, this allows asynchronous messaging of voice and graphic annotations within a real-time collaboration session. This enables users to exchange information at one's own pace and yet participate in a near real-time collaboration session.

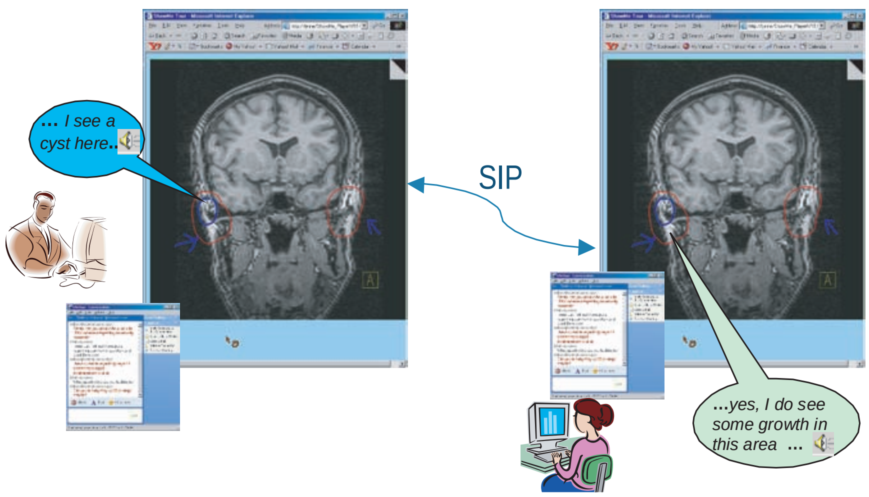
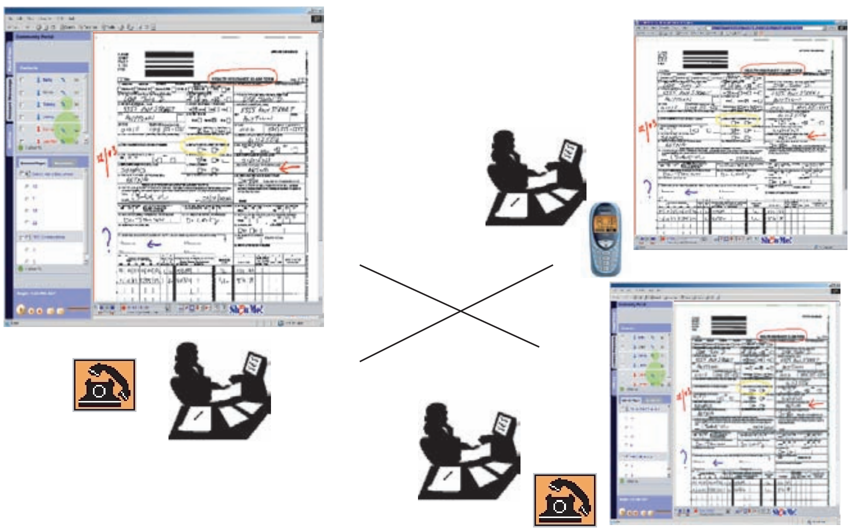


Figure 4. Multi-participant Real-Time Collaboration: Several remote participants using their web browser can collaborate on the generated composite medical document. The collaboration is accompanied by a voice conference.



These modes of collaboration—whether off-line, IM-based, or real-time—take place using a regular web browser with the requisite collaboration plug-ins. This allows the participants to collaborate within the familiar environment of a Web browser. The annotations by various participants during a collaboration session on composite medical documents can be archived into a database in a very lightweight manner. The voice and graphic annotations along with the composite document can be archived with high granularity along with meta-data describing the various annotations. This would allow for searching and retrieval of not only medical information/documents exchanged during collaboration sessions, but also to obtain information regarding comments, interactions and dialogue between various participants. For instance, one can query and retrieve specific comments/annotations made by particular participant from a past collaboration session on a specific medical document. In addition, one can easily follow the changes in the medical condition of the patient by comparing the medical documents and associated annotations made during successive patient visits.

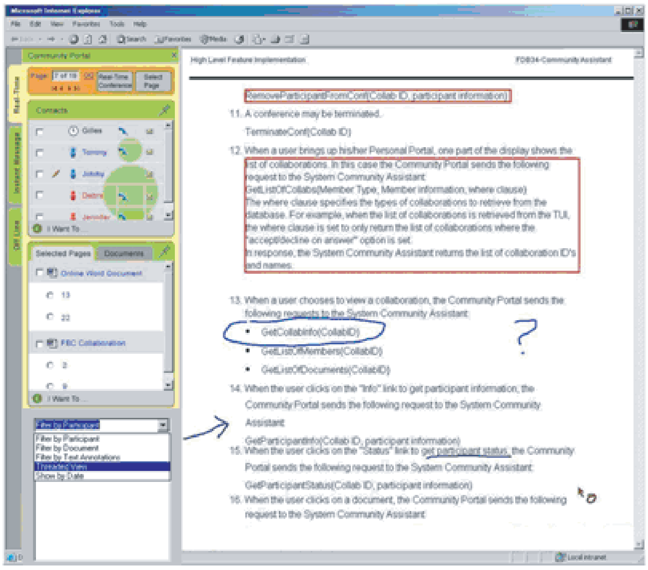
COLLABORATION KNOWLEDGE ACCESS AND MANAGEMENT

Access to and the management of the knowledge contained within the collaboration documents introduced above is reviewed in this section.

Filtering Collaboration Annotations

The ability to save annotations from a real time, offline or IM based document collaboration enables participants to filter and view a conference in several different ways. The figure below illustrates

Figure 5. The clinician can filter and quickly access specific segments from past collaborative sessions and reuse to address the current problem.



how an archived conference may be viewed in different ways by applying different filters. For example, the filters can be to show the conference view by participants, by documents collaborated on, by threaded view, by type of annotations, by session, and so on. New filters can be easily created based on the use case scenario.

Navigation, Access and Reusability of Knowledge Documents

The ability to archive annotations (both temporal and spatial) allows the users to retrieve and reuse segments of existing annotated documents from any mode of collaboration. For example, during a real time conference, several participants collaborated on different composite pages (where the composite pages might have come from different original documents). A user can select a particular page from an existing collaboration document, filter annotations based on any criteria (as described above), add any more composite pages, add more temporal/spatial annotations and collaborate in off-line, IM, or real time mode. This allows the enterprise to preserve the knowledge gathered during several collaboration sessions performed in any mode, while still enabling users to select parts of annotated documents from previous sessions for further reuse in future collaboration sessions.

Multimedia Response and Discussion Boards

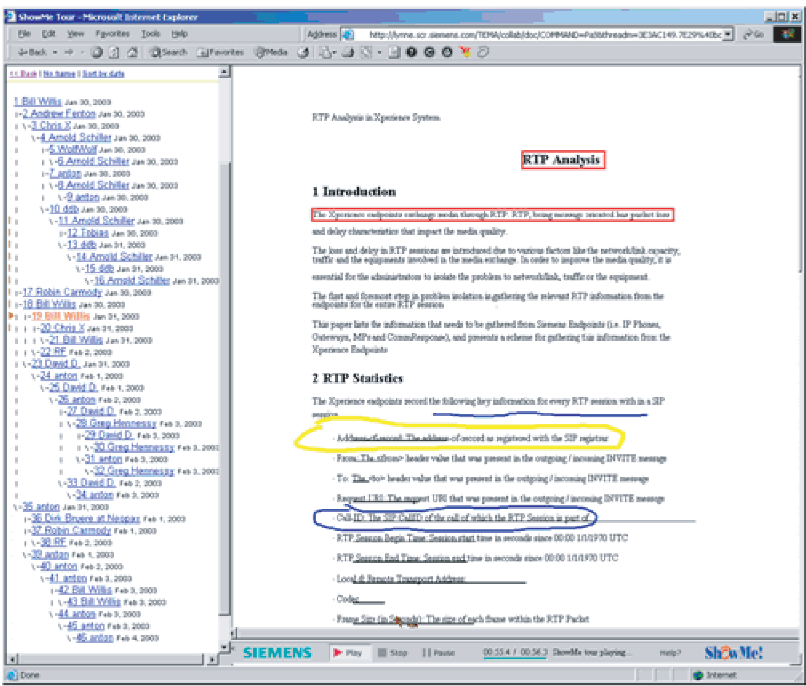
The structure of the collaboration archive allows one user to respond to any particular comment or annotation made by another user. The response could be in the form of a temporal or spatial annotation, or both. One scenario is that a sender can compose a composite document, make his or her annotations and send to the recipient(s). The annotated document could be sent as an attachment, or accessed from a central server. In the latter case, the annotated document is sent as a URL link. The recipient(s) can overlay their replies (annotations) and send back the annotated document, or the annotated document can be further annotated by other users (forwarding via e-mail.) By quickly overlaying temporal or spatial annotations it allows users to imbue information and temporal context to their responses.

Figure 6 shows document(s) being collaborated upon by several users in different collaboration modes using a threaded approach. These annotations could have been made in offline mode by different users or some of the annotations could have happened in a real time or IM conference and then imported into the discussion thread. For example, a user creates a composite document, adds various annotations in offline mode and sends it to her workgroup. The workgroup meets later and discusses in real time conference mode where annotations are captured as temporally with high granularity. During the real-time conference, they add more composite pages and perform collaborations above them. When finished, one user adds the resulting composite document with the temporal and spatial annotations to the discussion group. Subsequently, participants can add/edit/delete more comments (or annotations), or respond to any particular comment—hence a rich threaded discussion is facilitated. This scenario illustrates how group of users can work in a newsgroup discussion manner and leverage rich multimedia to express their thoughts.

Query and Retrieval of Multimedia Knowledge Base

As reported in the previous sections, the collaboration archive of interactions—voice, graphic, text, or mouse pointer annotations—between

Figure 6. A multimedia threaded discussion board



participants over several documents in different collaboration modes being captured and archived in a structured manner over time. As knowledge in the form of annotations is captured and reused in high granularity, there is a need for a simple search mechanism to locate appropriate segments of annotated documents from a large archive of annotated composite documents.

Queries to the knowledge base can be based on various criteria, for example, using metadata captured during collaboration session, the annotations using voice, text and the document content, and also by using feature relative annotations one can get the textual content of the document on which annotations were overlaid.

Representation, Visualization and Browsing of Collaborations

To leverage the knowledge contained within archived collaboration sessions, we have also explored various approaches for representing,

Figure 7. A visual overview of a session that conveys structure, documents used, and action items assigned

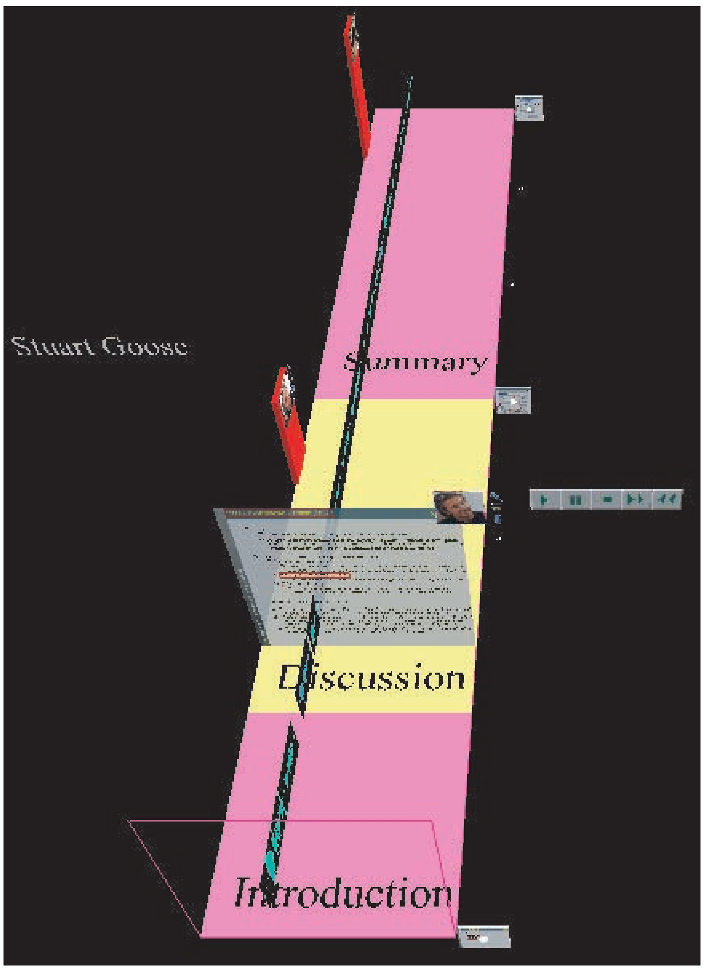
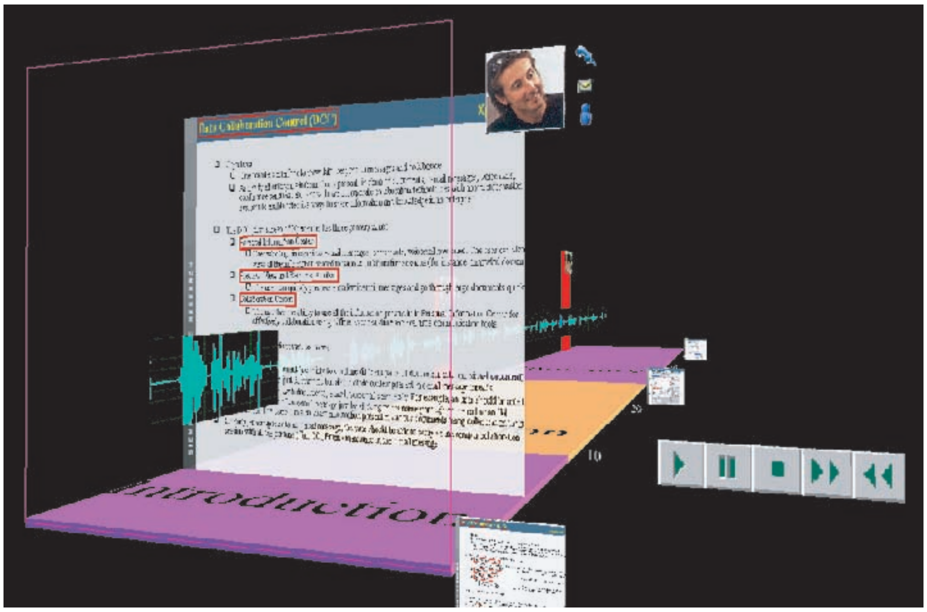


Figure 8. The detail view of a session



visualizing and browsing archived collaboration sessions. As collaborations often involve two dimensional documents and are by nature temporal, we are investigating representing the structure and content of collaborations in a three dimensional space. Arguably the most prevalent standard in the 3D graphics arena is VRML: a high-level textual language for describing the geometry and behavior of 3D scenes. Fortunately, a plethora of browser plug-ins are readily available. Following an iterative design/evaluation cycle, we converged on the design of a single VRML model with an interface that embodied and combined many of the characteristics that we sought:

- A viewpoint providing a visual overview/summary of the session
- A viewpoint providing a detail view of the session
- Interactivity and browsing capabilities at both overview and detail levels

Figures 7 and 8 show two viewpoints on the same VRML model, with each viewpoint having a distinct purpose.

The viewpoint shown in Figure 8 conveys the structure of the session (three topics were discussed), the documents used in the course of the discussion (indicated by the thumbnail icons on the right of the timeline), and that two action items were assigned (the red columns on the right of the timeline).

The viewpoint shown in Figure 8 exposes more detail regarding the content of the session. An audio waveform running along the timeline illustrates the presence of noise and is also color-indexed to the participants. An exploded view of the current document under discussion is show in the middle of the visualization. A small portrait image of the current speaker is shown in the corner of the current document, along with an icon that can be clicked on to initiate a phone call, e-mail, or instant message to that person. In addition, red columns along the left side of the timeline indicate assigned action items with a portrait image of the person responsible.

A VCR metaphor is provided to assist with navigation, and a VCR control panel can be seen at the right of the interface. When the play button is activated, the exploded view of the current document begins to glide backwards through time in synchrony with the audio stream played at normal speed. The forward and rewind buttons move the current position to the beginning of the respective session topic.

IN SUPPORT OF HOME HEALTH: NOMADIC NURSE

Home healthcare nursing is an increasingly widespread type of healthcare that typically involves a nurse driving to a patient's place of residence to provide the necessary monitoring and treatment. There are a wide variety of cases in which home healthcare is recommended by physicians, and recent years have seen a steady increase in the need for this type of care (Giles, 1996). While many industry observers believe home healthcare will increase in the future, many current home healthcare providers are either non-profit agencies or operate with conservative profit margins. In addition, as nurses' time is a scarce resource and IT spending limited, any new technologies that are not economically priced or that require nurses to increase the time spent with patients have a high probability of being passed over or abandoned.

Home healthcare nursing is by nature a peripatetic profession, and as such nurses need to transport their equipment from one home to the next. From our studies described previously, it was observed that the preponderance of nurses used paper and pencil notes augmented by their memory to record the interactions with their patients throughout their working day. The written and memorized notes were entered into the computer-based system upon their return home or to the office. There were a plethora of reasons as to why some nurses chose to operate in this mode. For example, some asserted that anything that breaks the contact between the clinician and the patient breaks the treatment involved in the visit. "There is a healing involved in the physical touch between the nurse and the patient" was the expression used. To avoid breaking this important connection, the application would need to use less obtrusive techniques that still provide for sterile-hands operation. In addition, the application would need to integrate well with the nurses' workflow and their frequent need for non-linear information access.

Hardware and Software Selection

The hardware selection was influenced by the following factors:

- Laptops were identified as the device of choice for the majority of home healthcare clinicians interviewed during the study. Lowering costs of laptops make them relatively affordable even for low-budget agencies; lightweight of the devices is appropriate in context of patient visits.
- The study revealed that clinicians were open to the idea of using a PDA for reasons of size, weight, and no boot-up latency. However, concern was expressed as to whether the screen size would be adequate for their needs.
- New government regulations (HIPPA) place significant emphasis on ensuring secure access to sensitive patient information in order to preserve patient privacy. Towards satisfying the HIPPA regulations, a Siemens biometric mouse was incorporated (Siemens Biometric Mouse).
- To reduce the impact of the interaction upon the nursing tasks, a discreet wireless Bluetooth earpiece was incorporated. This

enables the nurse to issue spoken commands, but also to receive spoken feedback without the patient hearing. The absence of wires was crucial so as not to inhibit the nursing duties.

The software technology selection was influenced by the following factors:

- Clinicians may access the application from a variety of different locations, including the office, their homes, patient homes, from the car while driving, etc.
- Administering clinical care requires sterile conditions, which makes traditional input devices unsuitable. This requirement indicates a multimodal interface (Multimodal Interaction Working Group), which, if necessary, can be controlled entirely by voice.
- Home healthcare practitioners would prefer continuous access to the patient database, however the existing wireless coverage of rural areas remains too fragmented to be reliable. The application needs to be able to work in either offline or online modes of connectivity.

Collectively, these requirements led us to conclude that a WWW-based solution was feasible, and that recent advances in multimodal technologies provide support on various devices. As such, the user interface was developed using a combination of HTML, Java and Javascript.

Notebook Design: Capturing Patient Vital Signs

The goal of our prototype is to show how cost-effective technology can be integrated into the workflow of a nurse to prove that patient vital signs can be captured unobtrusively. If successful, this could obviate the need for the nurse to enter this data into a computer system upon returning to the office.

In order to address the majority of agencies that expressed interest in notebook and PDA platforms, our design sought to offer a similar user experience while attempting to leverage the respective advantages of each. To provide hands-free operation, the nurse's notebook computer is equipped with a Bluetooth (Bluetooth) capability. Bluetooth wireless headset (Bluetooth headset from Siemens) supports mobile speech interaction with the application within an adequate radius. The initial implementation was developed for a notebook, as seen in Figure 9.

As can be seen from Figures 10 and 11, a multimodal interface allows the nurse to use the keyboard/mouse and/or speech to navigate and enter values into the visualization. For the laptop, SALT (SALT Forum) was selected as the technology used to develop the multimodal interface. In the classical SALT paradigm, speech recognition is initiated using either a keyboard or a mouse, but to offer truly hands-free operations we introduced some novel approaches to support continuous recognition and pause/resume functionality. This enables nurses to use verbal commands to indicate to the application that they are about to start dictating commands, or whether they are engaged in the conversation with a patient. Additionally, after temporarily deactivating the

Figure 9. Nurse's laptop, Bluetooth PCMCIA card and Bluetooth enabled headset

Figure 10. While taking measurements from the patient, the nurse can speak the clinical measurements via the Bluetooth enabled headset directly into the HTML form

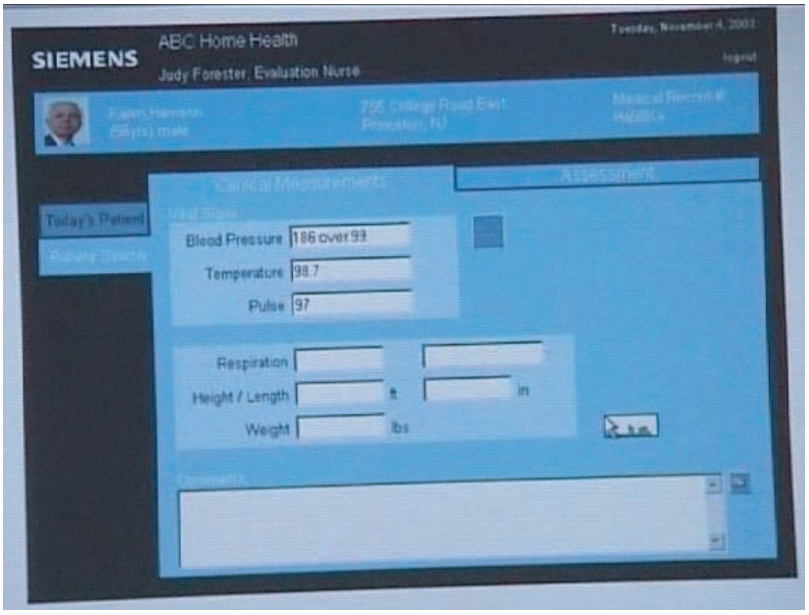
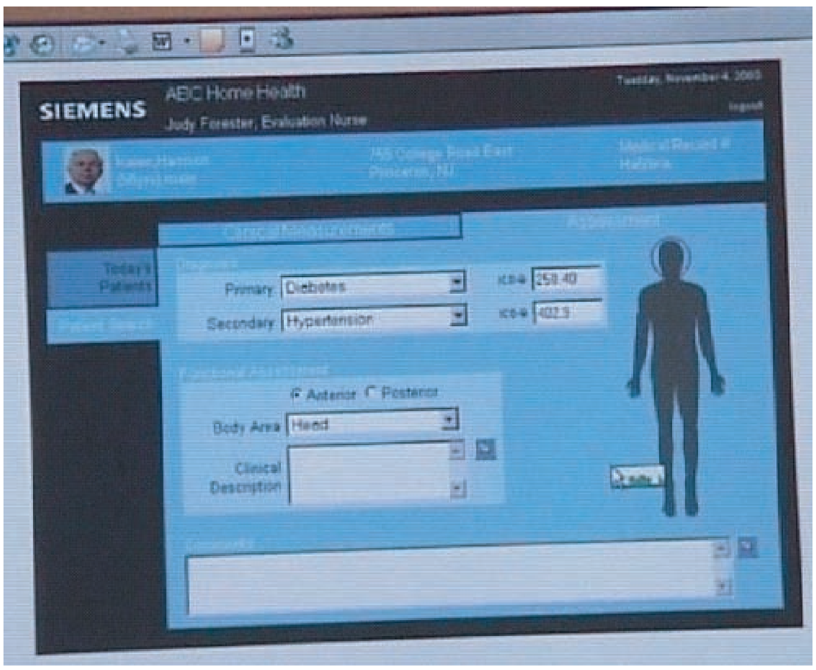


Figure 11. While interviewing the patient, the nurse can speak the diagnosis and functional assessment data via the Bluetooth enabled headset directly into the HTML form



speech recognition, the nurse can resume working by simply issuing a voice command.

PDA Design: Less is More

The notebook implementation was heavily leveraged for the subsequent implementation for the Pocket PC PDA. While the functionality was preserved, the HTML was simplified and modified for appropriate consumption and interaction on the PDA form factor, as can be seen in Figure 12.

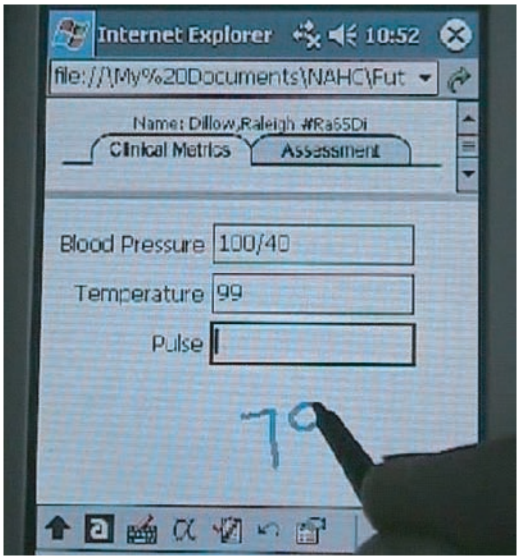
Although SALT technology can be demonstrated using a Pocket PC PDA, the speech processing is not performed locally on the mobile device but redirected to a server machine on the LAN. While this is not practical for deployment, it enabled us to experiment with the approach. It is anticipated that speech processing on the PDA will become available in the near future.

Speech is not the most appropriate input mechanism for every occasion, but one tool in the palette of a multimodal interface designer. As many of the nurses that we studied rely on paper and pencil to record patient notes, we sought to exploit handwriting recognition technology as a means to harness this activity and increase nurses' productivity by capturing this text and entering in directly into HTML form fields. This approach can be seen in Figure 12.

In our interviews we found that the old adage of a picture capturing a thousand words is not lost on nurses. Hence, we sought to offer in our prototype the seamless support for capturing images and integrating them directly into the patient information. A small and inexpensive digital camera peripheral connected via the SDIO port can be used for this purpose. The process of capture, abstraction through a thumbnail representation, and the viewing of the image can be seen in Figures 13 and 14.

In addition to capturing an image, it is often desirable to be able to augment an image with a synchronized audio commentary and associated pen markings to describe specific aspects

Figure 12. Leveraging handwriting recognition to capture vital signs into an HTML form



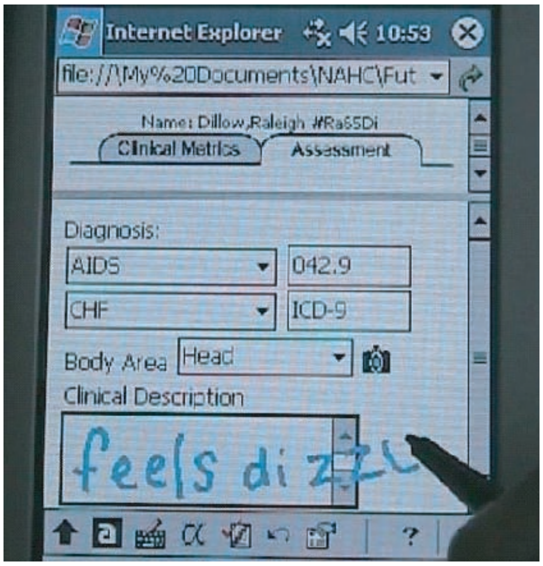
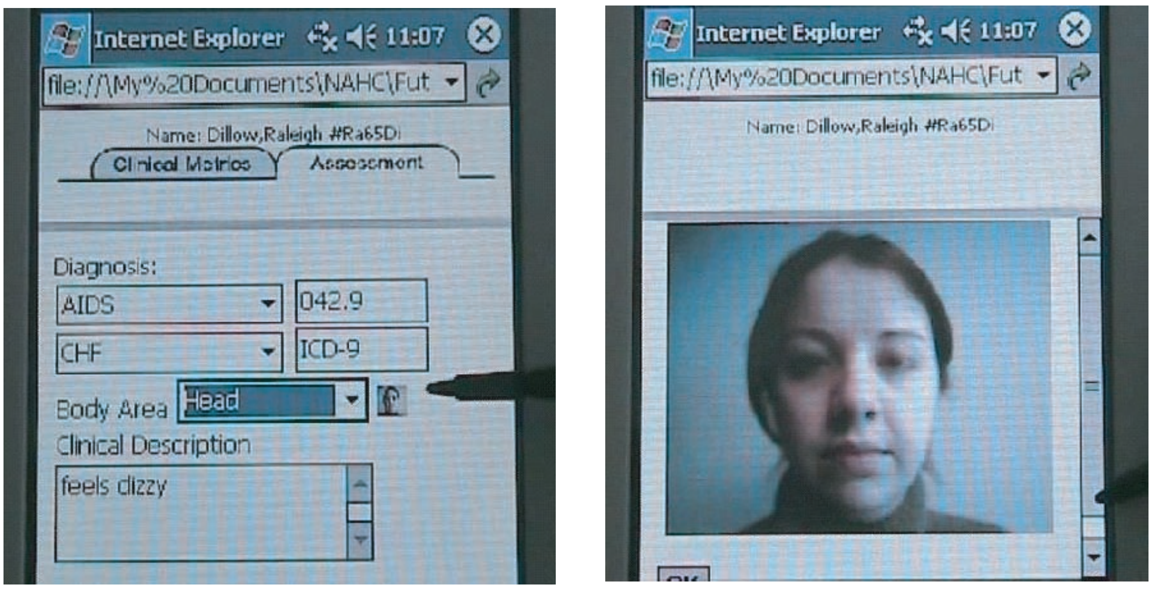


Figure 13. Convenient image capture is seamlessly integrated into the patient record

Figure 14. A thumbnail icon of the captured image can simply be clicked-on for closer inspection



of the patient's condition. Hence, a multimedia annotation capability is offered that can support this requirement and be stored along with the patient record.

Current and future work includes conducting formal user studies with nursing practitioners from two home healthcare agencies to evaluate the usability and efficacy of the devices and approaches described above to inform the subsequent iteration of the prototype design.

CONCLUSIONS

The manner in which a networked enterprise can facilitate a plethora of ways for healthcare personnel to communicate and collaborate was explored within this chapter. The next generation of communication technologies augurs well for converged voice and data solutions on a single network. We anticipate a closer union between healthcare IT systems and web-based communications. Technology innovation has spawned a proliferation of communication and data devices, such as GPRS cellular phones and PDAs, and with it a significant opportunity for accessing clinical information anywhere, anytime, allowing healthcare practitioners to collaborate upon clinical information and reach conclusions more effectively.

Throughout the chapter a selection of technologies has been presented that can enable healthcare personnel to interact in a variety of styles. These approaches demonstrated how multimedia technologies can be harnessed to capture information and enable users to collaborate in range of modes in an effective manner. It was also described how the knowledge captured during collaboration interactions can be saved and archived for future search, reference and reusability. In addition, technology support for home healthcare nurses is presented that shows potential for streamlining the capture and entry of information into the patient record.

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REFERENCES

Bluetooth (n.d.). Online http://www.bluetooth.com

Bluetooth headset from Siemens. Online http://www.siemens-mobile.com/cds/frontdoor/0,2241,hq_en_0_49735_rArNrNrNrN,00.html

Giles, T. (1996). The cost-effective way forward for the management of the patient with heart failure. *Cardiology, 87*(1), 33-39.

Hibbert, D., Mair, F.S., May, C.R., Boland, A., O'Connor, J., Capewell, S., & Angus, R.M. (2004). Health professionals responses to the introduction of a home telehealth service. *Journal of Telemedicine and Telecare 10*(4), 226-230.

HIPPA (n.d.). Online http://www.hhs.gov/ocr/hipaa/

Multimodal Interaction Working Group (n.d.). Online http://www.w3.org/2002/mmi/

SALT Forum (n.d.). Online http://www.saltforum.org

Sastry, C., Lewis, D. & Pizano, A. (1999). Webtour: A system to record and playback dynamic multimedia annotations on Web document content. *Proceedings of the ACM International Conference on Multimedia*, Orlando, October (pp. 175-178).

Siemens Biometric Mouse (n.d.). Online http://www.siemensidmouse.com/

Siemens IMS (n.d.). Online http://www.siemens-mobile.com/cds/frontdoor/0%2C2241%2Chq_en_0_860_rArNrNrNrN%2C00.html

Siemens OpenScape (n.d.). Online http://www.siemensenterprise.com/prod_sol_serv/products/openscape/

Siemens Soarian (n.d.). Online http://www.medical.siemens.com/webapp/wcs/stores/servlet/CategoryDisplay?storeId=10001&langId=-

1&catalogId=-1&catTree=100001,19051,19027&categoryId=19027

Siemens Information and Communications Mobile (n.d.). Online http://www.siemens-mobile.com

Siemens Information and Communications Networks (n.d.). Online http://www.icn.siemens.com

Siemens Medical (n.d.). Online http://www.medical.siemens.com

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Chapter 3.26
Storage and Access Control Policies for XML Documents

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INTRODUCTION

The Internet (and networks overall) are currently the core media for data and knowledge exchange. XML is currently the most popular standardization for Web document representation and is rapidly becoming a standard for data representation and exchange over the Internet. One of the main issues is XML documents and in particular, storage and accessing. Among data management issues, storage and security techniques have a particular importance, since the performance of the overall XML-based Web information system relies on them. Storage issues mainly rely on the usage of typical database management systems (DBMSs), whereas XML documents can also be stored in other storage environments (such as file systems and LDAP directories) (Amer-Yahia & Fernandez, 2002; Kanne & Moerkotte, 2000; Silberschatz, Korth & Sudarshan, 2002). Additionally, in order to guarantee the security of the XML data, which are located in a variety of the above storage topologies, the majority of implementations also provide an appropriate access control. Most storage systems cooperate with access control modules implementing various models (Joshi, Aref, Ghafoor & Spafford, 2001), whereas there are few commercial access control products available. However, there are some standardized XML-based access control languages that can be adopted by most tools.

This article focuses on presenting an overview related to both storing and securing XML documents. Such an overview will contribute to identifying the most important policies for storage and access in Web-based information systems (which extensively use the XML as the data representation format). In addition, the most well-known related implementations are presented. A more integrated survey on these issues is presented in Pallis, Stoupa, and Vakali (2004).

BACKGROUND

Storage Policies

Several solutions for storing XML data have been proposed both in the scientific literature and in commercial products. In particular, storage approaches can be classified with respect to the type of system on which they rely and on the used XML document representation model. In this framework, they can be categorized as follows:

- Relational DBMS: Uses a collection of tables to represent both data and relationships among these data. More specifically, in order to represent XML data by using tables, it is necessary to break down the XML documents into rows and columns. The tree-like structure of XML facilitates both their decomposition and storage in relational tables. However, this process is expected to cause some performance overhead mainly due to the continuous translation of trees to tables (and vice versa). Due to its popularity, several models have been proposed to store XML documents in relational DBMSs (e.g., Bohannon, Freire, Roy & Simeon, 2002; Khan & Rao, 2001; Schmidt, Kersten, Windhouwer & Waas, 2000; Tian, DeWitt, Chen & Zhang, 2000; Zhu & Lu, 2001).
- Object-Oriented (O-O) DBMS: XML documents are stored as collections of object instances, using relationships based on the O-O idea (McHugh, Abiteboul, Goldman, Quass & Widom, 1997). O-O DBMSs have been designed to work well with object programming languages such as C++, C#, and Java. Inheritance and object-identity are their basic characteristics. However, O-O DBMSs cannot easily handle data with a dynamic structure since a new class definition for a new XML document is needed, and the use of O-O DBMSs for XML document storage is not as efficient and flexible.
- Object-Relational (O-R) DBMS: The XML documents are stored in a nested table, in which each tag name in DTD (or XML schema) corresponds to an attribute name in the nested table. Currently, researchers have showed a steadily increasing interest in O-R DBMSs, since they combine both the benefit of the relational maturity and the richness of O-O modeling (Pardede, Rahayu & Taniar, 2004). In O-R DBMSs, the procedure for storing XML data to relation mapping is modeled by an O-R model. In this context, a number of transformation steps from the XML schema to an O-R model are presented (Widjaya, Taniar & Rahayu, 2004). More specifically, each nested XML element is mapped into an object reference of the appropriate type. Then, several mapping rules are indirectly embedded in the underlying model.
- Native XML DBMS: In this case, the XML document is the fundamental unit of storage (Kanne & Moerkotte, 2000). Therefore, a native XML database defines a (logical) model for an XML document, and stores and retrieves documents according to that model. In particular, two basic steps are involved for storing the XML documents on a native XML DBMS: (1) the data are described by its structure (DTD or XML schema), and (2) a native database XML schema (or a data map) is defined. However, the native XML DBMSs have not yet become very popular, since these systems must be built from scratch.
- LDAP Directories: XML documents are stored in LDAP directories which can be

considered as a specialized database (Marron & Lausen, 2001). Therefore, the internal storage model of this database system is defined in terms of LDAP classes and attributes. More details about the architecture of the LDAP model and protocol are discussed by Howes, Smith, and Good (1999). Comparing the LDAP directories with the typical DBMSs, they are more widely distributed, more easily extended, and replicated on a higher scale.
- File Systems: Since an XML document is a file, a typical storage approach is to store it simply as a flat file. In particular, this approach uses a typical file-processing system, supported by a conventional operating system (as a basis for database applications). The wide availability of XML tools for data files results in a relatively easy accessing and querying of XML data (which are stored in files). By using a flat file for XML data, we have faster storing (or retrieving) of whole documents. However, this storage format has many disadvantages, such as difficulty in accessing and updating data, since the only way to accomplish this is to overwrite the whole file (Silberschatz et al., 2002).

Access Control Policies

In order to protect XML files, we need to design authorizations defining which client (subject) can access which protected resource (object) and under which mode. Since XML files are organized according to DTDs or XML schemas, protected resources can be both XML files, DTDs, or schemas, or parts of them, such as a specific element or even attribute.

The basic access control models are:

- Discretionary Access Control (DAC): Every subject and object is enumerated, and there are authorizations connecting each subject and object. The owner is responsible for defining policies in order to protect his/her resources, and (s)he can also define who is going to be assigned some access privileges. It is the most flexible and simple access control model. However, it does not provide high levels of protection, and it cannot be used in case multiple security levels are required.
- Mandatory Access Control (MAC): This is based on the existence of one central administrator responsible for the definition of policies and authorizations. It is expressed with the use of security labels associated with both subjects and objects. Every object has a classification label defining its sensitivity, and each subject is assigned a clearance label defining its trustworthiness. This model is more secure than DAC, but it cannot be used in wide distributed Internet-based environments. Therefore, their usage is gradually decreased.
- Role-Based Access Control (RBAC): The most widely used access control model in modern environments (Sandhu, Coyne & Feinstein, 1996). Subjects are assigned roles that are categorizations of subjects according to their duties in an organization. Thus, every subject is assigned roles that in their part have some authorizations. Therefore, the number of the needed policies is highly decreased. RBAC model is a super set, since it can also express DAC and MAC policies. It is appropriate for distributed heterogeneous networks offering Internet access. Moreover, it is recommended to protect hypertext documents (HTML or XML files). Lately, a generalized RBAC model has been proposed where objects and environmental conditions are assigned roles (Moyer & Ahamad, 2001).

FUTURE TRENDS

Implementations

Some of the most popular database vendors (like IBM, Microsoft, and Oracle) have developed (mainly) database tools for the storage of XML documents, and several storage techniques have been adopted in order to maximize functionality and performance. Furthermore, for reasons of integrity, the majority of the DBMSs are supported by access control mechanisms.

In general, the most well-known software tools that employ XML document storage and access control can be categorized in the following types of databases:

- XML-Enabled DBMSs: These provide various interfaces for extracting structured data from XML documents and then to be stored in DBMSs (according to their model). Table 1 presents the basic products of such an approach.
- Native XML DBMSs: XML documents are stored in XML internally in the database. Table 2 shows some of the most popular DBMSs.

Currently, the most widely adopted technology to enforce the security guarantees of the XML-based databases is the Microsoft (MS) .NET platform. MS .NET has been recently proposed and has been adjusted to support XML Web Services. Its security mechanism is adopted by MS SQL Server 2000 (Rys, 2001), Oracle 9i, and DB2, which have been designed to cooperate with Microsoft .NET technology.

All of the above storage systems can be supported by access control modules. Most of them support the Microsoft .NET access control framework. The idea of protecting XML files is quite new, and therefore most of the implemented systems still belong to the scientific literature and they have not stepped into the market.

The core of every access control mechanism is a language used for expressing all of the various components of access control policies, such as subjects, objects, constraints, and so forth. To date several languages have been proposed. Since XML is a structured language, it can be used in the definition of access control issues, such as roles, policies, and authorizations. Therefore, the most well-known general-purpose XML-based access control languages are:

Table 1. Storage in XML-enabled databases

Product	DBMS Model	Storage
Oracle 9i *technet.oracle.com*	Object-Relational	XML documents are stored as relational tables.
MS SQL Server 2000 *www.microsoft.com*	Object-Relational	Each XML document is stored as a relational table, and an element is created for each row.
IBM's DB2 *www-4.ibm.com*	Object-Relational	XML documents are stored as relational tables.
XIS *www.exceloncorp.com/xis/*	Object-Oriented	XML documents are stored in a B-tree-like structure.
Lore (McHugh et. al., 1997)	Object-Oriented	XML documents are stored using an Object Exchange Model (OEM).
SHORE (Hess, Schulz & Brossler, 2000)	Object-Oriented	This stores information extracted from XML documents using a variant of R-trees and B-trees structure.

Table 2. Storage in native XML databases

Product	**Storage Model**
NATIX (Kanne & Moerkotte, 2000)	Tree structure: XML documents are split into sub-trees (basic storage and query units) based on certain criteria.
SODA *www.cse.unsw.edu.au/~soda/*	Tree structure: XML documents are stored in a single tree, which preserves all XML information.
Xyleme *www.xyleme.com*	Tree structure: XML documents are stored as trees until a certain depth where byte streams are used.
Ipedo *www.ipedo.com/html/products.html*	Collection structure: XML documents are organized into collections (like directories), which can be typed or un-typed.
eXist *exist.sourceforge.net*	Collection structure: XML documents are stored using a DOM-tree (built from SAX-events) and are organized into hierarchical collections, similar to storing files in a file system.
Tamino (Schoning, 2001)	Collection structure: Each XML document is stored in exactly one collection.
Xindice *www.dbxml.org*	Collection structure: Each XML document is stored in at least one collection (a collection can be created either consisting of documents of the same type, or a single collection can be created to store all documents together).

- XACML (eXtensible Access Control Markup Language): This is an OASIS standard that defines both a policy language and an access control decision request/response language (both written in XML) (www.oasis-open.org/committees/xacml/repository). The policy language is used to describe general access control requirements, and has standard extension points for defining new functions, data types, combining logic, and so forth. The request/response language permits forming a query in order to ask whether a given action should be allowed (or not), and to interpret the result that defines the response.
- XrML (eXtensible rights Markup Language): This is a language for digital rights management (Wang et al.). By using XrML, the owner of a digital resource can specify who can use the resource (principal) and under what circumstances (constraints). The owner thus produces licenses containing such information that are then given to the appropriate principal. Since XrML is mainly used for protecting digital media, it contains schemas defining the metadata of such resources, such as audio or video files. Of course, it can be easily extended for controlling access to any other type of resource.
- ODRL (Open Digital Rights Management): This is a language used for Digital Rights Management (DRM) in open environments (odrl.net/1.1/). It can express rights for protecting any digital content, like electronic publications, digital images, audio and movies, learning objects, computer software, and so forth.

Except for the languages, research has to present several access control tools protecting XML files. Those can be categorized into non XML-based and XML-based. Table 3 contains some of the tools belonging to both categories.1 The only

Table 3. Examples of access control tools

Product	Type	Access Control
XENA (Tan & Zhao, 2000)	Non XML-Based	Centralized tool protecting XML repositories using relational database technology.
Author-X (Bertino, Castano & Ferrari, 2001)	XML-Based	Java-implemented tool, supporting varying security granularity levels. PULL and PUSH dissemination technology.
ACP (Access Control Processor) (Damiani, De Capitani di Vimercati, Paraboschi & Samarati, 2000)	XML-Based	Decentralized system supporting distributed XML repositories by using both local and global authorizations.
ProvAuth (Kudo & Hada, 2000)	XML-Based	Access control environment where access is allowed with some provisions. It uses XACL.

tool using a standardized access control language is ProvAuth (Provisional Authorizations) (Kudo & Hada, 2000). As its name suggests, access is allowed to users only after (or before) the execution of some provisional actions, like logging the session, encrypting the view of a protected document, and so forth. To support such functionality, a specific-scope XML access control language (XACL) has been introduced which is part of the IBM XML Security Suite. Due to its extensibility and flexibility, the model can be integrated into a conventional Web application consisting of clients and servers.

CONCLUSION

This article has presented an overview for storage and access control of XML documents. It is important to indicate that no definite guidelines have yet been proposed for selecting an optimal solution when storing and securing XML documents. In order to improve the management of XML documents, some issues should require further research. In particular, the storage of XML documents may be improved by using some data mining techniques (e.g., specific clustering algorithms). Furthermore, the XML management techniques should further extend existing access control policies, in order to improve the security in XML documents accessing. Finally, the commercial DBMSs should be extended to support more sophisticated storage and access control techniques such as integrated methods for locating and accessing dynamic XML documents.

REFERENCES

Amer-Yahia, S. & Fernandez, M. (2002). Techniques for storing XML. *Proceedings of the 18th International Conference on Data Engineering (ICDE 2002),* San Jose, California, USA.

Bertino, E., Castano, S. & Ferrari, E. (2001). Securing XML documents with Author-X. *IEEE Internet Computing, 5*(3), 21-31.

Bohannon, P., Freire, J., Roy, P. & Simeon, J. (2002). From XML schema to relations: A cost-based approach to XML storage. *Proceedings* *of the 18th International Conference on Data Engineering (ICDE 2002)*, San Jose, California, USA.

Damiani, E., De Capitani di Vimercati, S., Paraboschi, S. & Samarati, P. (2000). Designing and implementation of an access control processor for XML documents. *Proceedings of 9th World Wide Web Conference (WWW9) and Computer Networks*, Amsterdam, Holland.

Hess, A., Schulz, H. & Brossler, P. (2000). *SHORE—a hypertext repository based on XML*. Technical Report, SD&M Corporation, Software Design and Management, Southfield, USA.

Howes, T.A., Smith, M.C. & Good, G..S. (1999). *Understanding and deploying LDAP directory services.* Macmillan Technical Publishing.

Joshi, J.B.D., Aref, W.G., Ghafoor, A. & Spafford, E.H. (2001). Security models for Web-based applications. *Communications of the ACM, 44*(2), 38-44.

Kanne, C.C. & Moerkotte, G. (2000). Efficient storage of XML data. *Proceedings of the 16th International Conference on Data Engineering (ICDE 2000),* San Diego, California, USA.

Khan, L. & Rao, Y. (2001). A performance evaluation of storing XML data in relational DBMS. *Proceedings of the 3rd ACM CIKM'01 Workshop on Web Information and Data Management (WIDM 2001)* (pp. 31-38), Atlanta, Georgia, USA.

Kudo, M. & Hada, S. (2000). XML document security based on provisional authorization. *Proceedings of the 7th ACM Conference on Computer and Communications Security* (pp. 87-96), Athens, Greece.

Marron, P.J. & Lausen, G.. (2001). On processing XML in LDAP. *Proceedings of the 27th Conference on Very Large Data Bases (VLDB 2001)* (pp. 601-610), Roma, Italy.

McHugh, J., Abiteboul, S., Goldman, R., Quass, D. & Widom, J. (1997). Lore: A database management system for semi-structured data. *ACM SIGMOD Record*, *26*(3), 54-66.

OASIS eXtensible Access Control Markup Language Technical Committee. eXtensible Access Control Markup Language (XACML) Committee Specification, Version 1.1. Retrieved February 15, 2004, from www.oasis-open.org/committees/xacml/repository

Open Digital Rights Language Initiative. Open Digital Rights Language (ODRL) Specification, Version 1.1. Retrieved February 15, 2004, from odrl.net/1.1/

Pallis, G., Stoupa, K. & Vakali, A. (2004). Storage and access control issues for XML documents. In D. Taniar & W. Rahayu (Eds.), *Web information systems* (Chapter 4, pp. 104-140). Hershey, PA: Idea Group Publishing.

Pardede, E., Rahayu, J.W. & Taniar, D. (2004). On using collection for aggregation and association relationships in XML object-relational storage. *Proceedings of the 19th ACM Symposium on Applied Computing (SAC 2004)*, Nicosia, Cyprus.

Rys, M. (2001). Bringing the Internet to your database: Using SQL Server 2000 and XML to build loosely coupled systems. *Proceedings of the 17th International Conference on Data Engineering (ICDE 2001)* (pp. 465-475), Heidelberg, Germany.

Sandhu, R.S., Coyne, E.J. & Feinstein, H.L. (1996). Role-based access control models. *IEEE Computer*, *29*(2), 38-47.

Schmidt, A., Kersten, M., Windhouwer, M. & Waas, F. (2000, May). Efficient relational storage and retrieval of XML documents. *Proceedings of the 3rd International Workshop on the Web and Databases (WebDB 2000)* (pp. 137-150), Dallas, Texas.

Schoning, H. (2001). Tamino—a DBMS designed for XML. *Proceedings of the 17th International Conference on Data Engineering (ICDE 2001)* (pp. 149-154). Heidelberg, Germany.

Silberschatz, A., Korth, H. & Sudarshan, S. (2002). *Database system concepts* (4th Edition). McGraw-Hill.

Tan, K. & Zhao, J. (2000). *Effective storage and access control of XML documents with relational database system*. Retrieved November 16, 1997, from xena1. ddns.comp. nus.edu.sg:8080 /Xena/ paper.pdf

Tian, F., DeWitt, D.J., Chen, J. & Zhang, C. (2002). The design and performance evaluation of alternative XML storage policies. *ACM SIGMOD Record*, *31*(1), 5-10.

Wang, X., Lao, G., DeMartini, T., Reddy, H., Nguyen, M. & Valenzuela, E. XrML-eXtensible Rights Markup Language. *Proceedings of the ACM Workshop on XML Security* (pp. 71-79), Fairfax, Virginia.

Widjaya, N.D., Taniar, D. & Rahayu, J.W. (2004). Transformation of XML schema to object relational database. In D. Taniar & W. Rahayu (Eds.), *Web information systems* (Chapter 5, pp. 141-189). Hershey, PA: Idea Group Publishing.

Zhu, Y. & Lu, K. (2001). An effective data placement strategy for XML documents. *Proceedings of the 18th British National Conference on Databases (BNCOD 2001)* (pp. 43-56), Chilton, UK.

ENDNOTE

1 The names of the tools, ACP and ProvAuth, are assigned by us for reasons of brevity.

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Chapter 3.27
Technology and Knowledge Management

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INTRODUCTION

Rapid and extensive advances in technology, particularly in the area of communications, have had a considerable impact on the way organizations operate and opened pathways to access vast amounts of information. Information, however, is static unless knowledge is applied to translate it into something meaningful and with the potential to be actionable. From the time organizations commence business, they accumulate information about the markets in which they operate, yet often, knowledge is not applied in a way that it can be exploited to bring benefit. The ability to share knowledge, to develop ideas, and to become more innovative is increasingly important for businesses, and the range of technologies now available provides a conduit for knowledge to flow through the organization to enable sharing to occur. Technology is frequently referred to as "just an enabler," but it can also be identified as a value-adder.

INFORMATION AND KNOWLEDGE

In their paper, Evans and Wurster (1997, p. 71) referred to changes that had taken place over the previous 10 years as organizations adapted their "operating processes" to "information technologies," recognizing that accessing information was going to have an important bearing on where industries would be going in the future. During this period, technology was moving forward at a rapid rate, and organizations were investing huge sums of money in information technology.

Information is defined as facts and data organized to describe a particular situation or problem. The definition used for knowledge is that by Davenport and Prusak (1998):

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded *not only in documents or repositories but also in organizational routines, processes, practices, and norms. (p. 5)*

Connectivity, it is suggested by Evans and Wurster (1997), provided the most important change in the information revolution: "What is truly revolutionary about the explosion in connectivity is the possibility it offers to unbundle information from its physical carrier" (p. 73). Amidon (1997) referred to the major change from information processing to knowledge processing that has taken place, "which includes the concepts of learning tools, intelligent electronic coaching, decision-making systems, and more" (p. 87). The availability of such tools, and their ongoing development, add considerable value to an organization by providing a means through which more efficient and effective management techniques can be introduced. This evolving of expectations indicates that organizations are not only anticipating more from technology but are also becoming more reliant upon it.

As interest grows beyond information per se, organizations are looking to technology to progress toward the development of knowledge management systems. Bhatt (2001) referred to business managers who believe computers and communication technologies provide an avenue for the harvesting of knowledge from data repositories of organizations, while other managers say knowledge "resides in human minds, and therefore, employee training and motivation are the key factors to knowledge management" (p. 68). The development of technology has taken the drudgery out of searching, analyzing, and converting data into information to which knowledge can be applied.

Technology and knowledge, however, do not stand in isolation. There are many interacting factors, not least of which is the environment in which the organisation operates. According to Bhatt (2001), the "…pattern of interaction between technologies, techniques and people is unique to an organization" (p. 69). Such uniqueness is important, because it is not easy to replicate. The organisation that promotes the value of the knowledge, skills, and competencies of its people, and recognizes the importance of technology, is providing well for its future (Carneiro, 2000; Bhatt, 2001).

From a productivity perspective, Grant (2000) indicated the value of digital technology. He referred to knowledge no longer being held exclusively by people. Codification and use of technology provides the opportunity for knowledge replication. While costly to create, replication and distribution can be reduced to almost "zero marginal cost" (Grant, 2000, p. 32). In the long term, and with the arrival of new technologies, the rate of productivity growth is likely to accelerate (Grant, 2000). People have skills and knowledge, but it is technology that enables them to access in a timely manner huge amounts of data available both internally and externally to the organization. While technology enables people to access data, the added value comes in its ability to allow the data to be assembled in a meaningful way for the purpose of decision making.

SHARING KNOWLEDGE

An environment in which knowledge sharing is encouraged leads to the creation of new knowledge, but as Marshall, Prusak, and Shpilberg (1996) indicated, it is not easy to encourage voluntary sharing of knowledge by employees. An organisation that develops a knowledge-sharing environment increases opportunities for the creation of new ideas that have the potential to add value to it.

Barriers to sharing knowledge exist, and for managers advocating knowledge sharing, they should examine the existing practices within the organization. It is possible that somewhere in the organization, the "knowledge is power" syndrome exists, and if so, it does not auger well for knowledge sharing. There may also be concern over job security, "if I share my knowledge, I am no longer of value to the organization, and therefore, my job will be in jeopardy." A barrier to knowledge sharing may simply rest on the premise that a person may not realize that knowledge acquired in another situation could be of value to the organization. Managers may need to look to changing the organizational culture to one that recognizes, and acknowledges, the value of shared knowledge.

Bhatt (2001), referring to the need for the distribution and sharing of knowledge throughout the organisation, suggested that interactions among technologies, techniques, and people have a direct bearing on the effectiveness of the distribution of knowledge.

RANGE OF TECHNOLOGIES

According to Frappaola and Capshaw (1999): "Knowledge management refers to the practices and technologies that facilitate the efficient creation and exchange of knowledge on an organizational level" (p. 44).

From the literature, it appears that there are a number of applications specifically designed for sharing knowledge (Davenport, 1997; LaPlante, 1997; Fahey & Prusak, 1998). The benefits of applications, such as groupware, data warehousing, knowledge maps, client server systems, and chat rooms, are recognized as providing the means through which knowledge can be shared. A useful aspect of such applications is that they allow for interaction and sharing of information that is highly unstructured in nature (Shani, Sena, & Stebbins, 2000). Research carried out by Mitchell in 1999 indicated that people are finding groupware applications useful mechanisms for sharing knowledge.

A number of writers, Allee (1997), Amidon (1997), Marshall (1997), Watt (1997), and Davenport and Prusak (1998), refer to the intranet as providing channels through which organizational knowledge can flow. E-mail is now well accepted as a useful and valuable medium of communication, and for knowledge to flow through an organization (Bontis, Fearon, & Hishon, 2003). The advent of electronic conferencing provides an avenue through which people geographically dispersed can interact without the time and cost involved in traveling. Networking, bulletin boards, and the establishment of virtual teams also provide opportunities for people to interact over distances and to share knowledge.

Reference is made by Beckett (2000) to the "Data warehousing knowledge set" containing reference data, defined as market trends, operational data, and customer performance needs. From this knowledge set, actions can be taken that ultimately benefit stakeholders and customers. While the knowledge set may be considerable, ideally, its value only becomes realistic when there is in place the means to allow for the "free" flow of knowledge throughout the organisation and when there are people who can recognize that value can be gained from it. It is most unlikely that organizations allow for a free flow of knowledge, because issues such as privacy and confidentiality, "need to know," and other constraints restrict access to knowledge. However, providing access to knowledge that can be made available should be the aim of organizations wanting to encourage a knowledge-sharing environment.

Technology has opened avenues to the customer to search for opportunities and products that may better serve their needs. The opportunity, however, is also open to the organization to exploit the potential of technology to create greater value for its customers.

KNOWLEDGE MANAGEMENT STRATEGY

Hansen, Nohria, and Tierney (1999) identified management consultants as being among the first to recognize the potential of information technology for the capture and dissemination of knowledge. It was found that organizations tend to employ two very different strategies for the management of knowledge. One is the "codification strategy," where maximizing the use of technology shows a strong focus on codifying knowledge and storing it in databases for access by anyone in the company. The second approach viewing knowledge being shared through person-to-person contacts is identified as the "personalization strategy" (Hansen, Nohria, & Tierney, 1999, p. 107).

From their research, Hansen et al. (1999) found that organizations pursuing "an assemble-to-order product or service strategy emphasized the codification and reuse of knowledge. Those that pursued highly customized service offerings, or a product innovation strategy, invested mainly in person-to person knowledge sharing" (p.112). Whichever strategy is used, there is inevitably the inclusion, as a support mechanism, of an element of the other strategy. Hansen et al. suggest an 80:20 split, that is, "80% of their knowledge sharing following one strategy, 20% the other." They go on to say that "Executives who try to excel at both strategies risk failing at both" (p. 112).

In his article, Beckett (2000) referred to the fastest knowledge-transfer vehicles, relating them to the work of Nonaka and Takeuchi (1995). The tacit/tacit transfer is fast, "because people use multiple sensors in working together in teams" (p. 317). Using electronic media for the transfer of explicit/explicit transfer can also be fast. However, there is evidence that "tacit/explicit transfers are slow, as specialist skills are needed to draw out and carefully enunciate tacit knowledge" (p. 317). Becket indicated that explicit/tacit transfers are similarly positioned, and provides the example of formal education.

Giving consideration to the perspectives of Hansen et al. (1999) and Beckett (2000), and others, such as Ericsson and Avdic (2003), Mockler and Dologite (2002), Jentzsch and Prekop (2002), and Frappaolo and Capshaw (1999), determining a knowledge management strategy needs careful thought if it is to meet the requirements of the organization.

TECHNOLOGY: ENABLER OR VALUE-ADDER?

Lloyd (1996) referred to the use by organizations of worldwide networks and said that new technology is "the catalyst which is forcing all organizations to re-evaluate what they know, what they do with that knowledge, and how they continually add value (or not) to that knowledge in meeting changing customer needs" (p. 576). Technology has advanced considerably since Lloyd made this comment, and it will continue to evolve in the years ahead, providing for greater enrichment of organizational operations. While the cost of "keeping up" with technological developments has always been a problem for organizations that have made a strong commitment to technology, others recognize that they need to work smarter with what they have.

If technology is just an enabler, what is it that adds value to the organisation? Binney (2001, p. 33) addressed the question of knowledge-management (KM) investments. What has emerged is the KM spectrum, in which he identifies KM applications and places them into "six common categories to establish the elements of the KM spectrum" (p. 34). Binney identified from the literature six categories to provide the elements of the KM spectrum: transactional, analytical, asset management, process, developmental, and innovation and creation. He then mapped KM applications to the elements:

1. Transactional—Order entry applications; help desk applications
2. Analytical—Data warehousing, customer relationship management, DSS, MIS

3. Asset management—Document management, intellectual property
4. Process—TQM, process automation, benchmarking
5. Developmental—Skills development, training
6. Innovation and creation—Communities, virtual teams, networking

The next stage of the process added to the various elements, enabling technologies:

1. Transactional—Expert systems, probability networks
2. Analytical—Intelligent agents, data analysis and reporting tools
3. Asset management—Document management tools, knowledge maps
4. Process—Workflow management, process-modeling tools
5. Developmental—Computer-based training, online training
6. Innovation and creation—Search engines, voice mail, groupware

The KM spectrum provides organizations with the means to identify their present positions and to make use of the framework to map their future investments in knowledge management. The examples given above illustrate the wide range of applications available to organizations, and their potential and value emerges through maximizing their use for the purpose of effective decision-making in an increasingly competitive environment.

Technology has provided the impetus for the growth of the information age, but it should not be regarded as a dominant partner. As Pemberton (1998) commented, "The IT exponents of KM tend to downplay the central role of human factors in KM…IT doesn't itself create knowledge any more than does a library, an office, or a classroom" (p.60). But, as Carneiro (2000) indicated, the combining of knowledge and information technology is a major success factor in strategic planning formulation. The future will bring ever more sophisticated advancements in technology providing new avenues of exploration for seeking, creating, and sharing knowledge.

CONCLUSION

Is technology just an enabler, or is it also a value-adder? From the literature, technology, while recognized as being important, tends to be regarded as an enabler rather than a value-adder. Yet the continual movement in technological progress, as shown in Binney's KM spectrum, clearly identifies the developments that have taken place in technology to enhance the operation of business. People provide value through the application of their knowledge, but their ability to do so is considerably enhanced by the availability of technology. Technology enriches opportunities for disseminating and sharing knowledge, and through providing the means to access information for decision making. While the role of technology may be seen as that of enabler to access information, value is added through the ability to assemble data, put it into meaningful information, and manipulate it into various scenarios before determining the best decision. Technology is adding value by allowing organizations to do this. Without the range of technology available to organizations, they would be considerably restricted in their ability to effectively manage their business. Therefore, technology should be identified as an adder of value.

REFERENCES

Allee, V. (1997). *The knowledge evolution: Expanding organizational intelligence*. Oxford: Butterworth-Heinemann.

Amidon, D. M. (1997). *Innovation strategy for the knowledge economy: The Ken Awakening.* Oxford: Butterworth-Heinemann.

Beckett, R. C. (2000). A characterization of corporate memory as a knowledge system. *Journal of Knowledge Management, 4*(4), 311–319.

Bhatt, G. D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68–75. Available at http://angelina.emeraldinsight.com/v1=…/rpsv/cw/mcb/13673270/v5n1/s6/p68.html

Binney, D. (2001). The knowledge management spectrum—Understanding the KM landscape. *Journal of Knowledge Management, 5*(1), 32–42.

Bontis, N., Fearon, M., & Hishon, M. (2003). The e-flow audit: An evaluation of knowledge flow within and outside a high-tech firm. *Journal of Knowledge Management, 7*(1), 6–19.

Carneiro, A. (2000). How does knowledge management influence innovation and competitiveness? *Journal of Knowledge Management, 4*(2), 87–98.

Davenport, T. H. (1997, June 15). Known evils: Common pitfalls of knowledge management. *CIO,* 34–36.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Cambridge, MA: Harvard Business School Press.

Ericsson, F., & Avdic, A. (2003). Knowledge management systems acceptance. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges.* Hershey, PA: IRM Press.

Evans, P. B., & Wurster, T. S. (1997, September–October). Strategy and the new economics of information. *Harvard Business Review,* 71–82.

Fahey, L., & Prusak, L. (1998, Spring). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265–275.

Frappaola, C., & Capshaw, S. (1999, July). Knowledge management software: Capturing the essence of know-how and innovation. *The Information Management Journal,* 44-48.

Grant, R. M. (2000). Shifts in the world economy: The drivers of knowledge management. In C. Despres & D. Chauvel (Eds.), *Knowledge horizons.* Oxford: Butterworth-Heinemann.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March–April). What's your strategy for managing knowledge? *Harvard Business Review,* 106–116.

Hurley, M. A., & Harris, R. (1997). Facilitating corporate knowledge: Building the data warehouse. *Information Management and Computer Security, 5*(5), 170–174.

Jentzsch, R., & Prekop, P. (2002). A conceptual model of collaborative information seeking. In D. White (Ed.), *Knowledge mapping and management.* Hershey, PA: IRM Press.

LaPlante, A. (1997, June 2). Sharing the wisdom. *Computerworld,* 73–74.

Lloyd, B. (1996). Knowledge management: The key to long-term organizational success. *Long Range Planning, 29*(4), 576–580.

Marshall, C., Prusak, L., & Shpilberg, D. (1996, Spring). Financial risk and the need for superior knowledge management. *California Management Review, 38*(3), 77–101.

Marshall, L. (1997, September/October). New opportunities for information professionals. *Online,* 93–98.

Martiny, M. (1998, Autumn). Knowledge management at HP consulting. American Management

Association, *Organizational Dynamics, 27*(2), 71–77.

Mockler, R. J., & Dologite, D. G. (2002). Strategically-focused enterprise knowledge management. In D. White (Ed.), *Knowledge mapping and management.* Hershey, PA: IRM Press.

Pemberton, J. M. (1998, July). Knowledge management (KM) and the epistemic tradition. *Records Management Quarterly*, 58–62.

Shani, A. B., Sena, J. A., & Stebbins, M. W. (2000). Knowledge work teams and groupware technology: Learning from Seagate's experience. *Journal of Knowledge Management, 4*(2), 111–124.

Watt, P. (1997, August). Knowing it all. *Intranet*, 17–18.

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Section 4
Utilization and Application of Knowledge Management

This section discusses a variety of applications and opportunities available that can be considered by practitioners in developing viable and effective knowledge management programs and processes. This section includes more than 50 chapters, some of which review knowledge management literature published in top-tier journals, offering findings on the most popular trends researched within the academic community. Other chapters discuss the utilization of knowledge management within the governmental realm. Also considered in this section are the challenges faced when utilizing knowledge management with healthcare systems. The adaptability of governmental agencies in response to disasters is given consideration as well through research which investigates major hurdles faced in knowledge sharing in the face of disasters, spanning the globe. Contributions included in this section provide excellent coverage of today's global community and how knowledge management research is impacting the social fabric of our present-day global village.

Chapter 4.1
A Hierarchical Model for Knowledge Management

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INTRODUCTION

Knowledge management (KM) is a multidisciplinary subject, with contributions from such disciplines as information systems (IS) and information technology (IT), strategic management, organizational theory, human-resource management, education science, psychology, cognitive science, and artificial intelligence. In order to take full advantage of these various contributions, the necessity of a multidisciplinary approach to KM is currently widely acknowledged, particularly in the IS and IT, management, and artificial-intelligence communities (Alavi & Leidner, 2001; Dieng-Kuntz et al., 2001; Grover & Davenport, 2001; Nonaka & Konno, 1998; O'Leary & Studer, 2001; Zacklad & Grundstein, 2001).

Several KM models have been proposed in the literature. These models reflect the diversity of disciplines contributing to KM. By describing KM concepts and investigating their relationships, they provide a useful conceptual tool for KM research and practice. However, they suffer from three major limitations.

- They are often incomplete. This may be intentional (in the case of models focusing on a specific aspect of KM) or reflect disproportionate emphasis on one of the disciplines contributing to KM, for example, IS and IT.
- They are inappropriate for navigating between abstraction levels of KM topics ("drill down" or "drill up").
- They do not provide a structure for the quantitative assessment of KM research and/or practice (e.g., for auditing KM practice in a specific company).

This article presents a KM model that aims at providing a solution to these three problems. The model is formalized and structured as a hierarchy, which enables navigation between the abstraction levels of KM topics. Furthermore, by combining this hierarchical structure with the analytic hierarchy process (Saaty, 1980), the KM model may be applied to quantitatively assess KM practice and/or research. The model is organized into three components: knowledge types, KM processes, and KM context. It integrates the contribution of previous models and reflects the multidisciplinary aspect of KM.

The article is structured as follows. The next section provides an overview of extant KM models, that is, the background of our work. Then the article presents our hierarchical KM model, develops its three components, and discusses and illustrates how the model may be applied to KM research and practice. Before concluding, we present our view of future trends and research opportunities regarding KM models.

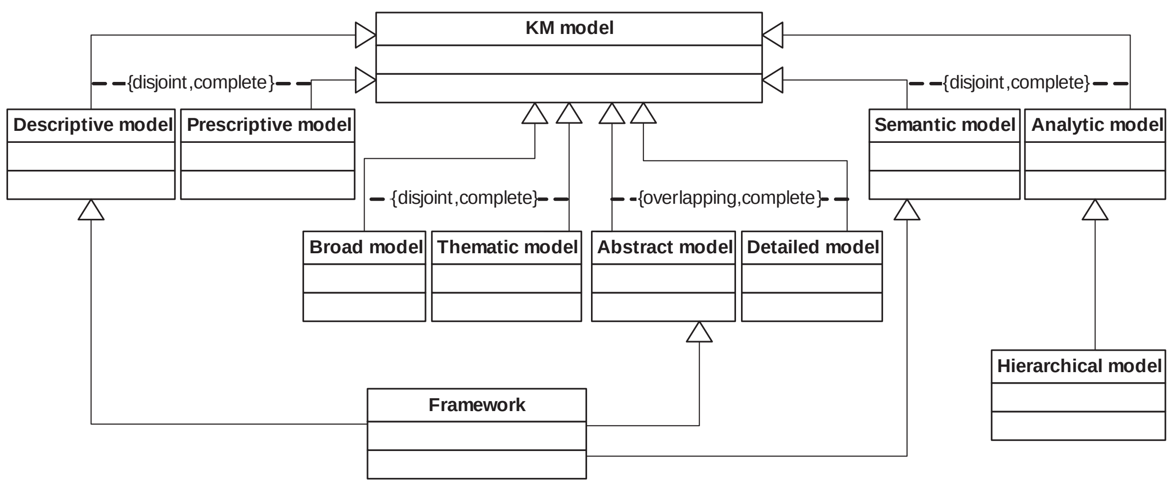
KM MODELS

ISO (2004) defines a model as a "limited representation of something suitable for some purpose." This definition applies to KM models. In broad terms, the purpose of these models is to provide conceptual tools for KM research and/or practice.

Figure 1 proposes a classification of KM models. This classification elaborates on and refines the classification criteria proposed by Holsapple and Joshi (1999) for KM frameworks. Figure 1 uses the UML (unified modeling language) formalism (OMG, 2003) for representing classes, generalizations, and generalization constraints. We classify KM models according to four complementary criteria (the first two criteria are those defined in Holsapple and Joshi).

- A KM model is either descriptive (i.e., describing the nature of KM phenomena) or prescriptive (i.e., proposing methodologies for performing KM).
- KM models are either broad or thematic. Broad models attempt to cover the whole of KM, while thematic models focus on a specific topic.
- A KM model may be abstract, detailed, or both (as indicated by the generalization constraint in Figure 1). This classification complements the distinction between broad and thematic models. For example, a broad model may be both abstract (providing a global view of KM concepts or topics) and detailed (enabling navigation into the details of a topic).

Figure 1. A classification of KM models



- The last classification distinguishes between semantic and analytic models. Semantic models describe the meaning of KM concepts and their interrelationships. Analytic models adopt a deductive approach, progressively detailing KM topics by decomposing them into subtopics.

In addition to these four classifications, Figure 1 represents two specific types of KM models: frameworks (defined as KM models that are at the same time descriptive, abstract, and semantic) and hierarchical models (a special kind of analytic model).

Several KM models have been proposed in the literature (Alavi & Leidner, 2001; Davenport & Prusak, 2000; Despres & Chauvel, 2000; Fowler, 2000; Grover & Davenport, 2001; Handzic, 2001; Holsapple & Joshi, 2004; Newman & Conrad, 2000; Nissen, 2002; Nonaka, 1994). A comparative analysis is presented later in this article. If we consider the above-presented classifications, we notice that existing KM models are often descriptive, abstract, and semantic models, that is, frameworks. All the models are semantic. Consequently, elaborating on the contribution of these models, our objective is to define an integrated, analytic KM model. This broad, analytic model will facilitate navigation into the details of KM topics and enable the quantitative assessment of KM research and/or practice.

A HIERARCHICAL KM MODEL

In this section, we present our KM model and compare it with previous models; we discuss and illustrate how it may be applied to KM research and practice.

Introduction

KM comprises a set of processes. These processes concern knowledge (e.g., knowledge transfer) and are influenced by context (e.g., the organizational culture). Consequently, KM models are often structured around the concepts of KM processes, knowledge, and/or context (Alavi & Leidner, 2001; Despres & Chauvel, 2000; Grover & Davenport, 2001; Handzic, 2001; Holsapple & Joshi, 2004). These concepts form the three basic components of our model.

- The knowledge types component characterizes knowledge according to several complementary classifications.
- The KM processes component is dedicated to KM activities.
- Finally, the KM context component comprises the factors that influence (positively or negatively) the conduct of KM. Depending or their nature, these factors may (more or less easily) be controlled to improve KM.

The components of our KM model are organized into a hierarchy. The concepts of the model are represented as nodes. The parent-child relationships between nodes are abstraction relationships: A parent node is detailed by its children nodes (or conversely, a child is abstracted into its parent). There are no generally applicable structural criteria indicating when decomposition should stop. This is guided by semantic and practical considerations (e.g., the decomposition of a concept stops when the concept is easy enough to measure in practice or when further decomposition would be meaningless).

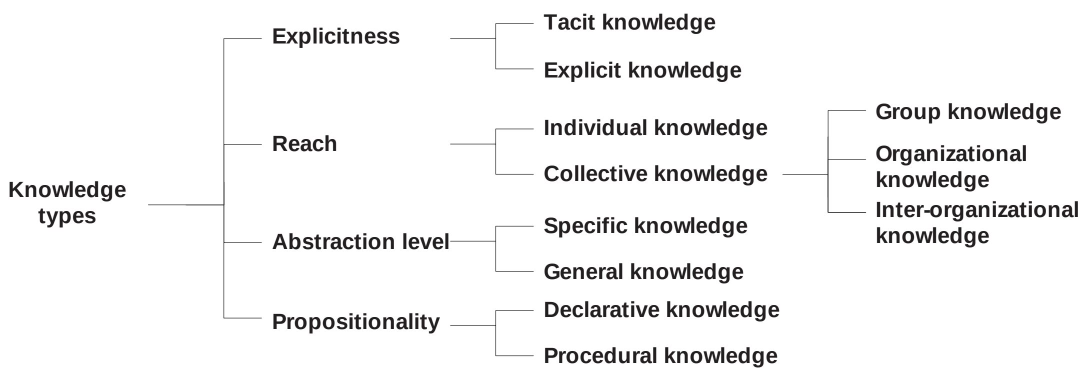
We describe the three components of the KM model.

Knowledge Types

The part of the KM model pertaining to knowledge types is represented in Figure 2. Elaborating on previous work, we propose four complementary classifications for characterizing knowledge.

The first classification, which is almost universally adopted in previous KM models,

Figure 2. Knowledge types



distinguishes between tacit and explicit knowledge. Similarly to Nissen (2002), we use the term explicitness to name this classification. The distinction between tacit and explicit knowledge was first applied to KM by Nonaka (1994). Tacit knowledge is deeply rooted in the individual's mind and may not be easily codified as opposed to explicit knowledge.

The reach classification makes the distinction between individual and collective knowledge. Collective knowledge is further decomposed into group, organizational, and interorganizational knowledge. In general terms, the concept of organizational knowledge may designate knowledge at the organization or at the group level. The reach classification appears in many KM models (e.g., the model of Nissen, 2002, has a reach dimension).

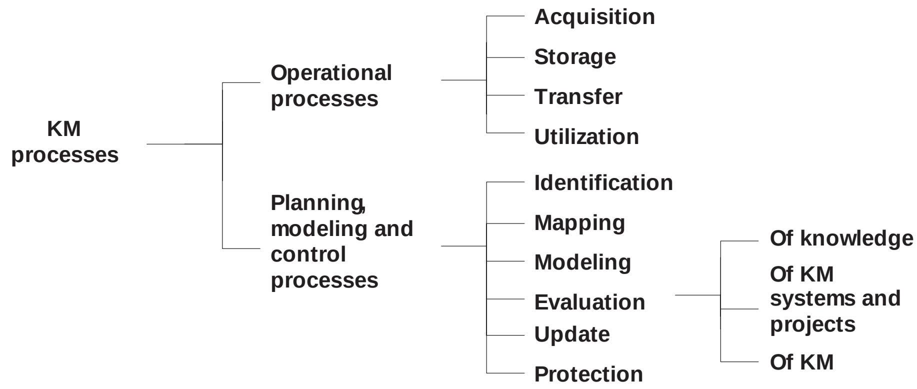
The abstraction-level classification distinguishes between specific and general (abstract) knowledge. This distinction appears explicitly in the model of Fowler (2000). The distinction is relevant to KM since knowledge is often more easily transmitted when it is in a specific form (examples). This principle is applied in such methods as case-based reasoning (Kolodner, 1993; Prat, 2001a) and narratives (Soulier, 2000).

The last classification distinguishes between declarative knowledge ("know-what") and procedural knowledge ("know-how"). Since declarative knowledge is made of propositions, this classification is called propositionality. Procedural and declarative knowledge are often assimilated to tacit and explicit knowledge respectively. However, the two classifications are not equivalent (For example, the sequence of steps necessary to make a coffee with a coffee machine is procedural knowledge that may easily be made explicit). Procedural knowledge is richer than declarative knowledge. In particular, procedural knowledge comprises the various choice alternatives considered: and the choice criteria (Rolland, Souveyet, & Moreno, 1995). In this respect, the traceability of design processes and decisions is a key research direction for KM (Karsenty, 2001; Prat, 2001b; Zamfiroiu & Prat, 2001).

KM Processes

Figure 3 represents the KM processes component. In contrast with previous KM models, which often focus on the basic processes (knowledge creation, storage, transfer, and utilization) and/or consider all the processes to be at the same level, we dis-

Figure 3. KM processes



tinguish between an operational level comprising the basic processes and a strategic or tactical level (planning, modeling, and control).

Operational processes are the basic processes of KM. Even if the number and names of operational processes may vary, the majority of KM models comprise the same fundamental processes. The typology we use in our model draws heavily from Prat (2001a).

- Knowledge acquisition comprises all activities that increase the global stock of knowledge potentially useful to the organization.
- Knowledge storage consists in retaining knowledge in individual or collective memory. Knowledge is indexed to facilitate future retrieval.
- Knowledge transfer is the sharing of knowledge between individuals, groups, and organizations.
- Knowledge utilization is the application of knowledge to business processes.

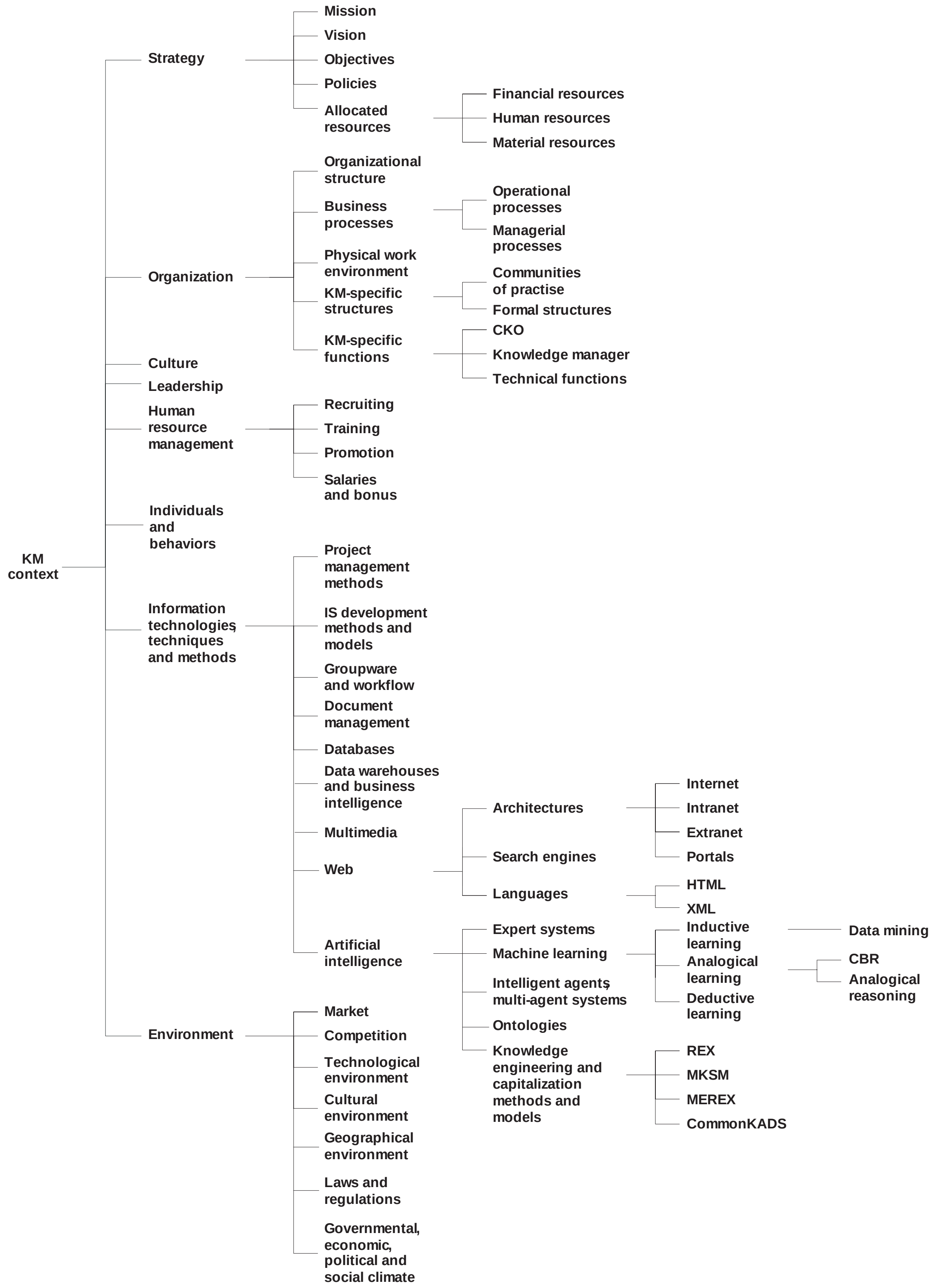
The planning, modeling, and control processes encompass the following processes.

- The identification, mapping, and modeling of current knowledge or of knowledge necessary to achieve previously defined objectives.
- Evaluation, which may be operated at various levels: the evaluation of knowledge, the evaluation of KM projects and/or of KM systems (KMSs) resulting from these projects, and the evaluation of KM.
- Knowledge update. This process includes unlearning (forgetting). Although unlearning is often neglected by the IS and IT community, the organizational-theory and strategic-management literature often emphasise this key process, which is often a condition for the acquisition of new knowledge (Huber, 1991; Tarondeau, 2002; Walsh & Ungson, 1991).
- The protection of knowledge through various means (patents, firewalls, etc.).

KM Context

This last component of the KM model comprises the factors that may positively or negatively influ-

Figure 4. KM context



ence KM (Figure 4). Whenever possible, these factors should be used to leverage KM efforts.

Strategy is refined into mission, vision, objectives, policies (rules), and allocated resources. The latter may be financial, human, or material resources.

The organization comprises the following subtopics:

- Organizational structure.
- Business processes, into which the KM processes should ideally be incorporated. Following Davenport and Short (1990), we distinguish between operational and managerial processes, the latter being often more knowledge based.
- The physical work environment.
- KM-specific structures, that is, communities of practice or formal structures.
- KM-specific functions: chief knowledge officer (CKO), knowledge manager, technical functions.

The culture of an organization is crucial to the success of KM (Grover & Davenport, 2001).

Leadership is mentioned in several KM models, underlying the role of senior management support in the success of KM.

Human-resource management influences individuals and their behaviors.

Information technologies, techniques, and methods are a key KM enabler and facilitator, although it is generally admitted that technology should not represent more than one third of a KM project (Davenport & Prusak, 2000; Smith & Farquhar, 2000).

Information technologies, techniques, and methods include project management methods, IS development methods and models, groupware and workflow, document management, databases, data warehouses and business intelligence, multimedia, the Web, and artificial intelligence. The latter two are discussed in detail below.

The Web comprises architectures (Internet, intranet, extranet, and portals), search engines, and languages (primarily HTML [hypertext markup language] and XML [extensible markup language]).

Artificial intelligence includes the following topics.

- Expert systems apply to the representation and utilization of explicit knowledge.
- Machine learning permits the generation of new knowledge. Following Michalski (1993), we distinguish three types of learning: inductive learning (from specific to general), analogical learning (specific to specific, or general to general), and deductive learning (general to specific).
- Intelligent agents and multiagent systems apply to knowledge searching on the Web.
- Ontologies also permit the improvement of knowledge searching on the Web in conjunction with XML (semantic Web).
- The methods and models of knowledge engineering and capitalization include REX (Eichenbaum, Malvache, & Prieur, 1994), MKSM (Ermine, 2001), MEREX (Corbel, 1997), and CommonKADS (Breuker & van de Welde, 1994).

Finally, KM is influenced by the environment. Drawing from Holsapple and Joshi (2004) and Reix (2000), we decompose the environment into the market; the competition; the technological, cultural, and geographical environments; laws and regulations; and the governmental, economic, political, and social climates.

Comparison with Previous Models

Table 1 illustrates which topics of our KM model are covered by previous work. For the sake of readability, we only consider the first two detail levels of our model. Table 1 shows that while previ-

Table 1. Topics covered by KM models

	Alavi & Leidner (2001)	Davenport & Prusak (2000); Grover & Davenport (2001)	Despres & Chauvel (2000)	Fowler (2000)	Handzic (2001)	Holsapple & Joshi (2004)	Newman & Conrad (2000)	Nissen (2002)	Nonaka (1994)
1. Knowledge types	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered
1.1. Explicitness	Covered	Partly	Covered	Covered	Covered	Covered	Covered	Covered	Covered
1.2. Reach	Covered	Covered	Covered	Partly	Not covered	Covered	Covered	Covered	Covered
1.3. Abstraction level	Not covered	Partly	Not covered	Covered	Not covered	Not covered	Partly	Not covered	Not covered
1.4. Propositionality	Covered	Not covered	Not covered	Covered	Covered	Covered	Not covered	Not covered	Not covered
2. KM processes	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered
2.1. Operational processes	Covered	Covered	Covered	Covered	Covered	Covered	Covered	Covered	Partly
2.2. Planning, modeling, and control processes	Partly	Covered	Covered	Partly	Not covered	Covered	Partly	Covered	Not covered
3. KM context	Not covered	Not covered	Partly	Not covered	Not covered	Not covered	Not covered	Not covered	Not covered
3.1. Strategy	Partly	Covered	Not covered	Not covered	Not covered	Covered	Not covered	Not covered	Partly
3.2. Organization	Partly	Covered	Not covered	Not covered	Covered	Covered	Not covered	Not covered	Partly
3.3. Culture	Partly	Covered	Not covered	Partly	Covered	Covered	Not covered	Not covered	Partly
3.4. Leadership	Not covered	Partly	Not covered	Partly	Covered	Covered	Not covered	Not covered	Partly
3.5. Human-resource management	Partly	Covered	Not covered	Partly	Partly	Covered	Not covered	Not covered	Partly
3.6. Individuals and behaviors	Partly	Covered	Not covered	Partly	Partly	Covered	Not covered	Not covered	Partly
3.7. Information technologies, techniques, and methods	Covered	Covered	Not covered	Partly	Covered	Covered	Covered	Partly	Partly
3.8. Environment	Partly	Partly	Not covered	Partly	Partly	Covered	Not covered	Partly	Partly

Legend :
□ = Not covered ▒ = Partly or informally covered ■ = Covered

ous KM models are complementary and thereby contribute to the definition of our model, none of these models covers the whole range of topics covered by ours (this would have been made even more visible if we had considered the more detailed levels of our hierarchy). The most complete model that we have found is the ontology developed by Holsapple and Joshi (2004). However, this ontology, like the other models, is a semantic model, which is inappropriate for navigating between abstraction levels of KM topics and for quantitatively assessing KM research and practice. On the contrary, navigation and quantitative assessment are facilitated by our hierarchical KM model. This opens the way to different applications both in research and practice.

Application to KM Research and Practice

Navigation Between Abstraction Levels of KM Topics

KM models (more specifically, broad models) should enable researchers and practitioners to examine KM concepts at various levels of detail, and to navigate from abstract levels to detailed levels (drill down) or from detailed levels to abstract levels (drill up). However, even if semantic KM models may comprise concepts of various levels of detail, they do not allow easy navigation between these levels. On the contrary, hierarchies provide a natural mechanism for organizing information of various detail levels, and for navigating between these levels (Saaty, 1999). Consequently, our KM model, by its very hierarchical structure, enables KM practitioners and researchers to master the complexity of KM phenomena.

Quantitative Assessment of KM Research and Practice

Based on the hierarchical structure of the KM model, the analytic hierarchy process (Saaty, 1980) may be applied to the quantitative assessment of KM by taking the following steps.

1. A subhierarchy of the hierarchical KM model is selected depending on what needs to be assessed and for what purpose.
2. Weights are determined for the nodes of the subhierarchy.
3. The weighed subhierarchy is used for performing evaluations. For each evaluated item, scores are entered for the end nodes of the subhierarchy. Aggregated scores, including the global score of the item, are calculated based on the previously defined weights.

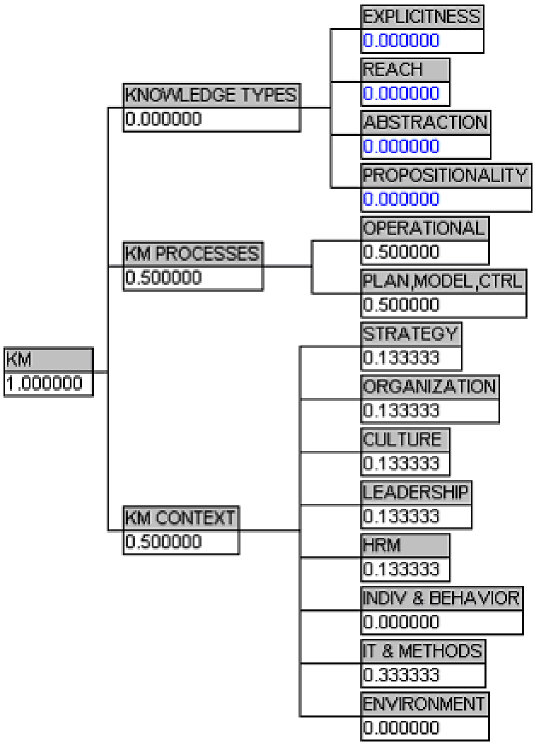
Assessment of KM Practice

In practice, the KM model can be applied to evaluate (audit) the KM maturity of a given organization. The analytic hierarchy process is perfectly adapted to auditing, as illustrated by the INFAUDITOR system (Akoka, Comyn-Wattiau, & Prat, 1993). The subhierarchy of the KM model chosen for KM auditing typically includes the KM processes and KM context. Weights assigned to the nodes of the subhierarchy reflect the relative priorities of the audited organization with respect to KM (e.g., information technologies, techniques, and methods are more important than leadership, etc.).

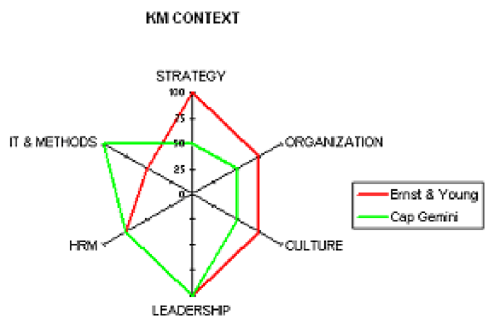
We illustrate this application of the KM model with the Cap Gemini and Ernst & Young case (Figure 5). This is simply an illustrating example and by no means a judgment on the way these two companies have handled KM. Information was gathered from secondary sources (Davenport, 1997; Hjertzén & Toll, 1999; Lara, Andreu, & Sieber, 2002). The example was treated using the Descriptor® tool, which supports the analytic hierarchy process (Adexys, 2004).

We consider KM at Ernst & Young and Cap Gemini respectively, before Cap Gemini acquired Ernst & Young in 2000. Our KM model is applied to evaluate and compare KM practices in these two companies. We assume that two levels of detail (not counting the root) are sufficient for getting a first impression of KM practices in the two companies. We exclude the KM types component. Moreover, in the KM context, we exclude the factors environment, and individuals and behaviors (the companies supposedly have limited control on the environment and can

Figure 5. Applying the KM model



Scores %	Ernst & Young	Cap Gemini
KM	**67,9**	**63,3**
KM PROCESSES	62,5	50
KM CONTEXT	73,3	76,7
OPERATIONAL	75	50
PLAN,MODEL,CTRL	50	50
STRATEGY	100	50
ORGANIZATION	75	50
CULTURE	75	50
LEADERSHIP	100	100
HRM	75	75
IT & METHODS	50	100



control individuals and behaviors only indirectly). We assign weights to the remaining nodes of the subhierarchy. We obtain the weighed subhierarchy represented in the left part of Figure 5 (e.g., information technologies, techniques, and methods count as one third of the KM context). We then use this weighed subhierarchy to assess KM for the two companies, entering scores for the end nodes. The final and intermediary KM scores for the two companies are computed and shown in the table of Figure 5. The final results illustrate the predominant KM orientation for the two companies (IT for Cap Gemini and strategy, organization, and culture for Ernst & Young). Based on these results, we may decide to investigate more precisely one aspect of the KM process or context (e.g., the topic of planning, modeling, and control processes). To this end, we would need to change the selection of the subhierarchy and the definition of the weights; however, the approach would remain the same.

Assessment of KM Research

In research, the KM model can be used to compare, contrast, and combine the contributions of different disciplines to KM. Thanks to the hierarchical structure, the commonalities, differences, and profiles of different disciplines can be represented and analyzed at various levels of detail. For example, the score of a given discipline for the tacit-knowledge end node of the KM model can be computed as the frequency in which the word tacit appears in a sample of publications of this discipline relating to KM.

FUTURE TRENDS

By their very structure, hierarchical KM models support navigation between the levels of detail of KM topics. Furthermore, coupled with the analytic hierarchy process, they permit the quantitative evaluation of KM practice and research at various levels of detail. Due to these advantages, we predict a growing interest for such models.

Despite the advantages of hierarchical KM models, they can not replace semantic models for describing and defining KM concepts and explicitly representing the complexity of their relationships. Therefore, since the two types of models do not serve the same purposes, we suggest that they be used complementarily.

Our future research plans concern (a) further applications of our hierarchical KM model to the quantitative assessment of KM research and practice, and (b) ways of combining in practice our KM model with one or several semantic models.

CONCLUSION

In this article, we have presented a hierarchical model for KM research and practice. The model integrates the contributions of previous works. Furthermore, its hierarchical structure eases the navigation between the detail levels of KM topics, and permits quantitative evaluations of KM research and practice.

To the best of our knowledge, no hierarchical KM model had been defined so far. Marchand, Kettinger, and Rollins (2000) present a model to assess the information orientation of a firm. However, this model has few levels of detail and concerns information rather than knowledge management. Van den Hooff, Vijvers, and de Ridder (2003) present an instrument that companies can use to assess their KM maturity. However, for the most part, this instrument is informal and therefore may not appropriately be called a model.

We do not contend that our KM model is completely stable. However, the hierarchical structure of the model makes it easy to update.

It is our hope that this article will incite more research on hierarchical KM models and on their application to KM-research and practice quantitative assessment.

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REFERENCES

Adexys. (2004). Descriptor, version 4.1. Retrieved June 30, 2004, from http://www.adexys.com

Akoka, J., Comyn-Wattiau, I., & Prat, N. (1993). INFAUDITOR: An expert system for information system auditing. *Proceedings of the International Computing Congress (ICC'93),* Hyderabad, India.

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Breuker, J., & van de Welde, W. (Eds.). (1994). *CommonKADS Library for expertise modeling, reusable problem solving components.* Amsterdam: IOS Press.

Corbel, J.-C. (1997). Méthodologie de retour d'expérience: Démarche MEREX de Renault. In

J.-M. Fouet (Ed.), *Connaissances et savoir-faire en entreprise.* Paris: Hermès.

Davenport, T. (1997). Knowledge management case study: Knowledge management at Ernst & Young, 1997. Retrieved October 15, 2004, from http://www.bus.utexas.edu/kman/E&Y.htm

Davenport, T., & Short, J. E. (1990). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review, 31*(4), 11-27.

Davenport, T. H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know.* Harvard Business School Press.

Despres, C., & Chauvel, D. (2000). How to map knowledge management. In D. Marchand, T. Davenport, & T. Dickson (Eds.), *Mastering information management* (pp. 170-176). London: Prentice Hall.

Dieng-Kuntz, R., Corby, O., Gandon, F., Giboin, A., Golebiowska, J., Matta, N., et al. (2001). *Méthodes et outils pour la gestion des connaissances: Une approche pluridisciplinaire du knowledge management.* Paris: Dunod.

Eichenbaum, C., Malvache, P., & Prieur, P. (1994). La maîtrise du retour d'expérience avec la méthode REX. *Performances Humaines et Techniques, 3-4*(69), 6-20.

Ermine, J.-L. (2001). Capitaliser et partager les connaissances avec la méthode MKSM. In M. Zacklad & M. Grundstein (Eds.), *Ingénierie et capitalisation des connaissances.* Paris: Hermès.

Fowler, A. (2000). The role of AI-based technology in support of the knowledge management value activity cycle. *Journal of Strategic Information Systems, 9*(2-3), 107-128.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Handzic, M. (2001). Knowledge management: A research framework. *Proceedings of the 2nd European Conference on Knowledge Management (ECKM 2001),* Bled, Slovenia.

Hjertzén, E., & Toll, J. (1999). Knowledge management at Cap Gemini. In Measuring knowledge management at Cap Gemini AB (chap. 5, pp. 55-64). Master's thesis, Linköpings Universitet. Retrieved October 15, 2004, from http://www.tollsoft.com/thesis/paper.html

Holsapple, C. W., & Joshi, K. D. (1999). Description and analysis of existing knowledge management frameworks. *Proceedings of the 32nd Hawaii International Conference on System Sciences (HICSS 99),* HI.

Holsapple, C. W., & Joshi, K. D. (2004). A formal knowledge management ontology: Conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

ISO. (2004). *ISO 18876 integration of industrial data for exchange, access, and sharing: Glossary of terms.* Retrieved October 15, 2004, from http://www.tc184-sc4.org/ISO18876/glossary.cfm

Karsenty, L. (2001). Capitaliser le contexte des décisions en conception. In M. Zacklad & M. Grundstein (Eds.), *Management des connaissances: Modèles d'entreprise et applications* (pp. 49-70). Paris: Hermès.

Kolodner, J. (1993). *Case-based reasoning.* San Mateo, CA: Morgan Kaufmann.

Lara, E., Andreu, R., & Sieber, S. (2002). A case study of knowledge management at Cap Gemini

Ernst & Young. (European Case Clearing House [ECCH] No. 302-164-1)

Marchand, D., Kettinger, W., & Rollins, J. (2000). Information orientation: People, technology and the bottom line. *Sloan Management Review, 41*(4), 69-80.

Michalski, R. S. (1993). Toward a unified theory of learning: Multi-strategy task-adaptive learning. In B. G. Buchanan & D. C. Wilkins (Eds.), *Readings in knowledge acquisition and learning: Automating the construction and improvement of expert systems.* Morgan Kaufmann.

Newman, B., & Conrad, K. (2000). A framework for characterizing knowledge management methods, practices, and technologies. *Proceedings of the 3rd International Conference on Practical Aspects of Knowledge Management (PAKM 2000),* Basel, Switzerland.

Nissen, M. E. (2002). An extended model of knowledge-flow dynamics. *Communications of the Association for Information Systems, 8*, 251-266.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

O'Leary, D. E., & Studer, R. (2001). Knowledge management: An interdisciplinary approach. *IEEE Intelligent Systems, 16*(1), 24-25.

OMG. (2003). Unified modeling language (UML) specification, version 1.5. Retrieved January 15, 2004, from http://www.omg.org/technnology/documents/formal/uml.htm

Prat, N. (2001a). Automating knowledge indexing and retrieval in soft domains. *Proceedings of the 2nd European Conference on Knowledge Management (ECKM 2001),* Bled, Slovenia.

Prat, N. (2001b). STEP PC: A generic tool for design knowledge capture and reuse. In R. Roy (Ed.), *Industrial knowledge management: A micro-level approach* (pp. 317-334). London: Springer Verlag.

Reix, R. (2000). *Systèmes d'information et management des organisations.* Paris: Vuibert.

Rolland, C., Souveyet, C., & Moreno, M. (1995). An approach for defining ways of working. *Information Systems Journal, 20*(4), 337-359.

Saaty, T. (1980). *The analytic hierarchy process.* New York: McGraw Hill.

Saaty, T. (1999). *Decision making for leaders.* Pittsburgh, PA: RWS Publications.

Smith, R. G., & Farquhar, A. (2000). The road ahead for knowledge management. *AI Magazine, 21*(4), 17-40.

Soulier, E. (2000). Les récits d'apprentissage et le partage des connaissances dans les organisations: Nouvelles pistes de recherche. *Systèmes d'Information et Management, 5*(2), 59-78.

Tarondeau, J.-C. (2002). *Le management des savoirs.* Paris: PUF. In Collection que sais-je?

van den Hooff, B., Vijvers, J., & de Ridder, J. (2003). Foundations and applications of a knowledge management scan. *European Management Journal, 21*(2), 237-245.

Walsh, J. P., & Ungson, G. R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Zacklad, M., & Grundstein, M. (Eds.). (2001). *Management des connaissances: Modèles d'entreprise et applications.* Paris: Hermès.

Zamfiroiu, M., & Prat, N. (2001). Traçabilité du processus de conception des systèmes d'information.

In C. Cauvet & C. Rosenthal-Sabroux (Eds.), *Ingénierie des systèmes d'information.* Paris: Hermès.

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Chapter 4.2
Applications of Agent-Based Technologies in Smart Organizations

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ABSTRACT

This chapter introduces agent technology as a means of creating dynamic software systems for the changing needs of smart organizations. The notion of agency is introduced, and individual and collective agent architectures are described. Agent interaction methods and agent system design techniques are discussed. Application areas of agent technology are overviewed. The chapter argues that the autonomous and proactive nature of agent systems make them suitable as the new information infrastructure for the networked components of dynamically changing smart organizations.

INTRODUCTION

Nowadays the whole world is networked into the Internet and if an organization is not connected to the Internet, then it has serious competitive drawbacks. Private persons are using the Internet more and more as well, so organizations keep contact with their clients through e-mail and give them information on their products and services on information portals. Customers can do the shopping in electronic shops and get all the information they want from the portal server; they can even configure the product they want to order. In order to satisfy individual needs, smart organizations must feed online information from the Internet into their internal information system and then further to their internal production control, accounting, design, resource planning, and several other components. The organization can adapt to these requirements only if it requires the same type of information management from its suppliers, so the interorganizational communication must become part of this networked environment as well.

In this environment, we can less and less talk about individual software products, because software components are interconnected and sooner or later almost every software component must be capable to interoperate with other software systems. This way, the information system of smart organizations becomes part of the worldwide Internet, so individual solutions cannot be applied. The software technology of smart organizations means less and less the design and implementation of individual software systems; rather, we can talk about the development of the design and implementation of a single distributed worldwide information system. In this context, the designers of subsystems cannot apply individual solutions, they have to adapt to global practice and standards. At the time of the design of such a global information system, the designer does not have enough information and resources to make a complete solution, so the designed system must integrate into the worldwide system with the ability to adapt to unforeseen changes and requirements using incomplete information at run-time.

Satisfying these requirements is among the goals of several technologies, including the Web services technology characterized by SOAP1, WSDL2, UDDI3 abbreviations (Web Services, 2004; UDDI, 2004), the semantic Web technology (Berners-Lee, Hendler, & Lassila, 2001), the grid (Foster & Kesselman, 1999) and maybe the most complete approach, which is agent-based computing (Wooldridge, 2002).

This chapter presents the most important elements of agent technology and how they can be applied in smart organizations. First, we define what agents and agent systems are, then we overview the history of agent developments. We discuss the internal structures of agents, then how these agents can form smart organizations, then the methods of agent system analysis and design. Finally, we discuss the applications of agent systems and the conditions of their wide adoption.

THE AGENT METAPHOR

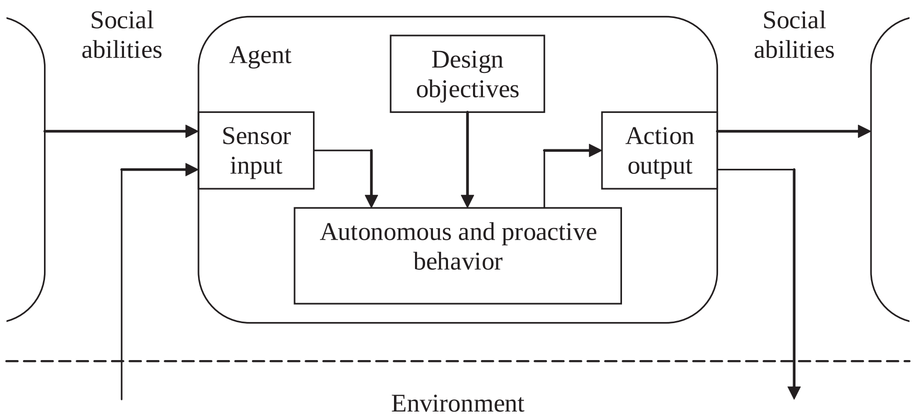
The word "agent" has different meanings in different contexts, so computer scientists working in the agent field may have somewhat different definitions of agency. There is agreement on the main characteristics, but some researchers consider other characteristics important as well, while some researchers think that these are not important, depending on their background.

Intelligent Agents

The notion of agent emerged from many different fields, including economics, game theory, philosophy, logic, ecology, social sciences, computer science, artificial intelligence, and later distributed artificial intelligence. In all these fields, an agent is an active component that behaves intelligently in a complex environment to achieve some kind of goal. Artificial intelligence is the branch of computer science which investigates how to implement in computer systems intelligence comparable to human intelligence. While the goal of artificial intelligence focuses mainly on intelligent performance comparable to an individual person, distributed artificial intelligence investigates how a group of software components called agents can achieve intelligent behavior comparable to a group of persons.

From a software technology point of view, agent technology promises to enable system designers to handle more complex systems than before. As systems become more and more complex, software development processes need higher and higher abstractions. In the beginning, functional and modular programming techniques provided enough level of abstraction, then object-oriented systems became the most commonly used technique to model complex systems. Agent technology promises to handle systems that object-oriented techniques cannot adequately model, like

Figure 1. The most important characteristics of intelligent agents



large, distributed organizations with incomplete information and distributed responsibility, where individual components must dynamically adapt to unforeseen changes.

Experts from the different fields tend to agree that the most important characteristics of agents are those which are defined by Wooldridge and Jennings (1995) and shown in Figure 1. First of all, an agent is a computer system situated in some environment. The agent is reactive, which means that it is capable of sensing its environment and acting on it. The agent can autonomously act in its environment and make decisions itself. The agent has design objectives and can decide itself how to achieve them. While taking the decisions the agent is not just passive, but can take initiatives towards its goals. The agent has social abilities and can interact with the actors in its environment.

Agents as Building Blocks in Smart Organizations

The above-mentioned characteristics make the agent concept an important element in modeling systems needed for smart organizations. First of all, multi-agent systems are distributed cooperative computing systems, therefore they themselves form an intelligent organization. The reactive, autonomous, and proactive features of agents require that they are knowledge-driven, dynamically adaptive, agile, and learning computing elements. The social abilities of agents mean that they are usually internetworked, as well as dynamically adaptive to new organizational forms and practices. Since these features are necessary for smart organizations, we can expect that software systems built with agent technology will play an important role in smart organizations. A multi-agent system itself can be regarded as a smart organization, because the above-mentioned characteristics are in line with the definition of smart organizations. The term "smart organization" is used for organizations that are knowledge-driven, internetworked, dynamically adaptive to new organizational forms and practices, learning, as well as agile in their ability to create and exploit the opportunities offered by the new economy (Filos & Banahan, 2000).

In the following sections, we will discuss agent systems in order to be able to understand their importance for smart organizations. Agent technology offers new techniques for smart organizations, but it cannot solve everything. Several design techniques and software tools have been developed to support and implement agent oriented systems. Although these techniques and tools allow the designer to think in the way an agent system needs, the major challenge in implementing agent systems is related to the intelligence of the agents.

HISTORY AND STANDARDS

Current interest in autonomous agents emerged mainly from artificial intelligence research, but object-oriented programming and human-computer interface design also contributed among the many other fields mentioned earlier. Although we could think that agency is central to artificial intelligence (AI), because AI is about building intelligent systems, artificial intelligence researchers did not intensively study intelligent agents until the 1980s. The focus of AI research was on the different components of intelligent behavior, like learning, reasoning, problem solving, and so forth. Among these independent investigations, AI planning was most closely related to agents, because AI planning is related to what and how to do, and agents also have to plan what they are going to perform autonomously in their environment. AI planning first used a symbolic reasoning approach, but when the ultimate viability of this approach was questioned, the attention of researchers turned toward behavioral or reactive AI. According to this approach, theorem provers cannot produce intelligent behavior; rather, intelligence is a product of the interaction between the intelligent system and its environment. In this approach, intelligence emerges from the interaction of several simpler behaviors and competing behaviors can suppress each other. However, emergence is purely reactive, so in the early 1990s researchers started to combine reactive behavior with the deliberative approach of symbolic reasoning. The combination of reactive and deliberative approaches was later replaced with the practical reasoning approach, where reasoning is influenced by a kind of mental state with three components: Beliefs, desires, and intentions, where beliefs represent the information that the agent has about its environment, desires represent the different possible states the agent may choose to commit to, and intentions represent the states the agent has chosen and committed resources to.

The Beginnings

Agent research became a separate branch of AI in 1980 at the first Distributed Artificial Intelligence (DAI) workshop at the Massachusetts Institute of Technology, where participants decided that there is need to investigate issues of how intelligent problem solvers can coordinate their activities to solve common problems, and these issues are on a higher level than the parallelism issues of how to distribute processing over machines and parallelize centralized algorithms. The first multi-agent model was the actors model, in which self-contained, interactive components communicate by asynchronous message passing. Task allocation then became an important topic, and the Contract Net Protocol was defined to allocate tasks from the contractor to bidders through an announcement—bidding—allocation process. The early applications were related to the coordination of physically moving vehicles. Later, the research focused on teams working toward a common goal, and theoretical foundations of cooperation were investigated, including notions of commitment and joint intention. A group of agents jointly intends a team action if all of them are committed to completing the team action and they mutually believe that they are doing it. In this case, the joint commitment is a joint persistent goal. Agents enter into a joint commitment by establishing appropriate mutual beliefs and commitments through an exchange of request and confirm speech acts.

The investigation of how to achieve joint commitment centered on the notion of negotiation. It turned out that negotiation was a good method for coordination, conflict resolution, communication of plan changes, task allocation, and resolution of constraints violations as well. The common characteristics of these are that agents have to resolve some conflict in a distributed way by exchanging proposals and counter proposals, the agents have their own goals, they have bounded rationality and incomplete information.

At this time, agent architectures focused on the internal modules of agents and how the above-mentioned concepts can be handled with software engineering methods. Agents usually had five components: the communication layer, the agent acquaintance module, the self module, the inference engine, and the knowledge base. The communication layer was responsible for performing the necessary transformations on the messages the agent wanted to send and receive to and from its environment, in order that these messages conform to the external and the internal world of the agent. The agent acquaintance module contained information about the environment of the agent and modeled the capabilities of the agents to interact with. The self module contained information about the capabilities of the agent itself. The inference engine was responsible for executing the actions of the agent based on the knowledge of the agent stored in the knowledge base.

Networked Agents

In the 1990s, the Internet and hypertext protocol was spreading rapidly, and more and more applications were deployed on the Internet. This open environment gave way to the wide-spread application of software agents communicating over Internet protocols. Previously, multi-agent systems were designed and implemented usually by a single team, but now multi-agent systems from different backgrounds and design approaches had to communicate and interact. The most important issues in this environment are discovery and interoperability. Discovery is the problem of how agents can find each other even when they do not know anything about the other agent. Interoperability is the problem of understanding the syntax and semantics of the language of other agents, which means that agents have to be able to parse the message of other agents and find out the meaning of the elements of the messages.

To solve the discovery issue in open environments, the notion of middle agents has been introduced. Agents can advertise their capabilities to some kind of middle agent. Different types of middle agents have been identified, including yellow page middle agents that match advertisements with requested capabilities, blackboard middle agents that collect requests, and broker middle agents that do both. Of course, this middle agent approach works only if agents know how to find the appropriate middle agent. In practice, this can be solved by having a few well-known middle agents, which preferably even talk with each other so that if there is no match at a specific middle agent, then the request can be forwarded to another one. These well-known middle agents form the basis of the infrastructure of an open agent environment. The first attempt for a world wide agent infrastructure was the Agentcities network (Willmott, Dale, Burg, Charlton, & O'Brien,2001).

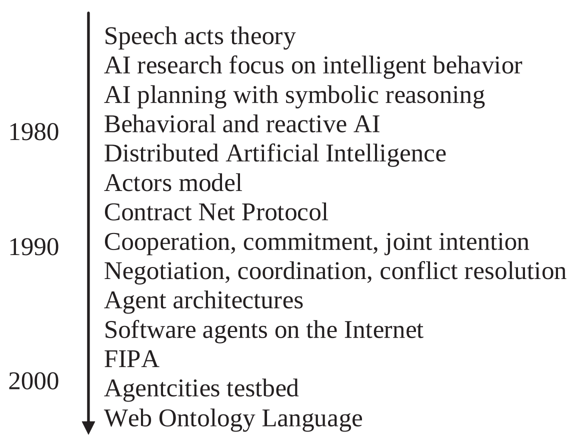
Solving agent interoperability is approached on two levels: on the agent communication language level and the agent content language level. The agent communication language defines the types and the format of the messages between agents. Agent communication languages provide a set of performatives, like "request" and "inform," based on the speech acts theory (Searle, 1969), where communications are modeled as actions that change the mental state of communication participants. Using the agent communication language, an agent can send to another one a request for "something," or can inform the other agent about "something," where the "something" is the content of the message. The schema for the agent content language is the ontology which formally describes a domain of discourse. Agents can understand the content of the messages if they share their content language ontologies, preferably by publishing them on ontology servers. Ontology servers are also an important part of an open agent infrastructure like the Agentcities network (Willmott et al., 2001)

Standards and FIPA

The need for interoperable agent communication created the standardization body of agent systems, which is called Foundation for Intelligent Physical Agents (FIPA). FIPA was founded in 1996 and registered in Geneva, Switzerland as an international nonprofit organization. The aim of FIPA is to develop software standards for heterogeneous and interoperating agents and agent systems, in order to enable the interworking of agents and agent systems operating on platforms of different vendors in industrial and commercial environments. As a result of the FIPA standardization activity, many research labs and industrial organizations started to develop competing agent platforms independently all over the world. FIPA standard agent platforms provide an environment where agents can be deployed, and with the help of the agent platform services they can interact with other agents on any FIPA standard agent platform in a FIPA conformant way, achieving agent communication level interoperability. Agent platforms from more than 15 vendors show interoperability in the Agentcities testbed. More than half of the Agentcities nodes use the Jade agent platform from Telecom Italia Laboratories (Balboni, 2003).

The most important agent standardization activities are done in FIPA, but significant activity was also carried out in the Object Management Group (OMG) and agent standards are starting to become highly relevant to bodies such as the World Wide Web Consortium (W3C) and the Global Grid Forum (GGF), because developments such as Web Services (Web Services, 2004) and

Figure 2. Trends in agent research



Semantic Web Services (DAML Services Coalition, 2002; Bussler, Maedche, & Fensel, 2002) also investigate many of the issues agent technologies have already addressed.

Figure 2 summarizes the history and trends in agent research as discussed in this section.

AGENT ARCHITECTURES

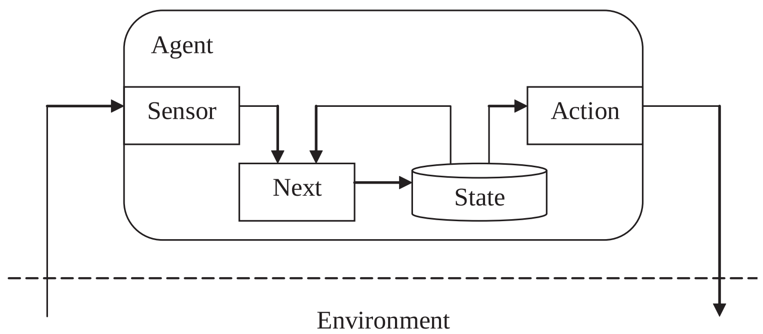
As we have seen in the previous section, the agent concept evolved over time. Different aspects of agency were discovered and in the end merged into the currently applied agent architectures. Nowadays, agents that show traits of only one aspect are not considered real intelligent agents. For example, a stock exchange trading agent in charge of a stop-loss order is a purely reactive agent, but does not satisfy the current notion of intelligent agency. In this section, we are going to elaborate on the different aspects of agency.

Reactive Agents and Agents with State

One of the first aspects is that agents are reactive. A purely reactive agent decides what to do without reference to its history. The behavior of a purely reactive agent is the function of the state of its environment. This type of agent architecture has two main subsystems: perception and action. The perception subsystem contains the agent's ability to observe its environment. In the case of agents in the physical world, like robots, this may be a video camera, and in the case of an agent in the software world this may be system or network routines like finger, ping, or network messages. The output of the perception module is a percept, or the internal representation of the environment. The action subsystem of the agent contains the agent's ability to act on its environment. In the case of a physical agent this may be a robot arm, and in the case of a software agent this may be system commands. The action subsystem maps the sequences of percepts into actions. The perception subsystem of the agent grabs those features of the environment which are relevant for the goals of the agent. For example, in the case of the stock exchange trading agent in charge of a stop-loss order, the whole range of the stock price is mapped into two values: hold and sell. If the price falls below a certain value, then the agent has to issue a sell order.

Purely reactive agents often compose a fine-grained multi-agent system. A fine-grained multi-agent system consists of many simple agents,

Figure 3. Agent with state



and the intelligent behavior of the fine-grained multi-agent system emerges from the interaction of the simple agents. Coarse-grained multi-agent systems consist of fewer, but more intelligent, agents. Agents in a coarse-grained multi-agent system usually have one of the architectures discussed below.

Purely reactive agents do not remember the history of their environment. Agents with state, shown in Figure 3, can do so by having additional components in their architecture: a state and a next function. The state represents the current mental status of the agent, while the next function maps the percept of the agent and the current state of the agent to the next state of the agent. The action subsystem of agents with state maps the current state of the agent into actions. Agents with state have the full power of agency; they are behaviorally equivalent to agent architectures discussed later in this section, but the other architectures grab more of intelligent behavior and help better understand the notion of agency.

Agent Reasoning

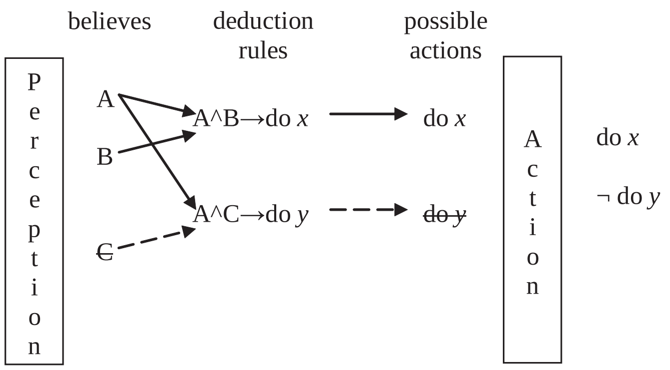
Agents usually have to act in a dynamically changing environment, therefore it is better not to tell the agent exactly how to carry out the tasks. It is better to tell the agent what to do without telling how to do it. This can be done by defining tasks indirectly with some kind of performance measure.

One way of defining tasks indirectly is by associating utilities with states of the environment. The utility function maps the environment states to real numbers and tells how good the state is: the higher the value, the better the state. A disadvantage of the utility function is that it assigns utilities to local states and does not take into account long term values. However, we can use overall utility; for example, by defining the worst state that might be encountered by the agent or as the average utility of all states encountered. Although this model is useful to understanding agent behavior, in practice sometimes it is very difficult or even impossible to implement the desired utility function.

Another way of indirect task specification is predicate task specification. Predicates are utility functions that have either true or false values. A predicate task specification maps the set of all possible runs of the agent to true or false value, and the agent achieves the desired goal if the predicate function results in true value either for all runs, or at least for one run or for a given percentage of runs of the agent, depending on how pessimistic or optimistic the definition of success is. Some common forms of predicate task specifications are the achievement tasks and the maintenance tasks. In the achievement task the goal of the agent is to achieve a state, while in the maintenance task the goal of the agent is to maintain a state. In the achievement task, the agent is successful if it can force its environment into one of the goal states, while in the maintenance task the goal of the agent can be characterized as to avoid some state. Complex tasks can be specified as combinations of achievement and maintenance tasks.

Deductive reasoning agents originate from symbolic AI, which says that intelligent behavior can be generated using logical deduction or theorem proving from symbolic representation of the world. In this approach there are two key problems: the transduction and the reasoning problem. The transduction problem is how to translate the real world into an accurate and adequate symbolic representation. This may be very hard; for example, in the case when a photo has to be converted into a set of declarative statements representing that photo. The reasoning problem is how to manipulate symbolic information to be useful in time. Since the computational complexity of theorem proving may require long computation, theorem provers may not always operate effectively in time-constrained environments. A deductive reasoning agent (shown in Figure 4) is an agent with state and its perception module translates external information into symbolic representa-

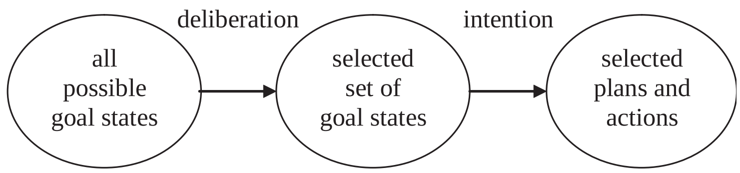
Figure 4. Deductive reasoning agent



tion. Once there is a symbolic representation of a fact in the database of an agent, then the agent believes this fact, although in the real world this might not be the case. The next function of the deductive reasoning agent maps the agent database and a perception into a new database. The action subsystem of deductive reasoning agents use deductive reasoning to deduce the action of the agent. The deduction rules of the agent are defined in a way that if a formula "do action A" can be derived from the fact database using the rule database, then the action of the agent will be action "A." The reasoning engine of the action subsystem takes each of the possible actions "x" of the agent and tries to prove "do action x." If there is no action for which this formula can be proved, then the reasoning engine tries to find an action "x" for which "do not do action x" cannot be derived. If there is such action "x," then this action is consistent with the rules, so the agent can execute this action. If this also fails, then the agent does nothing.

Practical reasoning agents try to improve the deductive reasoning agent architecture by reducing the search space of deductive reasoning. One of the main problems of deductive reasoning agents is that deducing all possible logical consequences takes too much time and sometimes is even impossible. In practical human reasoning, the logical reasoning is influenced by the current state of the mind. Human practical reasoning first tries to reduce the search space by deciding what state we want to achieve. This is called deliberation. Once deliberation is done, the reasoning concentrates on how to achieve the selected state. This is called means-ends reasoning. There must be a good balance between deliberation and means-ends reasoning, or else practical reasoning agents do not perform well or even do nothing. Deliberation cannot go on forever—some goal state has to be chosen and the process of achieving this state has to be started even if the selected goal state is not optimal. The process of achieving the selected goal state is called intention. Intention involves the process of creating a plan to achieve the selected goal state and actions taken according to the created plan. Deliberation and intention are shown in Figure 5. Intentions drive the means-end reasoning and if one plan creation fails, then another is tried. An intention must persist typically until it is believed that it is successfully achieved, or it is believed

Figure 5. Steps of practical reasoning



that it cannot be achieved, or it is believed that the reason for the intention no longer exists. Intentions constrain deliberation, and options which are not consistent with the current intentions are dropped. Intentions restrict the beliefs on which practical reasoning is based, and beliefs that are not consistent with the intention are dropped.

The deliberation process of practical reasoning agents has two parts: the option generation function and the filtering function. The option generation function produces a set of options, called desires. The filter function selects the best one(s) from the set of desires based on the current beliefs, desires, and intentions.

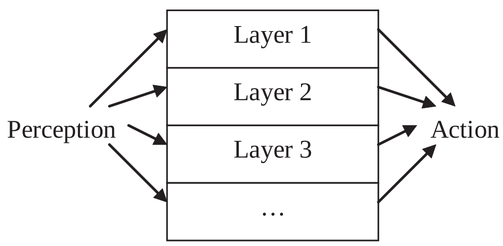
Once a desire passes the filter function and becomes part of the set of currently selected intentions of the agent, then we say that the agent has made a commitment to that intention. The commitment strategy of the agent is the mechanism used to determine how long a commitment must persist. Blind commitment strategy is to keep the intention as long as the agent believes that the intention has been achieved. Single-minded commitment strategy is to keep the intention as long as the agent believes that either the intention has been achieved, or the agent currently has no plans to achieve the goals of the intention. Open-minded commitment strategy is to keep the intention as long as the agent believes that the goals of the intention are possible. The agent has to reconsider its commitments from time to time to check if they still have to be kept. There must be a good balance, because if the agent reconsiders its commitments very often, then it does not have enough computing resources to achieve them; on the other hand, if the agent does not reconsider its commitments often enough, then it may continue to pursue them for a long time after it is obvious that they cannot be achieved.

Means-ends reasoning produces a plan to achieve the selected goal state based on the current intentions, the current beliefs (i.e., the state of the environment), and the actions available to the agent. In many implementations, the planning function does not create a plan from scratch; rather, the agent has a set of plans given by the agent designer, and the agent searches through the set of plans to find one that has the needed intention as a post condition and is in accordance with the current beliefs and available actions.

Layered Agent Architectures

An alternative to the reasoning agent architecture is the hybrid agent architecture, or layered agent architecture, in which there are layers responsible for different agent-like behaviors. In the horizontally layered hybrid architecture, each layer is directly connected to the perception and the activation modules, as shown in Figure 6. In horizontal layering, each layer produces competing suggestions as to what to do, and a control subsystem must decide which layer actually takes control over the agent. Some of the layers are responsible for low-level actions; for example, in a financial organization, to avoid

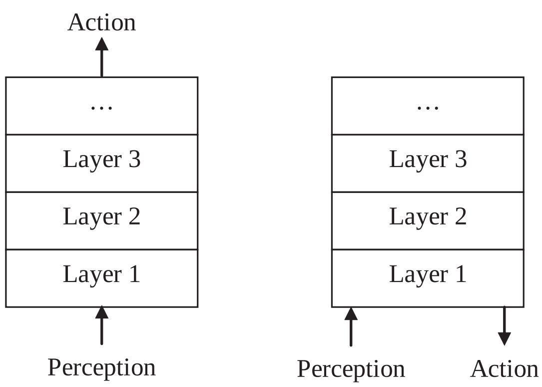
Figure 6. Horizontally layered agent architecture



bankruptcy some of the other layers are responsible for higher-level actions like deciding where to invest. The control subsystem gives priority to low-level actions in urgency and gives way to higher levels otherwise.

In vertically layered hybrid architectures, perception and activation are connected to at most one layer, as shown in Figure 7. Layers make processing and pass information to each other. In two pass vertical layering information flaws up the architecture to higher and higher level processing. Decision is made at the upper-most level where action is generated, which then flaws down to lower levels.

Figure 7. Vertically layered agent architectures



Not long ago, a popular agent model was the mobile agent architecture. In this model, agents are seen as programs roaming the network to collect business-related data. This approach had a lot of problems related to authorization policies; that is, hosts and agents had to be protected against each other. Since network bandwidth is usually available, mobile agents did not have much advantage over nonmobile agents except in a few cases—for example, in auctions when different network latencies were not allowed for fairness. Because of the difficulties, mobile agents have not yet been taken up by the mainstream; however, mobility issues may be investigated again when agents running on mobile devices become widespread.

AGENT ORGANIZATIONS

Up to now, we have been discussing how agents can organize and plan their activity on their own, but agents have to act in a networked environment; for example, as part of a smart organization. In this environment, they act on the real world, and sometimes the real world imposes restrictions on their activities; for example, because two agents want to use the same resource at the same time. In this case, it is obvious that the agents have to coordinate their plans. Even if there is no conflict in the real world, the agents want to distribute the task allocations among themselves, and there must be some kind of interaction between the agents. The interactions are even more complex when the conflict in the real world arises between the activities of two groups of agents. In this case, the groups of agents have to coordinate among themselves as how to interact with the other group.

In order to model the interactions among agents, the utility function is used. The utility function of an agent assigns to each state a real value. If the utility function gives higher value for a state s1 than for another state s2, then the agent has preference for s1 compared to s2. Many times the utility function is linear, but nonlinear utility function models that situation when the agent achieved most of its goals and is satisfied with the state, therefore its utility function does not give much higher values when the state improves somewhat. Similarly, if the agent has not achieved any goal, then a small improvement in the state gives higher increase in its utility function than in a more or less satisfied status.

Properties of Agent Organizations

When several agents act on the environment, their actions may depend on the actions of the other agents. If one agent makes a choice, then the other agent is already restricted and has to make a choice depending on the choice of the other agent. In an ideal situation, the different agents have preference for the same state and all other states are less preferable for all of the agents. A somewhat less ideal but still very good situation is when agents can still find a state which is most preferable for all the agents, but there are other states which give the same utility value for all the agents. In this case, agents can select one of these preferable states, but they must agree which one, because if an agent deviates from this state toward another more preferable state, then none of the agents achieve the most preferred state. It is also possible that there are more than one state with which agents are all satisfied and do not want to deviate from it if the others do not deviate; however, one of these preferable states may be better than the other one. All the situations in this paragraph are called Nash equilibrium, because no agent has the incentive to unilaterally deviate from the preferable state.

The efficiency of the agent system can be measured as a combination of the utility functions of all of the agents. A simple efficiency measure is the sum of the utilities of all the agents, and according to this measure an agent system is in sum optimal state if the sum of the utilities is maximal. An agent system is in a Hicks optimal state if the utility is maximized for all of the agents in the agent system. An agent system is in Pareto optimal state if it satisfies, more or less, all of the agents, and in all other states at least one agent's utility function gives smaller value if at least another agent's utility function gives higher value. Note that Hicks optimal state cannot always be achieved. Also note that sum optimal and Pareto optimal state may not be equilibrium state, if at least one agent might achieve better utility by deviating from the optimal state. An example of this is the prisoner's dilemma, in which the equilibrium is not optimal.

Agreement in Agent Organizations

Now that we have seen the different types of states multiple agents can achieve, let us turn our attention to how they can reach agreement to get to the desired state. Agents coordinate their actions by exchanging messages. The messages are exchanged similarly to usual network communication protocols, which are governed by protocol rules so that the participating partners can get to some useful result and are not locked in, for example, a deadlock. Agent interaction protocols build on communication protocols and strive to ensure, for example, community level results (Sandholm, 1999). It is expected that an agent interaction protocol guarantees that agents eventually get to some agreement and this agreement leads to either sum, Hicks, or Pareto optimal state. Participating in agent interaction protocols must be Nash equilibrium behavior for the participating agents, that is, all of the agents must be interested in keeping to the protocol rules, which must be simple enough so that agents can easily determine the optimal strategy. Multi-agent systems are usually distributed and there is no centralized node, and this must be the case for agent interaction protocols as well.

Although agents may interact in many different ways, there are three types of interaction protocols which are the most used and studied. These are the auction, the negotiation, and the argumentation interaction protocols.

The auction protocol can be used to allocate a given resource to one of the agents from a group. The resource can be a good or a task to be executed; in the latter case the auction protocol is also called a contract net protocol. The roles in the auction protocol are the auctioneer and the bidder. The auctioneer agent has the resource to be allocated and wants to maximize the price for it. The bidders are the agents to which the resource is to be allocated and want to minimize its price. In many cases the exact value of the resource is not known or is not unambiguous. The agents may value the price of the resource differently according to their different interests in the resource and different knowledge about the current and future value of the resource. The auction protocol helps the agents agree on a price and allocation which is most acceptable for them. According to the different rules, the auction interaction protocol can be one shot, if there is only a single round of bids, or it can be ascending or descending sequential, if there are several rounds with the necessity of ascending or descending bids. The auction interaction protocol can be open cry, if every agent sees the bid of every other agent, or can be sealed bid, if they do not see each other's bid. The auction protocol is first price if the winner is the one with the best bid and pays its own bid, or it can be second price if the winner is the one with the best bid, but pays the second best bid.

Auction is a special form of negotiation which is a somewhat more general form of agent interaction. The negotiation interaction protocol is defined with the negotiation set, the proposal order, a set of strategies, and an agreement criterion. The negotiation set contains all the possible proposals the agents can make. In the simplest case, the proposal contains one issue to be negotiated, like the price in auction protocols, or can contain multiple issues which may be interrelated. The proposal order defines the set of allowed proposals as a function of the negotiation history and the timing of proposal making. Typically, agents make the proposals at the same time or one after the other, and they are not allowed to repeat previous proposals. Each agent has a negotiation strategy which defines the proposal selection method from its allowed proposals. Negotiation strategies are not public and are related to how the agent is going to achieve its goal. The agreement criterion defines when the negotiation stops and what the accepted proposal is.

The most complex form of agent interaction protocol is argumentation, which most resembles human negotiation and allows dynamic negotiation and the justification of the negotiated deal. Argumentation is based on formal logic. In formal logic there are statements and logic rules. Using the logic rules other statements can be derived from a set of statements. In the beginning of the argumentation interaction protocol, the agents have in their knowledge base different sets of statements which represent their beliefs about the state of affairs. During the argumentation process agents can send each other the statements they have, the derivation rules they are capable of, and concrete derivation instances in order to get to a status when all the agents have the same statement about the issue to be agreed in their knowledge base.

Communication in Agent Organizations

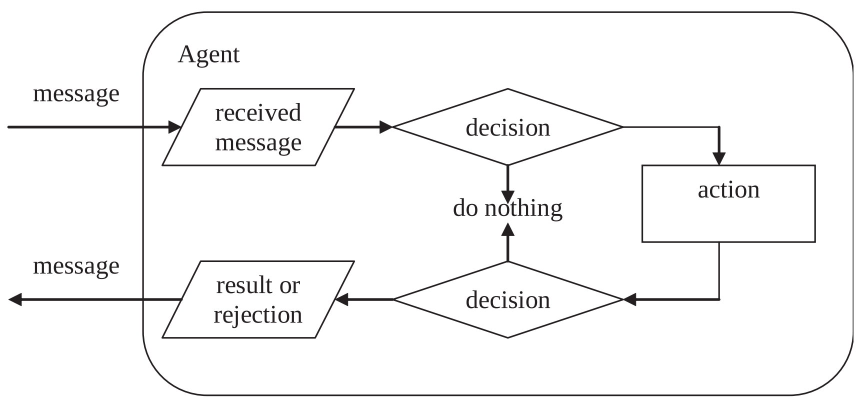
We have seen how agents can get to agreements by exchanging messages; now let us see how they communicate these messages. In usual-distributed computing environments, like in object-oriented systems, one object can call the method of another remote object. In this kind of communication, the calling object causes the execution of the procedure in the remote object. This may happen synchronously if the thread of control returns to the calling object only after the execution of the remote procedure, or asynchronously if the thread of control immediately returns to the calling object and the remote procedure is executed in parallel. In both cases the calling object executes the remote procedure. However, agents are autonomous and their communication is even less coupled, as in the asynchronous remote procedure call.

Agents are autonomous, and when agents send messages to each other, they do not force the execution of a remote procedure, or write data into the internal data representation of the remote agent. When a sending agent sends a message to a remote agent, the sending agent performs an action to influence the behavior or the beliefs of the remote agent. This kind of communication is based on the speech act theory, which treats communication as action (Austin, 1962; Searle, 1969). When a fact is sent from the sending agent as an information to the remote agent, the sending agent intends the remote agent to believe the fact, but it is up to the remote agent whether it trusts the sending agent and builds the belief into its knowledge base or not, as shown in Figure 8.

Based on the speech act theory, the Knowledge Query and Manipulation Language (KQML) was developed (Finin, McKay, Fritzson, & McEntire, 1993) in the framework of the DARPA funded Knowledge Sharing Effort. The KQML language defines the envelope format for agent messages, and the content of the message is described in the Knowledge Interchange Format (KIF) (Genesereth & Fikes, 1992). The KQML envelope contains what the intention of the sending agent is with the information contained in the content part. The KQML part of the message has slots for the type of the message (inform, request, reply, etc.), the sender, the receiver, the language of the content (e.g., KIF), the ontology the content is related to (e.g., electronic products), the content itself, and possibly other features.

We should say a few words about the content language and the ontology. The content language is the format of the description of the content. However, the content cannot be anything, it belongs to a specific domain of discourse that both agents understand. The ontology specifies the notions of the allowed content, the possible properties of the notions, and relations between the notions of the domain. Roughly we could say that the content is the data and the ontology is the schema of the content, but the ontology defines not only the syntax of the allowed content, but the semantic dependencies as well. An ontology describes the common understanding of a specific domain of discourse; it is described in an ontology

Figure 8. Autonomous communication



description language, and it is usually published so that everybody can use it to understand the same. KIF itself is an ontology language, but the most recent ontology language used on the Web is the Web Ontology Language (OWL) defined and standardized by the World Wide Web Consortium (Dean & Schreiber, 2004).

Although KQML defined a framework for agent communication, it was never precisely defined, therefore many versions of KQML were implemented and when agents started to inhabit the Internet, they could not interoperate. Based on the KQML efforts, FIPA standardized agent communication with the specification of the FIPA Agent Communication Language (ACL), interaction protocols, and architecture. As a result of the standardization effort, many vendors implemented agent platforms interoperable on the communication language level.

Trust and Security

In industrial and business environments, special attention has to be made to trust and security aspects, especially in the open and dynamically changing society of agents forming smart organizations. In the open and dynamic environment, agents interact with each other on an occasional basis without having reliable information on each other and the organization they represent. As identified by Wong and Sycara (1999), the most important security threats in agent systems are the corrupted naming and directory services, the insecure communication channels, the insecure delegation, and the lack of accountability.

A naming service in a distributed environment maps names of components to their addresses. A directory service maps services and capabilities to their providers. These services are not part of agent architectures; rather, they are part of the infrastructure of an agent society. However, the agent society cannot function if the members cannot find each other and their services. A naming service or a directory service is corrupted if some entries are missing or contain a wrong value. A wrong value may be entered, for example, by a misbehaving agent.

The communication channels are secure if authentication, integrity, confidentiality, and nonrepudiation are guaranteed. Authentication means that agents know that they talk to agents they think they are talking to. Integrity of messages is guaranteed if the message is not modified or falsely inserted in the communication channel. The message is confidential if other agents cannot intercept the message. Nonrepudiation is guaranteed if nobody can deny having sent a message which was sent.

Insecure delegation occurs if an agent impersonates itself as a delegate of someone who did not entrust to it. Lack of accountability occurs if agents cannot be held accountable for what they are doing and their services cannot be trusted.

As proposed by Wong and Sycara (1999), several measures have to be taken in an agent society to give protection against the above-mentioned trust and security threats. The naming and directory services must service only valid requests coming from a rightful requester and the request is valid. The naming and directory service databases must be kept consistent. The agents and their delegators must have unique identity which can safely be proved. The communication channels must be protected. Agents can be deployed only if there is someone who can be made liable for their actions.

Theoretical models have been developed to guarantee these protective elements, and agent architectures implement more and more of them.

AGENT-ORIENTED SOFTWARE ENGINEERING

In the previous sections, we wrote about how agent systems work, but if we want to write about how such agent systems can be designed and implemented, then we have to select from several approaches. Many agent systems have been implemented and now there are dominant standards, tools, and platforms to operate them, but there is no unique methodology for their design. As we have seen, agent systems propose solutions to problems which the traditional software products do not cover; therefore, we cannot expect that traditional software engineering techniques provide solution to agent-oriented software engineering. Of course, when a specific component of an agent system has to be implemented, then traditional software engineering methods can be applied and traditional software components can be used in the implementation. However, we need new methodology until we get to the point at which we can apply traditional techniques.

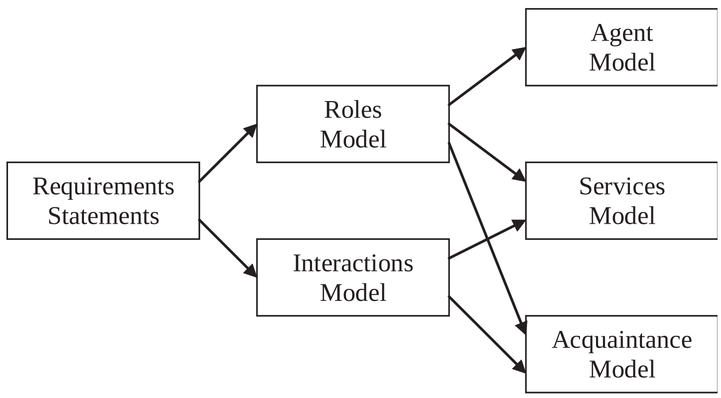
Usually an analysis and design method provides techniques to understand the problem domain and how to handle the complexity of the system so that it can be designed. This is usually done by creating models of the system at different levels, and then transforming higher level models to models closer to the implementation using formal guidelines. What are needed for agent-oriented software engineering are those high-level models that are above the traditional software engineering methods.

There are many agent-oriented software engineering approaches (Giorgini, Müller, & Odell, 2002) among which probably the agent extensions of UML (Odell, Parunak, & Bauer, 2001) and the Gaia methods (Wooldridge, Jennings, & Kinny, 2000) are the most well known. We are going to write about the latter one here, because this method focuses mainly on the agent levels of agent-oriented software engineering and is based on the organizational view of the system, which is important for smart organizations.

The Gaia methodology starts from the requirements statements, which are the textual and formal descriptions of what the system is supposed to do. The requirements capture phase is independent of the paradigm used for the analysis and design, so traditional methods can be used. The Gaia methodology uses the roles and the interactions models for analysis, and the agent, services, and acquaintance models for design. These models and their dependency, as shown in Figure 9, are discussed in the following paragraphs.

The roles model identifies the key roles in the system. The role is an abstract description of the expected function of an entity. The roles are similar to offices in organizations. The role is characterized by the responsibilities and the permissions

Figure 9. Gaia models



of the role. The responsibilities are the functions to be performed by the role. A responsibility can either be liveness or safety responsibility. A liveness responsibility says what the role is supposed to do, while safety responsibility is an invariant that the role must keep. Invariants are described as predicates. The permissions associated with the role either identify the resources that can be used to carry out the responsibilities of the role, or define the resource limits within which the execution of the responsibilities can be carried out.

The interaction model captures the interaction links between the various roles in a smart organization. The interaction model consists of a set of protocol definitions for each type of interrole interaction. In this model, a protocol is abstracted away from the concrete execution steps and is described by a brief textual description of the protocol, the roles responsible for starting the interaction, the roles with which the initiator interacts, the information used by the initiator while executing the protocol, the information supplied by the initiator and responder roles, and a brief textual description of the processing activities during the protocol execution.

The agent model consists of a set of agent types used in the system under development. The agent types are marked with information on how many instances of them will be implemented in the actual system (zero, one or more, n to m, etc.). The agent type is defined as a set of agent roles to be fulfilled by an agent of the given type. Agent types are organized into an agent type tree, where the leaf nodes correspond to roles and the upper-level nodes correspond to agent types. An agent type is composed of the roles of its children agent types in the tree. The agent type tree is derived from the roles model.

The service model specifies the functions associated with each agent role. A service is a single coherent block of activity to be carried out by the given agent type. A service is specified with the inputs, outputs, pre-conditions, and post-conditions of the service. The inputs and outputs are derived from the protocol definitions of the interaction model, while the pre- and post-conditions are derived from the safety responsibilities of the roles model.

The acquaintance model defines the communication links between agent types. The agent acquaintance model is a directed graph in which each graph node corresponds to agent types and arcs correspond to communication links. Arcs are directed and indicate that an agent of one type will send messages to an agent of the other type. The acquaintance model does not specify what messages are sent or when messages are sent, the goal of the acquaintance model is to identify potential communication bottlenecks.

Using these models the designer can specify most of the agent features of the system under development. Further design and implementation can use any traditional design techniques to implement the agent instances.

AGENT APPLICATIONS

In the previous sections, we discussed what agents are, what their internal structure can be, how agents behave in organizations, and how agent systems can be designed. Now we are going to discuss the applications of agent systems in smart organizations. Basically, agent applications in smart organizations can be classified into three categories: distributed agent systems (or multi-agent systems), assistant agents, and multi-agent simulation systems. In the first two types of applications, agents become part of the smart organization, while in the third type of applications agents are used to evaluate and design the structure of the organization. In the first type of applications, several agents make collective decisions and actions within the organization to improve the operation of the organization. In the second type of applications there may be several agents deployed within the organization, and these agents may even interact with each other, but the main function of each agent is to assist its individual user in autonomous and proactive decision-making.

In distributed agent system applications the agent system becomes an integral part of the organization and agents assist the distributed intelligent operation of the organization. Typical areas where distributed agent systems can be applied are business process management, distributed sensing, distributed resource management, process control, trading and purchasing networks. Distributed agent systems can outperform centralized business process management systems, because they are more responsive and are able to cope with unpredictable events. In an agent-based business process management system, the organizational structure and the roles in the organization are mapped to agents, which are responsible for the given role and embody the knowledge needed for the role. These agents can then autonomously and proactively execute most of the automatic processes of the organization with minimal user intervention and approval. Distributed agent systems help distributed sensing by allowing cooperation between the sensors and predicting future trends in the area of one sensor from the data of another sensor. Distributed resource management can benefit from the proactive behavior of agent systems. For example, agents can monitor the network load in telecommunication networks and jointly make predictions on trends and future needs to reallocate resources. Agents can coordinate the workload and the schedule of the field engineers—for example, of electricity provider or telecommunication companies—by taking into account the location and capabilities of the field engineers. Agents can execute the job of automatically negotiating and trading with the suppliers of an organization. Since agents are dynamic, they can adapt to the changing needs of virtual organizations and supply chains.

Assistant agents help their users in gathering and filtering information, or executing some task on behalf of their users. Information retrieval agents can gather information and categorize it according to predefined conditions. This helps the user overview huge amounts of information. More advanced assistant agents learn from the activities of their users; for example, by recording the activities and decisions of the user and deriving rules with knowledge discovery and data mining techniques.

Organizations can also benefit from multi-agent simulation systems, which can simulate real-world environments with a high degree of complexity and dynamism. In a multi-agent simulation system, many individual behaviors can be encoded, thus giving a more complex and real picture of what might happen. The organization can make decisions regarding future products and product features based on a multi-agent simulation of the market where the product is to be sold.

AGENTS SUPPORTING SMART ORGANIZATIONS

As we can see, agent technology discussed in this section has a lot of features that support smart organizations. Smart organizations act in a globally distributed system in which software applications must appear in a new way. A software application in this distributed system is just a component with possible utilizations not completely known at design time. The designer implements some functionalities into the component, but the component may be dynamically included in different temporary compositions in the globally distributed environment. The software component provides services to other software components and it may invoke services of other components. This architecture is in line with the dynamically changing organizations of the economy. Software components advertise their services and other software components can search for the desired services. In order to achieve the goals, software components can select and invoke the desired software services based on the service descriptions, the trust and reputation information available from different sources. In this environment, software components are formed into temporary alliances and their services are dynamically combined. The experiences learned in one temporary alliance are reused in another composition dynamically created later. This way, any software component available on the Web may become part of a Web application.

Agent-based computing provides a new software technology for this new changing environment of smart organizations. Agent technology allows that the creation of the complete functionality of the software system can be postponed beyond design, implementation, and deployment time to operation time, when the software components themselves compose their relation to other software components. This new way of software composition requires that the software components have dynamic and autonomous features.

It is also important that agent technology standards provide the glue for tightening the software components together. Agent technology standards provide machine processable, formal descriptions for the functionality, accessibility, and quality properties of the software components, the data used by the software components, as well as how they can be composed in a workflow. Agent technology also provides standards for registering and searching agents and their services in registries.

Agent technology also takes software components considerably closer to semantic interoperability, which is crucial to smart organizations. Semantics is the relation between the formal notation systems used by the computers and the real objects and notions used by humans. Although simple bit sequences may have semantic meaning, it is better to have the computer representation closer to the human representation, because this way computer interaction on a higher semantic level can be implemented more easily.

SUMMARY

In this chapter, we discussed how agent-based technologies can contribute to smart organizations. Agent technology forms the base of knowledge-driven, internetworked, dynamically changing systems like smart organizations. The most important characteristics of agents are that they are reactive, autonomous, have design objectives, can take initiatives towards their goals, have social abilities, and can interact with the actors in their environment. Agent technology emerged from artificial intelligence by dealing with distributed aspects, and lead to the semantic interoperability technologies of the current Internet. Agent architectures provide means for agents to organize and plan their activity on their own. The types of states multiple agents can achieve can be classified from stability, efficiency, and optimality aspects. Agents reach agreement to get to the desired state by exchanging messages. Agent interaction protocols build on communication protocols and strive to ensure community level results. Agent technology can also be viewed as a software engineering approach to design large, open, networked, dynamic software systems. Agent technology applications can be classified into three categories: distributed agent systems (or multi-agent systems), assistant agents, and multi-agent simulation systems. The methods and approaches discussed in this chapter show that agent technology is fundamental to smart organizations.

REFERENCES

Austin, J. L. (1962). *How to do things with words.* Oxford: Oxford University Press.

Balboni, G. P. (Ed.). (2003). EXP - in search of innovation [Special Issue]. *JADE, 3*(3), 1-141.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The Semantic Web. *Scientific American 284*(5), 34-43.

Bussler, C., Maedche, A., & Fensel, D. (2002). A conceptual architecture for Semantic Web enabled Web services. *ACM Special Interest Group on Management of Data, 31*(4).

DAML Services Coalition (2002). (alphabetically Ankolenkar, A., Burstein, M., Hobbs, J.R., Lassila, O., Martin, D.L., McDermott, D., McIlraith, S.A., Narayanan, S., Paolucci, M., Payne, T.R., Sycara, K.) *DAML-S: Web Service Description for the Semantic Web. The First International Semantic Web Conference (ISWC).* Sardinia (Italy).

Dean, M., & Schreiber, G. (Eds.). (2004). OWL Web Ontology Language Reference. Retrieved February 10, 2004, from http://www.w3.org/TR/owl-ref/

Filos, E., & Banahan, E. (2000). Will the organisation disappear? The challenges of the new economy and future perspectives. In L. M. Camarinha-Matos, H. Afsarmanesh, & R. J. Rabelo, R.J. (Eds.), *E-business & virtual enterprises* (pp. 3-20). Dordrecht: Kluwer.

Finin, T., McKay, D., Fritzson, R., & McEntire, R. (1993, December). KQML: an information and knowledge exchange protocol. *Proceedings of the 1993 International Conference on Building and Sharing of Very Large-Scale Knowledge Bases,* Tokyo, Japan.

FIPA (2001). The Foundation for Intelligent Physical Agents. http://www.fipa.org/.

Foster, I., & Kesselman, C. (Eds.). (1999). *The grid: Blueprint for a new computing infrastructure.* San Francisco: Morgan Kaufmann.

Genesereth, M. R., & Fikes, R. E. (1992). *Knowledge interchange format, Version 3.0 reference manual* (Tech. Rep. logic-92-1). Stanford, CA: Stanford University, Computer Science Department.

Giorgini, P., Müller, J. P., & Odell, J. (Eds.). (2002). Agent-oriented software engineering IV. *Proceedings of the 4th International Workshop, AOSE 2003*, Computer Science, 2935.

Odell, J., Parunak, H. V. D., & Bauer, B. (2001). Representing agent interaction protocols in UML. In: Agent-oriented software engineering. *Proceedings of the First International Workshop AOSE-2000* (editors Ciancarini, P. & Wooldridge, M.). Computer Science,1957,121-140.

Sandholm, T. (1999). Distributed rational decision-making. In G. Weiss (Ed.), *Multiagent systems* (pp. 201-258). Cambridge, MA: MIT Press.

Searle, J. R., (1969). *Speech acts.* Cambridge University Press.

UDDI (2004), Universal Description, Discovery and Integration of Business for the Web. Retrieved from http://www.uddi.org/

Web Services (2004). Retrieved from http://www.webservices.org/

Willmott, S. N., Dale, J., Burg, B., Charlton, P., & O'Brien, P. (2001). Agentcities: A worldwide open agent network [Electronic version]. *Agentlink News, 8,* 13-15.

Wong, H. C., & Sycara, K., (1999). Adding security and trust to multi-agent systems. *Proceedings of Autonomous Agents '99* (pp. 149-161).

Wooldridge, M. (2002). *An introduction to multiagent systems.* Chichester, UK: John Wiley & Sons

Wooldridge, M., & Jennings, N. R. (1995). Intelligent agents: Theory and practice. *The Knowledge Engineering Review, 10*(2), 115-152.

Wooldridge, M., Jennings, N. R., & Kinny, D. (2000). *The Gaia methodology for agent-oriented analysis and design: Autonomous agents and multi-agent systems, 3*(3), 285-312. Boston: Kluwer Academic Publishers.

ENDNOTES

1. SOAP: Simple Object Access Protocol—SOAP is an XML (Extensible Markup Language)-based, lightweight protocol for exchange of information in a decentralized, distributed environment.
2. WSDL: Web Services Description Language—WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.
3. UDDI: Universal Description, Discovery, and Integration—The UDDI protocol creates a standard interoperable platform that enables companies and applications to quickly, easily, and dynamically find and use Web services over the Internet.

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Chapter 4.3
IT-Based Project Knowledge Management

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ABSTRACT

This chapter presents IT solutions supporting knowledge management initiatives within project organizations. The first section describes the background of the problem, that is the difficulty of managing knowledge in project-based organizations. The second section presents a model of knowledge management as the activity of managing compromises on a number of dimensions, and uses this model to present IT solutions for project knowledge management. The last section discusses future trends and key challenges and focuses on knowledge representation.

INTRODUCTION

This chapter primarily deals with project management and more especially the increasing tendency of modern organizations to use project organizations to carry out a range of vital operations or innovative activities. The use of project organizations is to be expected in industries for which this operating system is a necessity, e.g., the construction industry. The use of project management in these industries actually originated in the 1950s. However, the use of projects can now be observed across all industries, for new product development or for business performance improvement. This means that in today's economy the leverage of project performance on overall business performance keeps intensifying.

This chapter discusses project management from a knowledge management perspective. The concept of knowledge management, initially popularized by Nonaka (1991), has been quickly adopted by the business and communities at large; see Despres and Chauvel (1999) for a discussion of the rising popularity of the topic. This suggests that knowledge management is also a managerial approach which is here to stay.

The goal of this paper is to discuss IT applications, present and future, designed for project knowledge management. Capitalizing on existing knowledge for greater profitability is nothing novel: It has been implemented through management science since the dawn of the industrial revolution. This approach has only been possible in business sectors where operations can be highly routinized and can be improved in small steps. In the volatile and uncertain environment of project organizations, complexity has blocked such an effective management of knowledge.

BACKGROUND

Micro-Scale Knowledge Management

This chapter deals with the management of knowledge within and across project teams. The research approach used by the authors was to analyze the problem of project knowledge management at the operational level. In other words, this chapter does not discuss how to design a knowledge strategy and what kind of top commitment is necessary from top management. This is consistent with the school of micro knowledge management (μKM) as defined by Vergison (2000):

- Micro-scale knowledge management focuses on the capture, structuring and use of knowledge at a local level and does not necessarily require strong management support. It is not very sensitive to strategic plan variations.
- Macro-scale knowledge management is very sensitive to company strategic plans and it deals with knowledge flows within a large business entity. It definitely requires strong top management support and commitment.

As described by Vergison (2000) the micro-scale approach is based on the assumption that a top-down approach to knowledge management is rather ambitious and exposed to implementation problems. Thus, the goal of this chapter is to identify generic micro knowledge management problems faced by project teams and to describe what type of IT solutions have been or may be developed. This is not to say that any μKM problem can be solved with IT: In this chapter, many of the problems evoked can only be dealt with by using organizational design techniques. The goal of this paper is show how IT solutions can either solve some problems or facilitate the process of solving them.

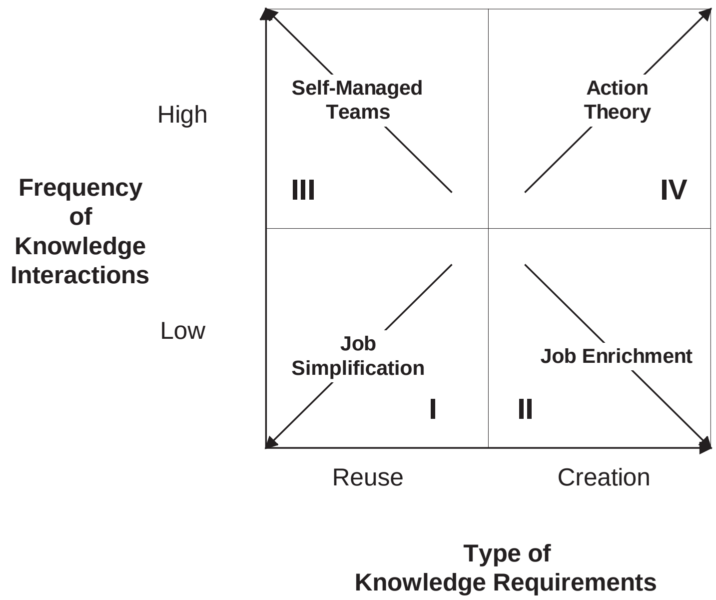
Job Context and Complexity of Managing Knowledge

Since its inception, knowledge management has already gone a long way and many models have been formulated. However most models, solutions, and techniques in knowledge management are either presented at the macro-scale level or in job contexts that are different from those encountered by project teams.

The typology of job design systems proposed by Leseure and Brookes (2000a) illustrates the criticality of the second point. Figure 1 indicates which job design theories are most appropriate when the context of knowledge usage is changing. The arrows indicate which job design practices are likely to be appropriate when one moves in a specific direction.

In this model, the technical interdependence of tasks and the environmental uncertainty of the task environment are combined to define the vertical contextual variable: the required frequency of knowledge interactions. Technical interdependency creates the background for knowledge interaction. Environmental uncertainty adds a time (frequency) dimension and controls how often these interactions need to take place.

Figure 1. Job design framework



Technical uncertainty is the second dimension of the context of micro-knowledge management. A low uncertainty describes a system that is primarily based on the reuse of routine knowledge. A high uncertainty occurs in systems where problems and products vary too broadly to be handled simply through reuse of knowledge. In high technical uncertainty environments, new knowledge needs to be created.

It is important to stress that the model in Figure 1 does not present four archetypes: Instead it presents a continuous space of systems. Hence, the horizontal axis origin reads as "0% innovation – 100% reuse" and its extreme point as "100% innovation – 0% reuse," and a system can be observed in any state within these two limits.

The point of focus in this chapter is the fourth quadrant, where the requirements of knowledge creation and collective work are merged together. The problem in this quadrant is to find how to smoothly combine the independence of the specialist and the requirement of frequent, extensive interaction.

Action theory is a relatively unknown school of job design which was originally developed by German researchers (Frese & Zapf, 1994). Work is defined as being action oriented, i.e., as being a collection of elementary activities. There are two important features of actions:

- An action encompasses a number of activities: defining a goal for the action, translating it into plans, executing these plans, and finally, receiving feedback from the action.
- Any action is subject to an individual cognitive regulation. Some actions become highly routinized (e.g., an assembly line worker's task) whilst some can never follow a rigid, identical structure (i.e., a commercial engineer's sales tactic).

The golden rule of action theory is that the active involvement of an employee is only possible if this employee is dealing with the entire action and not part of it. Second, action theory is probably less prescriptive than any other school in terms of practical recommendations. The tasks and context of executions of these tasks are the determinant of the final job design to implement. For this reason, action theory has been coined as a dynamic form of job design (for more information on these schools of job design, see Leseure & Brookes, 2000a).

Newman (1999) reports that lean production (a concept that relies extensively on teamwork and that lies in Quadrant III) improves productivity at the cost of innovative capability. This confirms the opposite, diverging directions of job enrichment and self-managed teams, and the fact that the task of seeking the benefits of both types of job design systems is not trivial. This is why Quadrant IV is in management terms the most difficult of all regions. It is the environment where innovation needs to take place on a daily basis and in parallel with design reuse. Knowledge interactions need to be frequent and efficient. This chapter draws the specifications of an IT-based knowledge management system for organizations operating in Quadrant IV.

Literature Review

A number of research studies, all from the UK, have recently targeted the improvement of project knowledge management. Gilbert and

Table 1. Data sources

Company	Industry	Interviewees	Size of Organizational Unit Being Discussed	Project Strategy
1	Aerospace	Project Manager	More than 1000	One-off
2	Aerospace	Business Development Manager	Less than 100	Focused Innovation
3	Aerospace	Program Manager	Less than 100	Focused Innovation
4	Aerospace	Engineering Manager	Less than 100	Focused Innovation
5	Aerospace	Program Manager	Between 100 and 500	One-off
6	Utilities	Project Manager	More than 1000	One-off
7	Capital Goods	Vice President	More than 1000	Both
8	Utilities	Director	More than 1000	Both
9	Capital Goods	Director Chief Engineer	Less than 100	One-off
10	Capital Goods	Director	Less than 100	Focused Innovation
11	Construction	Division Director Foreman Project Manager Construction Planner Estimator	Between 100 and 500	One-off
12	Service	Division Director	More than 1000	One-off
13	R&D, Engineering	Division Director	More than 1000	One-off
14	R&D, Engineering	Project Manager	More than 1000	One-off

Holder (2000) take an organizational stance on the problem of project knowledge management and propose organizational consulting services to address these problems. Braiden and Hicks (2000) study the management of knowledge in the engineered-to-order industry and adopt primarily a process-oriented approach to managing project knowledge. The IKON project studies the management of knowledge in conjunction with innovation processes (Hislop, Newell, Scarbourgh & Swan, 2000). In the IKON project, the term innovation is used in its broadest possible meaning—change of practices—and the objectives are to formulate best practices in knowledge management terms when a company is innovating. Finally, the B-Hive project formulated a Cross Organizational Learning Approach system, labeled COLA. COLA consists of innovative processes supported by information systems for the review, evaluation, feedback and organizational learning linked to project work (Orange, Cushman & Burke, 1999). The COLA system will be mentioned later in this chapter as an example of an IT solution.

Data Sources

The research and model presented in this paper are the outcomes of a multi-disciplinary research project at the University of Loughborough (UK). The data was collected through semi-structured interviews focusing on knowledge management problems and practices. Table 1 displays some general information about the interviews.

PROJECT KNOWLEDGE MANAGEMENT

Knowledge Management as Managing Compromises in System Configuration

Since the goal of this paper is to present which IT solutions have been or should be developed to support project knowledge management, it is necessary to benchmark the various problems observed in the companies surveyed against a generic model of an effective knowledge management system.

The model of knowledge management as compromise management of Leseure and Brookes (2000b) will be used to this end. This model is based on the premise that what is being questioned through the recent focus on knowledge management is the notion that work groups, teams, and organizations are systematically effective at managing collective knowledge. A more realistic model of collective work is to acknowledge that there are a number of dimensions which constrain, limit, or block an effective and timely exchange of knowledge between the different members of a project team.

The following list of compromise dimensions is used:

- Reuse/Innovation: Is a work unit achieving a productive compromise between the reuse of knowledge and innovation? Or does it have a tendency to reinvent the wheel? Or does it have a tendency to be a poor innovator?
- Collaboration/Competition: Is a work unit achieving a productive compromise between collaboration and competition (1) in its internal, interpersonal and intergroup interactions and (2) in its interaction with external parties?
- Tacit/Explicit: Is an organization achieving a compromise between the tacit and explicit forms of knowledge that it is manipulating in the course of operations? Or does is suffer from the predominance of tacit forms of knowledge? Or a predominance of explicit forms of knowledge?
- Informality/Formality: Does an organization achieve a productive compromise between informality and formality? Or does procedural compliance block spontaneity in the workplace? Or does spontaneity and

informality lead to chaos and anarchy?

- Internal/External: Does a work unit manage effectively its compromise of internal and external knowledge? Or does it tend to take unnecessary risk by reinventing or taking the responsibility for elements of knowledge that should be brought in by third parties? Or has a work unit lost its core competencies?
- Individual/Group: Does an organization distribute roles and responsibilities to individuals and group in a productive manner? Or does it suffer from knowledge bottlenecks attached to individuals? Or does it suffer from groups being unable to manage knowledge efficiently?
- Private/Public: Does an organization manage effectively the commercial sensitivity attached to knowledge? Does it suffer from an overly secretive corporate culture? Or does it suffer from diffusing its knowledge too broadly?

According to this model, a knowledge management problem can be explained by one (or several) imbalance along these dimensions.

Reuse vs. Innovation

Common Problems

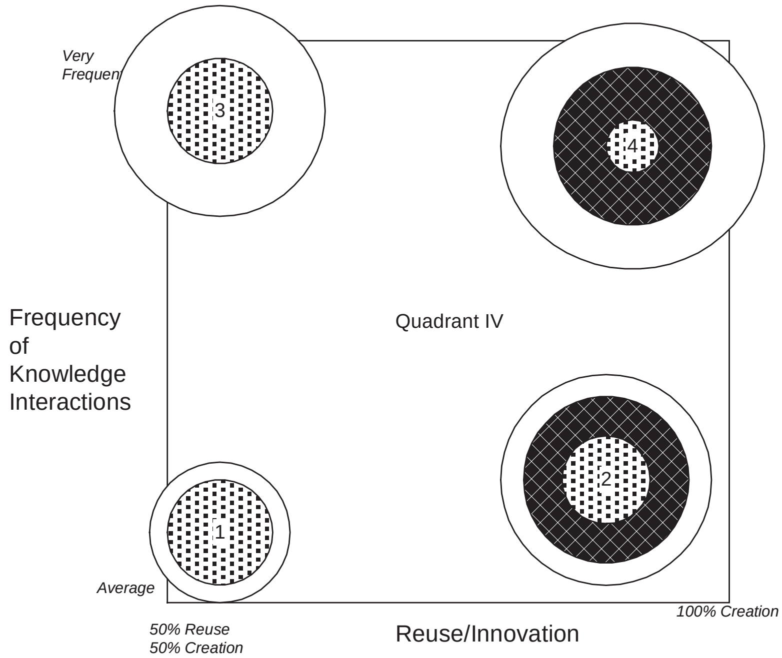
In the course of the research interviews, most interviewees stressed that they had difficulty with reusing knowledge. To be more precise, they indicated that they had problems re-creating previously used knowledge without making new mistakes and in many cases, without making exactly the same mistakes that they did in the past. This can be analyzed as an indication of a double problem:

1. Knowledge reuse capabilities are poor in project teams. This is not surprising if one considers that project organizations are structured for knowledge creation, i.e., to formulate solutions to new problems. As the organization of a project team targets knowledge creation capabilities, a side effect could be to naturally create a tendency to “reinvent” the wheel.
2. Despite the advantages of being organized as a project team, knowledge creation and innovation remain delicate tasks, and without clear guidelines, project teams are likely to reproduce past mistakes.

Some of the interviewed companies declared having solved these problems by adopting a focused innovation strategy as defined by Sivaloganthan and Shahin (1999): A company merges an existing design with other independent designs to develop a common core design, which can then be built in a variety of products. With this strategy, knowledge reuse is linked to the core design and easily managed and controlled. Innovation is limited to product variations and therefore is also easier to manage. However, it should be clear that this focused innovation strategy consists in moving away from Quadrant IV, as reuse increases and innovation diminishes. By generalizing this idea, one is at risk of transforming the upper right-hand corner of Quadrant IV into a “no-man’s-land” where activity is deemed impossible. Many companies, those selling engineered-to-order products and services (“one-off” projects), operate in this zone of Quadrant IV and are in crucial need of better knowledge management: Their problem is to improve innovative capabilities whilst reusing any relevant knowledge. This is illustrated in Figure 2, where a distinction is introduced between generic project knowledge and project-specific knowledge.

This section addresses how all the companies displayed in Figure 2 can improve their knowledge reuse capabilities. The issue of dealing with dealing with knowledge appropriation (a problem faced especially by Companies 2 and 4) is discussed in the Internal vs. External subsection.

Figure 2. Relative importance of reuse and creation in Quadrant IV



In this graph, dealing with project-specific knowledge (outer white circles) is a knowledge appropriation task which is different than knowledge creation. At the origin of the quadrant, Company 1 deals with a limited knowledge stock composed of a reusable core (dotted inner circle) and of some project-specific knowledge which requires integration. Company 2 deals with a limited amount of project-specific knowledge but has to create of lot of knowledge linked to its technical core (black circle). Company 1 primarily reuses knowledge in its technical core whereas Company 2's technical core is about innovation. Company 3 requires a lot more project-specific knowledge than creating new core knowledge: It is a problem of appropriation rather than creation. Company 4 combines the challenges faced by Companies 2 and 3.

Improving Knowledge Reuse

Matta, Ribière, Corby, Lewkowicz and Zaclad (2000) define project memory as "lessons and experiences from given projects" or as "project definition, activities, history and results." Although the model proposed by Matta and his colleagues deals exclusively with design projects, it can be generalized to other projects. Project memory is structured in two components:

- Project characteristic memory: This part of the memory includes all the information about the context, the organization and the results of the project. For instance, one may recall what the objectives of the project were, specific instructions received, the environment in which the project took place, who was part of the project team, what was each participant's respective responsibilities, etc.

- Project rationale memory: Project rationale memory covers the problem solving stage, that is, a description of which methodology was used and why, a list of the actors and their roles and views about solving the problem. This may include the memory of dissenting views within the project team. This may also include the memory of alternative solutions considered but rejected and of the rationale for doing so. Finally, project rationale memory includes all decisions made, from arguments about the decision to the analysis of each pro and con about the decision.

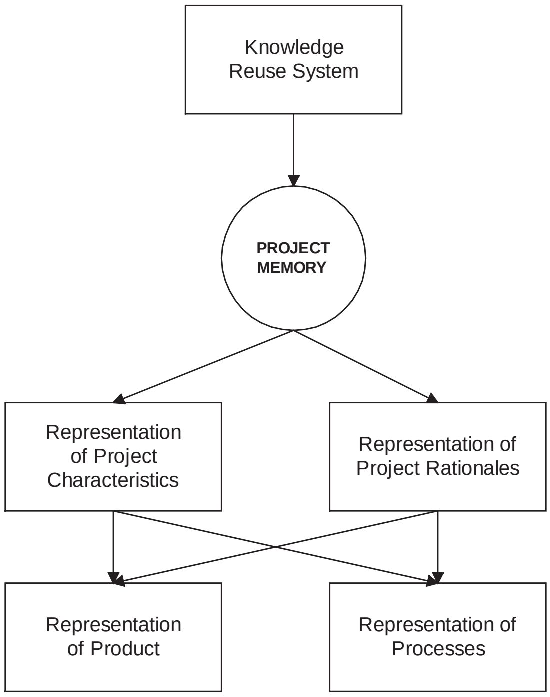
During the research interviews, most interviewees were aware of the possibility of using knowledge intranets to "memorize" knowledge. One of the interviewed companies in particular had developed internally a state-of-the-art knowledge intranet system including a bought-in search engine. However, after a review of what this intranet system could do, it became clear that it only dealt with project characteristic memory. At best, the system could memorize a problem with simple specifications (i.e., reasons for interrupting work on a site) and who solved that problem in the past in the company. This is consistent with the technical assessment of Matta et al. (2000), who report that as project characteristics are usually described in textual documents, tools that index textual documents such as LEXTER and FX-Nomino combined with database management tools are sufficient to implement a system for project characteristic memory.

Thus, the real challenge in terms of improving reuse of knowledge is to find a tool to memorize project rationales. This is a difficult issue given the evasive and fuzzy form of project rationale knowledge. Matta et al. present a review of existing models (2000):

- The tool IBIS is a process-oriented approach to support complex problem solving by structuring a problem as "issue, positions and arguments."
- QOC is a decision-oriented approach which structures rationales as "questions, options and criteria."
- The Drama system uses goals, options, criteria and choices to build a decision table representative of a decision made.
- DCRS is a system based on three sub-models. An intent model describes the problem at stake and its context. A version model represents the different options in terms of solutions, and the argumentation model describes how the decision is made.
- DIPA is a model attempting to model cognitive processes in terms of design rationales. It structures a rationale formulation situation as a problem, facts, interpretations, abstract and actual constraints, proposition and arguments. An interesting feature of DIPA is the capability of differentiating the processes of analysis and synthesis and memorizing both.

During the research interviews, many project managers or senior managers agreed that their organization would benefit from more knowledge reuse. Although they did not have an IT system which would capture project memory, it was clear that they themselves had memorized projects' characteristics and rationales. Despite this fact, they were still unable to generalize knowledge reuse within their company. This means that project memory is a necessary but not a sufficient condition for knowledge reuse. The other component that is needed is a reuse management system that provides a systematic method to specify when to store, retrieve, and update project memory. Shahin, Sivaloganathan, and Gilliver (1997) provide an

Figure 3. Project knowledge reuse system



example of such a reuse system in the case of a design project.

Figure 3 displays the full structure of a knowledge reuse system as discussed in this section. As shown in Figure 3, one should bear in mind that a project memory model relies on two other systems: one representing the product (or service) and the second representing processes.

Collaboration vs. Competition

The collaboration/competition compromise dimension is concerned with the environment of a project task. Whereas a competitive spirit can be a powerful driver of productivity, too much competition can be unproductive. The actual balance between competition and collaboration is a function of the context of the project. In the research interviews, managers all agreed that their organizations could benefit for more collaboration at several levels:

- Across ongoing projects: Project managers' performance is assessed on their ability to complete a project on time, within budget, and according to specifications. Project managers consider (legitimately) that time spent visiting another site to help a peer and sending another team member to another site would only endanger their own performance. This blocks any type of cross-project collaboration, and hence blocks knowledge sharing.
- Across hierarchical levels or fields of specialization: During the interviews, a lot of problems were identified with people refusing to collaborate because "it was not their job." In these cases, individuals had job descriptions and although they had the knowledge to solve a problem, they would not do so because they felt this violated the instructions that they had received. This is clearly a confusion of Quadrant I and Quadrant IV. This observation is confirmed by experts in work design, who report that the job simplification school tends to often be a "default model" (Parker & Wall, 1998).
- Along the supply chain: Subcontractors often perceive their relationship with their customer as adversarial. Their customer will require tasks not laid out in the contract whilst the supplier will try to provide less. This leads to a form of relationship management based on strict contract management and leaves little room and incentive for knowledge sharing along the supply chain.

It is necessary to distinguish the two reasons explaining why collaborative behavior is difficult in project teams. The first reason is cultural: Through involvement in projects, individuals have developed a certain distrust of suppliers and dislike the project schedule not being respected. The lessons learned are reinforced by senior managers' stance on these problems and by the guidelines they issue. These are internalized and become a way of thinking. When cultural habits turn out to be unproductive, they need to be changed. This task is addressed by the management and organization design disciplines and is beyond the scope of this chapter.

The second reason is infrastructural: Individuals do not collaborate because they feel that doing so would violate a written procedure and would go against orders; they cannot collaborate because they do not know who to collaborate with, or if they know, they are not able to collaborate because their counterpart is located elsewhere.

The IT solutions discussed in this section attempt to overcome infrastructural barriers. Although cultural barriers are not discussed here, they should not be overlooked. As stated by Davies (2000), using IT to facilitate knowledge sharing gives an opportunity to discover cultural resistance and to overcome it. In other words, IT can be used in this case as a technology driver to improve collaboration.

Know-who databases are the simplest IT tools that address the problems described above. Simply put, they allow a user to know who to contact to find the answer to a specific problem. It is noteworthy that a know-who database is a subsystem of the project memory system described in an earlier section.

Walström and Lindgren (2000) discuss the problems observed with five stand-alone know-who databases systems in seven companies through 24 semi-structured interviews. They identified five problems areas:

- Knowledge mapping: There is an ambiguity regarding what competencies are and how to provide an organizational structure for them.
- Knowledge evolution: Know-who knowledge is a volatile entity as both competencies and people change with time. This issue is complicated by the fact that individuals may also voluntarily omit some information when they fill in forms or prepare CVs.
- Knowledge isolation: The system may point to the individual who holds the knowledge sought, but hierarchy and/or procedures may prevent actual access to this individual or to the knowledge held.
- Knowledge interaction: Once a contact person is identified, there are often no corporate mechanisms to initiate the dialogue and for knowledge sharing to take place.
- Operative knowledge management: Know-who databases are unable to handle the logistical aspect of knowledge sharing. For instance, the system cannot express if an individual is free to collaborate when queried.

The conclusion of Walström and Lindgren (2000) is that know-who database systems often do not differ significantly from traditional personnel files as they only name individuals.

As stated in the section on the reuse/innovation compromise dimension, the concept of project memory needs, in order to be implemented on an IT system, an effective representation scheme of both product and process. Therefore, the concept of project memory as defined previously provides a solution to the knowledge mapping problem mentioned by Walström and Lindgren.

The issues of knowledge evolution, isolation and interaction are addressed by virtual communities of practice. A community of practice is a group of people who have similar functions or duties in a corporation, without necessarily knowing each other. There is nothing formal about communities of practice: They are an informal network of individuals connected by mutual interest and they get involved in the community on their own accord. Their corporation provides for them the platform and the infrastructure for knowledge sharing. An example of such a system is BT's

Jasper system, which is a WWW-based designed for knowledge sharing within BT. Jasper holds a list of registered users details and uses intelligent software agents to organize news, users' interests and users' documents (Davies, 2000). Although it is clear how such systems address the issues of knowledge evolution (as they are designed to evolve as users and their interests change) and knowledge isolation (as content is available from the system), it does not address the operative issue.

The operative component is a challenge left for IT solutions developers. The challenge is to go beyond connecting the people and helping them to actually collaborate. For example, BT has begun to develop interesting job trading systems where BT maintenance fleet employees can trade jobs whilst on the road. The objective is to optimize the productivity of the maintenance fleet by constantly revising its schedule according to the problems faced earlier in the day. This idea can be generalized to a "project trading system." The scope of such a system would be to support information sharing (or information trading), job trading (exchanging two workers between two project teams), and job sharing (temporarily sending a team member to another team). The difficulty in implementing such a system is to integrate it fully with the corporate planning system and to verify that trading/sharing activities do result in increased productivity.

Tacit vs. Explicit

During the research interviews, the following common problems were identified:

- Many companies suffered from knowledge being held in a tacit form. This, however, was not a universal problem. Some companies held tacit knowledge and had no problems working with it, whilst others need to go through the internalization process suggested by Nonaka (1991), that is, to transform tacit knowledge into explicit knowledge.
- In some cases, some companies indicated that although they may have an explicit source of knowledge, for instance, documents about a past project characteristic, they did not feel confident applying this knowledge, as they were unsure about the rationale aspect of this explicit knowledge.

In this section, we discussed IT issues in three cases:

1. The case of a company which has problems transferring tacit knowledge but which believes that the tacit/explicit balance is respected. In other words, it does not want to internalize knowledge, just to transfer it in a tacit form.
2. The case of a company which has concluded that it suffers from the tacit character of its knowledge and which has decided to internalize it. In others words, this company wants to use IT to reposition itself on the tacit/explicit dimension.
3. The case of a company which is satisfied with its tacit/explicit balance but its explicit knowledge base lacks scope and quality.

In the first case, the problem is to facilitate the transfer of tacit knowledge between different parties. The problem here is not the tacit nature of knowledge but the difficulty of transferring it. Nonaka (1991) describes this transfer as being based on a socialization process, for instance, between a master and an apprentice. This is a knowledge sharing problem and can be addressed by virtual communities of practice or project trading systems, as discussed in the collaboration/competition section.

In the second case, knowledge engineering and knowledge-based systems (KBS) provide the solution to internalization of tacit knowledge.

KBS are IT systems specialized in problem solving and decision making from the application of a substantial body of knowledge. With knowledge engineering, the knowledge of experts is analyzed, modeled and documented (i.e., made explicit). Once implemented in a knowledge-based system, the application of knowledge is automated. As there is an extensive literature available about KBS, the characteristics of these systems are not discussed further in this chapter.

In the third case, it is necessary to consider two different scenarios:

1. The poor quality of explicit knowledge is linked to the internalization process. For example, Carter (2000) gives the example of a utility company where a large body of engineers was replaced by a rule-based engineering system. When asked to comment about the knowledge engineering process, one of the engineers declared that since the rule-based engineering program was not a viable idea, he was purposefully giving wrong information to the knowledge engineers. In this scenario the problem is linked to the solution and not to knowledge itself. This is often an issue as verification and validation of KBS are issues that tend to be overlooked (Preece, 2000). Verification means checking that the specifications are matched (building the system right) whereas validation means checking that the system actually works (building the right system). The development of effective verification and validation procedures is a challenge for IT.
2. The second scenario takes place when the company has internalized some knowledge, but the nature of the knowledge itself is such that there is an unavoidable loss of content when converting it from a tacit form to an explicit form. The integration of a KBS with a project memory system addresses this problem as the project memory concept includes object attributes such as options, perspectives, opinions, etc. However, it is more realistic to acknowledge that there are limits to what explicit knowledge can convey. In this case, as stated by one of the interviewees, what needs to be in place is a system of "holding hands," i.e., a system where an individual can validate his or her assimilation of explicit knowledge by comparing it to the tacit knowledge of another individual. Communities of practice provide a platform for this.

Informal vs. Formal

It is more difficult to identify generic problems along this compromise dimension as the interviewed companies exhibited several types of problems:

- In some companies, knowledge was not accessed by some parties because of problems of compatibility between software, versions and formats. This is a case of lack of formality in the structure of information.
- In other companies, the opposite problem was observed. The structuring of information would be so formal that it would actually constrain the content of the message. For example, one interviewee reported that a memo from a project manager to a senior manager could only be written in a specific style and tone. Likewise, the answer from the senior manager would follow specific guidelines. Such a "bureaucracy of knowledge" prevents certain concepts (emotions, opinions, etc.) to be carried in a message. This level of formalism was seen as unproductive.
- Some companies relied heavily on procedures and a mechanistic organization of operations. This formalism can block

knowledge sharing, collaboration, innovation and any other activities based on informal relationships.
- In stark contrast, other companies preferred a more organic organizational approach and did not stress formalism and strict compliance to written operating procedures. These companies suffered from too much anarchy in operations.

As in the case of the collaboration/competition dimension, most of the problems faced in informal/formal dimension are either cultural or infrastructural. This section discusses how to address the latter and how to use IT as a technological driver to tackle the former.

First is the case of the company aware of the fact that it suffers from the fact that it is too formal. In this case virtual communities of practice provide the platform for informal exchanges as they are precisely designed as communities escaping the rules and structure of the formal organization.

In the second case, a company may be aware that it faces problems along the informal/formal dimension and may decide to improve its knowledge management capabilities by repositioning itself on this spectrum. This calls for a critical analysis of the relationship between project knowledge and project processes to identify when and why knowledge is not passed on, is lost, or is wrongly applied. What is needed in this case is a tool targeting the improvement of project knowledge management through process modeling. Modeling workshops are computerized integrated systems designed with this task in mind. Modeling workshops permit simulation of working practices under different scenarios of activity/role matrices within a working group and can help diagnose where knowledge management is inefficient. For an overview of MAMOSACO as an example of a Modeling workshop, see Vergison (2000). Another example is the COLA review process (Orange et al., 1999). Whereas MAMOSACO provides an example of a system that can be used for simulation (and improvement) purposes, the COLA review process is an example of a system able to trigger reflection and the formulation of lessons learned. COLA was developed in the construction industry to address the problem stated by Fisher (1998): "The construction industry struggles with its ability to capture the lessons learned from its projects and activities for the benefit of future, similar work." According to the designers of COLA, what lacks in the construction industry is reflective practice. Thus, COLA was designed to provide a review process forum for the social construction of knowledge.

Internal vs. External

In the case of project knowledge management, reaching a balance along this dimension means that all forms of generic project knowledge are internal to the company and are passed on to the different generations of project teams. It also means that project teams are able to assimilate project-specific knowledge without developing a full expertise about this external knowledge.

Common problems along these dimensions quoted by the interviewees were:

- A project team has to solve a very specific problem. Although there are sources both within and outside the company that could contribute to the supply of knowledge relevant to this problem, these sources are too dispersed (in space, time, objectives and values) for the project team to assimilate and aggregate their inputs. Instead, they prefer to engage in the risky and costly exercise of creating the missing knowledge themselves with limited resources. This often results in wrong decisions.
- A company has lost its internal competencies as people have moved on. In this case, internal knowledge has become external.

In the second case, project memorization and KBS are two IT solutions that provide the benefits of making sure that core knowledge remains within the company, as it has been internalized and embedded in IT systems. One of the interviewees gave the example of a key competency related to product testing. His company had a significant competitive advantage in terms of verifying that a product would match their industry regulations. Although this knowledge could have easily been applied from a manual, the company preferred to use a computerized system. Any modifications of the system are subject to extensive documentation requirements so that the company can trace (and revert when necessary) the evolution of the system. The interviewee stressed that the advantage of this procedure was to provide full management control about key internal knowledge.

A second interviewee provided the IT solution to the problem of assimilating quickly and in a cost effective manner external knowledge. One of his project teams had to work on a construction project where local conditions (weather, topology, nature of soil) were such that it was not clear how to apply regulations. In more standard projects, how to interpret and apply regulations was part of the experience of the company. In this specific project, conditions were such that the project team had to consider constraints and issues not dealt with previously in the company. However, there were a number of individuals from the project team, the company, and outside the company that had some ideas and experiences in some aspects of the problem faced by the interviewee. The problem was to find a tool that allowed the interviewee to tap into this dispersed source of knowledge and to aggregate the collected information into a whole. The interviewee decided to use a groupware system (in this case, Lotus Notes) to facilitate this acquisition and assimilation process. In his opinion, the project was a success thanks to the use of the groupware system.

In addition to groupware systems, knowledge intranets are useful in the acquisition and assimilation of external knowledge, provided that they are enriched with knowledge discovery and data mining capabilities. This constitutes an automation of the processes supported by groupware systems, but it is doubtful that the complex problems handled by project teams can all be solved by knowledge discovery applications, at least at the time of writing this chapter.

Individual vs. Group

The interviewed companies mentioned the following problems along this dimension:

- Knowledge retention, extinction and dominance: In an organizational process, an individual becomes a knowledge bottleneck when he or she retains some knowledge useful at the group level. A first major risk associated with knowledge retention is that of knowledge extinction when the individual or group at stake leaves the company. A typical example of knowledge extinction is the retirement problem: When an individual retires he or she takes with him or her product and process knowledge. The company often has to find a last-minute "quick-fix" solution to cope with this event. Downsizing operations were also blamed by interviewees as a factor weakening a group's knowledge stock. A second risk of knowledge retention is to use individually held knowledge to build authority and/or bargaining power. In this case, dysfunctional processes leading to delays, low innovation and poor performance can be observed.
- Knowledge dispersion: Knowledge is dispersed in and outside the organization but its application can only take place at the group/team level. This is a problem commonly encountered by project managers

installing IT systems or change programs. Knowledge exists dispersed in individuals but it is difficult to create group awareness.

- Knowledge factions: Knowledge may exist in different (conflicting) versions in different individuals or groups within the company. When different knowledge factions meet in a project team, a number of disputes and political issues arise. In the worst-case scenario, several people work in a project team with different objectives and specifications, as they refuse to exchange their information and experiences.

The basic challenge behind the individual/group compromise dimension is the management of ownership rights. In other words, it is to decide who has precedence and ownership of different classes of knowledge.

Knowledge retention is a problem solved by knowledge engineering as they force the expertise of an individual into a project memorization system. Another approach is to detect when knowledge retention is unproductive with a modeling workshop system. This would allow the company to reposition itself on the individual/group scale after it has decided if a specific class of knowledge is better owned by a single individual or by a group of individuals.

The knowledge faction problem is addressed by intranets and communities of practice. The knowledge dispersion problem is addressed by groupware systems.

All these modules (project memorization, modeling workshops, knowledge intranets, communities of practice and groupware systems) may all include their internal ownership rights specifications. However, as they all share the same needs, an optimal knowledge project management system should include a unique ownership rights module.

Private vs. Public

Whereas the individual/group dimension addressed who should own an element of knowledge, i.e., has the right to create and modify it, the private/public dimension defines who has the right to access and apply this knowledge.

The research interviews revealed the following generic problems:

- Too much corporate secrecy results in individuals needing some knowledge not being granted access to it. Such a corporate policy is motivated (1) by the fear that if too public, knowledge could get to the competitors and (2) by the fear that individuals may not be able to apply the knowledge properly.
- Too much leniency in protecting information does result in the problems quoted above and can also create anarchy and unproductive speculation about strategy, product and processes, as individuals feel free to voice their different perspectives, be they aligned or not with corporate objectives. For example, there is nothing more unproductive than the analysis of a quality problem about a cutting tool degenerating into a debate about the roles of project managers. Although the debate about project management may be relevant (by the parties allowed to do so), the debate about cutting tool quality should be addressed with the relevant actors focused on relevant knowledge.

The management of access rights to information is in fact easier to manage through IT than human systems. In the example of the product testing computerized system quoted above, the interviewee stressed that only accredited individuals were allowed to access the content of the software along specific rules. For normal team members, they interacted with the system through queries and answers.

FUTURE TRENDS

This section is divided in two parts. Throughout this chapter it is clear that knowledge representation is a fundamental issue in project knowledge management, especially with the concept of project memory. Project memory and representations about product and process are the link between each of the IT systems discussed in this chapter. Therefore, a unique and universal knowledge representation scheme is a sine qua non condition of an integrated project knowledge management system.

Challenges in Knowledge Representation

The key challenge in terms of knowledge representation is to develop a scheme which is universal enough to be queried and updated by all the other components of a project knowledge management system. To illustrate this challenge, consider the case of one of the interviewed companies which tried to design an expert system for the pricing of its project. The product is engineered to order production machines. The pricing is done by top management of the company (only three senior managers know how to formulate a price quote). Needless to say, this pricing knowledge is entirely tacit and unstructured. After a few knowledge engineering sessions it appears that the experts used three key pricing schemes:

- Technical pricing: The experts decompose a component of the machine in material, component and working hours. Then, they add all of the elements up and take into account margins and overhead expenses.
- Case-based reasoning: The experts see that a subset of the machine is similar to a subset previously designed on another machine. As they have some first-hand experience on what this previous subset cost, they can formulate a price estimate directly. It is noteworthy that the accounting department did not have any cost accounting capability and did not formulate what the costs of subsets were; in fact as far as accounting was concerned there were no subsets. The price estimate of the experts was based on the initial quote corrected for the problems encountered when the subset was designed and built.
- Function pricing: Experts have also devised rules of thumbs that are based on classification of functions. For instance, experts were able to give a price for the "grasping" function provided that they were specified the weight of the element to grasp, the speed of the machine, the dimension of the object, and the degree of precision required when grasping.

The problem is that when pricing, experts use these three approaches simultaneously. Although this may be perceived as a methodological flaw, this price assessment flexibility is what allows experts to give the price of a machine before it is designed solely from its specifications.

The accounting department of this company was particularly interested in this pricing project and wanted to develop a cost accounting system that would provide direct feedback on the original project. The problem was that although a pricing expert system was developed, it added apples and oranges, as it used the three approaches. It was a question-driven system, rather difficult to use, which did not integrate a concept of "machine" that could be tested for consistency and completeness. The accounting department implemented a cost accounting system based on subsets, but there was never any integration between the two systems.

This example illustrates the challenge faced by IT in terms of knowledge representation. It is easy to develop a knowledge representation or a set of representation schemes for one application but much more difficult to have a universal and flexible representation scheme for a variety of applications.

Other Key Challenges in Project Knowledge Management

The other key challenges are the development of modeling workshop systems and project trading systems. Modeling workshops are critical to project knowledge management as they address the performance assessment of how knowledge is managed within projects as well as how projects are organized in relation to the use of knowledge. It is through the modeling workshops that improvement in methods and practice for knowledge management comes from. Project trading systems can also contribute to a new generation of project management techniques as they allow project teams to move away from planning and scheduling rigidity toward a more flexible and dynamic approach to organizing projects.

CONCLUSION

In this chapter, a number of IT systems were presented to address project knowledge management issues. Amongst the most important are project memorization systems, knowledge intranets, know-who databases, communities of practices, knowledge-based systems, modeling workshops, etc. As stressed in the first part of this chapter, each of these systems can be easily developed at an operational level. It is possible to envision a large, integrated computer system including all the different systems discussed in this chapter. However, one should realize that such a system would definitely escape the micro-scale knowledge management approach used here: Such an integrated system would require considerable resources and top management support. Moreover, as stressed in the section discussing the issue of knowledge representation, a large integrated system could require such a level of formality in its specification that it could fail to capture the flexible methods through which knowledge can effectively be transferred between project teams. Although there is a cost to develop non-interfaced, isolated IT applications within a company, the research interviews showed that companies and project teams seldom have a crucial need in all these systems at once. For instance, "one-off" project organizations had a need for knowledge reuse and reflection process, IT project implementation teams had a more crucial need for communities of practice, large R&D department for knowledge intranets, and large project sites for groupware systems. These companies confirmed that once identified, simple and cost-effective IT tools could be built and adopted.

REFERENCES

Beer, M., Eisenstat, R. & Spector, B. (1990). Why change programs don't produce change. *Harvard Business Review*, November-December, pp.158-166.

Braiden, P. & Hicks, C. (2000). Assessing knowledge management activities in the design and manufacture of engineered to order capital goods. *Proceeding of the BPRC Knowledge Management: Concepts and Controversies Conference, 103.* Warwick, UK.

Carter, C. (2000). *The strange death of the professional engineer: A sojourn into the management of knowledge.* Unpublished Working Paper, University of Leicester Management Centre.

Davies, J. (2000). Supporting virtual communities of practice. In R. Rajkumar (Ed.), *Industrial Knowledge Management: A Micro Level Approach* (pp.199-212). London: Springer-Verlag.

Despres, C. & Chauvel, D. (1999). Knowledge management(s). *Journal of Knowledge Management, 3*(2), 110-120.

Frese, M. & Zapf, D. (1994). Action of the core of work psychology: A german approach. In H. Triandis, M. Dunette and J. Hough (Eds.), *Handbook of Industrial and Organisational Psychology* (4th ed.), 4, pp.271-340. Palo Alto, CA: Consulting Psychologists.

Gilbert, M. & Holder, N. (2000). An approach to project knowledge management. *Proceeding of the BPRC Knowledge Management: Concepts and Controversies Conference, 193*. Warwick, UK.

Hislop, D., Newell, S., Scarbrough, H. & Swan, J. (2000). Innovation processes and the management of knowledge. *Proceeding of the BPRC Knowledge Management: Concepts and Controversies Conference,* Warwick, UK.

Leseure, M. & Brookes, N. (2000a). Micro knowledge management: A job design framework. In R. Rajkumar (Ed.), *Industrial Knowledge Management: A Micro Level Approach* (pp.163-178). London: Springer-Verlag.

Leseure, M. & Brookes, N. (2000b). A support tool for knowledge management activities. *Proceedings of the 2000 IEEE International Conference on Management of Innovation and Technology* (pp.696-701), Singapore.

Matta, N., Ribière, M., Corby, O., Lewkowicz, M. & Zaclad, M. (2000). Project memory in design. In R. Rajkumar (Ed.), *Industrial Knowledge Management: A Micro Level Approach* (pp.147-162). London: Springer-Verlag.

Newman, V. (1999). *The limitations of knowledge management.* Unpublished presentation at the BPRC Seminar on Knowledge Management in Manufacturing, November 29, BPRC, University of Warwick, UK.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review*, November-December, 96-104.

Orange, G., Cushman, M. & Burke, A. (1999). *COLA: A cross organisational learning approach within UK industry.* Paper presented to 4th International Conference on Networking Entities (Neties '99), Donau-Universität, Krems, Austria, 18-19 March.

Parker, S. & Wall, T. (1998). *Job and Work Design.* London: Sage.

Preece, A. (2000). Evaluating verification and validation methods in knowledge engineering. In R. Rajkumar (Ed.), *Industrial Knowledge Management: A Micro Level Approach* (pp.91-104). London: Springer-Verlag.

Shahin T., Sivaloganathan, S. & Gilliver, R. (1997). Automation of feature-based modelling and finite element analysis for optimal design. *Proceedings of ICED97,* Tempere, Finland, August.

Sivaloganthan, S. & Shahin, T. (1999). Design reuse: An overview. *Proceedings of the Institute of Mechanical Engineers,* Part B, 213, 641-654.

Vergison, E. (2000). Micro-scale knowledge management: A necessary condition for getting corporate knowledge properly implemented. In R. Rajkumar (Ed.), *Industrial Knowledge Management: A Micro Level Approach*, 3-16. London: Springer-Verlag.

Wallström, C. & Lindgren, R. (2000). A close look at knowledge management systems. *Proceeding of the BPRC Knowledge Management: Concepts and Controversies Conference, 37.* Warwick, UK.

Chapter 4.4
Domain Ontologies

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INTRODUCTION

In conceptual modeling we need to consider a general level of abstraction where the domain of interest is formalized in an independent way with respect to the specific application for which the conceptual modeling process is performed. This leads to an integrated approach that takes into account knowledge about a domain and metaknowledge about a methodology. Indeed, knowledge about a domain is represented by a system of concepts and instances that reify the knowledge that is managed within a domain, and the metaknowledge about a methodology is the description of the knowledge deriving from the method used. For instance, when a technology is used to unveil ontologies within a specific domain, the knowledge about the domain is the resulting ontology, and the metaknowledge about a methodology is the description of the method used to construct the ontology. In this article, a novel method for the creation of both upper level and specific domain ontologies, called the bidirectional method for developing ontologies, is described. In particular, it will guide the developer to obtain ontologies resulting from the combination of both top-down and bottom-up approaches. The first one focuses on conceptual modeling through "armchair" research (philosophical, psychological, sociological aspects) and figures out a formal draft schema. The second approach employs an automatic (or semiautomatic) extraction of categories, taxonomies, partonomies, and dependency graphs in particular from linguistic corpora of documents related to the topics of the domain.

BACKGROUND

Formal ontologies are a popular research topic in several communities, such as knowledge management, knowledge engineering, natural language processing, artificial intelligence (AI), and others (Fensel, 2000). Formal ontology can be defined as the systematic, formal, axiomatic development of the logic of all forms and modes of being (Cocchiarella, 1991). More generally, we employ the term formal ontology to designate an explicit specification of a shared conceptualization that holds in a particular context. In other words, an ontology provides an explicit conceptualization that describes semantics of data, providing a shared and common understanding of a domain (from an AI perspective, see the definitions of Gruber, 1998, and Jasper & Ushold, 1999). Ontologies are used to manage knowledge within and among communities, to manage and organize corporate knowledge bases, and to negotiate meanings among individuals. Moreover, ontologies are used to share knowledge among people, and heterogeneous and widely spread application systems, such as semantic-Web applications (Schwartz, 2003). They are implied in projects, as conceptual models, to enable content-based access on corporate knowledge memories, knowledge bases, or data warehouses. They are employed to allow agents to understand each other when they need to interact, communicate, and negotiate meanings. Finally, they refer to common information and share a common understanding of their structure.

In computer science, knowledge management, knowledge representation, and other fields, several languages and tools exist for helping final users and system developers in creating good and effective ontologies. In particular, various tools help people in manually or semiautomatically creating categories, partonomies, taxonomies, and other organization levels of ontologies. The generally accepted term to designate these tools is ontology editors. Some of them are open source such as Protégé-2000, KAON, and SWOOP, and others are commercial suites for knowledge management based on ontology development, such as tools provided by the onto-Knowledge Project (for an in-depth description, see http://protege.stanford.edu, http://kaon.semantic web.org/, http://www.mindswap.org/2004/SWOOP/, http://www.ontoknowledge.org/index.shtml).

Some Important Methodologies

Behind these tools and techniques, different (domain-independent) approaches and methods are used to develop numerous heterogeneous ontologies. In particular, Ushold's (2000; who proposed codification in a formal language) methodology and methontology, which constructs an ontology in a sequence of intermediate representations finally translated into the actual object (Fernández, Gòmez-Pérez, & Juristo, 1997), are the most representative. Here are short descriptions of some important methodologies:

- One of the first modules of the foundational ontologies library is the descriptive ontology for linguistic cognitive engineering (DOLCE). DOLCE is an ontology of particulars and refers to cognitive artefacts that depend on human perception, cultural imprints, and social conventions. This ontology derives from armchair research in particular, referring to enduring and durable entities from philosophical literature. The main authors' idea is to develop not a monolithic module, but a library of ontologies (WonderWeb Foundation Ontologies Library) that allows agents to understand one another despite enforcing them to interoperate by the adoption of a single ontology (Masolo, Borgo, Gangemi, Guarino, & Oltramari, 2002). Finally, basic functions and relations (according to the methodology introduced by Gangemi, Pisanelli, & Steve, 1998) should be general enough to be applied to multiple domains, be sufficiently intuitive and well studied in the philosophical literature, and hold as soon as their relations are given without mediating additional entities.
- In Gatius and Rodríguez (1996), the authors developed a three-step process (natural-lan-

guage interface generator [GISE]) to build a domain ontology: the building and maintenance of general linguistic knowledge, a definition of the application in terms of the conceptual ontology, and a definition of the control structure. It includes the metarules for mapping objects in the domain ontology with those in the task ontology, the metarules for mapping the conceptual ontology onto the linguistic ontology, and those for allowing the generation of the specific interface knowledge sources, mainly the grammar and the lexicon.

- One of the most famous ontology-design environments is methontology. It tries to define the necessary activities that people carry out when building an ontology (Fernández et al., 1997). In other words, it is a flow of ontology development for three different processes: management, technology, and support. The ontology-development process is composed of the following steps: project-management activities that include planning, control, and quality assurance; development-oriented activities that include specification, conceptualization, formalization, and implementation; and activities that include knowledge acquisition, evaluation, integration, and documentation.
- The authors Lauser, Wildemann, Poulos, Fisseha, Keizer, and Katz (2002) use the multilingual methontology methodology defined by Fernández et al. (1997), and enrich this one by stressing on specific actions for supporting the creation process for ontology-driven conceptual analysis. The domain ontology is built by using two different knowledge-acquisition approaches: the creation of the core ontology and the derivation of the domain ontology from a thesaurus. The first one is basically comprised of the first three steps of methontology-development activities defining a list of frequent terms and a list of domain-specific documents to analyze. The second one consists of descriptive keywords linked by a basic set of relationships. The goal of this step is to refine an RDFS ontology model to develop a pruned ontology and a list of frequent terms.
- Toronto Virtual Enterprise (TOVE) is a methodology for ontological engineering that allows the developer to build ontology following these steps: scenarios motivation, ontology requirements definitions, terminology specification, formal description requirements, axiom specification, and completeness theorems (Fox & Gruninger, 1994, 1998).
- Ontology Development 101 has been developed by authors involved in these ontology-editing environments: Protégé-2000, Ontolingua, and Chimaera (Noy & McGuinnes, 2001). They propose a very simple guide, based on iterative design, that helps developers to create an ontology using these tools. The sequence of the steps to develop an ontology are to determine the domain and scope of the ontology, consider reusing existing ontologies (e.g., Ontolingua ontology library, DAML ontology library, UNSPSC, RosettaNet, and DMOZ), enumerate important terms in the ontology, define the classes and the class hierarchy, define the properties of class slots, define the facets of the slots, and create instances.
- Ushold's (2000) methodology uses formal language for building ontologies via a purely manual process, identifying purpose and scope, capturing (the identification of key concepts and relationships, and the provision of definitions), and finally coding ontology (committing to the basic terms for ontology), integrating existing ontologies, evaluating, and documenting the ontology processes.
- The On-to-Knowledge (OTK) methodology focuses on application-driven development of ontology during the introduction of

ontology-based knowledge-management systems (Fensel, van Harmelen, Klein, & Akkermans, 2000; Lau & Sure, 2002; Sure, Erdmann, Angele, Staab, Studer, & Wenke, 2002). It is based on the following steps: a feasibility study, an impacts and improvements study for the selected target solution, a kickoff phase, a refinement phase, a formalization phase, an evaluation phase, and an application and evolution phase. This methodology stresses the need for ensuring organizational acceptance and the integration of knowledge systems. Then it is based on bottom-up strategies, and gathering insights into the interrelationships between the business task, actors involved, and the use of knowledge for successful performance.

- The authors Izumy and Yamaguchi (2002) have used the business-object ontology to develop an ontology for business coordination. They constructed the business-activity thesaurus by employing WordNet as a general lexical repository. They have constructed the business-object ontology in the following way: by concentrating on the case-study models of e-business and extracting the taxonomy, counting the number of the appearances of each noun concept, comparing the noun hierarchy of WordNet and the taxonomy obtained and adding the number counted for the similar concepts, choosing the main concept with high scores as upper concepts and building upper ontologies by giving all the nouns the formal is-a relation, and merging all the noun hierarchies extracted from the whole process.

Comparing these Methodologies

Although there are relevant differences among the methodologies described above, a number of common points clearly emerge. Many of the methodologies take the domain definition as a starting-point task. From one point of view, it focuses on the acquisition, provides the potential for evaluation, and provides a useful description of the capabilities of the ontology, expressed as the ability to answer well-defined competency questions. On the other side, it seems to provide limitations to the reuse of the ontology and to the possible interactions among ontologies. Besides this, there are two different types of methodology models: the stage-based models (represented, for example, by TOVE) and evolving prototype models (represented by methontology). Both approaches have benefits and drawbacks: The first one seems more appropriate when the purposes and requirements of the ontology are clear, and the second one is more useful when the environment is dynamic and difficult to understand. Finally, both the informal description of the ontology and the formal embodiment in an ontology language are often developed in separate stages, and this separation increases the gap between real-world models and executable systems. There is no one correct way to model a domain; there are always viable alternatives. Most of the time, the best solution depends on the application that the developer has in mind, and the tools that he or she uses to develop the ontology. In particular, we can notice that the need for correspondence between existing methodologies and environments for building ontologies causes these consequences: Conceptual models are implicit in the implementation codes and a reengineering process is usually required to make the conceptual models explicit, ontological commitments and design criteria are implicit in the ontology code, and ontology developer preferences in a given language condition the implementation of the acquired knowledge.

MAIN FOCUS OF THE ARTICLE

In this article, the focus is the necessity for a tenable trade-off between a stable corporate model of knowledge and the dynamism of the very same knowledge in the history of real-world organizations. What is not sufficiently studied in the current literature of ontology methodology, which we believe to be the crucial aspect of this type of investigation from the knowledge-management viewpoint, is the nature of the knowledge of the methodology itself (the metaknowledge of the domain), which is very important for the choices we make in the deployment process of any ontology.

Our discussion focuses on how an explicit representation of the metaknowledge is helpful in knowledge-management practice. To demonstrate this, an analysis of the basic assumptions about ontology creation is provided, the bidirectional method for developing ontologies is described, and finally a knowledge-management viewpoint on ontology creation is presented.

Basic Assumptions on Ontology Creation

As explained above, one of the first steps in ontology creation is the choice of domains and categories that represent, in a neutral way, the real world. In fact, in the real world or in practical applications (e.g., information systems, knowledge-management systems, portals, and other ICT applications), general and universal categories are not widely being used. This is also due to the difficulties in implementing a general ontology within specific domains. Moreover, general and universal categories are very abstract and can lead to heterogeneous interpretations and different conceptualizations. For instance, everyone has a different interpretation and conceptualization of love, trust, or spatial-temporal regions. Besides this, the more a concept is abstract, the more it is difficult to define it. Then, workers very stressed by their daily activities might find it difficult or useless to make their daily used concepts more abstract and decontextualized. Namely, they might prefer to achieve, in short time, an effective agreement on shared spaces in their office than stay days and days talking about space regions.

More often, it is simply too expensive to create complex, complete, and general ontologies. Another important justification of the above-mentioned lack of general and supposedly complete ontologies in real-world applications is that, in the same project or domain, people might use different ontologies composed by several combinations of categories. Indeed, different ontologies might use different categories or systems of categories to describe the same kinds of entities. Even worse, two ontologies may use the same names or systems of categories for different kinds of entities. In fact, when trying to measure the similarity between two ontologies, it is necessary to pursue at both the lexical layer and the conceptual layer (Maedche & Staab, 2002). Therefore, it might be that two entities with different definitions are intended to be the same, but the task of proving that they are indeed the same may be difficult, if not impossible (see Sowa, 2000).

The basic reason for these behaviours is that what we know cannot be viewed simply as a unique picture of the world since it always presupposes some degree of interpretation. Indeed, depending on different interpretation schemas, people (with different perspectives, aims, and world interpretations) may use the same categories with different meanings, or different words to mean the same thing. For example, two groups of people may observe the same phenomenon, but still see different problems, different opportunities, and different challenges. This essential feature of knowledge was studied from different perspectives, and the interpretation schemas have been given various names, for example, paradigms in Kuhn (1979), frames in Goffman (1974), thought worlds in Dougherty (1992), contexts in Ghidini and Giunchiglia (2001), mental spaces in Fauconnier (1985), and cognitive paths in Weick (1979). This view, in which the explicit part of what we know gets its meaning from an (typically implicit, or taken for granted) interpretation schema, leads to some important consequences regarding the adoption and the use of categories and ontologies. An ontology is not a neutral organization of categories, but it is the emergence of some interpretation schema according to which it makes sense to organize and define things. In summary, an ontology is always the result of a sense-making process (conceptual modeling) and represents the point of view (the knowledge representation) of those who took part in that process (see Benerecetti, Bouquet, & Ghidini, 2000, for an in-depth discussion of the dimensions along which any representation, including an ontology, can vary depending on contextual factors).

Moreover, according to a structuration approach (for an in-depth discussion, see, for example, Giddens, 1984; Orlikowski, 1992; Orlikowski & Gash, 1994), technology cannot be considered as a neutral matter with respect to organizational structures and the managing of knowledge. Ontologies can shape knowledge sharing and managing processes, and organizational behaviours can affect the concrete appropriation of technology. Therefore, there is no one correct way to model a domain; there are always viable alternatives. Mainly, the best solution depends on the application that the developer has in mind, the system of artefacts that she or he wants to integrate with the ontology, and the tools that she or he uses to develop the ontology. Indeed, most of the tools only give support for designing and implementing the ontologies, but they do not support all the activities of the ontology life cycle. Besides this, most of the existing methodologies for building ontologies depend on their environments. Therefore, conceptual models are implicit in the implementation codes and a reengineering process is usually required to make the conceptual models explicit. Ontological commitments and design criteria are implicit in the ontology code, and ontology developer preferences, in a given language, condition the implementation of the acquired knowledge (Gruber, 1998).

The Bidirectional Method for Developing Ontologies

The bidirectional method for developing ontologies provides guidelines to assist the ontological engineer in making choices at different levels, from the high-level structure of the ontology to the fine details of whether or not to include distinctions. The bidirectional method for developing ontologies aims at satisfying all the developer needs and merging two different needs: a more adequate representation of the local domain and the very effective development of a top-level ontology. Taking into consideration these aspects, it seems useful to consider that manually constructed ontologies are time consuming, labour intensive, and error prone (Ding & Foo, 2002), but they are necessary to define a domain in which the quality and the general comprehension of the ontology are good. For example, experts might provide the system with a small number of seed words that represent high-level concepts. These concepts can emerge from theoretical ideas and knowledge or from the practice and the experiences of specialized workers. The steps defined by the bidirectional method for developing ontologies shortly are the following:

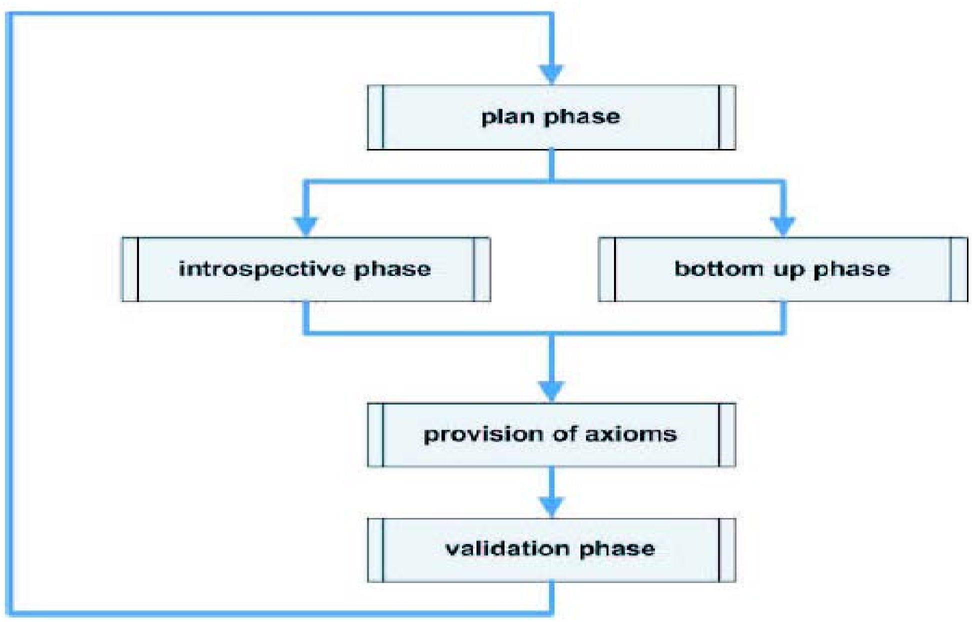
- Plan phase: The goals, amount of resources needed for the ontology development, and bonds (e.g., languages, timing, computational power, type of software used to describe the ontology) are defined. It is important to notice that there is a trade-off between the computational complexity (which is domain independent) and the expressive potential defined by the language.
- Introspective phase: The draft schema, such as the general specifications, categories, and relations; its formalization into the chosen formal language; and its demonstration are defined. It is important to notice that this phase is based on references to literature (philosophical, linguistic, psychological,

sociological literature) and on armchair research.

- Bottom-up phase: The draft terminology is automatically or semiautomatically generated, the description of relations among terms is extracted, and the refinement of draft terminology is handled. The lexical analysis is developed partly in an automated way (through the extraction of phrases containing seed words in documents, archives, and so on) and partly experienced (through expert discussion; domain experts can help the developer to refine the draft terminology). Notice that this phase is based on a very neat domain knowledge and on semiautomatic ontology generation, which depends, in particular, on data-mining processes, syntax systems of analysis, and so on.
- Provision of basic axioms: A set of ontology definitions is obtained through domain-expert interviews or participation.
- Validation phase: The set of definitions is tested, validated, and used.

The above-deployed analysis gives to the bidirectional method for developing ontologies the meaning of a metamethodology, namely, a methodology for operating the right choice among different possible methodologies. This is practically useful in ontology constructions within complex organizations. In fact, within big organizations, knowledge is managed according to different perspectives, and specialized knowledge is managed in the way that better suits specific needs. The presented bidirectional method for developing ontologies sustains the creation of very specialized, specific, and different domain ontologies, allowing a high level of flexibility in ontology-construction processes. Moreover, it allows one to manage a complicated ontology commitment that in practice is routed in dynamic contents and in specific methods. Contents and

Figure 1. A representation of the bidirectional method for developing ontologies



metaknowledge for ontology constructions can be managed and modified only at execution time, namely, at the moment in which the ontology is created. In Figure 1, a schematic analysis of the phases is described. Each phase is related in terms of the direct dependency on previous phases. The metaknowledge included in the ontology methodology adopted is rendered explicit by the definition of these dependencies. Note that the resulting phase set is minimal with respect to the possible phases in existing methodologies, and that the execution of the phase sequence is cyclic in order to provide a model for reusability.

A Knowledge Management Perspective on Ontology Creation

An ontology is a tool for knowledge management whenever it is used for meaning negotiation. However, a coherent perspective on ontology construction from the knowledge-management point of view is not well defined within the current literature of both artificial intelligence and organizational studies.

The perspective defined here is focused on three fundamental aspects of ontology creation: the widely recognized need for tools to be used in the generation of a shared conceptualization for corporate knowledge management; the generally acknowledged need for methodologies that developers of ontologies can follow in a coherent, systematic, and easy-to-implement way; and the economic value of ontologies as artefacts in the practice of knowledge management.

In particular, using the structuration-theory approach (Giddens, 1984; Orlikowski, 1992; Orlikowski & Gash, 1994), the main features of the bidirectional method should be analyzed, and the most important consequences generated by using a special methodology (the bidirectional method) should be unveiled. In particular, the method facilitates the management of some activities such as controlling the development of knowledge repositories in a corporate knowledge-management system, which may include a data warehouse, a corporate Web portal, and intranet tools for accessing distributed data.

The major value of a systematic definition of these aspects is the opportunity for measuring the quality of an ontology from a social and organizational point of view. Though the aim of this investigation is not so far to obtain metrics and evaluation methods for ontologies, we maintain that such a result is going to be shortly available once the methods for building ontologies have been defined.

An important observation is that we have three different situations for ontology development at different levels of difficulty: development from scratch, development as a completion of an existing ontology, and development as a merge (or coordination or alignment) of several ontologies. The three cases require different methodologies, and the methodology we have deployed in this article is valid only for the first case. The other two cases are also interesting extensions of the perspectives of knowledge management we consider as the focus of the article, and they deserve deep analysis. However, we believe that this is possible only when using a flexible methodology for the case from scratch.

FUTURE TRENDS

This article discusses a methodology for building a domain ontology from scratch. The intention of the investigation is to prove that extracting an ontology from a corpus (or from many corpora) is a tenable solution for certain paths, and the opposite way based upon a deep thinking on the topics of the domain is acceptable in other cases. The methodology we propose here is able to help the developer in discriminating between the two cases and provides a general schema for the mentioned purpose.

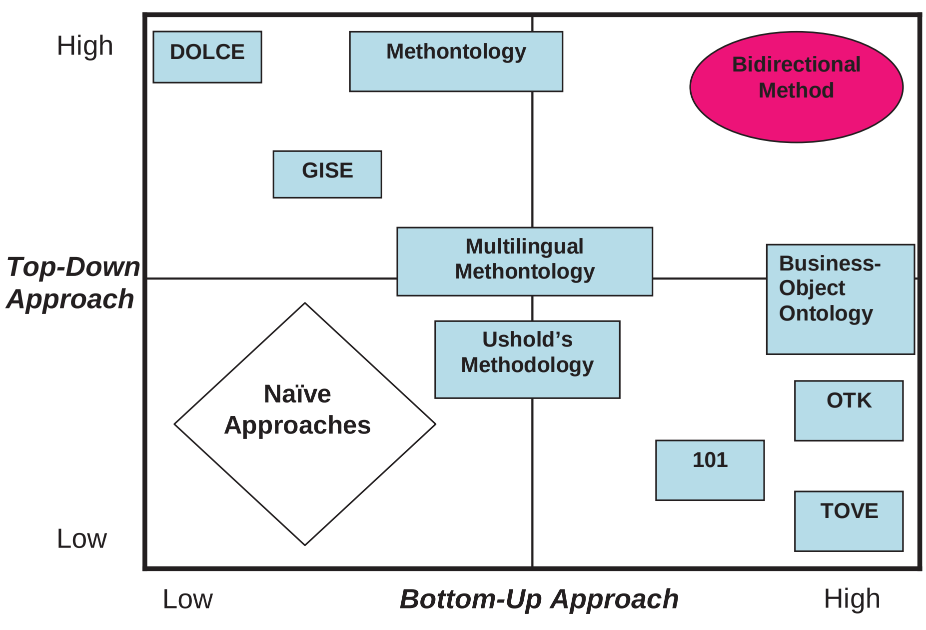
The investigation on the cases of the development of ontologies as an integration of existing models and as a merge has to be deepened. The other aspects that have to be covered are how this methodology can affect the updating processes, and how it can allow the integration of domain ontologies into an upper level ontology. Finally, the evaluation and measure of ontologies seem interesting issues in order to quantify how much an ontology costs and how one can improve the daily activities of workers. In particular, taking into account organizational and management studies, an ontology should be evaluated in terms of its ability to satisfy and its effectiveness.

The above-discussed needs and solutions can be deployed in technologies for knowledge management both as CASE (computer-aided software engineering) in the context of ontology creation, where the tool helps the developer in doing the right thing at the right moment, and as knowledge-sharing and -meaning negotiation tools, especially in network systems.

CONCLUSION

The major claim of this article is that an explicit representation of the methodological knowledge employed to provide conceptual analysis and express the model of knowledge by means of formal ontologies is a valuable plus for knowledge management. In the article, the existing major methodologies are described, and it is shown that everyone provides a framework for making tenable decisions upon the correct case to be used in each specific case, depending both upon the knowledge type and the domain. Although a lot of different methodologies for ontology creation are used in different domains, a good methodological approach should not change depending on the domain in which it is applied and on the type of technology that is used (see Figure 2). A metamethodology is needed, which allows the developer to use the same metamethodology even

Figure 2. A description of ontology-creation methodologies



if the domain, the tool for ontology creation, the needs, and so on change during the time.

In particular, both bottom-up and top-down approaches are very important and are both used in different stages of ontology creation. The bidirectional method for developing ontologies gives an explicit answer to the need of merging both approaches, accounting for the need of tenable, if not optimal, trade-offs between the stability of the model of knowledge and the dynamism of the knowledge itself, which is the actual reason for which an explicit methodology is invented.

REFERENCES

Benerecetti, M., Bouquet, P., & Ghidini, C. (2000). Contextual reasoning distilled. *Journal of Theoretical and Experimental Artificial Intelligence, 12*(3), 279-305.

Cocchiarella, N. (1991). Formal ontology. In B. Smith & H. Burkhardt (Eds.), *Handbook of metaphysics and ontology* (pp. 640-647). Munich, Germany: Philosophia Verlag.

Ding, Y., & Foo, S. (2002). Ontology research and development: Part 1. A review of ontology generation. *Journal of Information Science, 3*(28), 123-136.

Dougherty, D. (1992). Interpretative barriers to successful product innovation in large firms. *Organization Science, 3*(2).

Fauconnier, G. (1985). *Mental spaces: Aspects of meaning construction in natural language*. Cambridge, MA: MIT Press.

Fensel, D. (2000). *Ontologies: A silver bullet for knowledge management and electronic commerce*. Berlin: Springer-Verlag.

Fensel, D., van Harmelen, M., Klein, M, & Akkermans, H. (2000). On-to-knowledge: Ontology-based tools for knowledge management. *Proceedings of eBusiness and eWork*, Madrid, Spain.

Fernández, M., Gòmez-Pérez, A., & Juristo, N. (1997). *METHONTOLOGY: From ontological art towards ontological engineering.* Working Notes of the AAAI Spring Symposium on Ontological Engineering.

Fox, M. S., & Gruninger, M. (1994). Ontologies for enterprise integration. *Proceedings of the 2nd Conference on Cooperative Information Systems*, Toronto, Canada.

Fox, M. S., & Gruninger, M. (1998). Enterprise modelling. *AI Magazine*, 109-121.

Gangemi, A., Pisanelli, D. M., & Steve, G. (1998). Ontology integration: Experiences with medical terminologies. In N. Guarino (Ed.), *Formal ontology in information systems* (pp. 163-178). Amsterdam: IOS Press.

Gatius, M., & Rodríguez, H. (1996). A domain-restricted task-guided natural language interface generator. *Proceedings of the 2nd Edition of the Workshop Flexible Query Answering Systems (FQAS'96).*

Ghidini, C., & Giunchiglia, F. (2001). Local models semantics, or contextual reasoning = locality + compatibility. *Artificial Intelligence, 127*(2), 221-259.

Giddens, A. (1984). *The constitution of society.* Berkeley: University of California Press.

Goffman, I. (1974). *Frame analysis*. New York: Harper & Row.

Gruber, T. R. (1998). A translation approach to portable ontology specifications. *Knowledge Acquisition, 5,* 199-220.

Izumi, N., & Yamaguchi, T. (2002). Semantic coordination of Web services based on multi-layered repository. *PRICAI*, 597.

Jasper, R., & Ushold, M. (1999). A framework for understanding and classifying ontology applications. *Proceedings of the 12th Workshop on Knowledge Acquisition, Modelling, and Management,* Canada.

Kuhn, T. (1979). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Lau, T., & Sure, T. (2002). Introducing ontology-based skills management at a language insurance company. *Modellierung* (pp. 123-134).

Lauser, B., Wildemann, T., Poulos, A., Fisseha, F., Keizer, J., & Katz, S. (2002). A comprehensive framework for building multilingual domain ontologies: Creating a prototype biosecurity ontology. *Proceedings of the International Conference on Dublin Core and Metadata for e-Communities,* 113-123.

Maedche, A., & Staab, S. (2002). Measuring similarity between ontologies. *Proceedings of the European Conference on Knowledge Acquisition and Management: EKAW-2002* (pp. 251-263).

Masolo, C., Borgo, S., Gangemi, A., Guarino, N., & Oltramari, A. (2002). *Wonderweb deliverable d17: Intermediate report 2.0,* ISTC-CNR.

Noy, N. F., & McGuinnes, D. L. (2001). *Ontology development 101: A guide to creating your first ontology.* Stanford, CA: Stanford University.

Orlikowski, W. J. (1992). Learning from notes: Organizational issues in groupware implementation. In J. Turner & R. Kraut (Eds.)*, Proceedings of CSCW'92 Conference* (pp. 362-369). New York: The Association for Computing Machinery.

Orlikowski, W. J., & Gash, D. (1994). Technological frames: Making sense of information technology in organizations. *ACM Transactions on Information Systems, 12*, 174-207.

Schwartz, D. G. (2003). From open IS semantics to semantic Web: The road ahead. *IEEE Intelligent Systems, 18*(3), 52-58.

Sowa, J. F. (2000). *Knowledge representation: Logical, philosophical and computational foundations.* Cambridge, MA: Brooks/Cole.

Sure, Y., Erdmann, M., Angele, J., Staab, S., Studer, R., & Wenke, D. (2002). OntoEdit: Collaborative ontology development for semantic Web. *Proceedings of the 1st nternational Semantic Web Conference,* Sardinia, Italy.

Ushold, M. (2000). Creating, integrating and maintaining local and global ontologies. *Proceedings of the 1st Workshop on Ontology Learning (OL-2000) in conjunction with the 14th European Conference on Artificial Intelligence (ECAI 2000).*

Weick, E. K. (1979). *The social psychology of organizing.* Reading, MA: McGraw-Hill.

Chapter 4.5
Knowledge Reuse

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INTRODUCTION

Knowledge reuse is the process through which knowledge is captured, validated, stored, and retrieved. Through the reuse of knowledge, organizations may exploit internal capabilities and improve the effectiveness of their exploration activities (March, 1999). Knowledge reuse processes emphasize the centrality of knowledge within an organization by aligning information systems and communication technologies with human activity and organizational mechanisms, such as learning processes and organizational structures. The process of knowledge reuse can be systematic and planned; however, it can also be carried out in an informal manner through social networks and interpersonal ties (Newell, 2004). While knowledge reuse is explored from an entitative perspective, in which knowledge is generic, accessible, and codifiable, other views, such as social construction (Lave & Wenger, 1991), are also considered in this article. Furthermore, various contexts are considered in this article; however, the emphasis in this article is on knowledge reuse activities in product development and project management contexts.

In this article, the concept of knowledge reuse will be explored. First, a review of recent discussions in the academic and practical literature will be presented. Following this, a discussion about the processes, contexts, mechanisms, and challenges involved in reusing knowledge will be developed. Lastly, future research in this area and conclusions will be offered.

BACKGROUND

The study of knowledge reuse has evolved from the field of software development through object-oriented software development practices (Banker & Kauffman, 1991) to more strategic management concepts such as modularization and product design (Sanchez & Mahoney, 1996). Several authors (e.g., Markus, 2001) introduced knowledge reuse as an important concept in knowledge management. The practical relevance of knowledge reuse was considered from software and hardware engineering perspectives (Sanderson & Uzumeri, 1994), the management of multi-project environments (Cusumano & Nobeoka, 1998), and as a phase in the evolution of a firm (Victor & Boynton, 1998). More recently, research has explored additional scenarios for knowledge reuse providing further insight about the reuse of project-specific knowledge (Newell, 2004), templates, information about bids, components, and platforms (Nightingale, 2000).

Various mechanisms and processes have been associated with knowledge reuse. First and foremost, knowledge reuse has been perceived as a process that is based on documenting, verifying, indexing, and retrieving information from repositories (Markus, 2001). Indeed, the information systems approach to knowledge reuse is vital. Nonetheless, knowledge reuse is also an outcome of an informal, people-based activity (Newell, 2004), which can also be complementary to the information system approach. In this respect, the challenges organizations face when attempting to reuse knowledge involve aspects associated with both information systems and human behavior. On the one hand, knowledge re-users face challenges in properly storing, indexing, filtering, verifying, and retrieving information from repositories. On the other hand, these challenges intimately relate to motivational factors to share knowledge, which are human-related factors. The above topics will be discussed in detail in the following sections.

MAIN FOCUS OF THE ARTICLE

The Concept of Knowledge Reuse: Some Examples

Knowledge reuse is defined as the process through which knowledge is captured, verified, filtered, stored, and retrieved (Markus, 2001). There are at least three actors involved in this activity: the knowledge creator who creates the knowledge, the knowledge broker or intermediary who prepares the knowledge for reuse by synthesizing and documenting the knowledge, and the knowledge re-user who retrieves the knowledge and re-applies it in different contexts (Markus, 2001). Knowledge reuse activities are arguably related to organizational effectiveness through the exploitation of existing knowledge and resources (Dixon, 2000).

There are several knowledge processes related to the reuse of knowledge. In particular, knowledge sharing and transfer are two knowledge processes that were often associated with knowledge reuse. Unlike knowledge sharing and transfer, reusing knowledge is an activity in which specific knowledge or design is transferred from a knowledge holder to a knowledge seeker in order to make use and re-apply the knowledge or the design in different contexts. Some car models made by Toyota, for example, share the same components. This was achieved through the transfer of these components between different project teams. In such an activity, a knowledge base will be populated with information about designs and components; and through a knowledge search mechanism, a re-user will be able to verify, retrieve, and reapply a particular component. In this reuse activity, a modification of the reused design may take place in order to adjust the reused design to the requirements and specifications of the new product.

Advantages and Disadvantages in Reusing Knowledge

The advantages associated with the reuse of knowledge are many. By reusing knowledge, organizations may also avoid “reinventing the wheel” in terms of products, components, templates, and processes, thus freeing up resources to other core activities, be these customer responsiveness or innovation. In the context of product development, some more specific contributions were associated with the reuse of knowledge such as lower risk in new product development and a robust design (Nightingale, 2000), shorter time to market, reduced R&D costs, and higher responsiveness to customer needs (Datar, Clark, Sunder, Surendra, & Kannan, 1997; Nayak, Chen, & Simpson, 2000).

However, reusing knowledge may also bring stress to organizations. Excessive exploitation, in particular, may lead to a trap in which organizations that operate in "sub-optimal stable equilibriums" and enjoy the cost effectiveness associated with the reuse of knowledge may suffer from a lack of explorative activities that are crucial for the future development of organizations (March, 1999). Furthermore, information distortion, in the form of missing information or false information, could possibly negatively affect the reuse process and outcome (Carley & Lin, 1997). Therefore, to avoid these pitfalls, organizations require an understanding of the various aspects involved in knowledge reuse, and may design their internal processes and systems to respond to such challenges.

The Process of Knowledge Reuse

Several processes are involved in the reuse of knowledge. From an information systems perspective (Markus, 2001), the reuse of knowledge is based on the use of repositories and may involve four processes: First, knowledge is captured through documentation, something that can be a by-product of the work process or as an intentional activity using information systems. Capturing knowledge can also include filtering knowledge and preparing the knowledge for future reuse. Second, knowledge is classified and formatted by relating the content to existing and new classification schemes, and through the contextualization and de-contextualization of the content. Third is distributing the knowledge by either pull or push mechanisms. Populating a repository is an example of a pull mechanism, while an automatic e-mail that informs knowledge workers about project management templates available to reuse is a push mechanism. The reuse activity is the last stage in which the re-user is (re)applying the knowledge and updates the knowledge source with contextual context that may serve future re-users.

From a learning perspective (Prencipe & Tell, 2001), the reuse of knowledge can take place at three levels of the organization—individual, group or team, and organizational—through mechanisms that relate to experience accumulation, knowledge articulation, and knowledge codification. Knowledge reuse is more systematic and exploitative in nature when the learning is based on knowledge codification at the three levels of the organization, and tends to be more explorative in nature when the learning is based on accumulative experience at the individual level.

From a strategic management perspective (Victor & Boynton, 1998), knowledge reuse is a step towards building sustainable and dynamic capabilities. A full renewal lifecycle of a product from a knowledge-based perspective may consist of the creation of knowledge, the transformation of new knowledge into modular products and components, and the reuse of these modules, according to market needs, by reconfiguring and re-applying knowledge.

Achieving successful knowledge reuse requires the involvement of each of the aspects mentioned above. Information systems aspects are important for the storage and retrieval of the knowledge, while the learning aspects are key for the improvement of reuse activities. The following section will address the contexts within which knowledge reuse may occur.

The Context of Knowledge Reuse

Knowledge reuse may take place in different contexts, such as between organizations (interfirm knowledge reuse) or within an organization (intra-firm knowledge reuse). Sharing knowledge and designs between firms is not free of challenges. Issues pertaining to trust between suppliers of a supply chain may impede the sharing of knowledge. Furthermore, proprietary issues may restrict the reuse of designs across firms. Nonetheless, in recent years, research and development have seen an improvement in the level of knowledge sharing between firms. In particular, examples from the automobile industry provide an insight into the systems and processes that support product delivery through information sharing within a supply chain (Childerhouse, Hermiz, Mason-Jones, Popp, & Towill, 2003).

In the context of intra-firm knowledge reuse, firms put the emphasis on making generic and specific knowledge available for reuse through repositories, social networks, and interpersonal connections. Recent years have seen a growing interest in reusing project-specific knowledge (Newell, 2004). Projects have become a central vehicle through which companies learn—hence, requiring a systematic method to capture the learning and experiences and reusing them over time. The reuse of project-specific knowledge and the broad firm context will be discussed below.

Mechanisms Involved in Knowledge Reuse

Various mechanisms are mentioned in the context of knowledge reuse. These can be divided into three areas: information systems, managerial practices, and social networks mechanisms.

Information systems support knowledge reuse through the use of repositories (Markus, 2001). These repositories store and make available various types of information such as internal and external knowledge, data or documents, specific or generic information, or as a pointer to experts.

Managerial practices may include several mechanisms through which knowledge reuse is supported. Sharing work procedures is one important mechanism for knowledge reuse. In this respect, commonality across tools and technical procedures is important and may include, for example, the use of identical development tools (e.g., C++ or Microsoft Office) across several software development projects. Furthermore, shared work procedures may also include the involvement of different stakeholders in a decision-making process to ensure that past learning, from various perspectives, will be included in the process. Sharing past experiences, for example, is achieved when a multi-functional product development team meets every week to assess progress and suggest solutions, based on their individual and shared learning.

Furthermore, the organization of experts and expertise within the firm may have an impact on the possibilities of reusing knowledge. In this respect, two modes of organizing were considered. First is the functional structure in which experts and expertise are centered within the functional department and contribute to the project objectives from their departments. Second is the project-centered structure in which experts and expertise from different departments work as a project team towards common project goals. While the functional structure offers more possibilities to reuse knowledge within the department, mainly with regard to technologies and product concepts, the project-centered structure presents opportunities to reuse lessons learned between multi-functional teams with regard to product development process. The matrix structure, which combines functional with project-centered structures, includes the possibilities to reuse expert technical knowledge within the functional structure with the learning from past projects about the process of product development within project teams.

Another managerial practice that gained attention in recent years is project management practices (Cusumano & Nobeoka, 1998). Through a careful coordination of projects, the reuse of knowledge between projects can be improved. In this context, the emphasis has been on the reuse of components and platforms from a source project to other projects that are carried out concurrently.

Reward schemes were also considered as a driver to encourage knowledge reuse. Reward systems were designed to remunerate knowledge workers who documented and indexed valuable knowledge, as well as knowledge workers who made a useful (re)use of existing knowledge by reapplying concepts and solutions to new product and process introductions.

While technology and managerial practices dominated the discussion about knowledge reuse, social networks and interpersonal connections contributing to knowledge reuse are no less important to the exploitation of internal capabilities (Newell, 2004). Person-to-person communications, informal encounters, and social rituals within communities of practice are among the various activities that drive knowledge reuse through social interactions (Prencipe & Tell, 2001; Wenger, 1998).

There are several scenarios in which the mechanisms involved in knowledge reuse may play a role. Managerial practices, in particular project management practices, will enhance the reuse of knowledge between projects in a project environment. In this scenario, the use of information systems may further assist in documenting, screening, and retrieving knowledge to be re-configured and re-applied by another project team. Social interaction as a vehicle for knowledge reuse is more an explorative activity which drives knowledge exchanges between knowledge creators and re-users; however, it may enjoy the planning and discipline introduced by project management practices.

Challenges in Knowledge Reuse

The reuse of knowledge may face a number of challenges. From an information system perspective, there are several challenges at the individual, group, and organizational levels. Knowledge can be either tacit or explicit (Polanyi, 1966). Articulating tacit knowledge is a difficult task, let alone capturing, storing, and retrieving it. This is perhaps the most challenging task that a knowledge re-user is facing.

Secondly, properly creating and indexing knowledge may generate mistakes or confusion about the "true" meaning of the information stored or retrieved (Markus, 2001). A common problem, for example, is to search for specific information. The common system of indexing generates problems for knowledge seekers because of a misplacement of the information within the indexing system.

Thirdly, the costs involved in creating repositories by carefully documenting and indexing knowledge for future reuse are very high. Furthermore, data entries are long and can hardly be justified as a central activity within product development.

Lastly, the "stickiness" of knowledge presents additional barriers to transfer and reuse knowledge. The recipient's lacks of absorptive capacity is one example of the recipient's inability to value, assimilate, and apply new knowledge (Szulanski, 1996, p. 31).

From a managerial perspective, the process of knowledge reuse may face challenges in the area of the organizational structure, project management coordination, and planning and reward systems. In terms of the organizational structure, while adopting either a functional or project-centered structure would present advantages for knowledge reuse within and across projects respectively, each structure still cannot support the reuse of knowledge across the organization. The matrix organization combines functional departments and cross-functional teams in the form of projects. Under this structure, projects usually succeed in integrating knowledge across functional areas, therefore increasing the possibilities to reuse knowledge and designs (Cusumano & Nobeoka, 1998).

Rewarding knowledge re-users has also posed challenges in terms of the criteria that define what a valuable knowledge reuse process is. Some of the criteria suggested in this context are at the project level. Criteria assessing the exploitation of resources, for example, included: man/month software development saved following the reuse process, total reduction in project costs, and a shorter product lead-time. Both the number of hits per index in a repository and the number of times an existing solution was reapplied in different contexts were considered as criteria for the value and quality of a reuse process. Because a reuse process can also be based on social interactions, a process that is often unplanned and undocumented, rewarding those involved can be a difficult task.

Lastly, planning a reuse process through project management practices may not always be possible (Cusumano & Nobeoka, 1998). Indeed, in companies that can plan product introductions in advance, the possibilities to design and monitor the reuse of knowledge between projects are feasible. This is mainly the case in mass-producing companies such as Toyota and Sony. On the other hand, many organizations cannot rely on the project planning approach. Suppliers of complex systems and products (CoPS), for example, may not be able to plan in advance the reuse of knowledge by solely relying on project management practices. This is because of contractual arrangements between the supplier and the client that define the production time interval, the design, and the number of units to be produced (Hobday, 2000). For this reason, suppliers of CoPS are more likely to rely on information systems and social interactions as the drivers for knowledge reuse (Prencipe & Tell, 2001). In summary, the challenges involved in achieving a successful reuse process are many, bringing together aspects from the social, information system, and human behavior perspectives.

FUTURE TRENDS

Two main future trends can be considered: practical and research themes.

From a practical viewpoint, potential developments are in three areas: defining the role of knowledge facilitator in knowledge reuse activities, motivating individuals and teams to engage in knowledge reuse activities, and balancing between exploitation (reuse) and exploration (innovation) activities.

Firms face major challenges in building and successfully maintaining knowledge systems. Several studies confirmed that it takes more than information systems to reuse knowledge (Markus, 2001; Newell, 2004). It has been suggested that knowledge facilitators (also known as knowledge brokers and knowledge managers) can improve the capture and filtering of knowledge for reuse (Markus, 2001). Instead of relying on project teams to carry out the storage of knowledge in a repository, firms should follow some recent successful examples, such as Booz-Allen, in which knowledge managers accompanied the project team making sure that knowledge generated during the project is captured, indexed, and prepared for reuse (Markus, 2001). In addition to the need to continuously improve technology-based indexing and searching mechanisms, the development of transactive memory, a concept which emphasizes the idea of "who knows what," can be enhanced through the involvement of knowledge facilitators, acting as knowledge brokers.

While the rationale for reusing knowledge is well grounded in the economies of efficiencies, in practice empirical evidence suggests that many organizations do not pursue this activity. In many cases the reason for this behavior is a lack of awareness and incentives that would encourage individuals and teams to seek solutions in-house prior to launching an explorative activity which may well be a "reinvention of the wheel." Managers should consider developing educational programs relating to the many aspects involved in reusing knowledge, including methodologies that fit their organization and incentive schemes that link reuse activities to individual, team, and organizational performance.

Lastly, while this article represents a call to undertake knowledge reuse activities, organizations should still consider achieving a balance between exploitative and explorative activities. When launching a new product, for example, an assessment of the costs involved in reconfiguring an existing design for reuse versus developing a design from scratch should be undertaken.

From a theoretical viewpoint, future research trends may consider understanding the process and context of reuse activities in the following scenarios: (i) reuse of intangible products such as financial products, (ii) reuse of processes, and (iii) reuse between firms also coined here as inter-firm reuse process.

The study of processes and innovation of intangible products, in particular in the financial services, is very limited. More specifically, little is known about the reuse of knowledge of intangible products as opposed to tangible products (e.g., the broad research on reuse in the context of the automobile industry or the aircraft industry).

The study of knowledge reuse has traditionally focused on the potential to reuse products or sub-systems within products. More research is needed into the potential to reuse processes and templates of operations in the broad context of the firm, and more specifically within and between projects.

Lastly, knowledge reuse is perceived as an intra-firm activity. Little is known about the process through which inter-firm knowledge reuse can be achieved, the mechanisms involved in the reuse that may support it, and the challenges involved in the process.

CONCLUSION

This article explored the concept of knowledge reuse. Aspects associated with knowledge reuse were reviewed from information system, social, and strategic management perspectives. While research and practice has traditionally focused on information systems to support the reuse of knowledge, other tools and practices, such as managerial practices and social networks, were reviewed as complementary vehicles. While research and practice has made significant progress in understanding knowledge reuse contexts and processes, far more investment in methodologies, tools, and processes is still needed in order to exploit the potential offered by this practice.

REFERENCES

Banker, R.D., & Kauffman, R.J. (1991). Reuse and productivity in integrated computer-aided software engineering: An empirical study. *MIS Quarterly, 12*(2), 375-401.

Carley, K.M., & Lin, Z. (1997). A theoretical study of organizational performance under information distortion. *Management Science, 43*(7), 976-998.

Childerhouse, P., Hermiz, R., Mason-Jones, R., Popp, A., & Towill, D.R. (2003). Information flow in automotive supply chains—present industrial practice. *Industrial Management and Data Systems, 103*(3/4), 137-150.

Cusumano, M.A., & Nobeoka, K. (1998). *Thinking beyond lean: How multi-project environment is transforming product development at Toyota and other companies*. New York: The Free Press.

Datar, S., Clark, J., Sunder, K., Surendra, R., & Kannan, S. (1997). New product development structures and time-to-market. *Management Science, 43*(4), 452-464.

Dixon, N.M. (2000). *Common knowledge: How companies thrive by sharing what they know*. Boston: Harvard Business School Press.

Drucker, P. (1969). *The age of discontinuity.* NJ: Transaction Publisher.

Hobday, M. (2000). The project-based organization: An ideal form for managing complex products and systems? *Research Policy, 29*(Special Issue), 872-893.

Lave, J., & Wenger, E. (1991). *Situated learning legitimate peripheral participation.* Cambridge: Cambridge University Press.

March, J.G. (1999). *The pursuit of organizational intelligence.* Malden, MA: Blackwell.

Markus, M.J. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Nayak, R., Chen, W., & Simpson, T. (2000, September 10-13). A variation-based methodology for product family design. *Proceedings of the ASME Design Automation Conference* (Paper No. DAC14264), Baltimore.

Newell, S. (2004). Enhancing cross-project learning. *Engineering Management Journal, 16*(1), 12-21.

Nightingale, P. (2000). The product-process-organization relationship in complex development projects. *Research Policy, 29*(Special Issue), 913-930.

Polanyi, M. (1962). *Personal knowledge: Toward a post critical philosophy.* New York: Harper Torchbooks.

Prencipe, A., & Tell, F. (2001). Inter-project learning: Processes and outcomes of knowledge codification in project-based firms. *Research Policy, 30*(9), 1373-1394.

Sanchez, R., & Mahoney, J.T. (1996). Modularity, flexibility and knowledge management in product and organization design. *Strategic Management Journal, 17*(Special Issue), 63-76.

Sanderson, S., & Uzumeri, M. (1994). Managing product families: The case of the Sony Walkman. *Research Policy, 24*, 761-782.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*(Special Issue), 27-43.

Turner, J.R. (1993). *The handbook of project-based management.* Maidenhead: McGraw-Hill.

Victor, B., & Boyton, A.C. (1998). *Invented here.* Boston: Harvard Business School Press.

Wenger, E. (1998). *Communities of practice; learning, meaning and identity.* Cambridge: Cambridge University Press.

Winter, S. (1987). Knowledge and competence as strategic assets. In D.J. Teece (Ed.), *The competitive challenge: Strategies for industrial innovation and renewal* (pp. 159-184). Cambridge, MA: Ballinger Publishing Company.

Chapter 4.6
Direction and Trends in Knowledge Management Research:
Results from an Empirical Analysis of European Projects

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ABSTRACT

Knowledge and Information Management (KIM) has existed as a separate field of scientific research for almost a decade. It is therefore surprising that very few studies to date have been concerned with the identification of the scope and boundaries of the field, as well as the sub-topics and research themes that constitute it. This chapter reports on the results of an empirical analysis of more than 200 research projects in Knowledge and Information Management. Using an inductive methodology of pattern matching analysis, a more accurate definition of knowledge management is attempted, and an innovative taxonomy of research sub-themes within the 'umbrella' area of Knowledge and Information Management is proposed. Furthermore, a trend towards a gradual maturation of the presently prevailing research paradigm is identified, indicating a need for a 'paradigm shift' that will provide a new direction and vision for future research in the area. We suggest that targeted future research efforts in the area of knowledge technologies will contribute to the development of the 'next generation' knowledge management systems that will transform the existing 'passive' knowledge repositories into 'active' learning environments.

THE FIELD OF KNOWLEDGE AND INFORMATION MANAGEMENT

In a world of dynamic and discontinuous change, organisations are constantly seeking ways to adapt themselves to new conditions so that they are prepared to survive and flourish in an increasingly competitive environment. The proliferation of the knowledge economy (Castells, 1996), emphasizing the value of information as an enabler of competitive advantage, is naturally driving many companies to re-examine the ways they have treated their knowledge assets in the past and to identify ways in which they can exploit them more effectively in the future (Argyris, 1994; Albert, 1997).

In such a landscape, it is not surprising that Knowledge and Information Management (KIM) has emerged as one of the most popular strategic change management approaches in the dawn of the 21st century (Davenport and Prusak, 1997; Currie, 1999; Spiegler, 2000). Its supporters argue that organisations may achieve significant competitive advantages by analysing the data and information that often remain unexploited in organisational systems and by transforming them into useful and actionable knowledge. KIM has attracted significant attention in the spheres of both academic research and industrial practice in recent years (Davenport et al., 1998). This is hardly surprising: knowledge is long known to be one of the primary enablers of sustainable competitive advantage in periods of economic turbulence (Nonaka and Takeuchi, 1995). At the same time, the increasing capabilities of contemporary information systems to store, process, and disseminate information and to contribute to its transformation into knowledge, have also served to enhance the role of KIM in organisations.

Despite the wide attention being paid to KIM, the definition of the field (both as an academic discipline and as a managerial application area), together with a clear description of its scope and boundaries, is still a subject of intense debate. A small sample of definitions found both in academic textbooks and business-oriented sources serve to demonstrate the sources of disagreements usually encountered. For example, Starr (1999) defines knowledge management as "information or data management with the additional practice of capturing the tacit experience of the individual," while O'Brien (1999) defines it as "a tool of enterprise collaboration that facilitates the organisation, management, and sharing of the diverse forms of business information created by individuals and teams in organisations." Laudon and Laudon (1998) claim that knowledge management is "the process of systematically and actively managing and leveraging the stores of knowledge in an organisation," while Malhotra (1997) maintains that knowledge management "embodies organisational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings."

Even from this small sample of definitions, the epistemological and ontological basis of KIM as an independent and distinguishable field of research and practice is rather unclear. Some authors see it as an extension of traditional information management, while others view it as the synergistic outcome of combining information management and human creativity. Moreover, some definitions seem to adopt a primarily soft organisational stance and view KIM as a 'process,' while others follow a more technologically oriented hard approach and view KIM as a 'tool.'

Perhaps some of this confusion may be attributable to the fact that the terms 'knowledge' and 'information,' while not necessarily meaning the same thing to everybody, are explicitly or implicitly treated as synonymous in many definitions. Another source of confusion may be the fact that different types of knowledge seem to exist, each with potentially different management requirements by organisations and individuals. For example, the distinction between explicit and tacit knowledge may prove to be ultimately misleading (Marshall and Brady, 2000), as it tends to split the co-existent and inter-twined types of knowledge into mutually exclusive categories. Finally, a main source of disagreement seems to stem from the use of different analytical lenses to view KIM depending on one's background:

researchers from the computer science and information systems fields tend to view KIM as a tool and speak about knowledge management systems, while researchers from a management science background usually focus on the knowledge management process.

As usual in such cases, the truth is somewhere in the middle: knowledge and information management is an inherently interdisciplinary research field inasmuch as its implementation depends on technological systems and its application depends on user acceptance and embracement (managerial and employee alike). The interdisciplinary nature of the field renders its detailed epistemological study more difficult, albeit at the same time also more important. This chapter sets out on a roadmap to answering these questions through a combination of theoretical and empirical research. The next section identifies the boundaries of KIM by drawing on the relevant literature of the computer science and the management science reference disciplines. Following that, we present the results of an empirical investigation into more than 200 research projects in Knowledge and Information Management that were funded by the Commission of the European Communities during the years 1998-2001. These projects, most of them still ongoing, amount to a total cost of nearly one billion euro (€1bn), thus representing the largest coherent group of research efforts in the area. Therefore, their analysis can yield extremely interesting findings regarding the major research sub-topics within the 'umbrella' area of KIM as well as indicators of trends and future research directions. These findings are then encapsulated in a novel taxonomy of knowledge management research sub-fields that can serve as an analytical framework when assessing the usefulness and potential contribution of a given area of study within the overall field of knowledge management (including related aspects of information management as well). In turn, this understanding can assist towards formulating policy suggestions for effectively supporting and promoting coordinated knowledge management research for the future.

THEORETICAL ANALYSIS: 'HARD' AND 'SOFT' KIM RESEARCH

As argued earlier, research within the 'umbrella' field of Knowledge and Information Management can generally fall under two broad categories depending on the departing point of the research questions. On the one hand, one research stream draws predominantly on findings from the fields of computer science and information systems, and sees knowledge management as an application area that extends the traditional realm of databases and information management into so-called knowledge bases and knowledge management systems. In other words, this 'sub-area' of KIM is mostly concerned with investigating ways in which technological capabilities can be exploited by organisations in their pursuit of knowledge-driven competitiveness. On the other hand, a separate research stream is approaching the same kinds of problems from a complementary perspective and attempts to tackle the managerial, organisational, and human issues surrounding the successful introduction of knowledge management within organisations. Research under this 'sub-area' of KIM is mostly concerned with investigating ways in which the process of knowledge creation, assimilation, communication, and enactment can be managed by organisations. Table 1 summarises the characteristics and differences between these research perspectives.

'Hard' Research

Knowledge management systems can be thought of as computer-supported tools that address one or more of the following problems related to

Table 1. Different research approaches on knowledge and information management (KIM)

	'Hard' KIM Research	'Soft' KIM Research
Driven by	Technological Developments	Organisational Problems
Focus on	Information	Process
Reference Disciplines	Computer Science, Information Systems, Artificial Intelligence	Management Science, Cognitive Sciences, Psychology, Linguistics
Exemplary Outcomes	Knowledge Management Systems, Knowledge Ontologies	Collaborative Work Processes, Employee Empowerment Mechanisms

knowledge and information management (Ruggles, 1997): Knowledge Generation, Knowledge Codification, and Knowledge Transfer.

Knowledge Generation refers to the transformation of raw data or summarised information into actionable knowledge. A number of research problems can be thought of as belonging within this area. The first is the problem of pattern recognition (Brash, 2000), which is concerned with identifying useful patterns in data so that knowledge may be extracted from them. Questions related to data mining are relevant here, as is research in the field of artificial intelligence and knowledge-based systems. However, other research questions may also be relevant, such as real-time knowledge capture and computer-supported groupware.

Knowledge Codification is concerned with the process of codifying, categorising, and storing knowledge in an information system. One important research question here is indexing (Delesie and Croes, 2000), that is the appropriate data structuring schema to support knowledge discovery. Other relevant questions deal with problems of knowledge acquisition and knowledge representation (for example, knowledge ontologies).

Finally, Knowledge Transfer deals with the exchange of knowledge between individuals and organisations (O'Dell and Grayson, 1998). User interfaces in knowledge systems, technology-based learning, and knowledge assessment (Guns and Valikangas, 1998) are research issues that may be classified under this category.

'Soft' Research

The introduction of a knowledge tool may be a necessary, but it is definitely not an adequate condition of the successful implementation of knowledge management in an organisation (Gill, 1995). To this end, firms need to implement a surrounding knowledge environment (Irani and Sharp, 1997) that deals effectively with individual and organisation-wide aspects of managing knowledge as a corporate resource. Collective learning (Rzevski and Prasad, 1998), collaboration and trust (Constant et al., 1994), and change management (Burrows, 1994) are only some of the areas where 'soft' research issues related to KIM may become of importance.

Towards a More Accurate Definition of KIM

The aforementioned differences in departing points, scope, and expected outcomes in much of extant research in Knowledge and Information Management may serve, at least partially, to explain our difficulties when trying to define the area as a scientific field and portray its constituent elements. The differences between 'hard' and 'soft' approaches to KIM research may further mean that a single identifiable research field may simply just not exist. Instead, what we usually term as 'KIM research' may in reality hide two (or even more) separate research fields that, although intertwined and complementary, can be thought of as independent and distinguishable, even if only for analytical purposes.

However, such a hypothesis needs to be backed up by appropriate empirical evidence. To this end, a complementary analysis of empirical nature is needed to identify the pragmatics of ongoing KIM research and contribute towards enhancing our understanding of what the main research problems that constitute what we term as 'KIM research' are. The results of such an empirical analysis of more than 200 ongoing research projects in KIM are presented in the following section.

EMPIRICAL ANALYSIS: KIM RESEARCH PROJECTS

The discussion that follows is based on the results of the so-called Integrated Programme Portfolio Analysis (IPPA), which is organised by the European Commission at regular intervals in order to provide a strategic overview on the response to calls for research proposals in the area of the 'Information Society Technologies' (IST) programme. The last IPPA exercise, on which this analysis is based, was carried out in July 2001. IPPA is conducted by a group of independent experts and examines the project characteristics from the technical perspective, the time to market, the risk profile of projects related to market dynamics, and so on. In this chapter, the analysis is limited on the part of IPPA dealing with research into Knowledge and Information Management (KIM).

Global Picture

Out of the 1,725 proposals funded by the European Commission in the first six calls of the IST Programme (1998-2001), 316 (more than 18% of the total) were marked as addressing the technological area of 'Knowledge and Information Management' (KIM). Since this renders KIM the most popular of the technological areas addressed by the programme, it was decided to pursue a more detailed investigation of these projects to identify:

a) The major research sub-topics and themes that can be grouped under the general heading 'Knowledge and Information Management.'
b) The trends in KIM-oriented research, as well as the characteristics and directions of promising future research efforts.
c) Suggestions and recommendations for the effective management of this large-scale research portfolio at the European level.

The KIM projects represent a total funding on behalf of the European Commission of 440 million euro (€440m), while the project participants themselves commit an equivalent amount of money in self-financing the research efforts, thus resulting in a breathtaking amount of nearly one billion euro (€1bn) devoted to European-wide research in Knowledge and Information Management. The sheer magnitude of this amount makes a more detailed analysis of the research outcomes a worthwhile endeavour.

Out of the 316 KIM projects, 235 (or 74.4%) are classified as Research and Technology Development (RTD) projects. This sample of 235 projects was used as a basis for all the analyses presented herein.

Analysing these projects regarding their distribution of projects per Key Action Line (KALs represent the smallest classification unit of research areas in the IST programme) reveals a rather fragmented picture. KIM research projects can be found under no less than 55 different Key Action Lines. The most popular of those is naturally KAL 2.1.2 (Knowledge Management) with 24 projects, followed by KAL 2.2.2/2.2.3 (Smart Organisations) with 17 projects, and KAL 6.1.1 (Future and Emerging Technologies) with 13 projects.

Given the great diversity and dissimilar nature of Key Action Lines that seem to attract Knowledge and Information Management projects, it was felt that the projects might belong to more than one coherent research theme, thus providing an initial indication that our theoretically driven hypothesis discussed in the previous section may prove to be true. It was therefore decided, apart from the overall statistical analysis discussed in the next section, to pursue a more in-depth investigation of the individual projects submitted under the most popular Key Action Lines to identify pertinent research themes and future research directions in KIM.

Project Profiles

The first type of analyses performed on the KIM projects were of the single-variable type, aimed at identifying the project profiles based on a number of characteristics. The KIM projects, as expected, are quite interdisciplinary in nature in terms of the technologies addressed. Figure 1 illustrates the most popular technologies addressed by KIM projects. These include Visualisation, Virtual Environments, and Image Processing (14% of projects), followed by Optimisation Tools and Decision Support Systems (13%), Content Authoring Tools (12%), and Agent Technologies (11%). Other technologies that seem to form the underlying basis for research and development in KIM include: Mobile and Wireless Communications, Middleware and Distributed Systems, and Internet Technologies.

Most of the KIM projects are horizontal in nature, addressing the Cross Sector/Generic category, as illustrated in Figure 2. Of the remainder,

Figure 1. Technologies addressed in KIM research

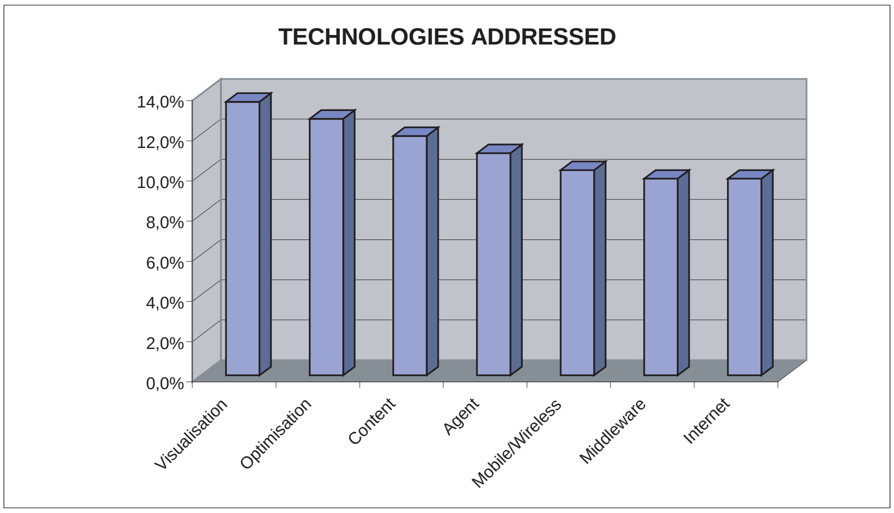
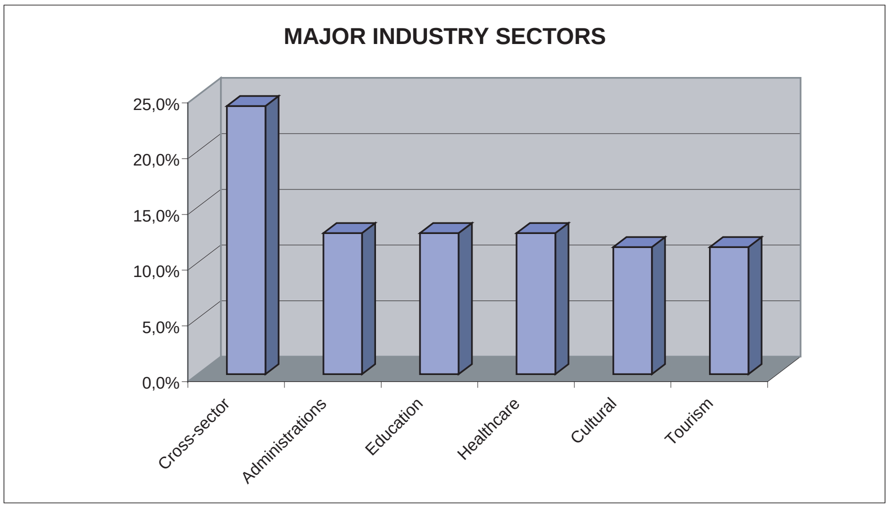


Figure 2. Industrial sectors addressed in KIM research



the interest seems to be almost evenly spread between Administrations (13%), Education and Training (13%), Healthcare (13%), Cultural (11%), and Tourism (11%).

Identifying The Trends

A second-level analysis was then performed to identify major differences between earlier Knowledge and Information Management projects (submitted within 1998 and 1999) and more recent ones (submitted within 2000 and 2001). This comparative analysis yielded interesting results regarding the trends of KIM research through time. Firstly, there is a marked decrease in the number of Research and Technology Development projects, from 84% to 60% of the total, as shown in Figure 3. Non-RTD work in the context of the IST programme refers mainly to demonstration projects, dissemination and technology transfer actions, studies, and so on.

As the non-RTD work refers mostly to projects that aim at demonstrating the commercial potential of already developed technological solutions, the aforementioned decrease in the number of RTD projects may imply a gradual maturation of KIM as a research field, coupled with a corresponding uptake of more industrial practice-oriented work. This assumption is also supported by other analyses. More specifically, there is a clear shift from more 'revolutionary' project outputs (including proof-of-concepts, improved methods, increased know-how) to rather 'evolutionary' outcomes that are closer to the market (new products and services), as illustrated in Figure 4.

The above might suggest that the area of Knowledge and Information Management is moving towards a gradual assimilation of the prevailing paradigm, as indicated by the fall in research being done. If this is true, a new 'vision' might be required to indicate new research orientations for the future. However, to substantiate

Figure 3. RTD vs. non-RTD knowledge and information management projects

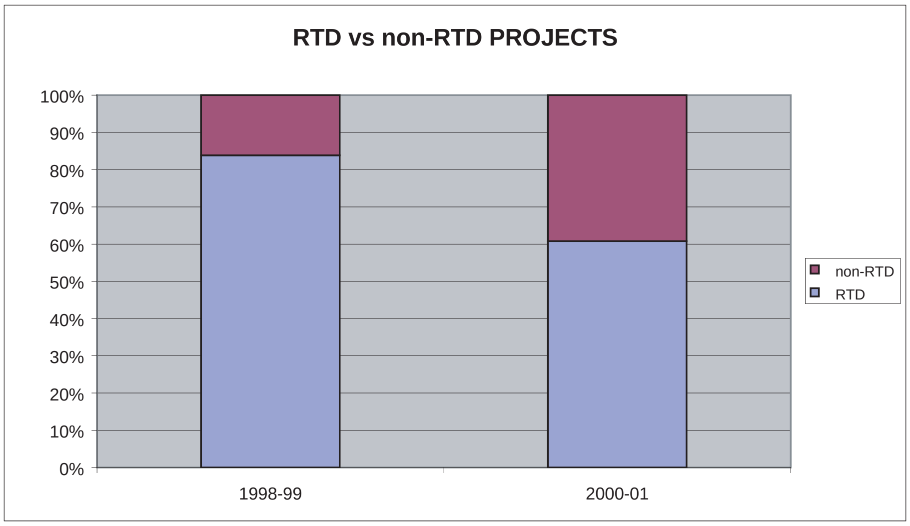
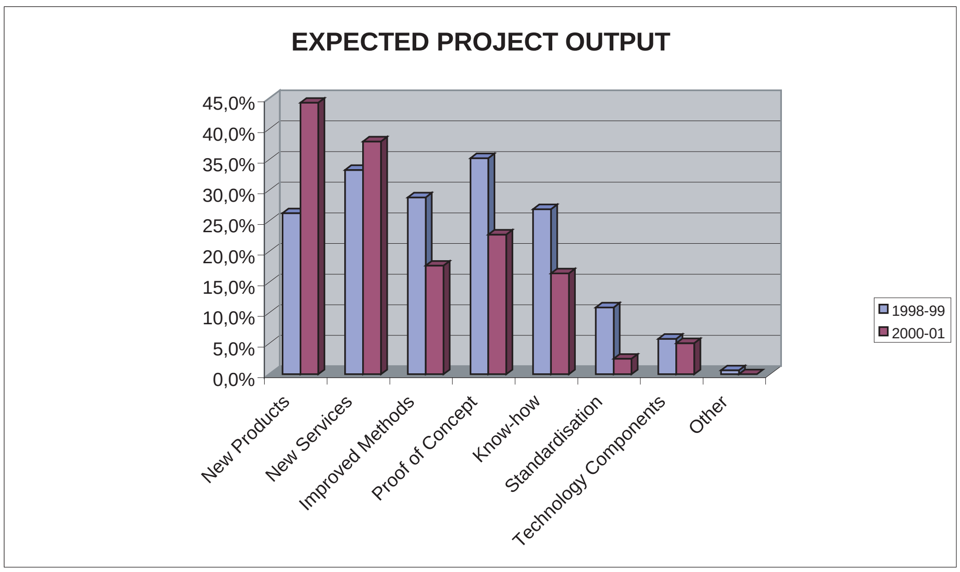


Figure 4. Expected output of KIM research projects



this finding and elaborate on what the new vision might be, the next section discusses the results of a detailed analysis of research themes as identified by an analysis of individual KIM projects. This analysis leads us to suggest a novel taxonomy of knowledge management and information management research.

TOWARDS A TAXONOMY OF KNOWLEDGE MANAGEMENT RESEARCH

The aforementioned empirical analysis suggests that a large and rather diverse number of research sub-themes are classified under the KIM research area. For example, in line with the theoretical analysis, a number of projects address corporate knowledge management applications, while some projects address primarily knowledge technologies (for example, technologies for knowledge representation and visualisation). This finding is also consistent with the preliminary results of the theoretical analysis of the literature and suggests that there might be an opportunity for drawing a list of sub-areas within the overall field of Knowledge and Information Management in the form of a taxonomy. It was therefore decided to pursue an exploratory analysis of individual projects to identify the most pertinent research themes and propose a more detailed classification of the KIM category.

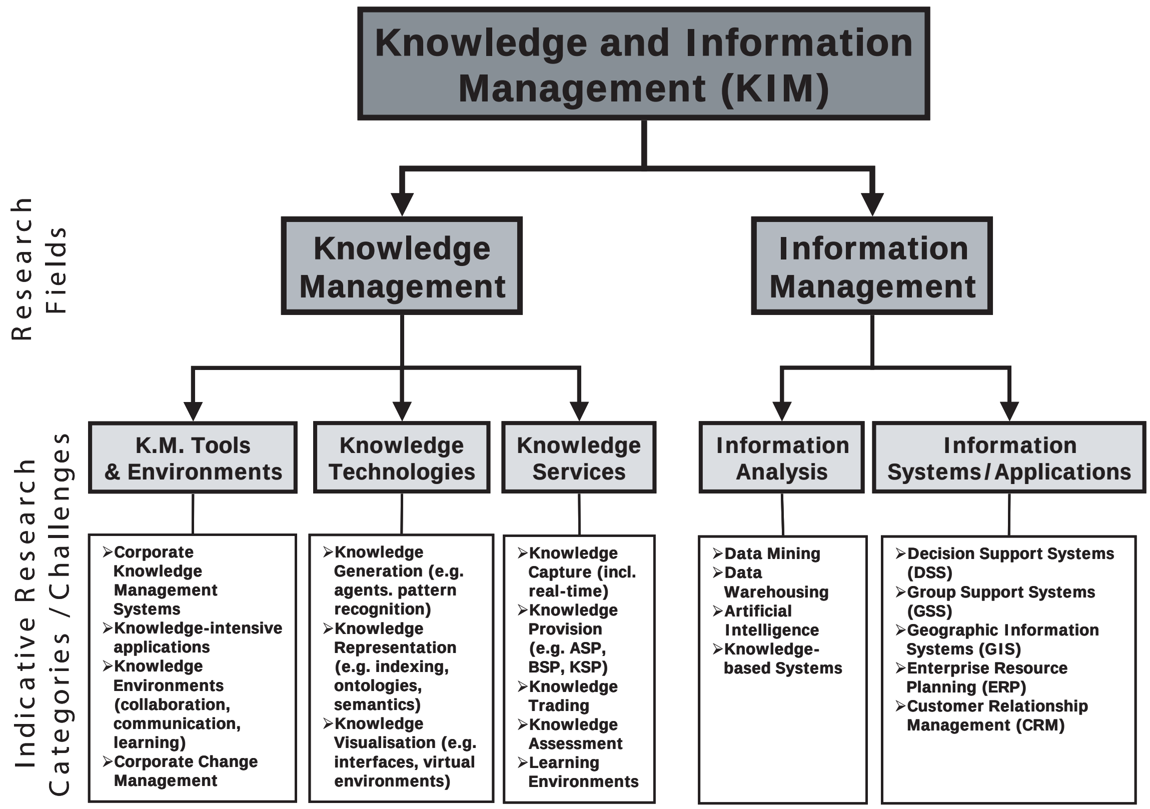
To this end, a more detailed analysis was conducted on the KIM research projects. This analysis was based on examining the project scope and objectives as provided by the researchers themselves in the description of each research project. This analysis produced the following outcomes:

- The majority of projects submitted in the Knowledge Management Key Action Line address either the provision of Knowledge Management Services (66%) or the development of Knowledge Management Systems (31%). However, more than half of these projects (55%) do not directly contribute to research and technology development, while some address issues such as ontologies (24%), knowledge visualisation (17%), and semantics (14%).
- The projects submitted in the Smart Organisations Key Action Line address primarily the provision of Knowledge Services (such as knowledge trading) (47%), Application Service Provision (12%), with limited research on knowledge technologies (12%).
- In the Open FET Domain Key Action Line that deals with high-risk long-term research, things are expectedly very different. No common research themes can be easily identified as projects deal with issues ranging from algorithms and data management to neurocomputing and learning (either for humans or machines).
- Finally, the projects submitted under the other Key Action Lines address somewhat different research themes. The majority deals with Information Analysis Methods & Indicators (33%), while some address data mining and data warehousing research problems. Finally, a minority of projects deals with organisational information systems, either in the form of decision support tools or geographic information systems.

Based on an inductive pattern matching analysis on the above findings, a novel classification for Knowledge and Information Management research is proposed (illustrated in Figure 5). According to this, the KIM area consists of two domains that present different characteristics and research roadmaps: Knowledge Management and Information Management. Each of these two main research areas can be further divided into a number of more detailed research sub-themes and challenges as shown in the figure.

It must be noted that neither the list of research sub-themes nor the list of research problems and challenges identified in Figure 5 are meant to be exhaustive. Both the fields of knowledge management and information management are very lively research areas, and any attempt to provide anything but an indicative list of current research problems would be fruitless. Instead, the taxonomy aims to suggest that the portfolio of research issues commonly placed under the

Figure 5. Taxonomy for research in knowledge and information management



KIM 'umbrella' is so complicated and diverse that it deprives KIM of the coherency that should be identifiable in any distinct research field.

At the same time, however, the fact that research in Knowledge Management presents problems and issues that are identifiable from those typically associated with the more 'traditional' field of Information Management does not mean that talking about KIM in general makes no sense. There is a clear need, identified earlier in this chapter, for an interdisciplinary approach to the overall problem of managing information and knowledge as organisational assets. However, we contend that, due to the complexity of this problem, only by a careful analytical decomposition and focused research effort may the research community address the entirety of this overall problem effectively.

CONCLUSIONS

Following a combination of theoretical and empirical research, this chapter has suggested that the research fields of Knowledge Management and Information Management are analytically separable and present distinct research challenges and issues, despite the fact that they are quite commonly treated as synonymous in much academic research and organisational practice.

Furthermore, we have shown that the overall domain of Knowledge and Information Management seems to be at a stage where the prevailing research paradigm has started to present signals of potential weaknesses, since the research community seems to be less focused on research work in recent years. Based on this observation, we may arrive at a conclusion that a paradigm shift may be required. From a research policy perspective, this would present the challenge of identifying the next paradigm, and providing the research community with support to address the research themes necessary to realise this paradigm in the near future.

However, this conclusion should be treated cautiously as significant further research is needed to substantiate it beyond reasonable doubt. Indeed, we have based our observation by examining only research projects being funded by the Commission of the European Communities. Further to the restriction of our sample within the confines of Europe only, this choice presents us with an additional potential bias. The European Commission has a certain viewpoint as to what constitutes 'research,' which is heavily oriented towards applied research and near-commercial tool development. This may explain, at least in part, the bias we have identified towards the lack of basic research and the alleged trend towards less research work being carried lately.

However, the policy implications of our findings remain significant. The challenges associated with the research categories shown in the taxonomy we have suggested are quite different from each other, and some research issues have received much less attention by policy makers (including the European Commission itself) than others. For example, we believe that the Knowledge Technologies area has been rather overlooked in comparison with other sub-fields of Knowledge Management. This includes research work in a number of frontier domains such as knowledge representation (including ontological developments and semantics), knowledge visualisation (including interfaces for knowledge presentation and understanding), and knowledge analysis (including agent-based and data mining-based knowledge analyses). Furthermore, in the Knowledge Management Tools and Environments domain, an identifiable research challenge exists to drive the development of the so-called 'next generation' Knowledge Management systems that will transform the existing 'passive' knowledge repositories into 'active' learning environments. Further research efforts may address this issue in more detail by explicating the current research challenges within the field of Knowledge Management, and devising research and policy programmes that would address this unbalanced rate of development, which, if left unsupported, will undoubtedly hinder the likelihood of successful Knowledge Management application in organisations.

REFERENCES

Albert, S. (1997). *Managing knowledge: Experts, agencies, and organisations.* Cambridge, UK: Cambridge University Press.

Argyris, C. (1994). *On organisational learning.* Cambridge, MA: Blackwell.

Brash, D. (2000, July 17-18). Developing and validating generic knowledge: An initial experience report. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham, UK.

Burrows, B. (1994). The power of information developing and knowledge based organisation. *Long Range Planning, 27*(1), 142-153.

Castells, M. (1996). *The rise of the network society.* Cambridge, MA: Blackwell Publishers.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-421.

Currie, W. (1999). Revisiting management innovation and change programmes: Strategic vision or tunnel vision? *OMEGA: The International Journal of Management Science, 27,* 647-660.

Davenport, T. H., & Prusak, L. (1997). *Working knowledge: How organisations manage what they know.* Boston: Harvard Business School Press.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2).

Delesie, L., & Croes, L. (2000, July 17-18). Managing the variability of medical care: Fostering consensus, benchmarking, and feedback. In J. Edwards & J. Kidd (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* Birmingham, UK.

Gill, T. G. (1995). High-tech hidebound: Case studies of information technologies that inhibited organisational learning. *Accounting, Management, and Information Technologies, 5*(1), 41-60.

Guns, W.D., & Valikangas, L. (1998). Rethinking knowledge work: Creating value through idiosyncratic knowledge. *Journal of Knowledge Management, 1*(4), 287-293.

Irani, Z., & Sharp, J. M. (1997). Integrating continuous improvement and innovation into a corporate culture: A case study. *The International Journal of Technological Innovation, Entrepreneurship, and Technology Management (Technovation), 17*(4), 199-206.

Laudon, K. C., & Laudon, J. P. (1998) *Management Information Systems: New Approaches to Organisation and Technology.* Englewood Cliffs, NJ: Prentice Hall.

Malhotra, Y. (1997). *Current Business Concerns and Knowledge Management*. Available online at: http://www.brint.com/interview/times.htm.

Marshall, N. and Brady, T. (2000). Knowledge management, knowledge guiding interests, and modes of action: Case studies from complex products and systems. In Edwards, J. and Kidd, J. (Eds.), *Proceedings of the Knowledge Management Conference (KMAC 2000),* July 17-18, Birmingham, UK.

Nonaka, I. and Takeuchi, H. (1995). *The Knowledge Creating Company: How Japanese Companies Create the Dynamics of Innovation*. Oxford, UK: Oxford University Press.

O'Brien, J. (1999). *Management Information Systems: Managing Information Technology in the Internetworked Enterprise.* New York: McGraw Hill.

O'Dell, C. and Grayson, C. J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154-174.

Ruggles, R. (1997). *Knowledge Tools: Using Technology to Manage Knowledge Better.* Ernst & Young Centre for Business Innovation Working Paper.

Rzevski, G. and Prasad, K. (1998). The synergy of learning organisations and flexible information technology. *AI and Society, 12*, 87-96.

Spiegler, I. (2000). Knowledge management: A new idea or a recycled concept? *Communications of the AIS, 14*(3). Available online at: http://cais.isworld.org/articles/3-14/article.htm.

Starr, J. (1999). *KMTool: Ideas for Sharing Knowledge.* Available online at: http://www.kmtool.net/vocabulary.htm.

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Chapter 4.7
Knowledge Management and the Leading Information Systems Journals:
An Analysis of Trends and Gaps in Published Research

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ABSTRACT

Knowledge management (KM) is maturing as a research topic, although there is still debate among researchers over what constructs form its basis. Because the topic has received increasing attention in academic journals, it is important for researchers to be aware of the research streams associated with KM. Accordingly, this paper reviews KM literature published in top-tier journals from 2000 to 2004. These articles are then classified into five constructs from two knowledge management frameworks. The results indicate that the majority of KM research has examined the construct of knowledge transfer. This conclusion holds whether examining academic or practitioner journals. Trends of published KM research, gaps, and imbalances in the examined literature and areas of potential research are presented.

INTRODUCTION

Academics and practitioners have stressed the significance of managing knowledge in today's competitive environment (Desouza, 2003). From the mid-1990s though 2004, KM has become one of the most dynamic research topics. Despite this increased attention and effort, several issues remain. Dissention exists by both academia and practitioners over the true definition of KM; there are also questions about the relevant constructs that comprise KM and where our collective research has taken us in our efforts to discover the underlying constructs. This paper examines current research in KM to determine which constructs are the most extensively researched and published in leading information systems (IS) journals.

Research in knowledge management has increased dramatically in recent years. From 1990 to 1995, a search of the ABI/Inform database using the key phrase knowledge management returned 43 articles. From 1995 to 2000, the number of articles increased to more than 700, and from 2000 to 2004, the number of articles increased yet again to more than 2,000. This research is published to varying degrees in a wide variety of disciplines, including management, hospitality, economics, health care and, of course, IS. If we examine the sample of published research in this study with consideration for the total number of articles published, we see that approximately 7% of this research is published in what are considered by many to be the leading IS journals. This is interesting in that some of those that are considered to be leading IS journals are cross-discipline journals, such as Decision Sciences and Management Science; other journals, such as Harvard Business Review and the Communications of the Association for Computing Machinery, are widely considered to be practitioner journals. These four journals alone account for more than 40% of our sample. From this we can infer that not only is there research in KM that originates from outside the IS arena, but that KM research appeals to a variety of journals with differing readership.

We propose that understanding the future direction of research in KM requires that we first know what constructs in KM have received the most attention from researchers and where there currently are gaps in the published literature. Given the quantity of current literature, there is an adequate sample size to determine the coverage of our collective research efforts. Our research indicates that the majority of KM research articles published in the leading IS journals cover the topic of knowledge transfer; this finding holds true for both academic and practitioner journals.

The first step in this research was to identify a framework or frameworks that would allow us to place published articles into a small range of categories. This review identified several frameworks for classifying KM. Our goal was to find frameworks that contained well-defined constructs suitable for categorization; we found that the Alavi and Leidner (2001) framework, in conjunction with Davenport and Prusak (1998) framework, provided a sound basis for our categorization scheme. These two works are respectively the fourth- and second-most cited KM manuscripts (Jennex & Croasdell, 2005). The second step of this study was to identify, classify and measure the quantity of research in each construct within the framework. By doing so, we will be able to provide a foundational understanding of published KM research, along with the constructs being addressed. This allows us to identify whether there is an imbalance of research in any particular area of KM within the constraints of our classification scheme.

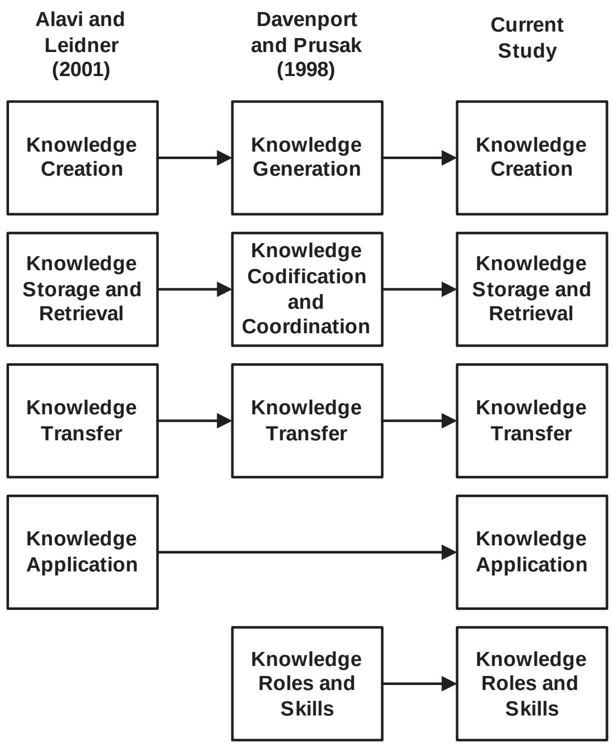
FRAMEWORK CONSTRUCTION

A coherent review emerges only from a coherent conceptual structuring of the topic itself (Bem, 1995). A number of frameworks are available for classifying KM research; one literature review identified 26 different frameworks from both practitioners and academics (Rubenstein-Montano, Liebowitz, Buchwalter, McCaw, Newman, Rebeck, The Knowledge Management Methodology Team, 2001). Some frameworks address specific concepts within the overall discipline of KM. For example, Griffith, Sawyer and Neale (2003) developed a framework to better facilitate understanding of knowledge transfer among groups and teams. Holsapple and Joshi (2001) proposed a framework to better understand an organization's knowledge resource hierarchy. These frameworks are significant contributions to the literature in their focused area. However, because a goal of this study is to identify trends prevalent to the overall concept of KM, the authors determined that the Alavi and Leidner (2001) and Davenport and Prusak (1998) frameworks are most appropriately aligned with that goal. Both of these frameworks are parsimonious in their structure and relevant to academics and practitioners alike.

The Alavi and Leidner (2001) framework separates KM research into four constructs: creation, storage and retrieval, transfer, and application. Alavi and Leidner (2001) provide extensive definitions of the four areas of KM used in this study to categorize research articles into construct categories. In addition to the articles reviewed for this study, source articles described in the Alavi and Leidner (2001) framework were also reviewed for consistency of categorization. Some of those source articles are described below in relation to specific definitions of the constructs used by Alavi and Leidner.

The Alavi and Leidner (2001) framework is formed around four constructs in the organizational knowledge management process. They state that, "organizations as knowledge systems consist of four sets of data: (1) creation (also referred to

Figure 1. Five construct categorization framework



as construction), (2) storage/retrieval, (3) transfer, and (4) application. The four constructs of this model are essential to effective organizational knowledge management" (p. 115).

Davenport and Prusak's (1998) research suggests another set of constructs: knowledge generation, knowledge codification and coordination, knowledge transfer, and knowledge roles and skills. They provide extensive definitions and examples of the different constructs. Knowledge generation, knowledge codification and coordination, and knowledge transfer are the key processes of KM; these processes are critical for an organization's successful management of knowledge (Davenport & Prusak, 1998). Knowledge roles and skills, along with technology, are enablers of KM (Davenport & Prusak, 1998). Because we cannot reasonably separate the people or the technology from the overall process of KM, combined with the fact that of the 26 frameworks identified by Rubenstein-Montano et al. (2001), none identified the supporting roles and skills necessary to make a KM initiative successful, the Davenport and Prusak framework was chosen as the second reference framework. Based on the definitions provided by the authors of both frameworks, we were able to develop a five-construct model for categorization (see Figure 1).

In the following section, the constructs are defined. These definitions are used for the classification of the papers that are the subject of this research. The definitions were developed from the material in the two reference frameworks. When noted, the original citation was reviewed to ensure the authors of this research correctly grasped the intent of the frameworks' authors.

Knowledge Creation

A significant amount has been written about the importance of knowledge to management, but little research appears to address how knowledge is created or managed (Nonaka, 1994). Alavi and Leidner's (2001) framework views organizational knowledge creation as involving a continual interplay between the tacit and explicit dimensions of knowledge (Nonaka, 1994) and a growing spiral flow as knowledge moves through individual, group and organizational levels. Nonaka (1994) stated that one dimension of the knowledge creation process can be drawn from the distinction between tacit and explicit knowledge. Explicit knowledge is knowledge that can be transmitted by formal, semantic means, while tacit knowledge has a personal quality that makes it difficult to formalize and communicate (Nonaka, 1994).

Davenport and Prusak focus on the conscious and intentional generation of knowledge. They posed five modes of knowledge generation: acquisition, dedicated resources, fusion, adaptation and networking (Davenport & Prusak, 1998). Knowledge can be acquired by an organization as well as developed from within it. Additionally, knowledge can be rented in the form of research grants and consulting contracts. Many organizations have dedicated staff to focus on knowledge generation in the form of research and development departments or other organizational think tanks. An organization that uses fusion for knowledge generation intentionally introduces conflict and complexity into the process to develop synergies. An organization's ability to adapt is critical to its long-term survival. The most important adaptive resources are employees who can easily acquire new knowledge and skills. Davenport and Prusak (1998) also refer to informal, self-organizing networks within organizations that may remain informal or eventually develop into a formal structure for knowledge generation.

Knowledge Storage and Retrieval

The process of storing, organizing and retrieving organizational knowledge is also referred to as organizational memory (Stein & Zwass, 1995; Walsh & Ungson, 1991). Two supporting technologies of knowledge storage and retrieval are data mining and learning tools. Data mining and advancing computer storage technology can be effective tools for enhancing organizational memory. One learning tool that has gained popularity in recent years is groupware. Groupware enables organizations to create intra-organizational memory in the form of both structured and unstructured information and to share this information across time and space (Walsh & Ungson, 1991). According to Stein and Zwass (1995), organizational memory is the means by which knowledge from the past is brought to bear on present activities, thus resulting in higher or lower levels of organizational effectiveness, depending on application. They proposed an Organizational Memory Information System (OMIS) that is composed of two layers: the first layer contains integrative, adaptive, goal attainment and pattern maintenance subsystems, and the second layer controls the mnemonic functions of knowledge acquisition, retention, maintenance, search and retrieval.

The aim of codification is to put organizational knowledge into a form that makes it accessible to those who need it (Davenport & Prusak, 1998). This knowledge is coded (although not necessarily computer coded) into a form that is organized, explicit, portable and easy to understand (Davenport & Prusak, 1998). The importance of mapping knowledge to the codification process was also noted. The principal purpose and clearest benefit of a knowledge map is to show people in the organization where they need to go when they need expertise (Davenport & Prusak, 1998).

Knowledge Transfer

The ability to transfer knowledge is key for an organization. Knowledge transfer occurs at many levels. Knowledge can be transferred between individuals, from individuals to explicit sources, from individuals to groups, between different groups, and between groups and the organization (Alavi & Leidner, 2001). Knowledge transfer between organizations is also gaining popularity. As organizations become more integrated, there is more transfer of knowledge between organizations through integrated supply chains and other cooperative systems. Knowledge flows within an organization are affected by five major elements: (a) the value of the source unit's knowledge stock, (b) motivational disposition of the source unit, (c) existence and richness of the transmission channels, (d) motivational disposition of the receiving unit, and (e) absorptive capacity of the target unit (Gupta & Govindarajan, 2000). Alavi and Leidner (2001) note that of these five elements of knowledge transfer, the majority of research in knowledge transfer focused on the third element, existence and richness of the transmission channels. However, in a majority of articles reviewed for this research, the respective authors noted that the channel is only part of the process of knowledge transfer.

Knowledge is transferred in organizations whether the process is managed at all (Davenport & Prusak, 1998). Davenport and Prusak extensively discuss knowledge transfer in both formal and informal intrapersonal exchange. Technology came into play as a threat to knowledge transfer by way of virtual offices and groupware (Davenport & Prusak, 1998). Research in KM asserts that technology can both increase and decrease knowledge transfer through its effects on the interpersonal contact between workers.

Knowledge transfer is the first area where the two frameworks diverge. While Alavi and Leidner (2001) separate transfer and application, Davenport and Prusak (1998) combine the constructs through the following equation: Transfer = transmission + absorption (and use).

For the purposes of our classification, we use the separate constructs as proposed by Alavi and Leidner (2001). This allows us a slightly more concise classification of the knowledge transfer concept.

Knowledge Application

The importance of knowledge application is that the source of competitive advantage lies in the application of the knowledge rather than in the knowledge itself (Grant, 1996). There are four mechanisms for integrating specialized knowledge: (a) rules and directives, (b) sequencing, (c) routines, and (d) group problem solving and decision-making (Grant, 1996). Technology can support knowledge application by embedding knowledge into organizational routines (Alavi & Leidner, 2001). Both the concepts pertinent to knowledge application and the relevant technology are important to ensure the most effective use of organizational knowledge.

Knowledge Roles and Skills

If KM is to thrive, organizations must create a set of roles and skills to do the work of capturing, distributing and using knowledge. Knowledge-oriented personnel, KM workers and chief knowledge officers all are important for successful organizational KM. Four levels of KM roles are: (a) line workers who must manage knowledge within their own jobs, (b) KM workers, (c) knowledge project managers, and (d) senior knowledge executives (Davenport & Prusak, 1998).

METHODOLOGY

Data Gathering

Major contributions in any domain are more likely to be represented in leading journals of that field (Webster & Watson, 2002). KM research has been published in a wide variety of journals in many disciplines; however, our focus is specifically that increasing amounts of research in a specific topic that is accepted into leading IS journals is generally a signal of a topic's increasing maturity and acceptance within mainstream academia. To determine which journals are generally considered to be leaders, we used two recently published articles that ranked IS journals to determine the list of publications to search for the relevant literature. The first is a recent article by Peffers and Ya (2003), and the second is an article by Mylonopoulos and Theoharakis (2001). Using two ranking schemes allowed us to increase the probability that the journals chosen for this study research did, in fact, represent the leading IS journals.

The Peffers and Ya (2003) article in the Journal of Information Technology Theory and Application (JITTA) identified 10 top-rated journals as: Information Systems Research, MIS Quarterly, Journal of Management Information Systems, European Journal of Information Systems, Decision Support Systems, Information and Management, Information Systems Journal, Journal of the Association for Information Systems, International Journal of Electronic Commerce and Information Systems. In this article, Peffers and Ya used several ranking schemes. For our purposes, we chose the ranking scheme that used the average weighted perceived value rating of journals as outlets for information systems research. In this scheme, Peffers and Ya (2003) used only rankings for journals that were rated by at least 10% of their respondents. This avoided the problem of artificially inflating a journal's ranking by a small number of researchers (Peffers & Ya, 2003).

Five of the journals in the Peffers and Ya (2003) study were also included in the article by Mylonopoulos and Theoharakis (2001). These were Information Systems Research, MIS Quarterly, Journal of MIS, Information and Management, and Decision Support Systems. Rounding out their top 10 were the Communications of the ACM, Management Science, IEEE Transactions, Harvard Business Review and Decision Sciences.

The journals chosen to represent IS also cross other disciplines and represent practitioners. For instance, both Communications of the ACM

Table 1. Leading IS journals

Peffers and Ya (2003)	Mylonopoulos and Theoharakis (2001)
MIS Quarterly	*MIS Quarterly*
Information Systems Research	*Information Systems Research*
*Journal of Management Information Systems**	*Journal of Management Information Systems*
Decision Support Systems	*Decision Support Systems*
Information and Management	*Information and Management*
Information Systems Journal	
Journal of the AIS	
International Journal of Electronic Commerce	
Information Systems	
European Journal of Information Systems	
	Communications of the ACM
	IEEE Transactions
	Harvard Business Review
	Decision Sciences
	Management Science

and Harvard Business Review are considered practitioner-oriented. Decision Sciences and Management Science are leading journals in the production and operations management disciplines as well as IS. Journals outside the IS discipline are beyond the scope of the current investigation. Table 1 summarizes the journals chosen for this study from the list of journals in the articles mentioned in this section.

The current study examines a four-year window. The ABI/Inform database was used to search the journals listed in Table 1 from January 1, 2000 through December 31, 2004. Each journal was searched using the advanced search option that allowed the authors to restrict the search dates and publication source. All of the journals listed in Table 1 were searched; however, there were no applicable articles that appeared in the International Journal of E-Commerce, and therefore this journal will not appear in the discussion to follow.

After applying date and publication constraints, the authors further restricted the search to the key phrase knowledge management. This key phrase was chosen because we were specifically searching for articles where the authors explicitly stated they were researching "knowledge management." We found that this term allowed us to find articles specific to individual constructs (for instance, knowledge transfer) as well as articles that may or may not represent constructs but are published under the general KM umbrella. We also found that many articles whose authors specifically used "knowledge management" as a key phrase were not in the mainstream of KM research. For example, one article focused on the effects of animation on information seeking on the World Wide Web (Zhang, 2000). Had we chosen only to search on specific construct terms, these more general articles may have been missed. The process outlined above presented a sample of 132 articles.

The identified articles were reviewed to determine which framework construct or constructs were represented in the research, and each was coded according to the number of constructs represented in the article, with a maximum sum of one. For example, an article describing research in knowledge creation was coded as a one. We expected, and found, that many articles represented more than one construct. When this was the case, the value was divided by the number of constructs addressed in the article. For example, if an article contained research in both knowledge creation and transfer, each construct was coded with .5, giving the total for the article a sum of 1. For a construct to receive credit from a specific article, the process had to have more than cursory coverage. Several articles briefly described one of the other functions without including it in the research or conceptual development. This coding process was conducted individually by our research team based on the collective understanding of the construct definitions and the example articles from our two frameworks. Cross-checking was conducted to identify inconsistencies in coding; although few were found, each was addressed and a consensus reached as to the correct coding scheme.

Results

The number of articles in the publications ranged from a high of 27 to a low of one. Knowledge transfer was the most frequently researched topic, with knowledge storage and retrieval the second most frequently researched topic. The constructs of creation, application and roles/skills were represented about equally across the publications.

Decision Support Systems and Management Science published the most articles on KM, with 23 and 27 articles respectively. However, each of these journals published a special KM issue. Decision Support Systems published nine articles in its knowledge management issue in May 2001; Management Science published 13 articles in its "Special Issue on Managing Knowledge in Organizations: Creating, Retaining, and Transferring Knowledge" in April 2003. Removing these special issue articles indicates that these journals have published about the same number of articles on KM as the next highest journals, European Journal of Information Systems, Journal of Management Information Systems and Harvard Business Review. Information Systems, Information Systems Journal and IEEE Transactions each published three articles. JAIS published the least number of articles on KM, with only one article each in the time period. Table 2 shows the complete distribution of the relevant articles published in the journals reviewed. The Number of Articles column contains the total number of articles published in the specific journal over the period in our study. The number in each of the other five columns reflects how many of the articles were coded into a specific knowledge management construct from each journal. Fractions may occur depending on the number of articles included that represent more than one construct.

Several articles described research in more than one of the construct areas. Twenty-seven articles were coded as research covering two constructs. One article was coded as research covering three constructs, and four articles were coded as containing research on four constructs. Nine articles that researched other areas of KM did not fit into any of the processes in the chosen frameworks; several of these articles proposed research agendas. Other articles identified in the search did not involve KM as the primary area of research, but were identified by the search engine, which often returns "information" as an alternative to knowledge.

Much of the research published in the top journals was based in the construct of knowledge transfer. Approximately 42% of all articles focused all or in part on knowledge transfer. Storage and retrieval was the second most-researched construct, with 21% of all the articles conducting research in this construct. Knowledge creation and knowledge application accounted for 13% and 14%, respectively, of the published articles. Knowledge roles and skills was the least-researched topic, accounting for 10% of the published articles. Previous research by Davenport et al. (1996) showed that

Table 2. Leading IS journals and KM articles

Journal	Number of Articles in each journal	Creation	Storage & Retrieval	Transfer	Application	Roles and Skills
Communications of the ACM	10	1	3.5	4.5	0	1
Decision Sciences	8	1	0	4	3	0
Decision Support Systems **	23	0.75	10.25	5.25	6.75	0
European Journal of Information Systems	10	1.75	0.75	2.75	4.75	0
Harvard Business Review	11	1	0	8.0	0.5	1.5
Information & Management	9	2	1	3.5	0	2.5
IEEE Transactions	3	1	2	0	0	0
Information Systems	3	0	3	0	0	0
Information Systems Journal	3	0	1	2	0	0
Information Systems Research	6	1	0.5	3.5	1	0
Journal of AIS	1	0	0	0	1	0
Journal of MIS	12	2.25	4.25	3.75	0.75	1
MIS Quarterly	6	0.75	0.25	2.75	0.25	2
Management Science**	27	4.33	1.33	15.33	0.5	5
Totals	132	16.83	27.83	55.33	18.5	13
** this journal published an entire issue on Knowledge Management						

there was a lack of research in knowledge generation. The results described in Table 2 show that researchers might have addressed Davenport's initial concerns. From 2000 through 2004, it appears that creation (generation) was researched at approximately the same frequency as application constructs, although still well behind either transfer or storage and retrieval. Table 3 shows the breakdown of the research by percentage of each of the constructs in KM.

Two of the journals from which articles were chosen are well-known practitioner journals. Both of these journals were ranked by Mylonopoulos and Theoharakis (2001) as leading places to publish IS research. An interesting question is whether the practitioner journals have a different focus than the other journals in this study. If we examine the articles only from Harvard Business Review and Communications of the ACM, we can see another interesting trend. Although the sample size is very small, n=21, knowledge transfer is researched significantly more than the other constructs. Storage and retrieval is still the second most-frequently-published construct, but

Table 3. Topic coverage in all journals

Knowledge Management Topic	%
Creation	12.75
Storage and Retrieval	21.08
Transfer	42.30
Application	14.02
Roles and Skills	9.85

Table 4. Topic coverage in practitioner journals

Knowledge Management Topic	%
Creation	9.52
Storage and Retrieval	16.67
Transfer	59.53
Application	2.38
Roles and Skills	11.90

Table 5. Topic coverage in academic journals

Knowledge Management Topic	%
Creation	13.36
Storage and Retrieval	21.92
Transfer	39.04
Application	16.22
Roles and Skills	9.46

there is marked difference between it and transfer. Further, unlike the complete journal set, these practitioner journals emphasize rolls and skills over either creation or application. In fact, application received only minimal coverage in the practitioner journals. Table 4 shows a summary of the articles published in practitioner journals.

Separating the practitioner journals from the other journals shows another interesting result. When the practitioner journals are removed from the sample, knowledge transfer is still the most heavily researched topic, but storage/retrieval and application increase. This, in conjunction with the decrease in the percentage of transfer articles, shows a narrowing of the gap between these constructs in academic journals. Table 5 summarizes these results.

We also investigated the result of removing the special issues from the the numbers above. We removed a total of 22 articles: nine from the

May 2001 issue of Decision Support Systems, and 13 from the April 2003 issue of Management Science. In doing so, we found that the percentage of storage and retrieval articles increased by approximately 3% and the percentage of application articles decreased by approximately 3%. The other constructs moved by less than 1%. This indicates that the constructs in the special issues were as broadly covered as those in the rest of the publications.

While trend data is of interest and shows, in general, that two of the constructs (transfer and storage/retrieval) are more frequently addressed in published work than the others, it is often insightful to apply statistics to determine whether the viewed differences also have statistical difference. Using the entire sample population, means differences were calculated to determine whether one or more constructs is significantly over or under represented.

We expected that research addressing the constructs used in our framework would be relatively evenly disbursed; that is, that each construct would be represented in about 20% of the sampled articles. With the exception of storage and retrieval, all constructs' expected values were significantly different than .2. The construct of transfer was significantly higher than the expected value, while the other constructs — creation, application, and roles and skills — were lower. When completing a means comparison between constructs, we found a significant difference between the coverage of knowledge transfer and all other constructs, at p=.000. Additionally, there was a significant difference between the roles and skills construct and the storage and retrieval construct, at p=.012. Finally, there was an arguably significant difference between creation and storage and retrieval, at p=.067. From the information above, it appears that only storage and retrieval is published at about the level we would expect. Transfer is published more than twice as often as the other constructs; the remaining constructs are under-published.

DISCUSSION

This research raised almost as many questions as it answered. Why is knowledge transfer the dominant construct within KM? Is knowledge transfer more interesting to researchers than the other constructs? Is it easier to operationalize and examine? One explanation may be that information technology supports the knowledge transfer construct; thus, many IS researchers choose to investigate the medium rather than the process of transfer. However, as noted earlier from both Alavi and Leidner (2001) and Davenport and Prusak (1998), knowledge transfer is more than just the channel, medium or technology. In fact, it is estimated that much, if not most, knowledge transfer happens during informal communication (e.g., the "water cooler" theory) and is separate from technology. Further, most researchers suggest that tacit to explicit knowledge conversion is difficult, if not impossible, despite advances in research in communication technology. Channel and media richness is researched, as have been collaborative systems, but less research has been done in the realm of learning behaviors. Given the results of this study, it documents that IS researchers are looking at KM through a "technical" lens and, thus, that research is published in IS-oriented journals.

However, while answers to these types of questions may explain the trend in academic journals, we still don't know why practitioner journals focus so heavily on knowledge transfer. Is it because many organizations believe that KM is appropriate use of technology, rather than a new process? That is, when the technology field leveled, and other avenues of competitive advantage were sought, did use of technology as a KM tool rise to the surface? Is it that we, as IS researchers, are able to inform the practitioners with best practices for technology management more easily than best practices for people management?

Another question this study begets is whether the balance of the academic and practitioner literature would still lean toward knowledge transfer if other journals that publish KM articles but were not included in the scope of this research were included in the study. To answer that question, we examined articles in top management journals as ranked by Johnson and Podsakoff (1994). The journals identified by this ranking were: Administrative Science Quarterly, Research in Organizational Behavior, Academy of Management Review, Academy of Management Journal, Journal of Applied Psychology, Strategic Management Journal, Organizational Behavior and Human Decision Processes, Industrial and Labor Relations Review, Harvard Business Review and American Sociological Review. Using the same constraints and key phrase search done for IS journals, we found approximately 20 articles in these 10 journals that referenced KM. The articles from Harvard Business Review were not included, as they were already classified in the original search; of the remaining articles, approximately 75% addressed the issue of knowledge transfer. The May 2003 issue of Organization Behavior and Human Decision Processes was almost exclusively composed of articles that addressed knowledge transfer in one form or another; however, if we remove this issue from the sample, knowledge transfer is the topic of almost half of the remaining articles. Apparently, knowledge transfer is the most commonly researched construct from a management viewpoint also, albeit in a less technical vein than within the IS community.

We believe that transfer, as well as storage and retrieval, remain topics of interest in the IS community because of their obvious tie with information technology. It is telling that academic journals publish articles on knowledge roles/skills least often, whereas practitioner journals published that construct as often as both creation and application. While both creation and application also have direct ties to information technology (e.g., data mining, discovery, expert systems), roles and skills are less directly associated. Nonetheless, IS are constructed to support people; skills necessary to succeed with new technology and roles designed to shepherd the process are necessary and should be included in research done by the IS community.

FUTURE RESEARCH

Webster and Watson (2002) stated that a review should identify critical knowledge gaps and thus motivate researchers to close this breach. With this in mind, the authors make the following recommendations. First, researchers should look to expand this study by extending this research to more KM-focused journals to determine if the conclusions still hold. The research could be expanded to see if the trends identified in this article are consistent among KM-focused publications. Specifically, journals that focus on KM, such as the International Journal of Knowledge Management, Journal of Knowledge Management and Journal and Knowledge Management Research and Practice, should be reviewed with a similar methodology and framework to determine if it is truly the research that is focused on knowledge transfer or if the leading IS journals tend to publish knowledge transfer articles more frequently than other topics in KM.

Second, other frameworks are available that would be appropriate for this methodology. Applying one of these frameworks may provide a differing view of the state of research in KM. A different framework may view the topic in a manner that sheds new light on the collective research efforts of the community. For example, Argote, McEvily and Reagans (2003) propose a matrix framework for organizing the literature in KM. Their framework proposes viewing KM outcomes of creation, retention and transfer vs. KM contexts of properties of units, properties of relationships between units and properties of knowledge. Given the two-dimensional nature of this framework, the results would be extremely useful for the discipline.

Researchers should try to expand the coverage of the constructs that are currently under-researched. As shown earlier, knowledge transfer has been the object of a disproportionate amount of effort relative to the other constructs. Given the current depth of theories and frameworks, there should be an adequate foundation to perform more research in the areas of creation, storage and retrieval, and application. If the conclusions of this research remain consistent after studying other KM publications, future research in KM should start to address the relative shortage of research in creation, application, and storage and retrieval. These areas have significantly less research than the construct of knowledge transfer. For the field to continue to grow, researchers must provide more even coverage to all the relevant constructs in KM.

An additional benefit of increased research of the other constructs within KM would be an increased precision in the respective definitions of the constructs. First, there is not universal acceptance that these constructs form KM. Next, as research coverage of the other constructs increases, there may likely be a natural selection of the most appropriate definitions. Finally, further research may influence researchers to determine the most appropriate framework to define KM and increase the precision of future research.

CONCLUSION

This study found that current research has investigated the construct of knowledge transfer more frequently than the other constructs in KM as developed from the Alavi and Leidner (2001) and Davenport and Prusak (1998) frameworks. This conclusion remains consistent whether examining academic research journals or practitioner-focused journals. While this is currently not a significant problem, it could be in the future. For KM to continue to grow as a respected topic within the IS research discipline, we must present well-rounded and parsimonious yet diverse research to the rest of the IS community. If one of the constructs within KM is researched extensively while the others are less developed, the topic as a whole will suffer from an imbalance. As a community of researchers, we know that KM is more than just knowledge transfer. For practitioners to deploy effective KM systems, the other constructs must be more fully developed. The Davenport and Prusak construct of knowledge roles and skills adds a critical area to the topic of KM. For KM to be truly effective, few could argue against the need for appropriate supporting skills. Researchers should more fully investigate the other constructs that form the foundation of KM.

This research raised a number of interesting questions about the research effort apparent in published work. A number of excellent articles are identified in this paper as well as many others that were not described in detail because of space constraints. Many of these articles proposed concepts that form an excellent foundation for further investigation. As a community of researchers, we know that KM is more than regeneration or integration of other, more mature topics such as expert systems or decision support systems. Additional research in the other core constructs while framed under the topic of KM will serve to enhance the understanding of the breadth of KM and ensure it remains a significant research topic in the future.

A list of the articles reviewed for classification may be obtained from the authors.

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REFERENCES

Alavi, M., & Leidner, D.E. (2001). Review: knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Argote, L., McEvily, W., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), 571-583.

Bem, D. (1995). Writing a review article for Psychological Bulletin. *Psychological Bulletin, 118*(2), 172-177.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Davenport, T.H., Jarvenpaa, S.L., & Beers, M.C. (1996). Improving knowledge work processes. *Sloan Management Review, 27*(4), 53-65.

Desouza, K.C. (2003). Strategic contributions of game rooms to knowledge management: Some preliminary insights. *Information & Management, 41*(4), 63-75.

Grant, R.M. (1996). Toward a knowledge based theory of the firm. *Strategic Management Journal, 17*(Winter Special Issue), 109-122.

Griffith, T.L., Sawyer, J.E., & Neale, M.A. (2003). Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology. *MIS Quarterly, 27*(2), 265-288.

Gupta, A.K., & Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal, 21*, 473-496.

Holsapple, C.W., & Joshi, K.D. (2001). Organizational knowledge resources. *Decision Support Systems, 31*(1), 39-55.

Jennex, M., & Croasdell, D. (2005). Editorial preface: Is knowledge management a discipline? *International Journal of Knowledge Management, 1*(1), i-v.

Johnson, J.L., & Podsakoff, P.M. (1994). Journal influence in the field of management: An analysis using Salancik's index in a dependency network. *Academy of Management Journal, 37*(5), 1392-1407.

Mylonopoulos, N.A., & Theoharakis, V. (2001). On-site: Global perceptions of IS journals. *Communications of the ACM, 44*(9), 29-33.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Peffers, K., & Ya, T. (2003). Identifying and evaluating the universe of outlets for information systems research: Ranking the journals. *Journal of Information Technology Theory and Application, 5*(1), 63-84.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., Rebeck, K., The Knowledge Management Methodology Team. (2001). A systems thinking framework for knowledge management. *Decision Support Systems, 31*(1), 5-16.

Stein, E. W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Webster, J., & Watson, R.T. (2002). Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly, 26*(2), xiii-xxiii.

Zhang, P. (2000). The effects of animation on information seeking performance on the Web: Securing attention or interfering with primary tasks. *Journal of the Association for Information Systems, 1*(1), 1-28.

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Chapter 4.8
Document Search Practices

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INTRODUCTION

A large portion of the knowledge of most organizations is contained in electronic documents. For users to get pertinent information from the accumulation of stored documents, they need effective document retrieval systems. Unfortunately, electronic document management has fallen into the same trap that electronic data processing fell into: simply automating what previously was done manually. Paper documents were stored in folders in drawers in file cabinets. Electronic documents are stored in folders in directories on disk drives.

The ability to find a document depends on the logic of the filing system, how familiar the individual is with the filing system, and how familiar the individual is with the problem domain of the item being sought. Some persons (e.g., research librarians) are much better than others at organizing and retrieving documents. Rarely, however, is a manager an expert at either storing or retrieving documents. Unfortunately, many electronic filing systems are set up by managers with little or no training on how to organize a filing system, and few tools, other than the Windows Search command, are available to help managers find documents that have been filed.

The filing systems for libraries and knowledge management systems are more sophisticated than the filing systems of most small offices or individual managers. But even libraries and knowledge management systems predominately rely on keyword searching for retrieval. For example, if one visits the Web site for the Journal of Management Information Systems at http://jmis.bentley.edu/keywords/, one notes that the only option available for searching (other than browsing the entire collection) is a keyword search.

Keyword searching has improved over the years. Knowledge seekers have benefited enormously from the ability to search remotely, the increased speed with which searches are conducted, and the ability of the search mechanism to identify variations of the keywords. Nevertheless, keyword searches have significant limitations. In particular, keyword searches cannot return all relevant documents nor can they filter out irrelevant documents. This article briefly reviews the difficulties associated with keyword searches, especially as the number of documents increases, and proposes a way to overcome those limitations.

BACKGROUND

In his 1990 seminal article on business process engineering, Hammer (1990) argues that organizations should use computers to redesign—not just automate—existing business processes. With document management systems, the opposite has been done. Documents were stored in file cabinets in offices or on shelves in libraries, and electronic document storage systems adopted the same basic principles.

Paper documents such as memos, white papers, reports, and so forth were filed based on the value of some specific field (e.g., project name). To retrieve a document, a user needed to know the value of the field which was used to organize the documents. Because of the shear mass of paper that quickly accumulated in any office, duplication for the purpose of access through multiple fields was not encouraged. In highly organized filing systems, cross-references were filed for important documents, resulting in the capacity to find some documents from two or three different fields. However, this was done infrequently, was quite time-consuming when it was done, and was difficult to maintain.

The logic of the paper filing system usually was determined by a secretary or office assistant, who also was the person primarily responsible for retrieving the documents. This person generally had significant knowledge of the content of the documents, and therefore the system worked quite well for that individual. Unfortunately, the system did not work as well for others.

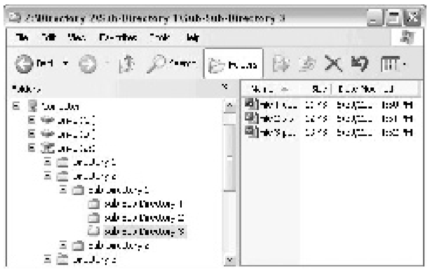
Today, most individuals organize their computer directories in the same manner in which their file cabinets were organized, or even more poorly because they have had little or no training on filing and tend to store all of their folders in the hard drive root directory. While this may be an acceptable strategy for a small set of documents, it is unacceptable when dealing with a large number of documents.

Figure 1 shows the similarity between paper filing systems and simple computerized filing systems. To find a file in the paper system, an individual needs to know which file cabinet to search, which drawer to select, and which folder contains the sought after file. To find a file in the computerized system, an individual follows a very similar strategy. The individual first selects the disk drive to examine, then searches the directory, sub-directory, sub-sub-directory, and so forth, until the file is located. The only advances made to this point are the amount of physical space saved and the ability to use the “find” command.

At the organizational/library level, document management systems require more structure. Generally, documents are organized by hierarchical levels of categories. For example, with the Dewey Decimal system, documents associated with “technology (applied sciences)” are grouped together. Within that category, “management” is separate from “manufacturing” and so on. A major benefit of this method of organization is that once the individual arrives at one document on the topic of interest, other potentially relevant documents are located in close proximity and are easily browsed for relevance. Everyone who has visited a library has located additional relevant books by browsing the library’s physical stacks.

Indexes make cross-referencing of materials possible. Though not physically stored together on

Figure 1. Filing cabinet vs. simple computerized system



shelves, documents that are similar with respect to some characteristic (other than the one used to physically store the document) can be referenced together in a card catalogue. Cross-referencing is very important for libraries. An article that describes how regression analysis is used to conduct mass appraisals, for example, should be locatable both by someone who is interested in applications of regression analysis and by someone who wants to understand how the county assessor determines the assessed value of a home using regression analysis. This only can be done with cross-referencing.

Even with cross-referencing, however, the problem remains of needing an entry point for retrieving relevant documents. Not knowing applicable keywords makes a library little more than a jumble of documents. Given the sheer number of documents that are stored, it no longer is possible for one, or a few individuals, to know the content of each document. Librarians are experts at the storage system, but to be useful to the individual they need to understand the subject matter (e.g., a chemical librarian vs. a general librarian). The ability of librarians to keep up with the content of documents is limited by the capacity of human cognition. As the volume of documents increases, the ability of librarians to help individuals diminishes. Further, librarians are limited in their capacity to identify documents from a different area that might be pertinent to the individual. The limitations on human memory prevent any single individual from retaining adequate information to be able to answer questions on a wide variety of subjects.

Current State

Today, more and more documents are being stored electronically. Several factors have contributed to the shift from paper to electronic documents, including the low cost of mass storage devices, the ease with which documents can be scanned and stored, government recognition of electronic signatures, the replacement of desktop computers with notebook computers, and ubiquitous access to the Internet. After more than 30 years of being just around the corner, the paperless office finally is moving from myth to reality. Many organizations provide their employees with notebook computers, and strongly encourage the use of digital documents for sharing information. Unfortunately, those same organizations provide little guidance on how to store or retrieve digital documents, and the ability to effectively retrieve documents has fallen far behind the capability to store documents.

The introduction of electronic document retrieval systems offered an opportunity to address three significant problems associated with the storage of paper documents. First, a large number of documents could be stored in very little space. Second, retrieval time after a document is located became almost zero. And third, anytime, anywhere, access enormously simplified retrieval. Unfortunately, increasing the speed and convenience with which a large number of documents can be retrieved does not help the individual to locate the documents that he or she needs. In fact, it produces a new problem: information overload.

Most document retrieval systems rely on keyword searching as their primary retrieval mechanism. Keyword searches have problems with respect to both locating all of the relevant documents and locating only relevant documents. The problems with respect to locating relevant materials are well documented (Blair, 2002a, 2002b; Gorla & Walker, 1998; LaBrie & St. Louis, 2003). Gorla and Walker (1998) group the problems into the following categories:

- Errors in spelling
- Inconsistencies of abbreviations
- Improper combining of dissimilar terms
- Inconsistent spelling of words
- Inconsistent compounding of words
- Redundant keywords

LaBrie (2004, p. 92) shows that because of these problems keyword searches find only 10% to 30% of the relevant documents in organizational holdings. This is a low percentage as compared to alternative retrieval mechanisms such as visual hierarchies.

Keyword searches also can overwhelm the individual with irrelevant articles. If a keyword insufficiently defines the search scope, many documents will be returned that are not relevant. For example, if a user needs information on the systems development life cycle (SDLC), selecting all documents with the keyword "system" will result in a large number of documents unrelated to the SDLC. This problem is annoying but manageable for small holdings. If 20 documents are returned and only 10% are pertinent, it does not take long to look through the 20 documents to find the two useful ones. However, if the result set size is 5,000 documents, the user will not be able to look through all 5,000 documents.

The scalability of retrieval systems is a serious problem. The Zipf distribution has been shown to apply to natural languages (Blair, 2002). Briefly, the Zipf distribution shows that as the number of documents increases, the number of documents in which a specific term occurs also increases. Further, as the library increases in size, the likelihood of a term being used with different meanings also increases. So not only does the result set size increase, but the percentage of irrelevant documents in the result set also increases.

Increased processing speed makes it possible to scan the full document for a keyword, as opposed to scanning just the keyword field, title, or abstract. This article uses the term "causal modeling" in Figure 2 and its associated text. With full document scanning, a search for documents dealing with causal modeling would return this article, although the content of this article has nothing to do with causal modeling. Blair (2002) labels this phenomenon as "over-description," and defines it as a situation where "some, or many, of the terms that are used to describe the document may misrepresent the intellectual content of the document" (p. 280). Though it is technically possible to perform full document scanning, or have a large set of keywords describing a document, doing so may be counterproductive to the objective of retrieving pertinent documents. Increasing the speed of search mechanisms does not solve the information overload problem.

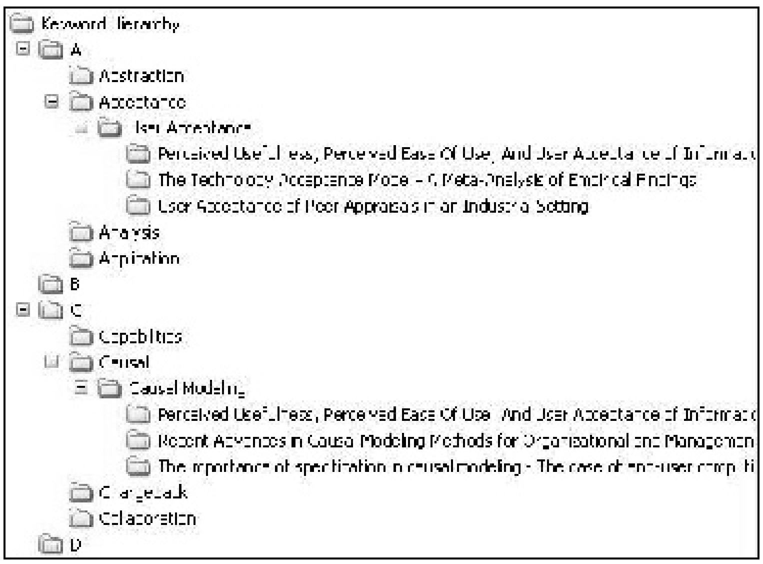
Cognitive psychologists have been studying human memory capacity for well over 100 years (Ebbinghaus, 1913) and have identified two predominant forms of retrieving information from memory: recall and recognition. Trying to remember the name of someone you met at a conference is recall. Recognition is remembering that person's name when looking at a list of conference attendees. Recognition routinely outperforms recall in retrieval accuracy, especially when context is added by organizing the information hierarchically (Anderson, 1995; Bower, Clark, Lesgold, & Winzenz, 1969; Clark, 1999; Simon, 1962).

Figure 2 is an example of a hierarchical arrangement of keywords. The hierarchy is based on the alphabet and has a four level structure. The root node, or highest level of the hierarchy, is the first letter of any word that has been used in any keyword phrase. The next level represents a unique word that was used in a keyword phrase. The third level identifies the actual keyword phrase provided by the author(s). The fourth and lowest level of this hierarchy is the title of the document that contains the keyword phrase. In an electronic document management system this title would contain a link to the actual document.

In Figure 2, note that all articles with the keyword phrase "user acceptance" are grouped together. Similarly, all articles with the keyword phrase "causal modeling" are grouped together. Although the documents themselves are stored in one location (eliminating duplicate copies which wastes disk space), links to the articles can be stored in multiple locations. This makes electronic browsing much more effective than physical browsing. As an example, suppose Davis' (1989) article on the technology acceptance model used as its keywords user acceptance and causal modeling. An individual who is interested in applications of causal modeling, easily finds Davis' article on "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology" even though he or she may never have thought to look under "User Acceptance," which is where the article may have been physically stored based on subject.

With existing low cost and pervasive technologies any individual or small office can create the search mechanism shown in Figure 2 (LaBrie & St. Louis, in press). The process to develop such a visual keyword hierarchy is quite simple. Keyword phrases are taken from an article's keywords list when the article is entered into the

Figure 2. Visual keyword hierarchy



system. The keyword phrases are broken down into individual words. Trivial words such as "a," "the," and "and," are removed. Individual words are linked to their original keyword phrase and the article with which the keyword is associated. The result is a hierarchy similar to Figure 2 that allows a user to search via any of the words within the keyword phrase. If someone were looking for articles on the "Technology Acceptance Model," they could find them in three different areas of the hierarchy: (1) Under A, Acceptance, Technology Acceptance Model; (2) Under T, Technology, Technology Acceptance Model; or (3) Under M, Model, Technology Acceptance Model.

Hierarchies built on keywords are easily maintained. As new articles with new keywords are added to the holdings, trigger mechanisms can be implemented to dynamically update the hierarchies (LaBrie & St. Louis, in press). These dynamic hierarchies are easily searched because both individual keywords and keyword phrases appear in them. This means the individual does not have to spell the keyword correctly nor recall the exact keyword phrase. The only requirements are that the individual recall the first letter of a relevant keyword (where to enter the hierarchy) and recognize relevant keywords or keyword phrases that appear in the article (browse the hierarchy). This overcomes many of the disadvantages of keyword searches and allows individuals to retrieve documents from their notebook computers or organizational servers as effectively (or more) than documents can be retrieved from a library.

FUTURE TRENDS

The number of stored documents is increasing at an astronomical pace (Ball, 2002). The advances that have occurred with respect to the ease and speed of searching have been equally dramatic. But as the collection of documents grows, the scalability of retrieval systems is adversely affected. As a consequence, both the number of articles and the percent of irrelevant articles in the result set increases. The real challenge now is to filter out the irrelevant documents. A promising approach is to filter articles on the basis of both context and keywords.

To capture the intellectual context of a document requires more than picking out words or phrases from the document. For example, a document that includes the results from a regression analysis that was performed using the SPSS statistical package on data from the assessor's rolls to create mass appraisal values for individual homeowners may be very useful to someone wanting to see an application of regression analysis, but may not be useful to someone wanting to understand how conditional means are calculated by software that enables regression analyses. Using keywords alone, there is no way to distinguish between documents that focus on applying regression analysis and documents that focus on explaining regression analysis. Yet regression analysis is a legitimate keyword for both searches.

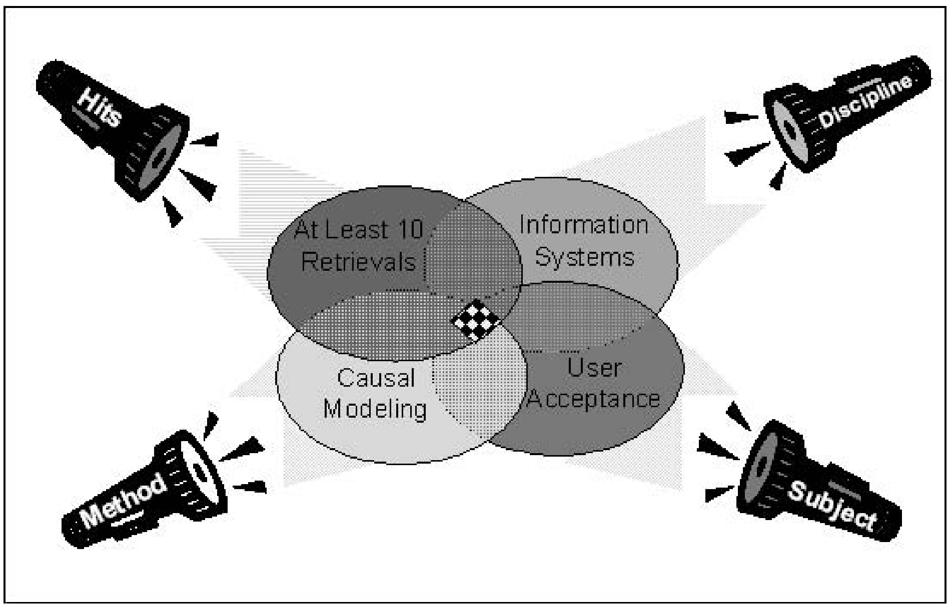
One role that the librarian fills is that of a domain expert. The librarian can distinguish between articles that apply regression analysis and articles that explain regression analysis, or even much finer distinctions of word use. Document retrieval systems need a context filtering mechanism that can substitute for the librarian. One reason why librarians are so effective at finding relevant articles is that they understand both the Library of Congress Subject Headings and the Dewey Decimal System. Categorization provides context. If electronic document retrieval systems are going to become as effective as librarians at filtering out irrelevant documents, then they need to use categorization schemes. Presenting the categorization scheme as a visual hierarchy contributes even more to effectiveness because the user can recognize the categories which are appropriate.

Continuing with the example of an article that applies regression analysis vs. an article that explains regression analysis, one lens through which to filter the articles might be "subject of document." The individual, when presented with the initial list of search lenses, would select "subject of document" and then be presented with a list of possible subjects which might include, among others, the subjects "residential property appraisals" and "regression analysis." The individual wanting an explanation of regression analysis would select the "regression analysis" subject and not the "residential property appraisals" subject. Another lens could be "most frequently retrieved," which is similar to one used by Google and other search engines. This presumes that the most useful documents will be retrieved most often. With electronic documents, it is easy to record the number of times a document has been retrieved for a particular subject category.

Applying lenses is different than applying an "and" search on keywords. It is cross-indexing documents by both keywords and the lens categories that are selected. Visual classification hierarchies enable the individual to use recognition-based rather than recall-based search mechanisms to select criteria, and thus enable the individual to see the context of the keyword. This greatly enhances the individual's ability to screen out irrelevant articles. It is important to note that the set of lenses does not have to be the same for every electronic document management system. Rather, a set of search lenses can be designed to fit the needs of the organization. A research lab's document management system, for example, might include a "methodology" lens, while a law office's document management system might not.

Knowledge workers spend a tremendous amount of time culling irrelevant documents. A keyword search can return thousands of documents with only a small fraction of those being relevant to the individual's needs. By adding multiple visual hierarchies as lenses, many of those irrelevant documents can be removed. It takes some time and effort to create and maintain the

Figure 3. Examples of lenses



classification schemes required to add the needed context. However, the amount of time and effort is not Herculean. Allowing users to specify subject headings, and arranging them into visual subject hierarchies using the same technique that is used to construct visual keyword hierarchies (LaBrie & St. Louis, in press), does not require a great deal of effort. Moreover, once established, these new visual classification schemes will greatly facilitate knowledge management. Figure 3 illustrates a situation where four lenses are used: discipline, subject, methodology, and number of hits. In this example, an article would be retrieved only if it were categorized as being in the information systems discipline, had a subject of "user acceptance," used causal modeling as its methodology, and had been retrieved at least 10 times.

CONCLUSION

There is a disconnect between the ability to store documents and the ability to retrieve them. It is extremely easy to save documents. In fact, it is so easy to save documents, and storage space is so inexpensive, that many individuals save all documents that are sent to them, rather than determining which ones might be needed later. Unfortunately, when it comes time to find a document, they frequently fail to do so, or take a long time to do so. The ease with which documents can be stored stands in stark contrast to the difficulty of finding a sought-after document that one knows is stored somewhere in a personal or organizational file.

A solution to this information overload is to add context to the keywords through the application of various classification schemes (subject, author, methodology, etc.). These classification schemes can be maintained and presented to the user in the form of multiple dynamic, visual hierarchies. This approach to document retrieval significantly reduces the numbers of irrelevant articles and therefore reduces information overload. Surprisingly, to combat information overload, "rather than needing less information, we actually may need lots more, specifically information about information, or metadata" (Farhoomand & Drury, 2002). The disconnect between the ability to store documents and the ability to retrieve documents can be resolved. This article explains how simply automating what was done with paper documents created that problem, and how reengineering the process to capture context can resolve the problem.

REFERENCES

Anderson, J.R. (1995). *Cognitive psychology and its implications* (4th Ed.). New York: W.H. Freeman and Company.

Ball, M.K. (2002, March). Knowledge management: Intelligence for today's business world. *KMWorld*, S14-S15.

Blair, D.C. (2002a). The challenge of commercial document retrieval, part I: Major issues, and a framework based on search exhaustivity, determinacy of representation and document collection size. *Information Processing & Management, 38*(2), 273-291.

Blair, D.C. (2002b). The challenge of commercial document retrieval, part II: A strategy for document searching based on identifiable document partitions. *Information Processing & Management, 38*(2), 293-304.

Bower, G.H., Clark, J.C., Lesgold, A.M., & Winzenz, D. (1969). Hierarchical retrieval schemes in recall of categorical word lists. *Journal of Verbal Learning & Verbal Behavior, 8,* 323-343.

Clark, S.E. (1999). Recalling to recognize and recognizing recall. In C. Izawa (Ed.), *On human memory: Evolution, progress, and reflections* *on the 30th anniversary of the Atkinson-Shiffrin model* (pp. 151-164). Mahwah, NJ: Lawrence Erlbaum Associates.

Davis, F.D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319-340.

Ebbinghaus, H. (1913). *Memory: A contribution to experimental psychology*. (H.A. Ruger & C.E. Bussenues, Trans.). New York: Teachers College, Columbia University. (Original work published 1885.)

Farhoomand, A.F., & Drury, D.H. (2002). Managerial information overload. *Communications of the ACM, 45*(10), 127-131.

Gorla, N., & Walker, G. (1998). Is the lack of keyword synergism inhibiting maturation in the MIS theory? An exploratory study. *Information Processing & Management, 34*(2-3), 325-339.

Hammer, M. (1990). Reengineering work: Don't automate, obliterate. *Harvard Business Review, 68*(4), 104-113.

LaBrie, R.C. (2004). *The impact of alternative search mechanisms on the effectiveness of knowledge retrieval.* Doctoral dissertaton, Arizona State University.

LaBrie, R.C., & St. Louis, R.D. (2003). Barriers of information retrieval from knowledge management systems: An examination of keyword limitations. *Proceedings of the Americas Conference on Information Systems,* Tampa, FL, 9 (pp. 2552-2563).

LaBrie, R.C., & St. Louis, R.D. (in press). Dynamic hierarchies for business intelligence information retrieval. *International Journal of Internet and Enterprise Management.*

Simon, H.A. (1962). The architecture of complexity: Hierarchical systems. *Proceedings of the Philosophical Society, 106* (pp. 467-482).

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Chapter 4.9
On the Design of Knowledge Management System for R&D Organization:
Integration of Process Management and Contents Management

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ABSTRACT

This chapter proposes a framework for designing knowledge management system (KMS) for R&D organization. Broadly, KMS comprises two principal modules: a process management module to administer knowledge activities to generate and utilize knowledge, and a contents management module to deal with knowledge contents, input and output of knowledge activities. The two modules are then materialized through two operational systems: workflow management system (WFMS) for R&D process and R&D knowledge management system (RKMS) for R&D contents. As a building block to integrate the two systems, workflow-based knowledge map is suggested. The authors admit that the research is an exploratory proposal that suggests merely a conceptual scheme. Therefore, it is required to elaborate detailed procedure and materialize real system.

INTRODUCTION

Recently, knowledge management (KM) has attracted increasing recognition from academicians and practitioners alike. In a corporate setting, the functional spectrum of KM is so ample, ranging from procurement of raw material to the marketing of end products. Amongst others, R&D organization serves as the primary actor of knowledge management (KM), since it is the major source of knowledge generation and dissemination. Furthermore, R&D organization may be a challenging test bed for KM in that it needs to coordinate collaborative work among knowledge workers and ill-defined workflows across knowledge nodes. Despite the importance, however, little attention has been paid to development and implementation of KM for R&D organization. In this regard, the main purpose of this chapter is to propose a framework for designing KM system (KMS) of R&D organization.

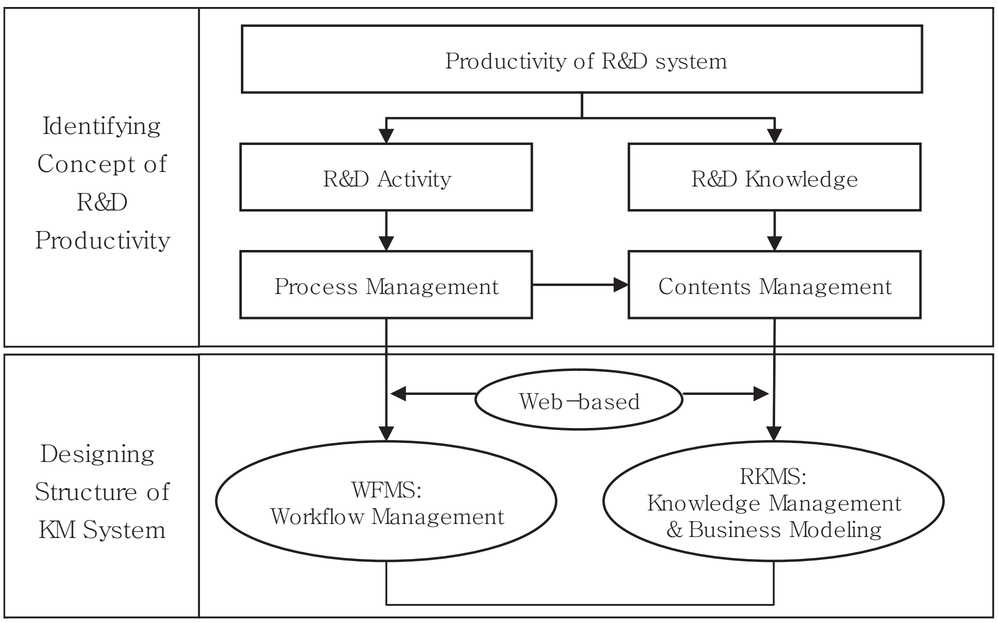
Broadly, KMS is composed of a process management module to administer knowledge activities to generate and utilize knowledge and a contents management module to deal with knowledge contents, input and output of knowledge activities. Accordingly, the framework is composed of two major pillars, process management for R&D activity and contents management for R&D knowledge. Then, we propose two operational systems: a workflow management system (WFMS) for R&D process and an R&D knowledge management system (RKMS) for R&D contents. The overall architectures of WFMS and RKMS are briefly described and the procedure to integrate RKMS and WFMS is explained. The proposed system is web-based in that it is designed and developed on the web environment.

OVERALL FRAMEWORK

Matching WFMS and RKMS

As explained before, KMS for R&D organization comprises two major components, R&D activities and knowledge contents. R&D activities are associated with processes to generate and utilize

Figure 1. Overall framework of KMS to integrate WFMS and RKMS



knowledge, and knowledge contents are related with input and output of knowledge activities. Therefore, the overall framework of KMS is constructed by matching process management to administer knowledge activities and contents management to deal with knowledge contents, as portrayed in Figure 1.

Matching R&D Organization Types and KMS Domains

KMS of R&D organization encompasses heterogeneous and multi-disciplinary knowledge that is hard to formalize and R&D activities comprise complicated and unstable processes that are hard to standardize (Polanyi, 1966; Saren, 1984; Cooper, 1983; Clark, 1985). In particular, the notion of a sectoral pattern of innovation highlights differences across industrial sectors in terms of knowledge management (Pavitt, 1984). Therefore, it is impossible to propose a general structure of KMS that is applicable to all the forms of R&D organizations. The design of KMS, thus, needs to be customized by matching characteristics of individual R&D units and characteristics of KMS domains. To this end, it is necessary to classify

Figure 2. Matching of R&D organization and KMS domain

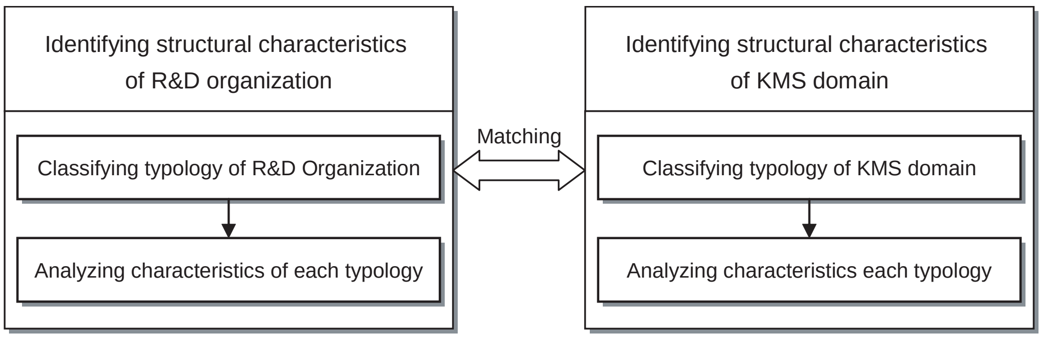


Table 1. Typology of R&D organizations

Typology of R&D organizations	Description
Product-oriented Organization	R&D organization comprise separate units, each takes charge of Development of individual product
Process-oriented Organization	R&D organization comprise separate units, each is related to different process of research and/or manufacturing
Technology-oriented Organization	R&D organization comprise separate units, each takes charge of development of component technology
Function-oriented Organization	R&D organization comprise separate units, each takes charge of management of different function
Matrix(hybrid) Organization	R&D organization comprise separate units, each is a combination of multiple features

R&D units into several types and to identify the best-practice form of KMS for each type of R&D units. The conceptual scheme of customization is depicted in Figure 2.

To illustrate, as presented in Table 1, it may be possible to classify R&D units into five types and develop customized KMS domains according to the characteristics of each type (Park, 2001).

DESIGN OF RKMS

Once the correspondence between R&D organization type and KMS domain is established, the blueprint of RKMS is developed. In this chapter, we suggest a comprehensive system that covers the whole cycle of R&D activities, from initial research to ultimate commercialization. To this end, RKMS is composed of a main system and several supporting tools. The main system includes a management module to create, store, secure, distribute and retrieve knowledge and a utilization module to structure knowledge map, evaluate knowledge asset and commercialize knowledge to business model. To support the main system, several supportive tools such as classification, visualization, agent, navigation and decision-making criteria are also included in the framework. Figure 3 describes the overall architecture of RKMS.

DESIGN OF WFMS

Broadly, workflow is a tool to define and administer business processes automatically and, in turn, becomes the core engine of WFMS that electronically operates and controls the R&D

Figure 3. Overall architecture of RKMS

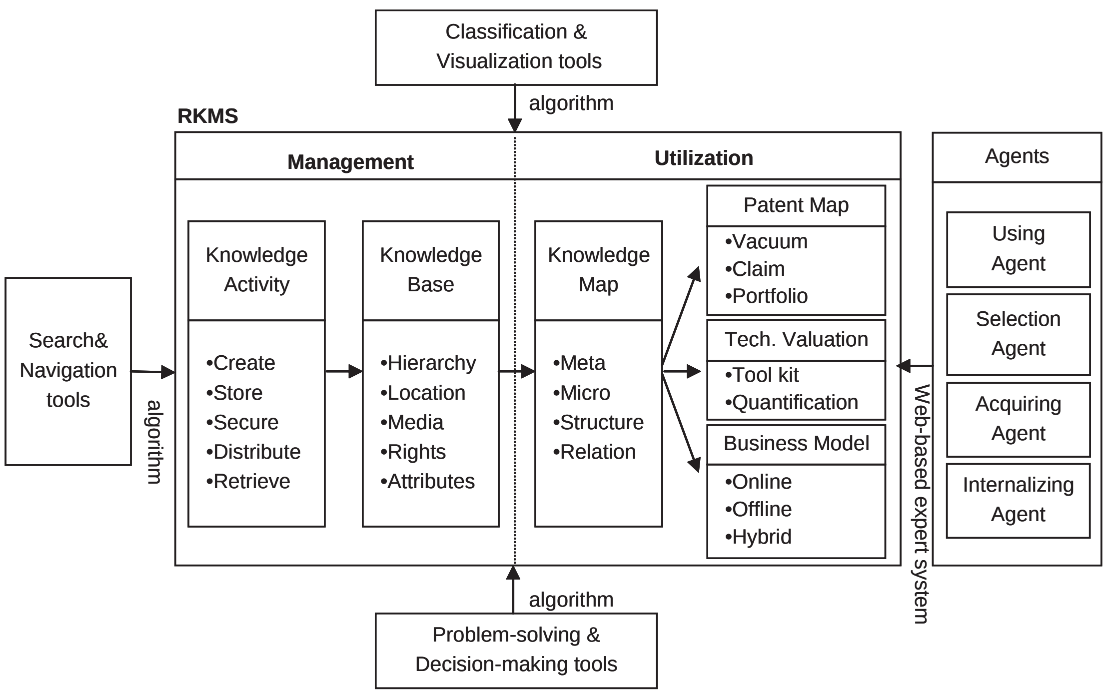
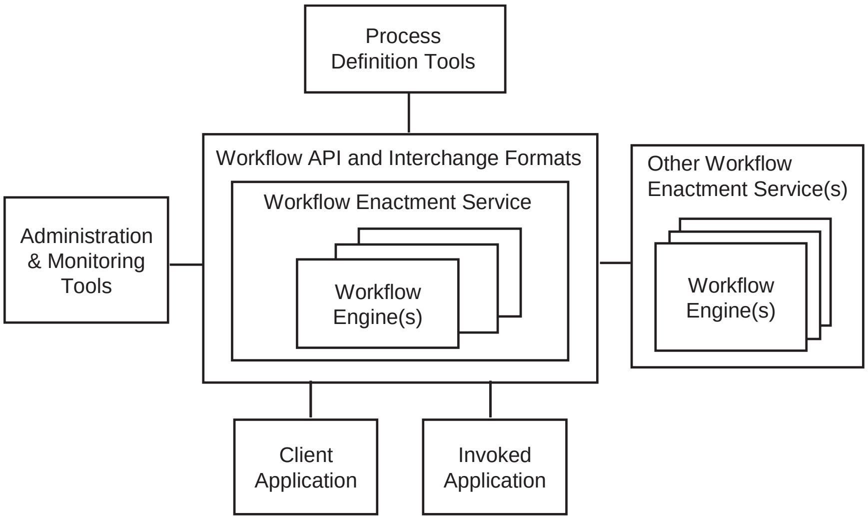


Figure 4. Overall architecture of WFMS



process. The usefulness of WFMS is highlighted as the amount of knowledge becomes intractably large, the business units are geographically decentralized but more closely networked and the importance of collaboration among individual workers is emphasized (WFMC, 2001; Kumar, Zhao, 1999; Kim et al., 2000).

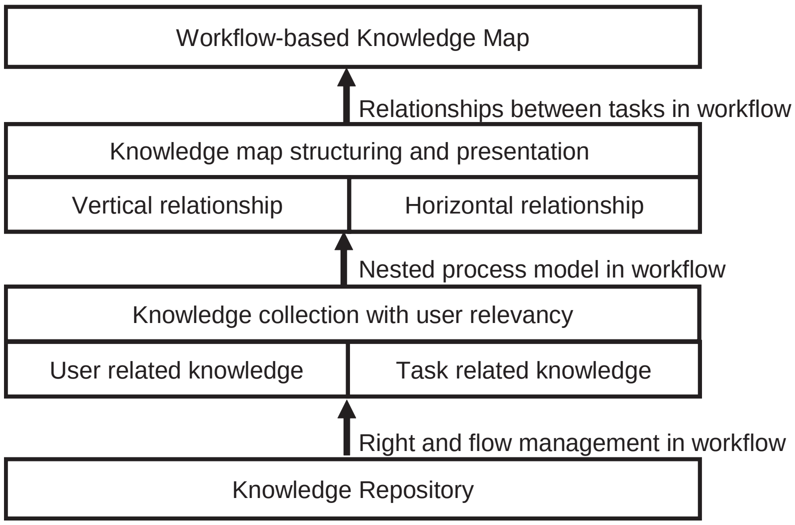
In this chapter, WFMS is composed of two main modules: a definition module to identify and design R&D processes and an execution module to monitor the progress of processes, control and carry out tasks and manage application programs. These modules are basically developed and implemented on the workflow engine. The overall architecture of WFMS is exhibited in Figure 4.

INTEGRATION OF WFMS AND RKMS

Finally, RKMS and WFMS need to be integrated. The integration of RKMS and WFMS is accomplished by developing a workflow-based knowledge map. The notion of knowledge map, defined as a visual architecture of knowledge domain, may be developed in diverse forms (Eppler, 1999), but a workflow-based map is suggested here. Since workflow is the backbone of process management and the knowledge map is the building block of contents management, the integration represents an exploratory effort to combine process management and contents management. Basically, the construction of a knowledge map of RKMS consists of two steps: knowledge collection and knowledge structuring. As depicted in Figure 5 and as explained below, these two steps of RKMS necessitate information from WFMS.

First, in the knowledge collection step, knowledge in the knowledge repository is filtered in accordance with knowledge users and related tasks. In building a knowledge map, it is critical to provide the right knowledge to the right user. For the relevancy in terms of knowledge contents and knowledge users, we need information on user

Figure 5. Integration of WFMS and RKMS



and task attributes. This information is obtained from the process definition in WFMS. By doing so, the knowledge collection takes the relationship of user-task and task-knowledge into account.

In the second step, the filtered knowledge is structured and presented based on the vertical relationship and horizontal relationship of knowledge. The term vertical relationship means the hierarchical linkage of knowledge artifacts, whereas horizontal relationship indicates the input-output relationship of knowledge artifacts. The information on the vertical and horizontal relationship among knowledge artifacts is also obtained the workflow definition of WFMS. The proposed system is web-based in that it is designed and developed on the web environment.

CONCLUSIONS AND FUTURE WORK

In this chapter, we proposed a framework for designing workflow-based KMS of R&D organization. The framework consists of two major components: WFMS for process management and RKMS for contents management, whereby RKMS derives necessary information from WFMS. In doing that, it was emphasized that the design of KMS needs to be customized by matching characteristics of R&D units and KMS domains.

This research in nature is an exploratory proposal that suggests merely a conceptual scheme. Therefore, it is required to elaborate detailed procedure and materialize real system. Specifically, the notion of workflow-based knowledge map needs to be put in a definite shape. The definition module of WFMS is another source of difficulty, since the workflow of the R&D process is hard to generalize. Finally, the identification and determination of the relationship among knowledge necessitates that more practical efforts should be made from the perspective of the knowledge user, rather than the system developer.

REFERENCES

Clark, K. (1985). The interaction of design hierarchies and market concepts in technological innovation. *Research Policy, 14*, 235-251.

Cooper, R. (1983). The new product process: An empirically-based classification scheme. *R&D Management, 13*(1), 1-13.

Eppler, M. (2001). Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. *Proceedings of 34th Hawaii International Conference on System Sciences* (pp. 1530-1539). IEEE.

Kim, Y., Kang, S., & Kim, D. (2000). WW-FLOW: Web-based workflow management with runtime encapsulation. *IEEE Internet Computing, 4*(3), 55-64.

Kumar, A., & Zhao, J. (1999). Dynamic routing and operational controls in workflow management systems. *Management Science, 45*(2), 253-272.

Park, Y. (2001). A framework for designing technological knowledge management systems: A sector-specific approach. In P. Banerjee & F. Richter (Eds.), *Intangibles in competition and cooperation.* New York: Palgrave.

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy, 13,* 343-373.

Polanyi, M. (1966). The tacit dimensions. New York: Doubleday.

Saren, M. (1984). A classification and review of models of the intra-firm innovation process. *R&D Management, 14*(1), 11-24.

WfMC (2001). *The workflow coalition specification – Interface 1: Process definition interchange process model.* Retrieved from http://www.wfms.org.

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Chapter 4.10
Knowledge Management: Analysis and Some Consequences

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ABSTRACT

Although the debate on the nature of 'knowledge' and 'information' is far from settled, it is now taken for granted throughout the academic world that the two notions are related but fundamentally distinct. This result, and its significant consequences, still need to be realised and understood by the great majority of the business world. In the first section of this chapter, we briefly comment on some characteristic views of 'knowledge' and 'knowledge management,' and subsequently we analyse in-depth the core constituent notion of the latter, that is, knowledge. In section two, we outline three major consequences of our analysis. The first concerns the limits of management for a certain class of activities involving knowledge. The second concerns the scope and limits of technology for the same class of activities. The third concerns the issue of knowledge market. The thesis we develop is that knowledge cannot be taken as a commodity; in other words, the notion of a knowledge market is not implementable.

WHAT IS KNOWLEDGE MANAGEMENT?

Attitudes towards 'knowledge management' (KM) have fluctuated widely since the term first appeared. At first, it was highly and sharply inflated, then a deep, albeit less sharp, disillusionment trough followed until recently. Now, a slightly upward leading slope has started to take form. This should not come as a surprise given the wide disagreements, in both the academic and business worlds, concerning both the term 'knowledge management' and its central constituent notion: 'knowledge.'

To start with compare the following three conceptions of KM that appeared in the Financial Times in November 1999.

"The systematic management of the knowledge processes by which knowledge is created, identified, gathered, shared and applied." (Newing, 1999).

"[Knowledge management] Is about spreading information throughout a corporate body." (Dempsey, 1999).

"The management of commercially valuable information." (Vernon, 1999).

What these conceptions exemplify is that KM is perceived in two substantially different senses: a) as synonymous to information management; and b) as distinct from it.

The former sense is the case, knowingly or unknowingly, in the majority of firms dealing with knowledge management. This mistaken identification is what Malhotra (2000) terms the information-processing paradigm to knowledge management. The business world needs to realise that the notions of 'knowledge' and 'information' are substantially different from each other. It follows that firms also need to realise that certain activities cannot be just renamed and expect successful resolution by the application of old techniques and approaches. As Gupta and Govindarjan (2000, p. 71) remark:

"A gap exists between the rhetoric of knowledge management and how knowledge is actually managed in organizations."

To be precise, the gap that exists is between the rhetoric of knowledge management and what is actually managed in organizations. And what is actually managed in the vast majority of companies is anything but 'knowledge'.

The latter of the two senses introduced above is now taken for granted throughout the academic world and by some major pioneering organisations like Slumberger and Nucor Steel. Such acceptance though has not led to a much-needed clarification of their foundations, that is, of the core constituent notions of 'knowledge' and 'information'. The rest of this section aims to contribute to the foundational clarification of the notion of 'knowledge'. For a summary presentation of the major views on information as well as a rudimentary theory of information and some of its consequences, see Gelepithis (1997).

Before proceeding with our task, we should stress that epistemology (i.e., the study of knowledge) is a vast area that has been studied for 2,500 years by the greatest minds in philosophy and, increasingly, by scientists in disciplines like psychology, neuroscience, and Artificial Intelligence (AI). This fact is ignored by or unknown to the great majority of books and papers on knowledge management, creating a distorted picture of the issues involved and hence of the appropriate solutions. To illustrate our point we present the following four viewpoints.

The easiest way out of the nexus of problems surrounding knowledge, without really addressing any, is exemplified by Newing's (1999) definition above in which knowledge is taken as something self-explainable or something we all know about and therefore is in need of no explanation at all. I would avoid commenting on such an approach. Let us concentrate on three views by, more or less, well-known workers in knowledge management who do accept not only the importance of the distinction between information and knowledge but also the need to explain what knowledge is.

Borghoff and Pareschi (1998, p. v) write:

"Information consists largely of data organised, grouped, and categorized into patterns to create meaning; knowledge is information put to productive use, enabling correct action. Knowledge is quite different from information, and managing knowledge is therefore decisively and qualitatively different from managing information. Information is converted into knowledge through a social,

human process of shared understanding and sense-making at both the personal level and the organizational level."

This viewpoint, however unintentionally, gives the impression that there are no problems in an area beset with significant issues. For instance, what about all that information that is not put to productive use? Is knowledge creation, however viewed, a manageable process? Why yes or no? Could human knowledge be shared through the use of information and communication technologies (ICT) or even of AI techniques? How information is actually converted into knowledge is a big, significant, and wide open issue.

Consider now a different viewpoint as exemplified by Davenport and Prusak (1998, p. 5):

"Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms."

This view restricts knowledge to informal expertise and assumes the incorporation of values. However valuable tacit knowledge is, it is definitely not the full story. The reader may juxtapose this view with the following two classification schemes attempting to specify what types of knowledge are most important for an organisation.

First according to Savage as quoted in Skyrme (1999):

- Know-how — a skill, procedures.
- Know-who — who can help me with this question or task.
- Know-what — structural knowledge, patterns.
- Know-why — a deeper kind of knowledge understanding the wider context.
- Know-when — a sense of timing, and rhythm.
- Know-where — a sense of place, where is it best to do something.

The second classification, due to Quinn, Baruch, and Zien (1997, pp. 2-3), structures the knowledge of an enterprise into the following five levels of increasing importance:

- Cognitive knowledge (or know what) — the rules and facts of a discipline.
- Advanced skills (know how) — the capacity to perform a task sufficiently well to compete effectively.
- System understanding (know why) — understanding the interrelationship and pacing rates of influences among key variables.
- Motivated creativity, discovery, or invention (care why) — the capacity to interrelate two or more disciplines to create totally new effects.
- Synthesis and trained intuition (perceptive how and why) — the capacity to understand or predict relationships that are not directly measurable.

It is interesting to note that both schemes accept the importance of the notions of understanding and sense (i.e., meaning) in, at least, some cases, but choose not to address the foundational issues involved.

We come now to our preliminary analysis of the nature of 'knowledge.' First, a couple of remarks and a disclaimer. The debate on the nature of 'knowledge' is far from settled and it is well beyond the scope of this chapter to review it. Equally, our analysis is only intended as a first draft outline contribution rather than a fully fledged theory of knowledge. For a philosophical and AI perspective on 'knowledge,' the reader is referred to Pollock (1986) and Newell (1990) respectively.

All theories (more accurately conceptions or schools of thought) of knowledge are based on the notion of belief. Where they differ is their stance on the justifiability of a belief.

We part with this tradition. Our basic building blocks are: a) the notion of meaning; and b) the process of understanding. Specifically, our thesis is that knowledge is the end result of the communication and understanding processes. The previous sentence seems to contradict the one immediately preceding it. It does not; it is coded for brevity and needs to be expanded in order to be clarified. First, both understanding and communication involve meaning. Second, there are two kinds of knowledge: individual and collective. As a first cut, individual knowledge is the end result of the understanding process; and collective knowledge is the end result of all communication processes among the members of a community. We now need to provide appropriate definitions of the related processes of understanding and communication so that proper definitions of individual and collective knowledge can also be given.

Although there had been general agreement that 'communication' involves sharing and 'understanding' (see, for example, Cherry, 1957; Ogden and Richards, 1923; Rogers 1983, 1986), no one had, axiomatically, defined them until Gelepithis (see 1984 for the overall framework and detailed argument, 1991 for a summary and a major key consequence). In what follows, we repeat those definitions and proceed with our analysis.

Definition of communication:

- H1 communicates with H2 on a topic T if, and only if: (i) H1 understands T {Symbol: U(H1 T)}; (ii) H2 understands T {Symbol: U(H2 T)}; (iii) U(H1 T) is describable to and understood by H2; and (iv) U(H2 T) is describable to and understood by H1.

Definition of understanding:

- An entity E has understood something, S, if and only if, E can describe S in terms of a system of own primitives (i.e., self-explainable notions).

Let us now develop a rudimentary theory of knowledge by clarifying and expanding some of the basic notions of our axiomatic system.

First, one's own primitives may refer to any idea, expression, belief or whatever someone may use to think. Second, primitives are of two kinds: linguistic and non-linguistic. It follows that such primitives may be either formal or informal. Usually, they are informal. Primitives may also be implicitly referred to. It is obvious that what may be a primitive for one person may not be a primitive for another. Even more to the point, what may be a primitive for one may be a complex idea for another. For example, 'water' was a primitive for my grandmother but it is not a primitive for those knowing that 'water' is really H2O. It follows that since one's understanding depends on one's own primitives, it may well vary very significantly from person to person depending on the system of primitives reached by each person on a particular topic by a certain time. Also, since one's primitives may change with time, one's understanding may change as well. Compare, for example, a toddler's primitives with those of a quantum physicist with respect to the notion of electricity (for a discussion, see Gelepithis 1995). In summary, one's understanding depends both on time and on one's primitives. Or, more accurately, it depends on one's own primitives, which in turn depend on time. With these remarks we move on to our definition of individual knowledge:

Knowledge of a topic T for an entity E at time t, is the end result of E's understanding at time t.

It follows that:

Knowledge of E at time t is the system of understandings that E has reached by that time.

This we call E's knowledge system at time t or equivalently, E's individual knowledge at time t (symbol, Ke,t). Obviously, Ke,t is a subsystem of E's semantic system at time t (symbol Se,t). Where, Se,t is the system of all meanings that E has acquired, or has produced, by that time.

Let us see now some further important characteristics of one's individual knowledge, which follow from our analysis so far. First, individual knowledge is both structured and extremely rich. Second, there is a single most important characteristic of both individual human knowledge and of human semantic systems: they both change and, crucially, their changes are unpredictable.

So far we considered only individual human knowledge. There is of course collective human knowledge, which may take two forms: shared (e.g., common beliefs); and shareable (e.g., books, databases). This distinction may be seen better when considering organisational knowledge (sometimes known as organisational memory). Organisational knowledge may refer to two fundamentally different types. First, it may refer to employed individuals and their individual knowledge. This is the most valuable type and the one that the company has no real power over it. Second it may refer to an organisation's databases (whether electronic or paper-based); as such it should better be termed organisational archives. The characteristic of the second type is its static nature. This is in sharp contrast to the claim of writers like Davenport and Prusak (1998, p. 25) that: "[i]n contrast to individual knowledge, organizational knowledge is highly dynamic: it is moved by a variety of forces."

Although extremely interesting, a discussion of collective human knowledge would take us far beyond the scope of this chapter; we, therefore, just make explicit a point we shall use later on. Namely, given the relation between understanding and communication, one easily deduces that individual and collective knowledge necessarily both overlap and they are fundamentally distinct. As a result, both types of human knowledge have both formal and informal elements.

The above definitions and remarks provide a rudimentary but useful body of knowledge. Let us see what consequences do follow from this.

OUTLINE OF CONSEQUENCES

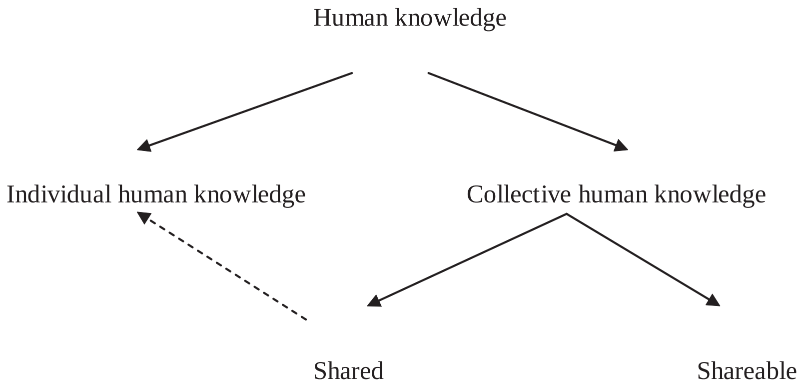
We present three major consequences of our rudimentary theory concerning:

a) The limits of management for a certain class of activities involving knowledge.
b) The scope and limits of technology for the same class of activities.
c) The issue of knowledge market.

The first consequence is both obvious and unlikely to be pleasing. The expression 'knowledge management', when it is not misleadingly used to refer to the management of information, is a misnomer since no-one can manage something that takes place inside another one's mind. Let us clarify this point. As we have seen in the previous section, human knowledge may be partitioned in the way (illustrated in Figure 1).

Where the hyphenated arrow stands for the fact that shared human knowledge is essentially individual human knowledge that is common to more than one human. Furthemore, individual human knowledge is the result of one's complex, internal process of understanding. As such it is not manageable. What we are left with then is shareable human knowledge. Such knowledge in a variety of media (e.g., electronic, paper-based) is fundamentally static and, as it stands, meaningless. In other words, information. It needs to be interpreted by a human to be useful in any way. Such interpreted information becomes inter-

Figure 1. Major partitionings of human knowledge (see text for the meeting of the hyphenated arrow)



nalised and subsequently may provide part of the constituents for further knowledge creation (e.g., innovation). There it is where the management of a company — not knowledge management — can help. It can facilitate the creation and mobilisation of the available intellectual capital (that is, human resources) required for any knowledge-creation activities. Equally, it can create, sustain, or, even better, develop further the appropriate environment that would nurture such activities. This can be extremely valuable but it has nothing to do with managing knowledge.

It is worth noting that those widely accepted as pioneers in what is now called 'knowledge management' (e.g., Itani, 1987; Nonaka 1991) did not talk of knowledge management. Their emphasis was on human resources and how they could be best nurtured so that they can be mobilised and innovate. Nonaka, for instance, talked about the knowledge-creating company and how it could be managed, not about KM. It follows that a more appropriate name for the field would be knowledge nurturing. But that would be, probably, too much to be expected from those managers whose professional behaviour is still, exclusively, hard-science based.

Talking about mobilisation of invisible assets and the knowledge-creating company, Itani and Nonaka identified the key issues needed to be addressed. For our purposes we shall focus our attention to the Identification, Creation, Acquisition, and Sharing of Knowledge or KICAS for short. Their solution is far from clear. Actually, we believe that there cannot be a solution in the traditional sense of the word since they refer to the ongoing, dynamic, and creative processes necessary for the solution of any kind of humanly solvable problem rather than to problems themselves. As such, and taking into account the key characteristics of knowledge as outlined earlier, managers need to become themselves the 'couriers' and, most importantly, the communicators of knowledge within their company. This is, in essence, the major new activity of what Hansen and Oetinger (2001) call T-shaped managers.

The first consequence referred to the limits of management for a certain class of activities, namely, the KICAS nexus of issues and the need for managers to refocus their activities. The second consequence concerns the scope and limits of technology in dealing with the KICAS issues. Without loss of force for our argument, we shall focus on two of the four issues, namely, the creation and sharing of human knowledge. These are the issues emphasised by organisational and management scientists like Nonaka and Takeuchi (1995), Quinn et al. (1997) — under the name diffusion for knowledge sharing — and Skyrme (1999) — under the name knowledge networking for the same issue.

Our second point may best be seen if we start with some historical remarks. The earliest, but neither easy nor permanent, way to solve the KICAS nexus of problems has been to attract the appropriate human(s). This practice, of all organisations, individuals, and states, is still the best prerequisite to the solution of the KICAS nexus of problems. Slowly, the development of networks of knowledgeable people started — sometimes in the form of schools of thought like the Platonic Academy and the Aristotelian Lyceum — and gradually were turned into what we now call Universities or Learned Societies. More recently, companies with sufficient resources started developing their own dedicated resources in the form of R&D departments. Usually, the objective of such divisions is the development of appropriate technology for the benefit of the company. Sometimes the objective was more general, such as developing aids to innovation. Instances are the Myers-Briggs type indicator and the Herrmann Brain dominance instrument (see Leonard and Straus, 1997, for discussion and references).

Most recently, the use of ICT and increasingly AI is at the forefront of developments facilitating innovation and providing solutions to aspects of the KICAS set of problems. Books and edited collections describing models or technological tools for enhancing human interaction or a human's ability to deal with the exponential explosion in exploring one's semantic structure abound (e.g., Quinn et al., 1997; Borghoff and Pareschi, 1998; Skyrme, 1999). What is common in all these developments is that despite the increasing use of artificial aids, the human remains in the loop. We cannot do without her too (see, for instance, Cross and Baird, 2000; Senge and Carstedt, 2001). Let us take a closer look.

In principle, AI/ICT can provide solutions to the following three types of problems:

- Overall integration of information and knowledge sources and tools.
- Identification of appropriately specified information through the use of Search Engines.
- Formalisation of certain aspects of Human Knowledge through R&D in Knowledge representation, and reasoning.

AI/ICT systems though, cannot, on their own, either create or share knowledge. This is a point that is very often overlooked with serious negative consequences. Let us briefly see the reason for these intrinsic limits of the AI/ICT systems.

Such systems may be distinguished into two categories (Gelepithis, 2001). The first category is characterised by tools employing representational systems, which are eventually human-based. Human-based AI systems, whether creative or not, are, at best, axiomatic systems with in-built procedures for the handling of the system's premises. At worst, they are ad hoc systems capable of providing a cost-effective and, quite often, enhanced solution with respect to their human counterparts. A better solution, nevertheless, does not constitute creation of new knowledge. In the best-case scenario, they are capable of producing consequences some of which are bound to be new. Such a capability is of course very desirable but it is ultimately checked and evaluated by humans. In other words, novel human knowledge could only be created by humans; creative AI systems, even in principle, can only create new consequences of existing knowledge. Creation of novel human knowledge is species-specific.

It should be noted that although humans are the only creators of novel human knowledge, ICT and in particular AI can facilitate the creation of such knowledge through the development of tools enabling: (a) increased connectivity within the semantic system of humans; and (b) increased and enhanced human-human communication. I believe the latter is what Skyrme (1999) calls knowledge networking.

The second category — say R — not yet developed but feasible, will be characterised by systems possessing their own representational systems, that is, by representational systems independent of the language of another kind of system —say human. Such systems will be able to create novel knowledge, but such knowledge will not be necessarily understood by humans. To be precise such knowledge will be understandable by humans only to the extent that it will be formalised. This is a point that need not concern us here though and we shall not expand on it (for more information on the two fundamental categories of representational systems, the reader is referred to Gelepithis (1995)).

We come now to our third consequence: a knowledge market is not implementable. The first thing that any knowledge market would need is a system that would measure knowledge. This is a requirement that, probably, the great majority would agree on but nobody has, so far, proposed a solution to it. Of course, no solution yet does not imply no solution ever. In what follows we first present two claims and one argument for the implementability of a 'knowledge market', and subsequently we briefly outline our argument against.

The first viewpoint may be termed the 'blind faith to market forces' approach. According to this, the situation in trying to create a knowledge market is problematic but: "Given time, market forces will undoubtedly take care of the situation" (Burton-Jones, 1999, p. 221). The second viewpoint may be termed the 'shifting the goalposts' approach. Its extreme form is illustrated by Gamble and Blackwell (2001, p. 185). They remark: "It is almost axiomatic in management that what you cannot measure you cannot manage." Unfortunately, the next step they go to is to create a metric for a "knowledge management initiative." No comments.

An almost acceptable 'shifting the goalposts' viewpoint has been put forward by Davenport and Prusak (1998). They first introduce the elements of a 'knowledge market' and subsequently they discuss its inefficiencies and pathologies as well as ways to overcome them. For the purpose of this chapter, we focus our attention on their presentation of the characteristic elements of a 'knowledge market'. Their starting point is that knowledge markets exist although not as "pure" markets (i.e., markets that operate solely in economic terms). On that basis they try to establish the elements for a good knowledge market. They see three:

"first of all, to recognize that market forces exist; second, to try to understand how it functions; and third, to make it more efficient" (ibid, p. 26).

On market forces they distinguish three players: buyers, sellers, and brokers. The problem is that the object of their transactions although named to be knowledge is, essentially, information. The two notions are related, but as we know, they are fundamentally distinct. Their next step is the mechanism of the knowledge market, that is, its price system. They claim that a price system for a knowledge market revolves around the notions of: money, reciprocity, reputation, altruism, and trust. In a nutshell they recognise that money is far from adequate and believe that reciprocity, reputation, and altruism (these three in diminishing degree), as well as their combinations, constitute the substitute for money. Since transactions involving reciprocity, reputation, and altruism do not constitute payment in the traditional monetary sense of the term, they are forced to introduce the notion of trust as the necessary factor for the workings of such a market. But trust is one of the goods (the other two are loyalty, and truth-telling), cited by Nobel Laureate Arrow (1974, p. 22), which "cannot, in principle, be taken as commodities in the market sense."

Linking knowledge to truth or truth-telling is an avenue worth taking and fully exploring but it is well beyond the scope of this chapter. Instead, we briefly outline here why a 'compromised' knowledge market of the sort that Davenport and Prusak have considered cannot really function by commenting on the first two elements of their methodology. In other words, we assume that markets require two elements for their existence. First, an object to be transacted among their players. Second, a price system as its mechanism for the transactions. Let us see why these two requirements are not applicable in the case of knowledge.

Attaining knowledge is a process whereby the start and end points are difficult if not impossible to define. The expert is knowledgeable in his particular field because of an integration of a number of factors such as factual information, experience and intuition. This process is ongoing, and even when a knowledgeable state is achieved the learning process still continues. Therefore knowledge is a special state or process which cannot be seen as a commodity. Davenport and Prusak's (1998) buyers, sellers, and traders cannot trade in knowledge but only in information.

When an expert gives some advice or judgment, we are gaining information that is based on his or her knowledge. We may say that the more knowledgeable the expert, the more valuable the information gleaned. Therefore what companies should be aiming to do is create the environment that allows the knowledge process and state to be achieved. The information resulting from such environments can be marketed. It is important to make the distinction between the two. Information can be treated as a commodity but the knowledge environment that produces the information is not subject to market forces.

Some may argue that 'knowledge' markets have existed, at least since humans started exchanging goods they produced themselves, for any good produced was bound to involve the use of some 'knowledge' at some point in the production process. Nevertheless, what was traded was the good produced, not the 'knowledge' involved in its production. The reason is simple. The 'knowledge' involved in the production of goods was but one element of a complex internal process. In those earlier times, that process was simply beyond any sort of measure. It is still today, and it will be tomorrow, because it involves too many tacit elements. The formal-informal boundary will keep shifting, creating ever larger areas of formalised knowledge and, at the same time, revealing larger areas of informal knowledge. Again a full discussion of this point exceeds the confines of this chapter.

Goods are there to be checked, compared against similar ones, and eventually assigned a price. Goods are objective entities persisting, more or less invariably, through considerable time intervals. Human knowledge, both individual and collective, changes. What is more, it changes unpredictably. No manager would wish to purchase a car that could be turned into a 10-meter boa constrictor. Seriously now, what should be the value of the 21st century equivalent of Newton's laws? How much should one pay for that imperceptible, yet consciously made, grimace that reveals a no-purchase of company-X? Human knowledge is not a rose, a cup, or a massage.

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REFERENCES

Arrow, K. (1974). *The limits of organization*. New York: W. W. Norton & Company.

Borghoff, U. M., & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management.* New York: Springer.

Burton-Jones, A. (1999). *Knowledge capitalism: Business, work, and learning in the new economy.* Oxford: Oxford University Press.

Cherry, C. (1978). *On human communication: A review, a survey, and a criticism* (3rd ed.). New York: The MIT Press.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 69-78.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dempsey, M. (1999). The need for vigilance in the information battle. Knowledge Management, *Financial Times Survey,* (November 10), 2.

Gamble, P. R., & Blackwell, J. (2001). *Knowledge management: A state of the art guide.* Kogan Page.

Gelepithis, P. A. M. (1984). *On the foundations of artificial intelligence and human cognition*. PhD Thesis, Brunel University, UK.

Gelepithis, P. A. M. (1991). The possibility of machine intelligence and the impossibility of human-machine communication. *Cybernetica, XXXIV*(4), 255-268.

Gelepithis, P. A. M. (1995). Revising Newell's conception of representation. *Cognitive Systems, 4*(2), 131-139. (Special issue on representation)

Gelepithis, P. A. M. (1997). A rudimentary theory of information: Consequences for information science and information systems. *World Futures, 49*, 263-274.

Gelepithis, P. A. M. (2001). *Intelligent systems Volume 1: Knowledge representation, social and psychological impact of artificial intelligence.* Athens, Hellas: Stamoulis Editions, Averof st. (In Greek)

Gupta, A. K., & Govindarajan, V. (2000). Knowledge management's social dimension: Lessons from Nucor Steel. *Sloan Management Review, 42*(1), 71-80.

Hansen, M. T., & von Oetinger, B. (2001). Introducing T-shaped managers: Knowledge management's next generation. *Harvard Business Review,* (March), 107-116.

Itani, H. (1987). Mobilizing invisible assets. Boston: Harvard University Press.

Leonard, D., & Straus, S. (1997). Putting your company's whole brain to work. *Harvard Business Review on Knowledge Management,* 109-136.

Malhotra, Y. (2000). Knowledge management and new organization forms: A framework for business model innovation. In Y. Malhotra (Ed.), *Knowledge management and virtual organisations.* Hershey, PA: Idea Group Publishing.

Newell, A. (1990). Unified theories of cognition. Boston: Harvard University Press.

Newing, R. (1999). Connecting people: Both through IT and face-to-face. Knowledge Management, *Financial Times Survey,* (November 10), 2.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review on Knowledge Management,* 21-45.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford: Oxford University Press.

Ogden, C. K., & Richards, I. A. (1923, 1956). *The meaning of meaning.* New Jersey: Harcourt Brace and Co.

Pollock, J. L. (1986). *Contemporary theories of knowledge.* Hutchinson.

Quinn, J. B., Baruch, J. J., & Zien, K. A. (1997). *Innovation explosion: Using intellect and software to revolutionize growth strategies.* New York: The Free Press.

Rogers, E. M. (1983, 1986). Elements of diffusion [Extracts from Chapter 1 of Rogers, E. M. (Ed.) (1983), Diffusion of Innovations, 3rd ed., New York: The Free Press.] In R. Roy & D. Wield (Eds.)*, Product design and technological innovation.* Open University Press.

Senge, P. M., & Carstedt, G. (2001). Innovating our way to the next industrial revolution. MIT *Sloan Management Review, 42*(2), 24-38.

Skyrme, D. J. (1999). *Knowledge networking: Creating the collaborative enterprise.* Oxford: Butterworth Heinemann.

Vernon, M. (1999). Enhancing links to the customer. Knowledge Management, *Financial Times Survey*, (November 10), 10.

Chapter 4.11
Knowledge Sharing Barriers

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INTRODUCTION

To ensure continued existence, an organization must develop ways to share the knowledge that is possessed within that organization with the people who need, or who will need, that knowledge. This critical organizational task transcends departmental boundaries and is a necessary element for the maintenance of every organizational function. Improving the efficiency of knowledge sharing is a highly desirable goal because it offers a promise of compounded returns as the organization works harder and smarter. As business practices have developed over the last few decades, knowledge workers have developed a variety of mechanisms and routines to share knowledge, but these have not yet been well studied. Specifically, the barriers to knowledge sharing remain somewhat elusive.

A better understanding of the knowledge-sharing process may provide managers with a set of tools that could be used to identify and combat barriers to knowledge sharing, which could lead to much more efficient organizational routines. In this article, the process of knowledge sharing will be examined by framing the knowledge-sharing transaction as a form of communication in order to identify and isolate the barriers to that type of communication. Once the barriers are isolated, they can be overcome.

BACKGROUND

In order to manage knowledge, researchers must first develop an understanding of the way that knowledge flows through an organization. The flow of knowledge is reflected in the most basic construct of this article: knowledge sharing. Opposing that flow of knowledge, barriers to knowledge sharing present a challenge to every organization. However, when the managers of an organization embark on a journey to improve knowledge sharing within that organization, they are met by a host of confusing issues. If they review the literature, they find a wide variety of issues that are thought to prevent knowledge sharing, each of which is typically deemed the most critical by the researcher who is promoting it. If they hire outside consultants, they may be offered solutions to problems that they do not even have. Until the managers are able to objectively measure how the specific barriers to knowledge sharing are perceived to exist within their organization, they will be unsure of the optimum method of overcoming those barriers. The first step to objectively measuring knowledge workers' perceptions of barriers to knowledge sharing in an organizational environment is the identification of the many barriers to knowledge sharing that exist within the organization.

It is proposed that barriers to knowledge sharing should actually be measured in terms of knowledge workers' perceptions of barriers to knowledge sharing. Though the difference is subtle, it acknowledges the fact that many decisions are made on a subconscious level, and that there is no surety that knowledge workers are cognizant of the particular barriers that they face, or even if they are, they will not always act rationally to promote the organizational good. In addition, even when knowledge workers understand why they act, they may not be able to explain their actions to researchers, and thus their perceptions must be used as a proxy to measure the effect of a barrier to knowledge sharing.

The concept of knowledge sharing is best illustrated by Foy (1999, p. 15.2): "facilitating learning, through sharing, into usable ideas, products and processes." This definition implies that the focus should be on sharing knowledge within an organization for a specific purpose. Thus, this concept diverges somewhat from the field of learning (because learning may or may not have an organizational imperative or objective) but may still draw from that field because learning is an artifact from the knowledge-sharing process.

UNMASKING BARRIERS TO KNOWLEDGE SHARING

The Knowledge-Sharing Process

A common tendency in knowledge management (KM) research has been to build on the work to understand knowledge that was begun in the 1960s. Polanyi (1962, 1967), who introduced the concepts of tacit and explicit knowledge, is widely cited. Nonaka's (1994) and Nonaka and Takeuchi's (1995) further research into the way that knowledge is created in organizations has also been of significant influence. Perhaps because of these three great contributors, most of the constructs that have been researched as possible barriers to knowledge sharing are cognitive or behavioral based. From the factors-for-success literature (Bennett & Gabriel, 1999; Broadbent, Weill, & St. Clair, 1999; Davenport & Prusak, 1998; Purvis, Sambamurthy, & Zmud, 2001), an emphasis has been placed on determining the factors that enable KM systems. The globalization research (Chow, Deng, & Ho, 2000; Gupta & Govindarajan, 2000; Hofstede, 1980; Hofstede, Neijen, Ohayv, & Sanders, 1990; Okunoye, 2002) emphasizes culture, including both the national and the organizational culture. McDermott and O'Dell (2001) found that organizational culture was more important to knowledge sharing than the approach or commitment to KM.

Barriers to Knowledge Sharing

The KM literature yields several articles that describe knowledge sharing as it occurs in sample organizations. KM researchers have identified a host of barriers to knowledge sharing, but generally focus on a single knowledge-sharing context. The issues that could potentially constitute barriers to knowledge sharing that have been identified in the KM literature are summarized in Table 1.

Table 1. Summary of potential barriers to knowledge sharing

Study	Issues
APQC (1996)	culture, technology, measurement
Buckman Model (1998)	simplicity, access, usability, motivation to participate
Okunoye (2002)	operating environmental factors, national culture and beliefs, local orientation
Bock & Kim (2002)	associations, contribution, (but not reward)
Fraser, Marcella & Middleton (2000)	lack of a *knowledge-sharing facility*
Weiss (1999)	time limitations, lack of rewards, common practices in professional services, lack of recognition, lack of reciprocity
Ellis (2001)	contribution, accuracy, recognition
Dixon (2002)	absorptive capacity, understanding of the context, perception that gaining knowledge will be of worth, confidence in the knowledge, feeling that the knowledge fits into current context
Hall (2001)	user friendliness
Levina (2001)	low trust, lack of contextual clues, memory loss, discontinuity in progress toward goals, inability to voice relevant knowledge, unwillingness to listen, and differences in unit: subculture, unit goals, local problem constraints, professional cultures, professional goals, specialized languages and methodologies, national cultures, languages
Dyer & Nobeoka (2000)	network that motivates participation, prevention of free riders, and reduction of the costs of knowledge search
McDermott & Odell (2001)	obvious link between knowledge sharing and business problems, tools and structures for knowledge sharing consistent with the overall style of the organization, reward and recognition systems that support knowledge sharing, availability of time
Barson, et al. (2000)	Personal - internal resistance, self-interest, trust, risk, fear of exploitation, fear of contamination, proprietary thinking, skepticism toward sharing, lack of common ground, and fear – of exploitation, contamination, penalty, becoming redundant, losing power, losing resources, losing confidentiality Organizational - targeting, costs, proprietary knowledge, distance, and technological - available technology, legacy systems, efficiency and effectiveness of system, compatibility of system Multidimensional - culture, rewards, and existing resources
Cabrera & Cabrera (2002)	payoffs for contributing, enhanced efficacy perceptions, strengthened group identity and personal responsibility

Note that there are some conflicting factors, such as expected rewards. Barson et al. (2000) and Weiss (1999) determined that rewards were important factors for encouraging knowledge sharing, while Bock and Kim (2002) found rewards were not significant. This conflict is disturbing, however, these researchers examined differing sets of barriers and used different knowledge-sharing contexts, and these differences could account for the differing results.

Communications

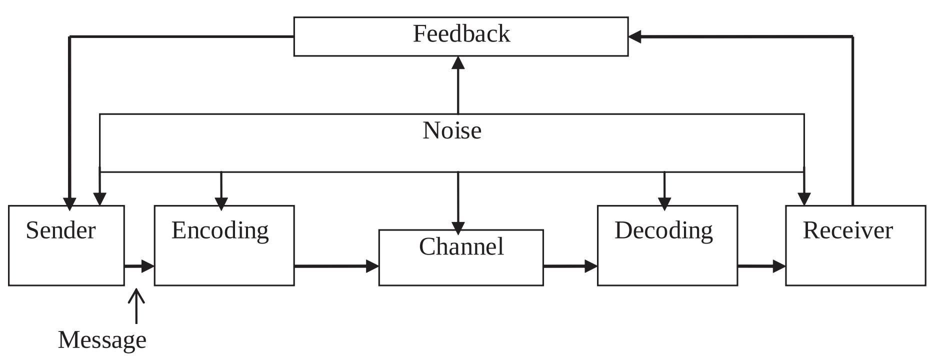
In just over 50 years, a great deal of communications research has been conducted, and this research has the potential to contribute some rigor to the field of KM. Though communications research initially ignored context, some recent results have noted the potential importance of context when the message to be communicated is complex. The work of Tucker, Meyer, and Westerman (1996) indicated that communication processes that enhance shared experiences (context) could result in improved organizational performance. The issue of context and the way that context emerges was further addressed by Augier, Shariq, and Vendelo (2001). They investigated the ways that context might emerge and be transformed, and the relationship between context and knowledge sharing. Consistent with Tucker et al., they found that context emerges as a result of the experiences that an individual brings to a situation. They also determined that context may subsequently transform over time as an individual's experiences change. Their final finding constitutes an important rationale to pursue the current research. They found that, for complex, unstructured problems, knowledge sharing will not occur unless there is a shared context. This research supports the conclusions drawn from the KM research that context is a variable that should be explicitly manipulated.

The Communication Process

This section will develop the communication model that will form the communication framework for evaluating knowledge sharing. The communication model employed in this research is presented in Figure 1. This model will be used to facilitate the identification of a complete set of barriers to knowledge sharing by providing a framework that suggests that barriers could be encountered in each area of the model.

This model is based upon the Shannon and Weaver (1949) transmission model of communication, a model suggested by Szulanski (2003) to be fundamental to most research on knowledge transfer. The Shannon and Weaver model has been adapted by Schramm (1965) to model human communication. Schramm made the model somewhat more generic by substituting encoding and decoding for Shannon and Weaver's transmitter and receiver. In addition, since Shannon and Weaver's original model was intended to apply to electronic transmission, noise was only conceptualized to affect the message while it was within the channel. In recognition that human communication is subject to a far wider range of interferences, the model presented in Figure 1 accounts for noise within each step of the communication process. Finally, to acknowledge the importance of meaning and context, a feedback loop is included. The feedback loop is based on the Osgood-Schramm circular model of communication (McQuail & Windahl, 1981), however, while the Osgood-Schramm model conceptualizes communication as an unending circular pattern of messages, this model (with a single feedback

Figure 1. The communications model



loop) acknowledges the directionality of knowledge sharing.

As defined by Jablin (1979), communication is the process used to transfer information and influence from one entity to another. The combination of information and influence could certainly be viewed as knowledge, and thus, the transfer of knowledge from one entity to another could be viewed either as knowledge sharing or communication.

Barriers to Communication

This section reports the result of a literature review to identify potential barriers to knowledge sharing that have been studied from a communications perspective. Table 2 summarizes the barriers to communication that have been addressed in the communications literature. In order to validate the assertion that these barriers are representative of a complete set of barriers to communication, they have been subjectively categorized using the elements of the communication model, and it can be seen that each element is represented. Some barriers are applicable to more than one category, for example, cultural differences apply to both sender and receiver. These barriers are listed only once in the table since only a single entry is necessary for barrier identification.

The communications literature presents a more broad perspective concerning these barriers to communication, and these barriers can clearly be deemed barriers to knowledge sharing. While there is a high degree of duplication, this is only indicative of the close relationship between communication and knowledge sharing.

Summary of Barriers to Communication and Knowledge Sharing

The list of barriers from the KM literature can be supplemented by the list of barriers to communication in order to create a more complete list of barriers to knowledge sharing. It is through this action that the importance of the communication framework is highlighted. After combining both lists, 124 barriers to knowledge sharing are identified. Table 3 presents these barriers, organized in alphabetical order.

Note that there is a significant level of duplication, which was expected since knowledge sharing and communication are similar events. The important issue is that by framing the knowledge-sharing transaction as a communication event, the communication model yielded significantly a larger and richer set of potential barriers to knowledge sharing derived from the communications literature.

FUTURE TRENDS

The most pressing issue is the resolution of conflicting reports, such as the importance of expected rewards. Recall that Barson et al. (2000) and Weiss (1999) determined that rewards were important factors for encouraging knowledge sharing, while Bock and Kim (2002) found rewards were not significant. As these researchers examined differing sets of barriers and used different knowledge-sharing contexts, this conflict is not an indication that some of the research may have been faulty. By analyzing a single, comprehensive set of barriers to knowledge sharing, future researchers may be able to resolve conflicts such as this.

Another important need is to analyze these barriers to knowledge sharing for context dependency. Recent research by Augier et al. (2001) noted that knowledge sharing requires a shared context, so it is possible that when the knowledge-sharing context changes, the barriers to knowledge sharing may change as well. Now that a single broad set of potential barriers to knowledge sharing has been identified, the set may be analyzed over several different knowledge-sharing contexts to determine whether knowledge workers' perceptions of these barriers change with the conditions.

Table 2. Summary of potential barriers to communication

Category	Study	Issues
Sender		
	Blagdon (1973)	power and status relationships, information ownership
	Golen & Boissoneau (1987)	status or position, poor organization of ideas
	Gupta & Govindarajan (2000)	motivational disposition of source (willingness to share), perceived value of source unit's knowledge
	Johlke, Duhan,	ambiguity regarding ethical situations, peers, or rewards
	Lewis (2000)	communicating goal achievements
Encoding		
	Blagdon (1973)	specialization of jobs
	Bennett & Olney (1986)	poor communication skills (lack of clarity and conciseness)
	Golen & Boissoneau (1987)	know-it-all attitude
	Hulbert (1994)	cultural differences play a significant role in encoding/decoding messages
	Buckman (1998)	global constraints including culture
Channel		
	Westmeyer, DiCioccio, & Rubin (1998)	appropriateness of a channel, effectiveness of a channel
	Weiss (1999)	use of static channels, use of dynamic channels
	Gupta & Govindarajan (2000)	existence and richness of transmission channels
	Johlke et al. (2000)	communication mode
Feedback		
	Golen & Boissoneau (1987), Messmer (1998)	improper feedback
	Lewis (2000)	sense making and feedback
Message		
	Johlke et al. (2000)	communication content, communication direction, communication frequency
Decoding		
	Golen (1980)	tendency not to listen
	Golen, Burns, & Gentry (1984)	information overload
	Rogers & Roethlisberger (1991)	tendency of the receiver to evaluate
	Golen & Boissoneau (1987)	defensiveness, differences in perceptions, emotional reactions, inability to understand nonverbal communication, prematurely jumping to conclusions, information overload, tendency not to listen
	Messmer (1998)	state of mind, preoccupation with an ongoing task, passive listening
Receiver		
	Golen (1980)	communicator's lack of credibility, hostile attitude
	Golen et al. (1984)	personality conflicts
	Golen & Boissoneau (1987)	lack of credibility, lack of interest in the subject matter, lack of subject-matter knowledge, lack of trust, lack of understanding of technical language, personality conflicts, prejudice or bias, resistance to change, hostile attitude, overly competitive attitude, either-or thinking
	Golen, Catanach, & Moeckel (1997)	credibility/background, conflict
	Gupta & Govindarajan (2000)	absorptive capacity of receiving unit, motivational disposition of receiving unit
	Lewis (2000)	establishing legitimacy
Noise		
	Blagdon (1973)	physical distance between members of an organization
	Golen & Boissoneau (1987)	inappropriate physical appearance, speaking too loudly, fear of distortion or omission of information, informal social groups or cliques, too many gatekeepers, physical distance between members of an organization, poor spatial arrangements, physical noise and distractions, use of profanity
	Buckman (1998)	structural barriers associated with hierarchical organizations
	Messmer (1998)	ambiguity regarding the knowledge-sharing task or procedures
	Johlke et al. (2000)	ambiguity regarding customers, ambiguity regarding supervisor support
	Lewis (2000)	creating and communicating vision
	McPhee, Corman, & Dooley (2002)	employees know what the knowledge is
	Lehr & Rice (2002)	use of measures

Table 3. Combined list of barriers to knowledge sharing

absorptive capacity of receiving unit
access to the knowledge
ambiguity regarding:
  ethical situations
  knowledge seekers
  peers
  reward
  supervisor support
  the knowledge-sharing task
  professional goals
appropriate communication mode
appropriateness of the sharing channel
availability of:
  dynamic channels to share knowledge
  knowledge-sharing technology
  static channels to share knowledge
  time to dedicate to knowledge sharing
communication direction
communication frequency
communication of organizational vision
communicator's lack of credibility
compatibility of legacy systems
sharing systems
confidence in the knowledge
cultural differences
defensiveness for gaining knowledge
desire to retain information ownership
differences in perceptions of workers
discontinuity in progress toward goals
effectiveness of sharing channel
effectiveness of the sharing system
efficiency of the sharing system
either-or thinking
emotional reactions to sharing
employees can identify the knowledge
richness of transmission channels
existing resources sufficient to share
expected:
  associations with other sharers
  contribution to the organization
  recognition for sharing knowledge
  rewards for sharing knowledge
obvious link between sharing and
  the business' problems
operating environmental factors
org. communicates goal achievements
overly competitive attitude
passive listening
perceived value of source's knowledge
perception that knowledge will be of worth
personality conflicts
physical distance between workers
physical noise and distractions
poor communication skills (lack of)
poor organization of ideas
poor spatial arrangements
power and status relationships
prejudice or bias
prematurely jumping to conclusions
preoccupation with an ongoing task
prevention of free riders
professional cultures
proprietary knowledge
proprietary thinking
questionable accuracy of information
receiver perceives enhanced efficacy
feeling that the knowledge fits current context
fear of:
  becoming redundant
  distortion or omission of information
  exploitation once knowledge is shared
  losing confidentiality
  losing power once knowledge is shared
  losing resources once knowledge is shared
  penalty if knowledge is shared
  risk
global constraints including culture
high costs of knowledge search
hostile attitude toward knowledge sharing
improper feedback
inability to understand nonverbal cues
inability to voice relevant knowledge
inappropriate physical appearance
informal social groups or cliques
information overload
internal resistance to knowledge sharing
know-it-all attitude
knowledge-sharing structures match compatibility of
  the organization's style
knowledge-sharing system simplicity
knowledge workers have a local orientation
lack of:
  a knowledge-sharing facility
  clarity and conciseness
  common ground
  contextual clues
  interest in the subject matter
  motivation to participate
  reciprocity
  subject-matter knowledge
  trust
  understanding of technical language
  willingness to share
local problem constraints
measurement of knowledge transfer
memory loss
motivational disposition of source
multiple languages used by knowledge workers
resistance to change
satisfactory content of the sharing transaction
self-interest
sender must establish legitimacy
sense making
skepticism toward sharing
specialization of jobs
specialized languages and methodologies
state of mind
status or position
strengthened group identity
strengthened personal responsibility
structural barriers in hierarchical organizations
tendency of the receiver to evaluate
time limitations
too many gatekeepers
understanding of the context
unit goals
unit subculture
unwillingness to listen
usability of the knowledge
use of a network that motivates participation
user friendliness of knowledge-sharing system

An important prerequisite for measuring context dependency is the development of an instrument to measure knowledge workers' perceptions of which barriers pertain to their specific knowledge-sharing task. Once a valid, reliable tool for identifying which barriers are important within an organization is made available, future researchers may then study a large number of organizations in order to draw general conclusions about knowledge workers.

After common barriers to knowledge sharing are identified, researchers can then work to develop ways to manage and improve the knowledge-sharing process in order to lessen (or even eliminate) the greatest barriers. This action could unlock vast organizational potential by improving the efficiency of knowledge sharing within an organization.

CONCLUSION

The exhaustive list of barriers to knowledge sharing presented in Table 3 begs reduction through further analysis. The Delphi method could be used to do this and to rank the factors accordingly; alternatively, factor analysis could be employed to reduce the data and detect structure in the relationships between them. A third alternative, which may be more difficult to accomplish but is of greater value to the development of management practices, would be to devise a field experiment to observe how knowledge workers perceive each of these barriers. By adopting a communications framework, this comprehensive set of potential barriers to knowledge workers was derived, and now this set can provide a structure for the objective analysis of all barriers simultaneously. Researchers can analyze these barriers in an organizational environment to determine which, if any, are most important, or at least which are perceived to be most important to knowledge workers. By sampling a large number of individuals, a pattern may be seen to emerge indicating areas that are worthy of management attention.

Knowledge sharing is a field that, as of yet, has not received a great deal of researcher attention. Rigorous research, based in theory, concerning knowledge sharing and the barriers to knowledge sharing can help frame this field as a legitimate academic pursuit and provide a basis for the discovery of fundamental truths that may be of real use to managers as the need for knowledge sharing becomes more important.

REFERENCES

Alavi, M. & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

American Productivity and Quality Center (APQC). (1996). *Knowledge management: Consortium benchmarking study final repor*t. Retrieved November 14, 2002, from http://www.store.apqc.org/reports/Summary/knowmng.pdf

Augier, M., Shariq, S., & Vendelo, M. (2001). Understanding context: Its emergence, transformation and role in tacit knowledge sharing. *Journal of Knowledge Management, 5*(2), 125-136.

Barson, R. J., Foster, G., Struck, T., Ratchev, S., Pawar, K., Weber, F., et al. (2000). *Inter- and intra-organisational barriers to sharing knowledge in the extended supply chain.* Retrieved December 2, 2002, from e2000 conference proceedings Web site: http://www.corma.net/download/e2000.doc

Bennett, J. C., & Olney, R. J. (1986). Executive priorities for effective communication in an information society. *The Journal of Business Communication, 23*(2), 13-22.

Bennett, R., & Gabriel, H. (1999). Organisational factors and knowledge management within large marketing departments: An empirical study. *Journal of Knowledge Management, 3*(3), 212-225.

Blagdon, C. (1973). Barriers to communication. *Business Communication Quarterly, 36*(3), 12.

Bock, G. W., & Kim, Y. G. (2002). Breaking the myths of rewards: An exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal, 15*(2), 14-21.

Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23*(2), 159-182.

Buckman, R. H. (1998). Knowledge sharing at Buckman Labs. *The Journal of Business Strategy, 19*(1), 11-15.

Cabrera, A., & Cabrera, E. F. (2002). Knowledge-sharing dilemmas. *Organization Studies, 23*(5), 687-710.

Chow, C. W., Deng, F. J., & Ho, J. L. (2000). The openness of knowledge sharing within organizations: A comparative study in the United States and the People's Republic of China. *Journal of Management Accounting Research, 12*, 65-95.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dixon, N. (2002). The neglected receiver of knowledge sharing. *Ivey Business Journal, 66*(4), 35-40.

Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal, 21*(3), 345-367.

Ellis, K. (2001). Dare to share. *Training, 38*(2), 74-77.

Foy, P. S. (1999). Knowledge management in industry. In J. Liebowitz (Ed.), *Knowledge management handbook* (pp. 15.1-15.10). New York: CRC Press.

Fraser, V., Marcella, R., & Middleton, I. (2000). Employee perceptions of knowledge sharing: Employment threat of synergy for the greater good? A case study. *Competitive Intelligence Review, 11*(2), 39-52.

Golen, S., Burns, A. C., & Gentry, J. W. (1984). An analysis of communication barriers in five methods of teaching business subjects. *The Journal of Business Communication, 21*(3), 45-52.

Golen, S. P. (1980). An analysis of communication barriers in public accounting firms. *The Journal of Business Communication, 17*(5), 39-51.

Golen, S. P., & Boissoneau, R. (1987). Health care supervisors identify communication barriers in their supervisor-subordinate relationships. *Health Care Supervisor, 6*(1), 26-38.

Golen, S. P., Catanach, A. H., Jr., & Moeckel, C. (1997). The frequency and seriousness of communication barriers in the auditor-client relationship. *Business Communication Quarterly, 69*(3), 23-37.

Gupta, A., & Govindarajan, V. (2000). Knowledge flows in multinational corporations. *Strategic Management Journal, 21,* 473-496.

Hall, H. (2001). Input-friendliness: Motivating knowledge sharing across intranets. *Journal of Information Science, 27*(3), 139-146.

Hofstede, G. (1980). *Culture's consequences.* Beverly Hills, CA: Sage.

Hofstede, G., Neijen, B., Ohayv, D. D., & Sanders, G. (1990). Measuring organizational cultures: A qualitative and quantitative study across twenty cases. *Administrative Science Quarterly, 35*(2), 286-316.

Hulbert, J. E. (1994). Overcoming intercultural communication barriers. *The Bulletin of the As-*

sociation for Business Communication, 57(1), 41-44.

Jablin, F. M. (1979). Superior-subordinate communication: The state of the art. *Psychological Bulletin, 86*, 1201-1222.

Johlke, M. C., Duhan, D. F., Howell, R. D., & Wilkes, R. W. (2000). An integrated model of sales managers' communication practices. *Journal of the Academy of Marketing Sciences, 28*(2), 263-277.

Lehr, J. K., & Rice, R. E. (2002). Organizational measures as a form of knowledge management: A multitheoretic, communication-based exploration. *Journal of the American Society for Information Science and Technology, 53*(12), 1060-1073.

Levina, N. (2001). Sharing knowledge in heterogeneous environments [Electronic version]. *Reflections: The SoL Journal, 2*(2), 32-42.

Lewis, L. K. (2000). Communicating change: Four cases of quality programs. *The Journal of Business Communication, 37*(2), 128-155.

McDermott, R., & O'Dell, C. (2001). Overcoming cultural barriers to sharing knowledge. *Journal of Knowledge Management, 5*(1), 76-85.

McPhee, R. D., Corman, S. R., & Dooley, K. (2002). Organizational knowledge expression and management. *Management Communication Quarterly: McQ, 16*(2), 274-281.

McQuail, D., & Windahl, S. (1981). *Communication models for the study of mass communications.* London: Longman.

Messmer, M. (1998). Improving your listening skills. *Strategic Finance, 79*(9), 14.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.

Okunoye, A. (2002). Where the global needs the local: Variation in enablers in the knowledge management process. *Journal of Global Information Technology Management, 5*(3), 12-31.

Polanyi, M. (1962). *Personal knowledge: Toward a post-critical philosophy.* New York: Harper Torchbooks.

Polanyi, M. (1967). *The tacit dimension*. London: Routledge & Keoan Paul.

Purvis, R. L., Sambamurthy, V., & Zmud, R. W. (2001). The assimilation of knowledge platforms in organizations: An empirical investigation. *Organization Science, 12*(2), 117-135.

Rogers, C. R., & Roethlisberger, F. J. (1991). Barriers and gateways to communication. *Harvard Business Review, 69*(6), 105-111.

Schramm, W. (1965). How communication works. In W. Schramm (Ed.), *The process and effects of mass communication* (pp. 3-26). Urbana, IL: University of Illinois Press.

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication.* Urbana, IL: University of Illinois Press.

Szulanski, G. (2003). *Sticky knowledge: Barriers to knowing in the firm.* Thousand Oaks, CA: Sage.

Tucker, M. L., Meyer, G. D., & Westerman, J. W. (1996). Organizational communication: Development of internal strategic competitive advantage. *The Journal of Business Communication, 33*(1), 51-69.

Weiss, L. (1999). Collection and connection: The anatomy of knowledge sharing in professional service firms. *Organization Development Journal, 17*(4), 61-77.

Westmeyer, S. A., DiCioccio, R. L., & Rubin, R. B. (1998). Appropriateness and effectiveness of communication channels in competent interpersonal communication. *Journal of Communications, 48*(3), 27-36.

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Chapter 4.12
Institutional Research (IR) Meets Knowledge Management (KM)

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ABSTRACT

In this study, a selected university's capacity to provide necessary and meaningful information under a KM framework in order to guide it through its current and new and sweeping initiatives was examined. Specifically, information generated from a university-created Study Committee charged with studying the IR function and key units that perform this function were analyzed. A critical analysis of the committee, its methodological approach to studying the IR function, the IR units, and the findings of the committee was conducted. It was found that KM principles were employed in a limited fashion, and that no knowledge creation was taking place. Another key finding was that the primary focus of the committee and a key unit in the IR function were much more concerned about the decision support systems and their ability to provide good data that, in turn, they believed would lead to excellent decision-making.

INTRODUCTION

Universities and colleges across the United States have an inherent desire and need to establish data/information systems in order to support and, purportedly, to optimize decision-making. In a changing higher education marketplace, this could not be any more central to universities' ability to compete and self-direct in ways that afford them comparative advantages in such a competitive marketplace. As a result of increasing competition and the creation of the field of knowledge management (KM) in the early 1990s, universities have moved in a direction that captures the cumulative endowment of knowledge that universities hold. In order to remain competitive and strategically contend with market forces, universities are engaged in this fast-moving field of knowledge management in several areas: human resources, organizational development, change management, information technology, brand and reputation management, performance measurement, and evaluation (Bukowitz & Williams, 1999). As the young and popular field of knowledge management continues to emerge, some universities will succeed in aligning their organizational activities with KM principles while others will not; others will only adopt parts of a KM framework. For example, some universities may only develop a capacity for data/information systems but fail to develop capacities in other critical areas that are necessary to interpret information that is created from such systems. That is, they will spend large sums of money building system-wide database warehouses and investing in the people that support such systems but will fail to invest in a commensurate fashion in the human capital needed to interpret the information generated from these systems in order to advise decision makers. Such is the case of Western University, a research extensive university and the subject of analysis for this chapter.

LITERATURE REVIEW

Knowledge Management (KM), a term and movement that was coined by the corporate world (Serban & Luan, 2002), is a fairly young field, yet it has gained momentum in both the public and private sectors. In fact, it is becoming a standard in universities whereby they can harness their cumulative knowledge in order to make informed decision-making by taking data in its raw form and create knowledge for decision-making consumption. KM principles are usually found in institutional research offices at universities, the function of which are explored in the following review of the literature.

Institutional Research (IR)

According to Saupe (1990), "Institutional research is conducted within an institution of higher education to provide information which supports institutional planning, policy formation and decision making" (p. 211). These activities include strategic planning, academic program reviews, environmental scans, enrollment management, faculty productivity analyses, budget analyses, and others. The IR function is a decision support model that is structured around applied and basic research—an approach that involves evaluation, problem identification, action research, and policy analysis.

Typical questions asked in an applied approach may involve questions such as: (1) How many sections of a specific course should be offered? (2) By what amount should tuition rates be increased to produce a target amount of tuition income? (3) What impact would increasing tuition have on access for low-income students? (4) Is attrition a problem at our institution? (5) Are our faculty salaries competitive with those paid by peer institutions? and (6) Are there statistically significant differences in salary between men and women or non-minorities and minorities?

As an evaluation function IR addresses the following areas: (1) information on cost and productivity that underlie judgments about efficiency; (2) information on other characteristics of programs, units, and outcomes that lead to judgments about effectiveness or quality; and (3) information on program purposes, on programs offered by other institutions, on the labor market and on potential demand that produce judgments about the need for academic programs.

Problem identification may surface when looking at results from routine queries or tabulations. For example, in the course of querying data for a routine retention report it might be found that certain racial/ethnic groups experience lower rates of persistence from year to year and overall retention during a six-year time period. An action research approach in IR, perhaps, holds the greatest promise for addressing complex questions such as this. IR offices are where the researcher and client (anyone in the organization) work closely throughout the problem definition, research design, data collection, analysis, interpretation, and implementation phases of the project. That is, the institutional researchers work with units throughout the organization in a consultative manner.

KM Overview

According to Serban and Luan (2002), "KM is the systematic and organized approach of organizations to manipulate and take advantage of both explicit and tacit knowledge, which in turn leads to the creation of new knowledge" (p. 8). On the one hand, Crowley (2000) argues that explicit knowledge is easily codified and transmittable in systematic language. On the other hand, Kidwell, Vander Linde, and Johnson (2000) suggest that tacit knowledge is personal, context-specific, difficult to articulate, and often poorly documented. However, Firestone and McElroy (2003) suggest that the dichotomy between explicit and tacit knowledge does not go far enough. In fact, he suggests that tacit knowledge can be made explicit. However, this goal is difficult to achieve in complex organizations such as higher education institutions. One of the greatest ironies in higher education is that such organizations' core business is to create, transform, and transmit knowledge, yet, they tend to lack organized knowledge management systems that may allow them to optimize institutional decision-making (Kidwell, Vander Linde, & Johnson, 2000; Laudon & Laudon, 1999).

IR Meets KM

Serban & Luan, (2002) present a careful overview of KM in the context of Institutional Research (IR). IR and strategic planning have multiple functions in colleges and universities. Joe Saupe (1990), perhaps, provides us with one of the best descriptions of the nature of institutional research, of its role in institutional governance and of the contributions it can make to the function of post-secondary institutions. J. Fredericks Volkwein (1999) provides us with a comprehensive volume about institutional research. Andrea M. Serban (2002) contributed to our understanding of IR by providing us with a look at the contemporary IR person in the knowledge management context. These foundations of IR literature reveal that, theoretically, IR should use and integrate knowledge management principles in order to provide key decision-making support. Moreover, in order for the IR person to be successful, this person must successfully navigate institutional database systems while providing analytical products to decision-makers.

According to J. Fredericks Volkwein (1999), the IR profession is described as having four faces, wholly based on the people served and the culture of the organization where IR is being executed. The four faces he described center around the notion that IR serves as information authority, spin doctor, policy analyst, and scholar and researcher. Andrea M. Serban (2002) adds a fifth face of IR: knowledge management. She contends that "in a knowledge management environment, these four facets continue to exist; however, they converge into a broader, more integrated dimension—the fifth face of institutional research—IR as knowledge manager" (Serban, 2002, p. 105) (see Table 1).

This fifth face of IR requires different training than that referred to by Saupe and Volkwein. In fact, knowledge management requires people with interpersonal skills that can negotiate an organization's culture and still have strong skills in business processes and technology.

IR in a KM framework has its benefits and challenges, and, therefore, it is best to understand them. According to Serban (2002), "there are clear advantages of implementing knowledge management frameworks and processes" (p. 108), which are summarized in Table 2.

The benefits to KM clearly outweigh the challenges associated with employing such principles.

Table 1. Purposes and roles of institutional research

	Purposes and Audiences	
	Formative and Internal (for Improvement)	*Summative and External (for Accountability)*
Organizational Role and Culture		
Administrative and Institutional	To describe the institution *IR as information authority*	To present the best case *IR as spin doctor*
Academic and Professional	To analyze alternatives *IR as policy analyst*	To supply impartial evidence of effectiveness *IR as scholar & researcher*
Knowledge Management	To gather and transform data into information and knowledge; to collaborate in the creation and maintenance of an institutional official repository of data, information, and knowledge (i.e., portals); to facilitate the process of knowledge creation, capturing, and sharing. *IR as knowledge manager*	

Adapted from Serban (2002, p. 106) and Volkwein (1999, p. 17)

Table 2. Benefits and challenges of KM

Benefits	**Challenges**
Access to and sharing of knowledge	Strategy—developing a clear sense of direction
Customer responsiveness	Tacit knowledge and organizational cultures
Better understanding of the organization and its customers	Skills and expertise—developing highly technical skills
Operational efficiencies and decentralization of functions	Cost—human and financial

For example, if an organization has a need to somehow leverage its endowed knowledge base in order to be competitive in the marketplace, this can be accomplished by providing its users access to institutional information so that knowledge creation can occur, thereby, adding to the effectiveness and efficiencies in decision-making. However, when information asymmetry exists, the rewards to this KM benefit fail to materialize. The main challenge arises when the organizational culture is not responsive to sharing information and to knowledge creation. Arguably, organizational culture can be an impediment instead of an enabler and can lead to a lack of clear institutional sense of purpose and direction. Culture as an impediment can be symptomatic of a much greater problem such as leadership void in IR, the IR function, and senior management. As an enabler, culture can be the key ingredient in a recipe that gives rise to competitive and innovative behavior in the higher education marketplace.

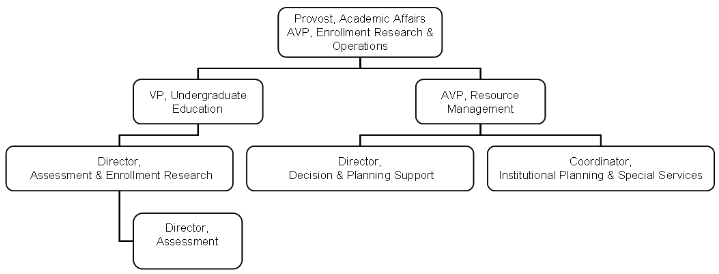
METHODS

The purpose of this study is to examine whether or not KM principles as described in the knowledge management field were evident and employed at Western University. This analysis uniquely explores deeply seeded beliefs about what the three departments that make up the IR function believed were their strengths. The analysis is a case study using various qualitative techniques. This approach adds depth of understanding as to how IR and strategic planning departments make use of or do not employ KM principles. We should be cognizant however, that this approach is not absent of its limitations, but it is a powerful approach to provide a fuller picture of how KM is used in practice.

Western University (a pseudonym) was selected for this study because it demonstrated a need to take raw data and move it efficiently and effectively through a continuum, beginning with raw facts and numbers and ending with decision-making and planning decisions. Having such a seamless process would be vital to the institution's ability to compete effectively in the marketplace. Further, an effective flow of data toward knowledge creation would help the university.

Western is a public research extensive university with an approximate student body enrollment of 37,000. This university was selected because its IR and strategic planning function has undergone a transformation with respect to its organizational hierarchy. Prior to the reorganization, the IR function within the organization was spread across three separate units. That is, the three units that make up the IR function at Western were: (1) decision & planning support; (2) institutional planning & special services; and (3) assessment and enrollment research. The decision support unit reported to a director, who in turn reported to a senior administrator that oversaw resources

Figure 1. Organizational chart pre-reorganization



in the academic affairs area. The planning unit was managed by a coordinator who also reported to the senior administrator in the academic affairs area. The assessment and enrollment research unit reported to a different senior administrator in academic affairs, a vice president for undergraduate education (see Figure 1).

Memoranda and various forms of correspondence from a study committee that was formed to examine the various IR functions and its committee members were analyzed. The author placed himself as a participant observer in some of the data gathering and analysis, providing valuable access to information.

FINDINGS

IR as a Fragmented University Function

In December 2002, a senior and powerful dean at Western sent a letter to the provost expressing concerns about duplication of efforts, resource efficiency, data accuracy, and ambiguity of roles between the decision support, planning, and assessment and enrollment research units. In the dean's letter, strong concerns were expressed about what appeared to be three "organizations doing many of the same things with little coordination."1 The dean conveyed that "the bottom line that we [the dean speaking on behalf of his college] face at the college level is the lack of accurate information upon which administrators can make informed decisions." Moreover, the dean made a specific recommendation in order to address the concerns expressed by suggesting that the senior administrators who directed these units meet with the academic council in order to address and remedy the dean's concerns. The concerns were never addressed at the venue requested by the dean; however, a team to study these concerns under the backdrop of a new and sweeping university reorganization initiative was formed. This letter would later serve as a significant trigger for the forming of a university-wide study team that came to be known as the "Data, Analysis, and Planning Study Team" (DAPST).

In June 2003, the president of the university and the provost created the new DAPST and charged the newly appointed chief information officer (CIO) to chair the team. According to the chair's invitation letter to prospective DAPST members, "the underlying goal behind this study is to improve the University's ability to bring data and analysis to bear on management decisions." In the same document it was expressed that the "administration is increasingly tied to assessment and projection, both of which are completely dependent on the quality of the data we collect and the analyses we conduct on the data." The chair also found it necessary to illustrate a significant example where IR failure had occurred. The chair stated that the "effort to set future priorities should have involved data-based assessment of academic and support units against a specific set of criteria, and reorganization plans should have been informed by analytic models projecting outcomes and costs for various possible lines of action. The Reorganization Initiative exercises were instead supported largely by such noncomparative narrative records as Academic Program Reviews and constituent testimonials." Clearly, the chair was suggesting that one of the units, if not all, did not successfully coordinate this effort in order to provide the best information possible to inform decision-making for such a high level management initiative.

The DAPST membership was "balanced between academic administration and the various offices that provide support for management through data collection, data warehousing, data analysis, or report generation."2 Although the DAPST membership did, in fact, comprise a decent balance of academic administrators and various offices of special interest, the attendance of the membership quickly and sharply decreased to just those offices that had a vested interest in the outcome of the “findings” as it pertained to their organizational units.

The Proceedings

At its inception, the chair of the DAPST conveyed a message to its membership that the team would address issues that hindered Western University’s ability to respond to sweeping institutional initiatives. It appeared that the problem identification rested in the notion that there was a broken IR function—a function that was unable to mine data elements, resulting in a lack of knowledge creation for tactical and strategic decision-making. The findings from the proceedings and behavior inferred from various membership correspondences suggest that some members agreed with the perceived problem definition and wanted to effectively address it while others dug in, circled the IR wagons and went to great lengths to preserve the status quo.

Digging In

Examining public electronic e-mails, facsimiles, and other documents such as correspondence between the DAPST membership itself, between membership and the chair, and the like suggests that there was a clear struggle among the members who believed that creating data through an existing decision support system known as the Integrated Information Warehouse (IIW) is knowledge creation whereas others believed that such processes are a good starting point for knowledge creation by fully integrating the analysis of such data.

The IIW is a data warehouse that contains Western University’s related historical, census, and start-of-business-current-week data, and it is maintained by the decision and planning support department’s servers from which internal and external reports can be generated. Census data comes from snapshots taken of operational data at the same time each year. Historical and Census data are used for viewing trends and the state of the institution at the same time each year. The Census data are taken from Western’s University Information System (UIS). The UIS is a university-wide data warehouse with start-of-business-current-day data from Western’s financial, personnel, space, sponsored project, student, and other operational systems. The UIS is maintained by Western University’s computing center that reports to the CIO.

Before the first meeting of the DAPST, there were questions from the three units being examined. For example, the senior executive who oversaw the decision support unit and the planning unit suggested that the provost was interested in hiring an external consultant to review the roles of the three units, a suggestion that was at odds with the articulated function of DAPST. In fact, language was used that appeared to undermine the DAPST chair, the charge of the study team, and the team’s eventual findings. When employees of those units raised questions, the executive withdrew from the desire to hire an outside consultant. The question remains as to what problem this executive and/or the provost was trying to address that was either different from or similar to that of DAPST. Moreover, it is possible that this interest had nothing to do with knowledge management and how to effectively deliver quality information and quality analysis of the information. Rather it can be construed as an exercise to signal to staff in the decision support and planning departments that this executive retained control of these two units and the likely outcome of any reviewing committee.

A member of the decision support unit and a member of the DAPST raised questions and introduced information that might have been helpful to the direction of the study team. This person suggested that to effectively address IR needs there needed to be a focus on “what we should be doing.” Moreover, through an electronic correspondence with the chair, this member asked the chair if the team could benefit from viewing the IR function through a systems and integrated approach. This person believed that "the lack of understanding, coordination, and cooperation on data, analysis, and planning from a systems view is a key piece of the puzzle on our suboptimal performance in these critical areas. Can we gain from taking a systems view and creating integrated, holistic, data, analysis, and planning function for our institution?" This was a powerful set of statements not only because the chair responded favorably to the suggestion but also because the DAPST had not previously considered an institutional information systems paradigm.

The decision support unit director highlighted his unit's most significant accomplishment—the Integrated Information Warehouse (IIW). The goals listed by this unit are consistent with KM principles as the unit sought to provide timely and accurate information and tried to be the central repository of institutional data for decision-making. This unit saw itself as playing a role in university "perception management." That is, the unit engaged in the IR role Volkwein (1999) called "spin doctor." Also, this unit, through its direction, seemed to focus much of its energies on data inputting, data editing for the sake of accuracy, and internal and external reporting. It expended its resources around the IIW, as the IIW was the perceived data creation generator and the means for better decision-making. The assumption was that the IIW, with its five gigabytes (GB) plus of data added annually, would somehow yield better decision-making. That is, great data equals great decision-making. The projected public discourse that the director of this unit propagated for DAPST can be summarized in three areas: goals, functions, and systematic information (see Table 3). However, in actuality, the unit diverged from its publicly stated rhetoric in a number of significant ways. For example, although the unit expressed the goal to "help the university understand and interpret its environment, self, and options on critical information," no evidence is found that administrators with decision-making authority on critical issues used any information from the IIW that strengthened their decision-making ability. As a result, the fact that this unit had been relatively absent in its provision of key university information also suggests that it had failed in

Table 3. Decision support goals, functions and systematic information

Goals	Functions	Systematic Information
Provide accessible information Provide accurate, timely, and comprehensive information for varied users Help the University understand and interpret its environment, self, and options on critical information	Collect missing information Address key university questions Improve perceptions of the university—"perception management" Provide valid and external reports	IIW—10 plus years of consistent data; 36 GB, add 5 GB more a year Clean, code, and compile system data for ease of use Census and other standard information for most university-wide, non-accounting reporting Flexible web answers to campus questions—X pages a year

one of its major functions of "address[ing] key university questions." The question does remain as to why this unit was not approached on key university questions on something as central as the university-wide reorganization plan that took place before the formation of DAPST.

Another example rests in the assertion that this unit through its IIW provides "flexible Web answers to campus questions …" This is referring to its ability to provide Web portals for various users (i.e., administrators, university community, and external community). The unit provided Web portals and for the most part one could retrieve information quickly. However, power users found it impossible to access the source codes. That is, in most cases a power user at Western was using Oracle-based SQL or a relational database application such as ACCESS or BrioQuery. These users tried to access the data through the Web portal, the IIW returned data in HTML format and downloadable EXCEL files, but the user was unable to identify the tables and table elements that were used. In other words, one would have to call the unit to request the source code in SQL. For an administrator, this may not be as important but for a support systems analyst that is supporting an administrator at the college level this is extremely important because, in most cases, the source code needs to be modified to fit the specific use.

So how did the assessment and enrollment research unit engage in pubic discourse and assert its projected domain of expertise? The director of the assessment and enrollment research put together a list of activities that were being performed on campus, attempting to make a clear demarcation of some of the questions that were going to be addressed by the DAPST. It was a list of different IR activities that were being performed throughout Western but made no attempt to affix any units to the activities. More importantly, this list took the form of a process-related exercise rather than an outcomes approach that would suggest a rational assignment of activities within domains and the units that would carry out such activities. Moreover, with respect to the assessment and enrollment research unit, examination of this list suggests that this director was not going to overtly project the unit's role within the IR function. Instead, it appears that this director placed the enrollment activity in his purview, in the analysis/planning domain. This is important because it suggests that this director appears to have valued this domain or may have had some reason to believe that administrators valued this domain for knowledge creation and enhanced decision-making. The list of activities is summarized in Table 4.

By the time the planning unit made its case, it had become clear that the discussions in the study team were about data, quality, and the ability to inform decision-making—and, not much about using or not using KM principles in the IR function. The planning department introduced a list of activities that it felt were in its domain and in the course of generating the list aggressively projected the capacity for certain domains. This unit went to great lengths to suggest that in addition to coordinating a university strategic plan, it performed activities designed to inform management. In other words, the unit, through its coordinator, tried to convey that it was central to management decision-making and, thereby, they created knowledge pursuant to KM principles.

In actuality, this unit indicated that it provided certain types of products, but these were not delivered. For example, this unit indicated that it provided quantitative and qualitative analysis. When the products that have been created by this unit were examined no products would fit those criteria. Instead, the five-year strategic plan, summaries of colleges' annual reports, and other similar products were created without any qualitative and/or quantitative techniques. This unit also listed a "departmental profile" as a key accomplishment. Indeed, this product was used for key decision-making as it contained information valuable to the discussion of departmental eliminations and/or mergers. However, it is im-

Table 4. The domain of analysis, planning, and assessment

Data Collection	Data Administration/ Management	Reporting/Basic Data	Analysis/ Planning	Assessment/ Evaluation
Admissions	Loading Databases (university database, integrated information warehouse[IIW] maintained by the decision support unit)	IPEDS	Enrollment	General Education Program
Curriculum & Registration	Edit Checks	Governing Board	Budget/Costs	Academic Programs
Financial Aid	Database Maintenance	State Planning Office	Faculty/Staff	Student Development
Bursar	Hardware/ Software	State Legislative Budget Committee	Space	Teaching Evaluation
College & Academic Departments	Documentation	AAUDE	Capital Projects	General Program Evaluation
HR	Software Training	Campus (APRs, Deans, Departments)	IT	Personnel Evaluation
Budget Office	Training on use of data	Ad hoc service requests	College & Academic Departments	Accountability for Governing Board & Accreditation Board
VP Research	Integration w/Subordinate and Shadow Systems	Fact Book/ websites	University Planning Advisory Group Support	Test Scoring & Analysis
Facilities Mgmt	Web (IIW) queries	Public Records	Operating Plan for State Legislative Budget Committee	N/A

portant to note that this departmental profile is the same report that attracted criticism from and was referred to by the influential dean that triggered the formation of the DAPST in the first place. The dean had indicated that the departmental profile was flawed. The activities of the planning unit can be summarized in Table 5 in the following way by their respective general function.

The findings suggest that the vested units were signaling within the organization how they wanted

Table 5. Planning activities

Institutional	Planning	Analysis	Ad hoc
Summarize college annual reports Consult & review units' academic program reviews Coordinate accreditation activities & reports	Staff the University Planning Advisory Group Prepare the five-year strategic plan	Quantitative/ qualitative	Departmental Profile

to be perceived, and what capacities they believed they possessed. This institutional maneuvering resulted in a carefully orchestrated dialogue that would, basically, preserve existing domains and spheres of influence. Interestingly, no final report was generated by the DAPST and none of the committee's findings were disseminated to the university community as promised by the provost and president. Instead, the chair of the DAPST electronically circulated a draft of the final report3 to its membership soliciting input. The question remains as to why such a high-level review team was charged with studying a generally understood and important function of the university and why the findings were not disseminated as is normally expected when a task force study team is assembled at a public university. Perhaps the report regarding the process and products of information management was considered too divisive for general review.

The Elusive Final Report

The draft of the final report revealed some very important social aspects. The report was organized into six key thematic groups: trust, culture, awareness, access, questions, and resources. Culture and awareness are the central themes of interest as these were the two areas where most of the conversations centered; whereas the other four themes were given cursory consideration. In the report much space was dedicated to these themes and not much was given to the delivery of services from an IR function in order to take data, create knowledge, and manage knowledge as Serban (2002) suggests is the fifth face of IR. The culture theme revealed:

The organizational culture does not include consensus on the importance of data or acceptance of shared responsibility for data quality. Complaints about errors in data breed cynicism *without feeding back into improved practice. We not only lack shared definitions and standardized metric; we also seem to lack an interest in developing them.*

Even when discussing culture it appeared that the focus immediately gravitated toward inputs in knowledge creation—data and data quality. The awareness theme revealed:

Data providers must be aware of the data needs of the colleges, and the colleges must be aware of what is available—what data sources, what tools, and what expertise. Everyone must understand what numbers in datasets mean and how they are meant to be used. We need heightened awareness of the "unintended consequences" of measurement and a more thoughtful approach to choice of metrics.

The report focused on one aspect of the battery of skill sets required of a modern day institutional researcher—advanced technical skills centered on data, data definitions, and a heightened awareness in decision rules when querying datasets. Unfortunately, this theme overlooks the other important prerequisite skills required of today's institutional researcher—institutional consultant, policy analyst, and knowledge contributor and creator.

Noticeably absent from the report was any analysis of any data that examined the veracity of the products that the respective IR units under study indicated they provided and, moreover, the quality of such products. The report made some references to the original charge of the DAPST with an astonishing shift in language, stating that "excellence in administration depends on the quality of our decision-making, including the quality of our decision support systems." In other words, the chair conflated good data support systems with quality decision-making. This is a significant finding because it suggests that data support systems such as the IIW are a means to and end rather than a foundational starting point for knowledge creation. Perhaps Patrick Terenzini (1993) put it best when he described three tiers of intelligence—defining the nature of institutional research and its prerequisite skills, whereby technological skills is the lowest of the three tiers. According to Terenzini, "this form of intelligence is foundational: by itself, however, it is of little value." (p. 9). What is more, the report made no recommendations for reorganization of the units that were studied. Notwithstanding, the units were reorganized approximately six months after the report was drafted. Remarkably, in the absence of a public dissemination of the DAPST findings, the reorganization further contributed to an organizational culture of misinformation.

Study Team & Its Findings: Do KM Principles and Practices Emerge?

There is no conclusive evidence from the data that was analyzed that KM principles were being employed in a thoughtful manner at Western University. To the contrary there is ample evidence to suggest that the IR function is fixed in data and data systems and has yet to make the necessary transformation along the KM continuum to knowledge creation. In short, at Western, technology is viewed as the panacea for good decision-making. Moreover, from the draft report itself there are no acknowledgments or recommendations addressing policy analysis and knowledge driven activities for better decision-making. However, arguably, the most significant finding is the units that made up the IR function and were under review underwent major reorganization six months after the report was drafted. This was unexpected given that the report was neither publicly disseminated nor was anyone seemingly following through on any set of recommendations that would have been advanced from the draft version of the report. The question still remains as to why these units were reorganized. Certainly, there must be other private reasoning that is not captured in the data analyzed.

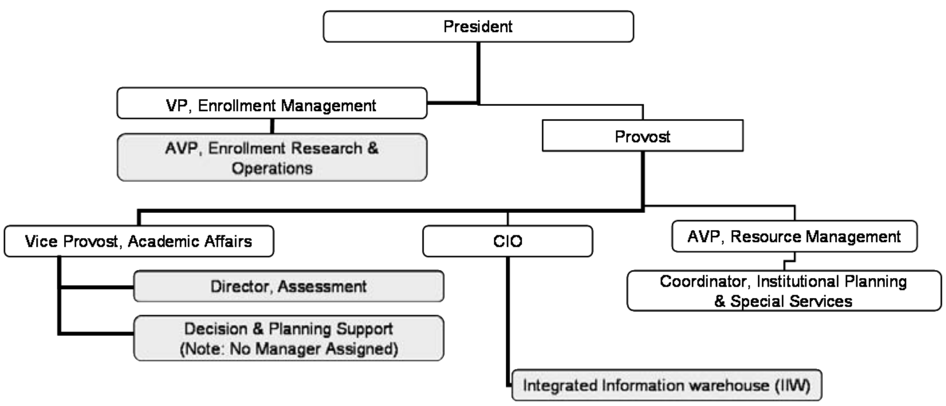
As a result of the reorganization, decision and planning support, institutional planning, analysis and special services, and assessment and enrollment research were separated into four distinct units reporting to three different senior administrators. The new units are as follows: decision and planning support, institutional planning, analysis and special services, assessment, and enrollment research and operations. They all remained in the academic affairs (provost's office) except for enrollment research and operations who now reported to a newly created area called enrollment management (president's office) (see Figure 2). Remarkably, in this reorganization, not a single person that was part of the original IR units under review was fired. However, two key individuals resigned and the director along with two other technical staff of the decision and planning support unit along with the IIW responsibilities were transferred out of that unit and into the CIOs area. One individual was a key architect of the IIW in the decision and planning support unit and the other was the administrator of the UIS. In addition, the former director and two systems support individuals of the decision and planning unit were reassigned to work with the IIW. In short, there was a shuffle in the organizational hierarchy with two key resignations and the transferring of a key director and other staff, none of which would be expected given the DAPST findings.

CONCLUSION

Western University is an example of an organization that only adopted parts of KM principles by developing the capacity for data/information systems through its IIW but failed to develop capacities in other critical areas necessary to interpret and create knowledge. That is, Western spent much of its energy discussing how to improve upon its data, data quality, and data access and invested in the people that support such systems but failed to invest in a commensurate fashion in the human capital needed to transform the information generated from these systems into knowledge in order to advise decision makers.

The DAPST and its draft report illustrate that KM principles were not at the core of its values. Its myopic focus on such a small part of KM rendered

Figure 2. Organizational chart post-reorganization



its team's report meaningless in helping to advance knowledge creation for enhanced decision-making, especially during a time when Western needed critical IR to help senior management navigate through its new and sweeping objectives and a changing higher education marketplace.

Recommendations

The DAPST team would had been better served if they focused their attention on: (1) developing a critical perspective of university colleges and departments performance and plans that are informed by a deep understanding of each unit's strategic objectives and overall operating environment; (2) executing consultative projects in close collaboration with various units to help address administrative and financial management questions and/or opportunities; (3) examining important university-wide academic/financial/physical planning issues and/or opportunities by working closely with units as well as by drawing on external data as appropriate and necessary to inform internal review processes; (4) collecting critical academic/financial/physical information from across the university for the purposes of not only supporting internal decisions-making but also to ensure timely and accessible responses to requests for data from regulatory agencies, peer institutions, and other interested parties; and (5) moving the IR function beyond information authority and into the realm of IR as policy analysis.

REFERENCES

Bukowitz, J.R., & Williams, R.L. (1999). *The knowledge management fieldbook.* Upper Saddle River, NJ: Financial Times, Prentice Hall.

Firestone, J.M., & McElroy, M.W. (2003). *Key issues in the new knowledge management*. Amsterdam: Knowledge Management Consortium International Press.

Kidwell, J.J., Vander Linde, K.M., & Johnson, S.L. (2000). Applying corporate knowledge management practices in higher education. *EDUCAUSE Quarterly, 4*, 28-33.

Laudon, K., & Laudon, J. (1999). *Management information systems-Organization and technology in the networked enterprise.* Englewood Cliffs, NJ: Prentice Hall.

Saupe, J.L. (1999). The functions of institutional research. In M.W. Peterson (Ed.), *ASHE reader on planning and institutional research* (pp. 211-223). Needham Heights, MA: Pearson Custom Publishing.

Serban, A.M. (2002). Knowledge management: The "Fifth Face" of institutional research. *New Directions for Institutional Research, 113*, 105-111.

Terenzini, P.T. (1993). On the nature of institutional research and the knowledge and skills it requires. *Research in Higher Education, 34*(1), 1-10.

Volkwien, J.F. (1999). The four faces of institutional research. What is institutional research all about? A critical and comprehensive assessment of the profession. *New Directions for Institutional Research, 104.* San Francisco: Jossey-Bass.

Whitley, M.A., Porter, J.D., & Fenske, R.H. (1992). *The primer for institutional research*. Tallahassee, FL: Association for Institutional Research.

ENDNOTES

[1] Letter from senior and influential dean to Western University provost requesting that the provost convene a high level meeting to discuss a more effective way to coordinate

the three units that make up the IR function dated December 4, 2002.

2 Letter sent to prospective members of the Study Committee by the CIO and chair of the Study Committee dated June 10, 2003.

3 Draft Final Report electronically sent to the Study Committee members by the CIO and chair of the Study Committee dated December 2003.

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Chapter 4.13

A Knowledge Management Case Study in Developing, Documenting, and Distributing Learning

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EXECUTIVE SUMMARY

This case study reflects the work of a global organization in its knowledge management efforts to sustain and transfer learning from a global leadership development curriculum. It focuses on the Knowledge Management (KM) solution developed to support employees to sustain their learning, to enable them to share their insights and experiences with others, and thus increase organizational capability. The paper is written to illustrate an example of a large organization's efforts to engage employees to share their learning from a management programme across geographical and cultural boundaries.

INTRODUCTION

This case study reflects the work of a global organization in its knowledge management efforts to sustain and transfer learning from a global leadership development curriculum. It focuses on the Knowledge Management (KM) solution developed to support employees to sustain their learning, to enable them to share their insights and experiences with others, and thus increase organizational capability. The paper is written to illustrate an example of a large organization's efforts to engage employees to share their learning from a management programme across geographical and cultural boundaries.

Georgensen (1982) estimates that learners retain approximately 10% of material covered in a tutor-led workshop when back at the workplace. The KM strategy in this project was to support high-performing, high-potential employees to retain a greater proportion of the tutor-led learning and experience. This in turn increases organizational capability by transferring the learning to colleagues and delivers a greater return on investment to the business.

A key challenge of the KM strategy was to effectively manipulate existing KM platforms within the business and research and propose the use of additional ones.

The issue was to make best use of the current multiple resources in the organization, acknowledging that not one of them was totally suited to meet the needs across the globe. The Learning and Development team worked to find a solution with either a range of existing platforms or, as a result of research and testing of new technologies, a new KM platform to support the strategy.

There are a number of cultural challenges associated with implementing effective KM across a global organization with presence in over 100 countries, with different levels of technology sophistication, language, and experience. Revenue-generating business demands mean implementing an effective KM strategy with "learning" content as another challenge entirely. For example, time spent documenting personal reflections from learning and on-the-job experiences, and reading others' reflections from learning and on-the-job experiences struggles to compete with business opportunities that deliver an immediate bottom-line return.

The nature of the insurance industry is relationship based. Interaction has historically been, and still is, predominantly face-to-face or over the telephone. As Nixon (2000) confirms, many other industries have found implementing effective technology-based KM solutions with only face-to-PC interaction is a cultural and pragmatic challenge. In their everyday role, brokers prefer to pick up the phone and talk to someone or go to see them versus logging on to a computer, entering a password they need to have remembered and change regularly to maintain security protocols. The Lloyds of London broking environment, established in 1688, reinforces the face-to-face relationship-based culture. Experience of working with an internal client group to support employees to use the system suggests that if the Internet connection is slow or a password is typed incorrectly thus denying access, users will pick up the phone before trying again, or worse, will avoid the system in future.

BACKGROUND

The Organisation

Marsh Inc. is the world's leading risk and insurance services firm. Its aim is "[t]o create and deliver risk solutions and services that make our clients more successful." Founded in 1871, it has grown into a global enterprise with 400 owned-and-operated offices and 42,000 colleagues, who serve clients in more than 100 countries. Marsh's annual revenues are $6.9 billion, and the company meets client needs in two principal categories:

- Risk Management, insurance-broking, and programme-management services are provided for businesses, public entities, professional services organisations, private clients, and associations under the Marsh name.
- Reinsurance-broking, risk and financing modeling, and associated advisory services are provided to insurance and reinsurance companies, principally under the Guy Carpenter name.

The organisation is made up of distinct divisions with specialist knowledge. One of the key business drivers for the future is to maintain and develop the specific knowledge within each of these divisions, while sharing more learning and experiences across the business, particularly to reduce "reinvention of the wheel" comments across divisions and geographies.

SETTING THE STAGE

Knowledge Management Platforms in Learning

Newman (1991) defines KM as "the collection of processes that govern the creation, dissemination, and utilization of knowledge." The cascade and consistent communication of corporate goals and performance management is pivotal to business success, learning interventions, and employees' personal development. In 2000, Marsh made a fundamental shift in the mechanism used to cascade company strategy across the globe. Local performance management tools, processes, and procedures were replaced with one common approach to aligning goals and consistently measuring performance with the Balanced Scorecard.1

At the beginning of 2001, there was no common, pan-European technology platform specifically targeting learning and the consistent documentation of learning in Marsh. E-mail provision was the one common tool and platform across the globe. The company had a variety of software to support the creation and application of databases and had the capability to share databases across geographies, through shared network drives, Internet-based secure "filing" programmes, Microsoft Access and Lotus Notes programmes. Few employees were aware of the range of these capabilities and even fewer were aware of how to manipulate such tools.

In 2001, the firm implemented a global learning management system with specific, pan-European capabilities including e-learning, registration for tutor-led learning, and an online lending library with books, CDs, tapes, videos, and computer-based training (CBT). The system also provided the capability to record for each learner what learning they had accessed and to allow an "approver" path for line manager involvement and alignment to learning. Usage statistics have increased from 11% of the total European population in 2001 to more than 28% in 2004.

In 2002, the organisation launched a company-wide portal, an interactive client and colleague platform to source information about Marsh to both external and internal requestors. The portal is intended to ultimately replace local country-specific intranet sites. The learning management system is now operating effectively from this medium. Local intranets are still in operation across Europe providing more specific local information to employees with the portal offering a platform that spans the entire region and links to colleagues and learning in the United States.

The business is using a number of communication tools to promote cost-effective knowledge sharing, the most common being an interactive, Internet-based tool WebexTM, used alongside the telephone for conference calls to share presentations, documents, and access to specialised software. This tool allows Internet dialogue over the course of a meeting and has "ownership" rights for a person or persons to own a presentation document and to be able to make adjustments online in real time with feedback from the conference call participants. This tool can also be used with external clients and has been particularly useful in sharing across boundaries as all colleagues have a desktop computer and access to a phone.

CASE DESCRIPTION

This paper will specifically focus on the KM strategy implemented for the European implementation of a global leadership programme. The programme is one of three core programmes in a Global Leadership Development Curriculum and targets high-performing, high-potential colleagues with people management responsibility. It is a three-day off-site event. Titled "Managing

Essentials," it was launched in the spring of 2002. The business used an external provider to deliver across the globe with a core team of dynamic and experienced facilitators. This strategic decision enabled consistency of message, delivery, language, and experience.

The audience for the programme is diverse in years within the organisation and in the industry, time in a management role, geography, and first language. In Europe alone, the target population of colleagues to attend the programme in the first 18 months was close to 500 (50% from the United Kingdom and 50% from continental Europe). Results from employee surveys and dialogue on the programme demonstrated the need to create ownership and responsibility for change at this level. The Learning and Development (L&D) network of colleagues managing the programme at the local level across the globe is also diverse. Technology has played a key role in communicating across geographies with both the delegate and the L&D communities by way of the telephone, Internet, e-mail, various global software platforms, and even camera.

The ultimate KM strategy for Managing Essentials is to improve organisational capability and capacity.2 Underpinning this are four main goals:

1. For delegates of the programme to sustain their learning of best-practice management tools and techniques
2. For delegates to sustain the pan-European colleague network from the programme
3. For delegates to share their learning and lessons learned from implementation with other colleagues
4. To demonstrate a measurable return on investment against the learning intervention

Next is an account of what actions have been taken to address each element of the strategy and the observed outcomes to date. Georgensen's (1982) hypothesis of learning retention was a key factor in the design of the strategy with pre- and postcontact with delegates at progressive intervals to reinforce the learning. For this reason, the material that follows identifies the cycle stage of the actions taken to the programme (pre, during, or post).

Sustaining the Learning

Pre Event

High-performing, high-potential colleagues were the target audience for Managing Essentials because this population was generally known to be more capable and willing to cascade learning, lead by example, and to therefore impact the majority of colleagues as a result of their experience on the event. To ensure appropriate employees with this skill set were exposed to the learning, employees could not self-register for the programme but had to be nominated by a senior colleague in their business.

To combat cultural issues that historically reinforced silos within the business and across geographies, Managing Essentials is delivered at a pan-European level as opposed to local country level. Nominations are managed by the Programme Manager through the database to ensure a 50/50 split of participants from the UK and continental Europe. The deliberate mix of delegates on each event, sharing and cascading knowledge and breaking down business segment and geographical boundaries, has been recognised by delegates as a core strength of the programme.

During the Event

Every delegate received a hard copy binder of materials covering the learning models and references from the three-day event and supplementary reading materials and references. The facilitators referred delegates to their binders throughout the programme and ensured key action points were documented in the binder to encourage participants to refer back to it and use it when back at the office.

On approximately 60% of the conference calls held with delegates post event, at least one employee referred to his/her frequently returning to the binder to remind him/her of his/her learning. Many claimed to keep their binder on their desk where it could be easily referred to.

Post Event

The Marsh internal Learning and Development team developed a sustainability timetable post programme using a variety of KM tools. A summary of activity is noted in Table 1.

Months three, six, and 12 of the postprogramme plan were proposed in first quarter 2003, but have not yet been fully implemented. Europe has consistently implemented up to the three-week stage in this timeline and has sporadically implemented the six-week and onwards activities.

Each of the KM tools and practices used in the above timeline has its pros and cons. The objective of using this range of tools and methods is to provide an overall synergy to all the learners involved, appreciating different learning styles. The feedback the team has had is that the facilitated conference call is useful for reminding delegates of their learning and bringing the "community" back together again. The conference call does not, however, lend itself to support those colleagues

Table 1.

Within a fortnight	Take time to reflect and think Receive group photo of delegates Commence 3-6 month challenge
Two weeks	Receive the following information by email: • Email distribution list along with ideas on how to use it, i.e. 'What I've learnt this month' • Copy of the APT[2] (see *Transferring Learning Across the Organisation*) model previously completed on-site • Copy of Excel spreadsheet with all delegates' Background pre-work • Excel spreadsheet with names of all participants on the programme across Europe since Spring of 2002 Receive an additional email directing delegates to specific e-learning materials to reinforce key learning points, accessible through the global learning management system Attend conference call with other delegates (recorded and transcribed for later reference)
Three weeks	Receive an A5 colour laminate for their desk with key models and messages from the 3-day event
6 weeks	Receive notification of bi-monthly Webex™ calls to share feedback on 3-6 month challenges
3 months	Line managers of participants receive on-line questionnaire to complete on noticeable changes in participants' performance since attendance on the programme
6 months	Attend video conference with delegates to reinforce the network
Annually	Attend a central conference of delegates to review content and lessons learned on implementation, and facilitated discussions around transfer of learning and knowledge management.

who speak English as a second language and the transcript of the call, while a valuable record of verbatim comments and stories, is detailed and time consuming to analyse at a later date.

As the networking opportunity of the event holds such great wealth for the participants and lends itself to the transfer of knowledge both to the network after the event and to their colleagues back in the office, a digital photo is now taken on site on the last day of the programme and circulated to the delegates approximately two weeks afterwards via e-mail. For those people who learn more effectively in a group and through visual stimulus (as opposed to audio or kinesthetic), the photo provides a reminder of the experience and the learning.

The A5 laminate needs no translation, it's colourful, and delegates do not need to actually "do" anything with it other than hang it somewhere prominent on their desk as a reminder. When walking around the offices, these laminates are becoming more and more visible with the numbers of colleagues attending the programme. This is a simple way to cascade the message as yet other colleagues ask questions about the laminate on the desk and the explanation cascades the learning.

The central conference would provide value to the delegates and the organisation, but taking more than 250 colleagues out of the business for a day and bringing them to a central location has financial and work flow implications. A compromise suggested by the participants has been to hold local country conferences. This is something the team considered implementing in fourth quarter, 2004.

Three years after implementation, the learning management system the business has implemented globally is becoming a powerful tool. European colleagues are beginning to embrace the tool although they are just scratching the surface to use it to its full functionality. Employees have been forced to become familiar with the system and to register for learning events through this medium where previously they called through to a learning team to manually register for events. Many, however, are not using the personal learning history, assigning a mentor, or reporting functionality of the system. The second e-mail sent at the two-week stage post programme (above) targeting the high-performing, high-potential employees, enforces strategic organisational goals of employing more blended learning, promoting the learning management system, e-learning, sustained learning, and the use of technology as a learning tool.

Transferring the Learning Across the Organisation

During the Event

Key learning from best-practice networks of learning professionals in the United Kingdom led to the discovery of Unilever's3 Transfer of Learning tool known as APT2 (Acquire, Practice, Transfer to Job and Transfer to Colleagues). This tool has been consistently utilized at the end of each of the three days in the Managing Essentials programme. Delegates identify and publicly document what learning they have acquired, how they will practice that learning (in a safe environment where they can afford to make mistakes), how they will transfer the learning to the job, and how they will transfer the learning to colleagues. At the end of each day, this is recorded by each participant on post-it notes and posted on flip charts, where it stays over the duration of the programme. Delegates can add to it as required over the three days. After the event, the data are recorded electronically by the programme management team for redistribution to delegates by e-mail, primarily providing an aid to sustain the learning but also to remind and share with the group how everyone committed to transfer the learning. Feedback on this process has been that it is a useful reminder of the programme content as everyone records what key learning they have acquired each day, and a generator of ideas of how to implement the learning. This record is also used as a tool to describe to senior leaders what key learning the participants are taking away from the programme and what they are committing to do back in the office on their return.

One of the richest sources of knowledge transfer and sustainability is storytelling. The power of the true story, the real experience of someone in the room or someone the participants know as a colleague has an impact few, if any, other mediums can match. Participants in the programme, like many others in the financial services industry, are rarely satisfied with theories. They need proof, not simply of how something has worked but of how something has worked in their environment under the same pressures they work under. The external providers Marsh work with to deliver the learning are insightful in the way they share their stories and experiences to emphasise and reinforce learning points. A key aspect of the KM strategy has become to collect, collate, and share participant stories across the relevant geographies, where a colleague can be named for their success at making a difference — not only for the what, but also the how — after attending the programme. The KM strategy reflects this as participants are asked to attend conference calls post programme and to share a story of their learning and implementation back at the office.

The stories from the conference calls are cascaded (with employee permission) back to the external providers who facilitate the programme. The external facilitators also elicit stories from participants over each three-day event, record the story and the source, and then use these stories at future events. For delegates experiencing later programmes, this makes the experience tailored when they hear the external facilitators referencing known employees and their real experiences with the material. One example of such a story was that of a woman who consistently used four key questions with her team in monthly one-to-one meetings. She had read a number of texts and had experimented with a variety of tools to develop her people to be proactive, show initiative, and involve her when appropriate. She shared these four questions on the programme and her experiences in asking them of her team; how they first reacted, how they reacted over the short term, and how they react today. As a result of her story and the reaction of the group on the programme, her story and the questions are now included as part of the learning event. A testament to the KM efforts is the fact that on recent programmes in Europe, delegates have brought this story to the workshop, having heard it from other colleagues or seen it practiced.

Demonstrating Return on Investment

Pre Event

At the launch of the first programme, all nominations were collected through e-mail. The team relied on e-mail to communicate the new programme and to connect with the target population. Lists of nominators, nominees, and delegate information were initially collated by a central team on a programme-by-programme basis on spreadsheets. Over time, as management information reporting was required, a more functional database was developed allowing easy access to all details of attendees from across Europe by country, business unit, programme attended, and nominator. The ease, speed, and flexibility of reporting available in this database has increased efficiency and accuracy in the information reported. For example, one leader in the business asked for a report of all the colleagues in his/her business unit who had attended the programme over a given time period. The leader used the list to ask all those colleagues who had attended to make a formal presentation in a full office meeting to share their knowledge. The learning management system has now been successfully implemented throughout the majority of Europe and options are currently being generated to maximise this facility in the nomination of participants, ensuring cross-business unit and cross-geography participants on each programme.

A three to six month Business Challenge is a key part of the prework for participants. The Business Challenge was devised together with the external provider delivering the workshop and the global Learning Team. The Challenge is agreed upon with the local line manager and brought to the event to share, discuss, and create an action plan. The Challenge meets a number of the KM strategy criteria in that it aligns the individual and his/her manager to a business output of his/her learning and demonstrating a return on investment measurement (subject to the goal being specific, measurable, achievable, realistic, and timed).

The Business Challenges are one example of thread being sewn between many of the delegates as discussion is generated when delegates realize many have the same or a very similar Challenge, albeit in a different business unit or geography. Connecting cross-function and cross-geographical border issues and people continues to be a focus for discussion around the return on investment for the event. The postprogramme conference calls have begun to identify business opportunities across divisions in the organization and direct revenue-generating projects as a result of the network established and promoted at the event. It is hoped that in time these trends and successes will be recorded by delegates on an Internet-based platform for any employee to see, learn from, and follow.

The networking and quick understanding of the knowledge and business representation in the room is a fundamental quick win of the curriculum and the platform on which further learning will be maintained and shared. Feedback after the first few programmes in 2002 alluded to the struggle to get to know everyone and how they contributed over the three-day event. As a result, Europe implemented an additional prework assignment named Background Information. Each participant was asked to complete a brief electronic proforma prior to the event documenting his/her name, office location, business unit, three to six month Business Challenge, time of service with the company, greatest achievement while at Marsh, and what they do on a Sunday afternoon. These data are e-mailed to the Programme Manager to be collated into a simple spreadsheet and circulated to delegates at the beginning of Day 1 of the event to help people know and remember colleagues they meet and learn from. This document is also circulated after the workshop by e-mail, along with an e-mail distribution list to encourage the network to sustain and grow.

Post Event

Marsh Europe invested in a questionnaire distributed to a random selection of colleagues who had attended the programme. These questionnaires were sent out to delegates six to eight months post event through an online Web-based interview tool allowing the results to be recorded electronically and transferred into a database for future reference. The outcome of the questionnaires was verbatim comments leading to a number of conclusions about the event itself, the impact of efforts to sustain learning, and the needs for KM tools.

The feedback identifies that while colleagues felt that the programme gave them much material to enrich their personal effectiveness, few were able to make the connection to how the learning had impacted the organisation. The Business Challenge template has been revised in the third year of delivery of the programme to include a specific question to the delegate of the hard-dollar value of the business challenge they hope to complete as a result of their learning. These documents are signed before each delegate leaves the event and sent to a central global team to collate. The next step proposed in this process, with a high-man-hour intervention, is to go back to each delegate three to six months after the programme to reconcile proposed dollar return with actual return to clearly demonstrate a tangible bottom-line impact. One particular Business Challenge has estimated a return equal to the financial value of delivering one Managing Essentials event for 30 employees.

It has been agreed to investigate the development of a leadership "portal" which would also enable colleagues across Europe to interact, share learning and lessons learned to a greater proportion of delegates with the tool targeting all those who have attended Managing Essentials, rather than those who attend each individual programme.

KM Across the Learning and Development Community

The global Learning and Development network has been investigating KM opportunities to enhance and ensure consistency in the role of colleagues increasingly involved in managing this programme around the globe. Through the programme's life of just more than two years, colleagues in different geographies have approached its implementation in slightly different ways, all sharing their experiences with the global Programme Manager based in New York. The global Learning network is now looking to use a specific database functionality through the cross-company e-mail system to communicate with each other, store documentation, and to share tasks.

The decision to use this particular database came after consideration of a number of internal options, including a Microsoft® Access database, use of an intranet, and use of technology known as E-Room. None of the above media allowed an economical, easy global access and storage of documents along with online interactive communication through electronic discussion boards. The Access database would be difficult to share and update across the globe on each regional internal network. Ensuring secure access to the intranet site to restrict access to only L&D colleagues would come with comparatively high expense on a direct cost basis and the "one more log-on and password" toll to colleagues in using it. The E-Room facility offered the closest match as a type of online filing cabinet where information could be stored, e-mails could be sent and access levels could be dictated; unfortunately, this option was prohibitively expensive for the number of users anticipated over the foreseeable future.

While the chosen database is not the most visually stimulating platform, the challenges of the other options make it the most practical and economical solution.

CONCLUSIONS

The KM strategy for a core Leadership Development programme in Europe is to sustain learning for colleagues who attend, cascade learning to others, and demonstrate return on investment from the event. While the organization had a number of KM tools available in various geographies, these were mainly used to manage day-to-day business knowledge. Sharing of learning materials and experiences was a relatively new concept in the organization. The existing tools have been flexed to implement a structured programme of interventions to increase organizational capacity through this sharing of knowledge. There is now a set of tools and practices in place to reinforce and cascade the learning across Europe aligned to the organizational culture using a variety of mediums including, but not limited to, the PC. These tools and practices are being shared in the internal learning community across the globe. The foundations of the strategy are in place and are being executed. It is too early to confirm the long-term success of this solution, but feedback to date suggests the strategy is supporting sustainable KM and breaking down geographical and business silos to improve organizational capacity.

Epilogue and Lessons Learned

The same external partners continue to deliver the three-day learning event across the globe. The challenge over recent months has been to maintain the organisations' commitment and energy to the KM strategy. Priorities in the business are regularly reviewed to ensure effective investment is appropriately placed where it can maximize return. The KM strategy has provided a measurement tool in the Business Challenges, although the financial implication of the Challenges has only recently been recorded and realized. Attendance on postprogramme conference calls is lower over the last eight months than what it was 12 months ago. In Europe, the number of colleagues comfortable with a three-day learning event in English outside of the United Kingdom is diminishing. Over this time, the organization has developed a more pan-European business, uniting colleagues from across Europe in an increasing number of projects. Delegates and learning professionals in the business are now pushing the KM strategy to deliver a global, Web-based interactive tool to share stories, post documents, and caretake the learning community. Lessons learned include:

- KM across a large organization with diversity across geographies, languages, and regional, local, and office cultures requires persistence, creativity, and ownership from the audience. Knowledge must be easy to access, relevant to the day job, and seen as an added value to individuals personally and professionally, and to individual and team performance.
- This programme benefited from transparent senior leader involvement and commitment. Senior leaders gave their time to be present at the three-day event and their endorsement to the KM strategy post event. Without this support, which included a time and a direct financial cost, the learning and therefore KM strategy would not be implemented.
- Stories from colleagues, peers, and senior leaders are rich, credible, and effective tools in transferring and sustaining learning, both for the storyteller and for the listener.
- Upon implementation of the Managing Essentials programme, the KM was necessarily owned by the L&D team. This meant a small number of people brainstorming on ideas to develop the strategy. Now that the programme is embedded, known and branded as a success, the L&D team can now hand this responsibility over to the end users who have already attended the programme. This will generate a wealth of more ideas immediately relevant to the business, hand in hand with ownership of those KM processes.
- Blend the KM activity with a variety of media to match learning styles in the audience. After a learning event, keep any KM intervention 60 minutes or less for two reasons: the delegate is more likely to clear time to attend in his/her diary, and the facilitator is more likely to retain the attention span of all attendees.
- Keep the key messages short and simple to allow easy, quick, and frequent reinforcement. The Managing Essentials learning event has approximately 10 key, high-level statements. While each delegate usually chooses between one and three of these messages to focus on first when back at the office, the programme manager refers to a variety of the 10 whenever communicating to the group.
- In this case, the external delivery partners' style, delivery method, and connection with the delegates have a significant impact on the effectiveness of the KM. On conference calls after the programme, delegates make consistent reference to the humor and personal teaching "stories" of the facilitators when reflecting on the event. The three-day event is, however, a relatively short interven-

tion in the overall strategy. Coupled with the dynamic facilitation, the role of the programme manager is important in reinforcing the key messages. Over the life of this case, the programme manager's job was to know and reinforce the relevant stories to share with delegates and to be a central source of connection between delegates to encourage the learning networks to continue.

- KM projects require significant resources. Organizations looking to build KM as an organizational capability need to expect it to take time. As this case demonstrates, KM is evolving from a technology-based field to one of business efficiency through the effective communication of common key messages. After working on the sustainability and KM for this single learning event for two years, this company has introduced a number of tools and processes that have impacted success. There is still, however, much to do to achieve behavioral change in managers across the business as a result of the learning event.

REFERENCES

Georgenson, D.L. (1982). The problem of transfer calls for partnership. *Training and Development Journal, 36*(10), 75-78.

Kaplan, R., & Norton, D. (1992). The Balanced Scorecard—Measures that drive performance. *Harvard Business Review, 70*(1), 71-79.

Newman, B. (1991). *From the introduction to "An open discussion of knowledge management."* Retrieved from www.km-forum.org/what_is.htm

Nixon, N.M. (2000). *Common knowledge: How companies thrive by sharing what they know.* Boston: Harvard Business School Press.

ENDNOTES

[1] Kaplan & Norton (1992).

[2] The programme is just one aspect of the effort to increase organisational capability and capacity.

[3] Unilever, USA – "APT2 is Unilever's expression of its learning organisation. The company uses APT2 to educate employees on the difference between 'training' and 'learning,' promote the many forms of learning outside the classroom, and actively engage its workforce in recycling knowledge for sustained competitive advantage."—Karen Pacent, Unilever

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Chapter 4.14
Dissemination in Portals

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INTRODUCTION

While there are many aspects to managing corporate knowledge, one key issue is how to disseminate corporate documents with appropriate context. Upon finding an article on a certain subject, for example the material properties of titanium, a reader is likely to be interested in related articles such as applications of titanium or manufacturing methods for titanium parts. Each related article has the potential to increase the reader's knowledge of the subject. Therefore, organizing documents into categories of interest plays an essential role in discovering and interpreting information. Furthermore, categories can be expected to provide historical context, describing how titanium was used in early designs or initial practices used for the repair of titanium parts.

While most large companies make a practice of cataloging and controlling well-established documents, there is a vast set of explicit information that has not traditionally been effectively disseminated. This class of information is less formal and may be exchanged, updated, and otherwise managed at the local level. Such information is usually not controlled at the corporate level or governed by the same organizations established to handle more stable information. Processes to disseminate such information tend to be ad hoc or nonexistent. In this article, we discuss the elements necessary to effectively disseminate informal and explicit information not controlled at the enterprise level. While the main emphasis of the article is to promote a general process for the dissemination of this type of material in large corporations, we will use a specific implementation of this process at the Boeing Company as an illustrative example.

BACKGROUND

Traditionally, the dissemination of corporate knowledge has taken a number of different forms. First, there are the methods of classic library science often as implemented by a formal corporate library staffed by trained librarians (Taylor, 2000). This is used for things that are well established such as textbooks, established how-to knowledge on a subject, published papers on a subject, and so on. Second, it has long been necessary to disseminate official policy and procedure through "Command and Control" processes and associated media. In addition, certain industries also require configuration control processes for special classes of information such as product data, drawings, and manufacturing rejection and acceptance documentation. These are all subject to an authentication process, flowing top-down to intended users. A third, extremely important approach to knowledge maintenance and dissemination has been through mentoring and establishment of departments aligned to technical specialties and communities of interest. These approaches are particularly well suited for tacit knowledge. A fourth category of knowledge sharing applies to the communication of explicit knowledge among peers but also includes dissemination to management and other reference groups. This method applies to information that is less formal and frequently ephemeral.

This fourth method is of an entirely more fluid nature and, in some cases, represents the majority of a corporation's explicit knowledge. While it is appropriate for the enterprise to disseminate formal information using traditional, formal means, there is a need to disseminate less formal information as well. This informal knowledge often includes the most current information within a company and without adequate dissemination, corporate decision-making is likely to fall short. In summary, stable and formal information is well handled by existing library or document release systems. Ephemeral, less formal, and generally less controlled content, while important, is currently only shared across the enterprise by a variety of ad hoc means, if at all.

MAIN FOCUS OF THE ARTICLE

This article focuses on how to systematically share this fourth category of informal and uncontrolled knowledge. The ideal for knowledge dissemination is to make sure information of this type can be well integrated into existing formal content, taking advantage of the context that has been created over time by librarians and other formal content management systems. To achieve this, it is necessary to organize this knowledge in a way that is consonant with the information categories of multiple existing systems. This is made possible by using an enterprise ontology or some form of controlled system of keywords which can be mapped to existing vocabularies. Portals, and other tools which allow content aggregation and term mapping, enable sharing of this knowledge at a physical level. It provides search and simple navigation across sources, as well as security services to restrict access as needed. A central ontology combined with an interactive text classification tool make dissemination of this knowledge possible at a content level.

In the matter of assigning documents to categories, we emphasize the importance of involving subject matter experts. Traditionally, this is done by librarians who are trained to catalog (categorize) content. However, in the case when authors are widely distributed throughout a complex corporate enterprise, we suggest that text classification software be used by these subject matter experts to facilitate broad knowledge dissemination. The challenge is to provide text classification services which can be used to produce high quality results by users who are not trained in library science.

The essential elements of a distributed dissemination scheme for this type of explicit but informal knowledge are a portal, an ontology, a text classification system, and a publication process. In combination, these four elements allow autonomous subgroups of a corporate entity to interact with common resources and tools to publish their local work in a way that places it within a context comprehensible to an enterprise audience.

Knowledge dissemination, as used here, applies specifically to explicit knowledge captured in documents from many sources. There are a number of frameworks that address the life cycle of explicit knowledge (Bock, 1997; O'Dell, 1998), but here we will follow the steps outlined by Mack (2001). In this framework, the basic tasks in knowledge work are Capture/Extract, Analyze/Organize, Find, Create/Synthesize, and Distribute/Share. In particular, text classification has direct benefit to the Analyze/Organize and Find stages and portal services will be the basis of the Distribute/Share stage. As discussed here, knowledge dissemination applies to the Analyze/Organize, Find, and Distribute/Share stages.

Portals

A portal is used to collect content from many different sources, resulting in a virtual collection available through a single point of access. This aggregation of content is perhaps the key characteristic of all portal products. In addition, a portal provides some capability for metadata management whereby tags and values can be directly replicated from source documents or harmonized within the virtual collection by mapping them to a centralized schema. In addition, a portal may permit the addition of metadata based on characteristics of the source system or based on the decisions made by the group about how ontology terms will be attached to documents. The documents themselves remain in their source system, maintained, refreshed, or deleted by the groups that own them.

Other kinds of information systems besides portals can be useful for knowledge dissemination. However portals, in one form or another, are well suited for publishing a distributed collection based on the intellectual products of many subgroups. Further, because of their flexibility in combining a variety of tools and services, portals can be customized to create a rich knowledge-sharing environment. For example, portals can readily support search and navigation. In addition, they can be extended to support personalization services, which would allow even more focused dissemination.

Thus, portals are a natural element to aid in knowledge dissemination. They can be used to achieve the key goal of achieving awareness (Alavi, 1999; Prusak, 1997). Indeed, creating awareness is a goal of dissemination and is a prerequisite to collaboration or further synthesis.

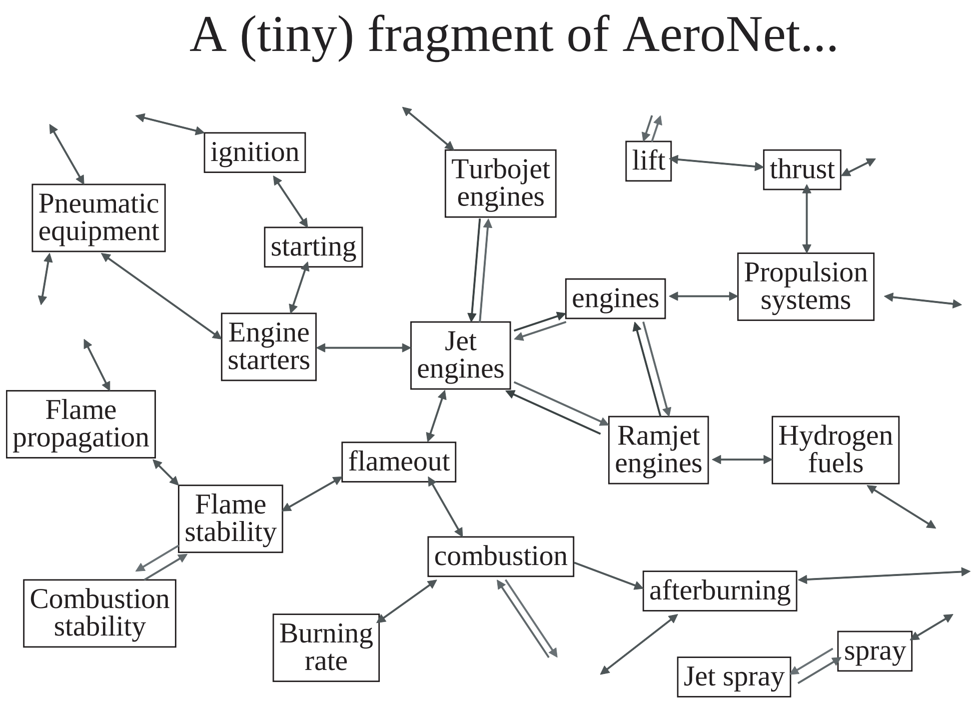
Ontologies

To produce an organization of corporate documents that can be readily shared, it is essential to have some standard in the form either of a corporate taxonomy, a corporate thesaurus, or both. What is minimally necessary is simply a list of controlled keywords expressing the topics that are important to the enterprise. We refer to the concepts expressed by these keywords as knowledge categories. Ideally, there is some kind of structure or organization to the knowledge categories, for example, a generalization-specialization hierarchy. Such a specification of the things that can be talked about and their relationships is referred to in artificial intelligence as an ontology. There is a strong advantage to organizing documents this way, because it enables much easier and better quality search, and greater use of the knowledge in those documents. In the Boeing case, there were about 60,000 knowledge categories as well as generalization-specialization relationships, synonymy relationships, and more general "is-related-to" relationships, so that the ontology is somewhat richer than a hierarchy (see Figure 1) (Clark, 2000).

This approach benefits most when it can build on an existing cataloging scheme, such as one maintained by an enterprise library system or a professional organization (e.g., the IEEE, Institute of Electrical and Electronics Engineers), or a taxonomy provided by an industrial consortium (e.g., the ATA, or Air Transport Association). The ontology used in the Boeing realization of the approach derives from the corporate thesaurus, a list of controlled keywords sanctioned by the Boeing technical library system, together with the relationships among them. By using a set of controlled keywords created by corporate librarians, not only was an immense amount of time saved in constructing the taxonomy, but the system also was able to leverage off of their collective and accumulated expertise.

However, with some additional effort, categories can be established and applied even when such a resource is not available or is not sufficiently complete. In this case, one approach

Figure 1. The AeroNet ontology contains more than 60,000 concepts used as categories for text classification and subsequent knowledge dissemination. This figure shows a small fragment of the total ontology.



is to use text clustering and automatic summarization (Kao, 2004). Text clustering serves to group documents together based on the words they contain. The words with the greatest frequency or strength either throughout or near the center of each cluster can summarize the documents in that cluster. Using this summary, domain experts, knowledge administrators or managers, or librarians can decide which clusters represent important categories to the enterprise and supply standard names for those categories. If desired, they can further subdivide or group the resulting categories giving generalization-specialization relationships, and shared summary words may suggest other relationships. Of course, while this approach will provide more consistency within the enterprise, it will lose the historical context provided by leveraging off of existing ontologies.

Once an ontology is available, the concepts must be attached to documents and used to retrieve those documents. We do not assume that those who are involved in knowledge dissemination, whether as knowledge provider or consumer, have either the training or perspective of librarians. Nevertheless, by allowing participants to interact with a controlled vocabulary in the context of their subject matter of interest and giving them a means to do so easily, the process can improve dissemination of knowledge by grouping topically similar documents together regardless of their original local vocabulary usage. What is required is a tool to aid the author or searcher in finding the appropriate categories, and that is the function of an automatic text classifier.

Text Classifier

An automatic text classifier takes a piece of text (e.g., a memo, an abstract, or a longer document), and based on its features (typically the words it contains) determines automatically which of a set of predetermined categories should be assigned to it. There are a number of different approaches, as summarized in Sebastiani (2002), including naïve Bayes (McCallum, 1998), support vector machines (Joachims, 1998), and logistic regression classifiers (Komarek, 2003).

Whichever approach is used, the first step in creating a classifier is to collect a training sample of texts that are already associated with the appropriate knowledge categories. Again, if the ontology derives from a set of keywords provided by a corporate library, there is likely a set of documents that have already been assigned these keywords or knowledge categories by the librarians (similarly for other sources of the controlled keywords, be it industrial consortia or professional societies or journals). At the Boeing Company, the abstracts for about 500,000 corporate documents in the technical library were used as the training sample.

If the categories are not a pre-existing set created by librarians or another standard professional body but have been developed as described using a text clustering algorithm, there may still be an easy way to create a training set. If the clustering algorithm generates convex clusters, as does K-means (Hartigan, 1975; Hartigan & Wong, 1979), the central members of the chosen clusters could serve as a training sample for those categories.

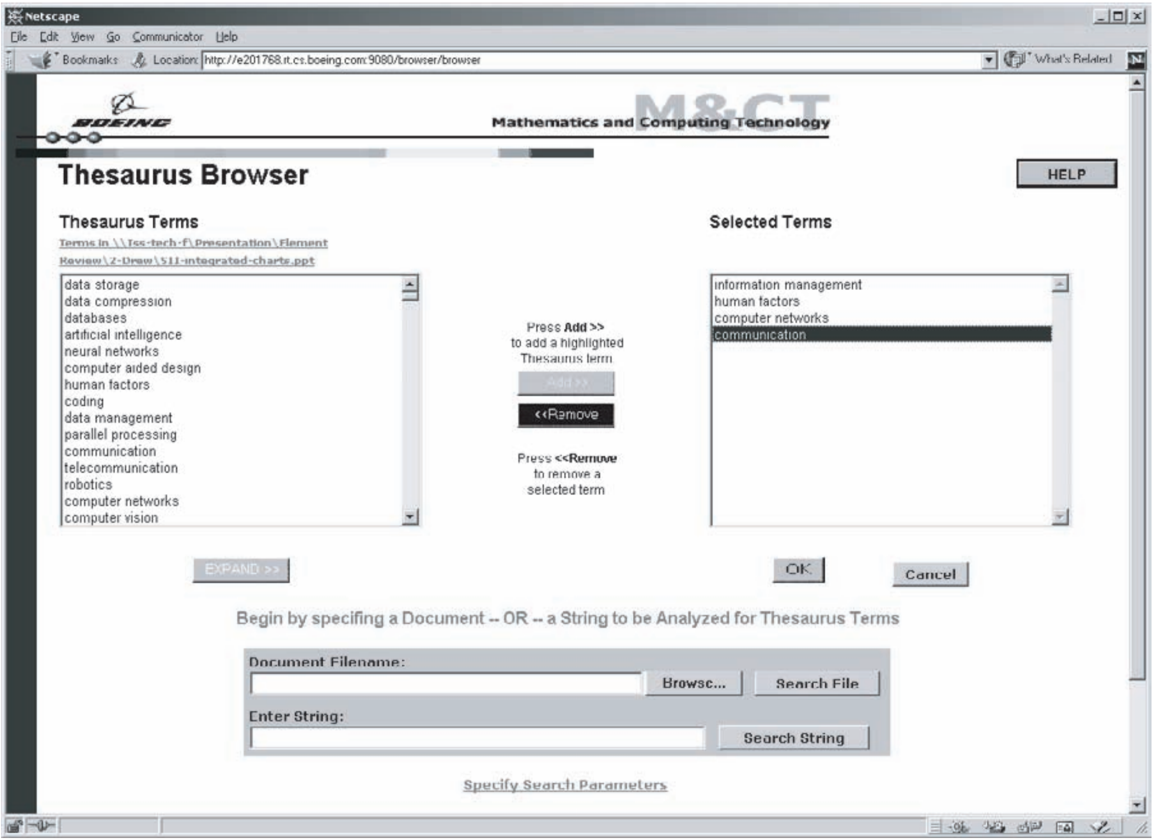
A text classifier is then constructed or trained based on the knowledge categories and the training sample of already categorized documents. The text classifier is then made available to both producers and consumers of the documents.

Authors of new documents to be entered into the system can use the text classifier to automatically propose knowledge categories appropriate to their document. In the Boeing implementation of this process, using the Graphical User Interface (GUI) shown in Figures 2 and 3, they first either type in the name and location of their document or browse to enter it into the classifier. The classifier then proposes the most likely knowledge categories ranked in order of likelihood in the box under the "Thesaurus Terms" label (see Figure 2). The authors can either select these terms or use AeroNet, a semantic network

Figure 2. The Graphical User Interface (GUI) allows users to scan documents and find suggested categories from the AeroNet ontology based on the results of a text classifier.

of thesaurus keywords developed at the Boeing Company (Clark, 2000), to navigate through the relationships among the categories to find more precise or more general knowledge categories to better describe their document. For example, the knowledge category "data management" might have been returned by the classifier (see Figure 3). By highlighting that and clicking on "EXPAND," AeroNet will bring up specializations like "factory data access system" and "data integration" and generalizations like "management" from which the user can select or use as a starting point for further navigation. If a category was selected incorrectly, they can remove it from the list by highlighting the category of interest and then clicking on the "Remove" button. When the list of selected knowledge categories is finalized, they associate it as metadata with the document by clicking on the "OK" button. This leads to not only much faster organization of information but also much more consistent quality in the organization of the information.

Figure 3. Users can use the GUI to expand terms and then select those that represent the best categories for a given document.



During the Find phase, the same text classifier can be used to identify information the user is interested in, without requiring the user to know the controlled vocabulary. Users may search for documents in the knowledge management system by entering a natural language query in a similar GUI and then selecting from the knowledge categories suggested to construct a precise query based on the content metadata. This allows the searcher to take advantage of the controlled vocabulary without memorizing it.

Publication Process

A workgroup needs to have a process that uses the classifier and portal for knowledge to be shared outside the group. Minimally, individuals would be required to add metadata to all documents they wish to publish. In addition, the group could use the text classifier on a representative sample of their documents to produce an initial down-selection of knowledge categories appropriate for most documents they are likely to produce.

FUTURE TRENDS

Effective classification and processes for knowledge dissemination have a positive impact on the evolution of the Semantic Web (Berners-Lee, 2001; Schwartz, 2003). The basic idea of the Semantic Web is to make content on the Web machine-sensible with regards to its semantics (what the content is about) and with regards to machine reasoning over (what the content is related to or implies). In achieving semantics it will be important to classify content in terms of one or more ontologies. Tools involving automatic text classification will probably be essential in making this feasible. Using classification based on existing library practices, as an underpinning, to provide these semantics will have the same advantage as mentioned: the meaning assigned to Web content will be more likely consistent with existing catalogs of knowledge. In knowledge dissemination as discussed here, users are able to traverse the relationships in the ontology when choosing terms. However, in the future Semantic Web, reasoning one or more ontologies is expected to occur automatically, at runtime, whenever a query is activated. One function of the Semantic Web will be to improve knowledge dissemination by using software agents to execute queries selectively, taking advantage of both the context of the content and the matching profiles of end users. The different ways that reasoning, and multiple domain ontologies, can be leveraged in the future Semantic Web should substantially extend what is used in current knowledge classification and dissemination. Nonetheless, the four essential elements discussed here will still be crucial. Without effective text classification, reasoning capabilities cannot be expected to provide significant improvements.

CONCLUSION

There is a broad class of explicit but informal knowledge created within almost any enterprise which is not well disseminated by conventional means. Taking advantage of the Web infrastructure, this knowledge can be effectively disseminated using four essential elements: a portal, an ontology, a text classification system, and a publication process. Perhaps most important is a broad, cost-effective means to classify content according to an ontology. We suggest that text classification tools can provide such a means. Given this, portals can be used to disseminate knowledge, subject to appropriate publication processes, according to consistent categories. This provides context that links each new item of content to the information previously collected in library catalogs and published from other content resources.

Further, text classification helps overcome a substantial obstacle to knowledge dissemination within a large enterprise. Users are notoriously reluctant to assign any kind of metadata to documents that they author or maintain. By providing aids to classification, basic users can accomplish cataloging tasks without much training, time, or effort, and are therefore more likely to do it. In the approach outlined, the list of proposed knowledge categories is essentially consistent with the practice of professional librarians. Overall, the quality of the user-selected categories is likely to be much better compared to categories selected without assistance from a large ontology. Consequently, using these four elements, enterprises have at their disposal a means to disseminate a class of information that is likely to aid corporate decision-making and which should qualitatively increase a company's understanding of itself.

REFERENCES

Alavi, M., & Leidner, D. (1999). Knowledge management systems: Issues, challenges and benefits. *Communications of the AIS, 1*(2es), Article 7.

Berners-Lee, B., Hendler, J., & Lassila, O. (2001). The Semantic Web. *Scientific American,* May, 34-43.

Berry, M., Dumais, S., & O'Brien, G. (1995). Using linear algebra for intelligent information retrieval. *SIAM Review, 37*(4), 573-595.

Bock, G. (1997). Knowledge management frameworks. *Patricia Seybold's World Computing Report, 20*(2), February 1997.

Clark, P., Thompson, J., Holmback, H., & Duncan, L. (2000). Exploiting a thesaurus-based semantic net for knowledge-based search. *Proceedings of the 12th Conference on Innovative Applications of AI (AAAI/IAAI'00)*, 12, (pp. 988-995).

Hartigan, J.A. (1975). *Clustering algorithms* (97-105). New York: Wiley

Hartigan, J.A., & Wong, M.A. (1979). A k-means clustering algorithm. *Applied Statistics 28,* 100-108.

Joachims, T. (1998). Text categorization with support vector machines: Learning with many relevant features. *Proceedings of ECML-98, 10th Eurpean Conference on Machine Learning,* Chemnitz, Germany (pp. 137-142).

Kao, A., Risch, J., & Poteet, S. (2004). Visualizing text data with TRUST and Starlight. To appear in *Interface 2004 Conference Proceedings.*

Komarek, P. (2003). Fast logistic regression for data mining, text classification and link detection. *Proceedings of NIPS2003, Conference on Neural Information Processing Systems.*

Mack, R., Ravin, Y., & Byrd, R.J. (2001). Knowledge portals and the emerging digital knowledge workplace. *IBM Systems Journal, 40*(4), 925-955.

McCallum, A., & Nigam, K. (1998). *A comparison of event models for naïve bayes text classification.* AAAI-98 Workshop on Learning for Text Classification.

O'Dell, C., Grayson, C. J., & Essaides, N. (1998). *If only we knew what we know: The transformation of internal knowledge and best practice.* New York: Free Press.

Prusak, L.(1997). Introduction to knowledge in organizations. In L. Prusak (Ed.)*, Knowledge organizations*. Boston: Butterworth-Heinemann.

Schwartz, D.G. (2003) Open IS semantics and the Semantic Web: The road ahead. *IEEE Intelligent Systems, 3*(18), May/June, 52-58.

Sebastiani, F. (2002). Machine learning in automated text categorization. *ACM Computing Surveys, 34*(1), 1-47.

Taylor, A.G. (2000). *Wynar's introduction to catalog-ng and classification.* Westport, CT: Libraries Unlimited.

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Chapter 4.15
Dynamic Taxonomies

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INTRODUCTION

End-user interactive access to complex information is one of the key functionalities of knowledge management systems. Traditionally, access paradigms have focused on retrieval of data on the basis of precise specifications: examples of this approach include queries on structured database systems, and information retrieval. However, most search tasks, and notably those typical of a knowledge worker, are exploratory and imprecise in essence: the user needs to explore the information base, find relationships among concepts, and thin alternatives out in a guided way.

Examples of this type of access include the selection of the "right" product to buy, of a candidate for a job, but also finding the likely cause of a malfunction, and so forth. Indeed, exploratory access applies to an extremely wide range of practical situations. Traditional access methods are not helpful in this context, and new access paradigms are needed. Effective end-user access requires a holistic approach, in which modeling, interface, and interaction issues are considered together.

BACKGROUND

Since the vast majority of knowledge is textual and unstructured in nature, information retrieval (IR) techniques (van Rijsbergen, 1979) have been extensively used in the past. IR techniques require almost no editorial work or manual preprocessing of information. However, their limitations have been known for some time: a study on a legal environment reported that only 20% of relevant documents were actually retrieved (Blair & Maron, 1985). Such a significant loss of information is due to the extremely wide semantic gap between the user model (concepts) and the model used by commercial retrieval systems (words). IR systems are also poor from the point of view of user interaction because the user has to formulate his query with no or very little assistance. Finally, results are presented as a flat list with no systematic organization, so that browsing/exploring the knowledge base is impossible.

Hypermedia (see Groenbaek & Trigg, 1994) addresses the problem of browsing/exploration, but it has a number of serious drawbacks: there is no systematic picture of relationships among knowledge base components; exploration is performed one document at a time, which is quite time consuming; and building and maintaining complex hypermedia networks is very expensive.

Traditional taxonomies are used by many systems, such as Yahoo. Here, a hierarchy of concepts can be used to select areas of interest and restrict the portion of the infobase to be retrieved. Taxonomies support abstraction and are easily understood by end-users. However, they are not scalable for large knowledge bases (Sacco, 2002) because they can be used for discrimination just down to terminal concepts, which are no further specialized. As the knowledge base grows, the average number of documents associated to a terminal concept becomes too large for manual inspection.

Solutions based on semantic networks were proposed in the past (e.g., Schmeltz Pedersen, 1993) and are being reconsidered in the current effort on ontologies and Semantic Web. Although more powerful and expressive than plain taxonomies, general semantic schemata are difficult to understand and manipulate by the casual user. They are better suited to programmatic access, and user interaction must be mediated by specialized agents. This increases costs, time to market, and decreases generality and flexibility of user access.

MAIN FOCUS OF THE ARTICLE

Dynamic taxonomies (Sacco, 1987, 2000; also known as faceted classification systems) are a general knowledge management model based on a multidimensional classification of heterogeneous data items and are used to explore/browse complex knowledge bases in a guided yet unconstrained way through a visual interface.

The intension of a dynamic taxonomy is a taxonomy designed by an expert. This taxonomy is a concept hierarchy going from the most general to the most specific concepts. Directed acyclic graph taxonomies modeling multiple inheritance are supported but rarely required. A dynamic taxonomy does not require any other relationships in addition to subsumptions (e.g., IS-A and PART-OF relationships).

In the extension, items can be freely classified under n (n>1) topics at any level of abstraction (i.e., at any level in the conceptual tree). This multidimensional classification is a departure from the monodimensional classification scheme used in conventional taxonomies. Besides being a generalization of a monodimensional classification, a multidimensional classification models common real-life situations. First, items are very often about different concepts: for example a news item on September 11, 2001, can be classified under "terrorism," "airlines," "USA," and so forth. Second, items to be classified usually have different features, "perspectives," or facets (e.g., Time, Location, etc.), each of which can be described by an independent taxonomy.

By taking a "nominalistic" approach—that is, concepts are defined by instances rather than by properties—a concept C is just a label that identifies all the items classified under C. Because of the subsumption relationship between a concept and its descendants, the items classified under C (items (C)) are all those items in the deep extension (Straube & Ozsu, 1990) of C; that is, the set of items identified by C includes the shallow extension of C (i.e., all the items directly classified under C) union the deep extension of C's sons. By construction, the shallow and the deep extension for a terminal concept are the same.

There are two important consequences of this approach. First, since concepts identify sets of items, logical operations on concepts can be performed by the corresponding set operations on their extension. This means that the user is able to restrict the information base (and to create derived concepts) by combining concepts through the normal logical operations (and, or, not).

Second, dynamic taxonomies can find all the concepts related to a given concept C; these concepts represent the conceptual summary of C. Concept relationships other than subsumptions are inferred through the extension only, according to the following extensional inference rule: two concepts A and B are related if there is at least one item d in the knowledge base which is classified at the same time under A or under one of A's descendants and under B or under one of B's descendants. For example, we can infer an unnamed relationship between Michelangelo and Rome, if an item classified under Michelangelo and Rome exists in the knowledge base. At the same time, since Rome is a descendant of Italy, also a relationship between Michelangelo and Italy can be inferred. The extensional inference rule can be seen as a device to infer relationships on the basis of empirical evidence.

The extensional inference rule can be easily extended to cover the relationship between a given concept C and a concept expressed by an arbitrary subset S of the universe: C is related to S if there is at least one item d in S which is also in items (C). Hence, the extensional inference rule can produce conceptual summaries not only for base concepts, but also for any logical combination of concepts. Since it is immaterial how S is produced, dynamic taxonomies can produce summaries for sets of items produced by other retrieval methods such as database queries, shape retrieval, and so forth, and therefore access through dynamic taxonomies can be easily combined with any other retrieval method.

Dynamic taxonomies work on conceptual descriptions of items, so that heterogeneous items of any type and format can be managed in a single, coherent framework. Finally, since concept C is just a label that identifies the set of the items classified under C, concepts are language-invariant, and multilingual access can be easily supported by maintaining different language directories, holding language-specific labels for each concept in the taxonomy. If the metadata descriptors used to describe an item use concepts from the taxonomy, then also the actual description of an item can be translated on the fly to different languages.

Exploration of the Knowledge Base

Dynamic taxonomies can be used to browse and explore the knowledge base in several ways. The preferred implementation follows. The user is initially presented with a tree representation of the initial taxonomy for the entire knowledge base. Each concept label also has a count of all the items classified under it—that is, the cardinality of items(C) for all Cs. The initial user focus F is the universe—all the items in the knowledge base.

In the simplest case, the user can then select a concept C in the taxonomy and zoom on it. The zoom operation changes the current state in two ways. First, concept C is used to refine the current user focus F, which becomes $F \cap$ items(C). Items not in the focus are discarded. Second, the tree representation of the taxonomy is modified in order to summarize the new focus. All and only the concepts related to F are retained, and the count for each retained concept C' is updated to reflect the number of items in the focus F that are classified under C'. The reduced taxonomy is derived from the initial taxonomy by pruning all the concepts not related to F, and it is a conceptual summary of the set of documents identified by F, exactly in the same way as the original taxonomy was a conceptual summary of the universe. In fact, the term dynamic taxonomy is used to indicate that the taxonomy can dynamically adapt to the subset of the universe on which the user is focusing, whereas traditional, static taxonomies can only describe the entire universe.

The retrieval process can be seen as an iterative thinning of the information base: the user selects a focus, which restricts the information base by discarding all the items not in the current focus. Only the concepts used to classify the items in the focus and their ancestors are retained. These concepts, which summarize the current focus, are those and only those concepts that can be used for further refinements. From the human computer interaction point of view, the user is effectively guided to reach his goal by a clear and consistent listing of all possible alternatives. This type of interaction is sometimes called guided thinning or guided navigation.

Dynamic taxonomies can be integrated with other retrieval methods in two basic ways. First, focus restrictions on the dynamic taxonomy can provide a context on which other retrieval methods can be applied, thereby increasing the precision of subsequent searches. Second, the user can start from an external retrieval method, and see a conceptual summary of the concepts that describe the result. Concepts in this summary can be used to set additional foci. These two approaches can be intermixed in different iteration steps during a single exploration.

An Example of Interaction

We show a simple systematic exploration on a multimedia knowledge base containing the works of the most important painters of the Italian Renaissance (Piero della Francesca, Masaccio, Antonello da Messina, Paolo Uccello, and Raffaello). Each work was thoroughly classified according to a number of subjects that are shown in Figure 1. The main difference with traditional methods is that no traditional method is able to taxonomically summarize a set of documents: there is no problem in selecting all the works by Masaccio through a database query, but there is no way of knowing where these works or what their themes are without exhaustively inspecting all the items.

Figure 1. Initial taxonomy: Preparing to zoom on Masaccio

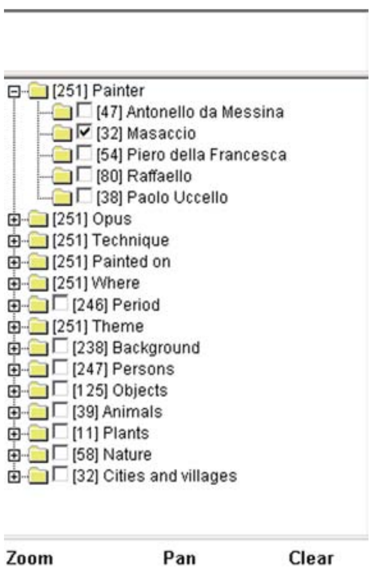


Figure 2. Locations for Masaccio's paintings: Preparing to zoom on USA; candidate items are reduced to 32 from 251

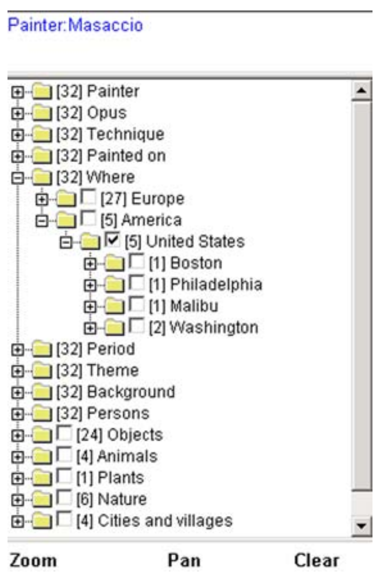
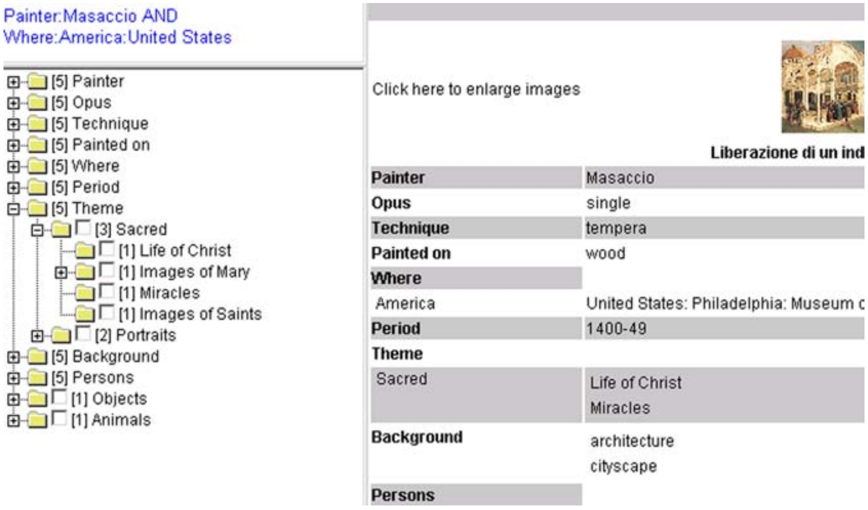


Figure 3. Themes for Masaccio's U.S. paintings: Miracles was clicked; candidate items are reduced from 32 to 5, and then to 1 by selecting the "Miracles" concept



Conventional taxonomies have the same problem: they give a description of the entire collection, but are unable to summarize subsets of it.

A simple interaction that shows the importance of conceptual summaries follows. In Figure 1, we have the initial taxonomy and we are preparing to zoom on Masaccio. In Figure 2, the taxonomy no longer describes the entire knowledge base, but only the subset of it that consists of Masaccio's paintings. In this reduced taxonomy, we have expanded the location branch (Where) and found out that five paintings are in the USA. A single zoom operation thinned our 251 item knowledge base to only five items. Note that we could have expanded any other branch, according to our interests. Finally, Figure 3 summarizes the Themes for Masaccio's U.S. paintings, after a zoom on USA, and further reduces the number of candidate items to be inspected.

Advantages

The advantages of dynamic taxonomies over traditional methods are dramatic in terms of convergence of exploratory patterns and in terms of human factors. The analysis and experimental data by Sacco (2002) show that three zoom operations on terminal concepts are sufficient to reduce a 1,000,000 item information base described by a compact taxonomy with 1,000 concepts to an average 10 items. Experimental data on a real newspaper corpus of over 110,000 articles, classified through a taxonomy of 1,100 concepts, reports an average 1,246 documents to be inspected by the user of a static taxonomy vs. an average 27 documents after a single zoom on a dynamic taxonomy.

Dynamic taxonomies require a very light theoretical background: namely, the concept of a taxonomic organization and the zoom operation, which seems to be very quickly understood by end-users. Hearst et al. (2002) and Yee et al. (2003) conducted usability tests on a corpus of art images. Despite an inefficient implementation that caused slow response times, their tests show that access through a dynamic taxonomy produced a faster overall interaction and a significantly better recall than access through text retrieval. Perhaps more important are the intangibles: the feeling that one has actually considered all the alternatives in reaching a result. Although few usability studies exist, the recent (2004) widespread adoption of systems based on dynamic taxonomies by e-commerce portals, such as Yahoo, Lycos, BizRate, and so forth empirically, in late 2003/early 2004 empirically supports this initial evidence.

The derivation of concept relationships through the extensional inference rule has important implications on conceptual modeling. First, it simplifies taxonomy creation and maintenance. In traditional approaches, only the relationships among concepts explicitly described in the conceptual schema are available to the user for browsing and retrieval. The schema designer must therefore anticipate and describe all possible relationships—a very difficult if not helpless task. In dynamic taxonomies, no relationships in addition to subsumptions are required, because concept relationships are automatically derived from the actual classification. For this reason, dynamic taxonomies easily adapt to new relationships and are able to discover new, unexpected ones. Second, since dynamic taxonomies synthesize compound concepts, these need usually not be represented explicitly. This means that the main cause of the combinatorial growth of traditional taxonomies is removed. Sacco (2000) developed a number of guidelines that produce taxonomies that are compact and easily understood by users. Some of these guidelines are similar to the faceted classification scheme by Ranganathan (1965), at least in its basic form: the taxonomy is organized as a set of independent, "orthogonal" subtaxonomies (facets or perspectives) to be used to describe data.

As an example, consider a compound concept such as "15th century Florentine paintings." First, we can break the compound concept into its facets: in the case at hand, we will have a Location taxonomy (of which Florence is a descendant), a Time taxonomy (of which the fifteenth century is a descendant), and finally an Art taxonomy (of which painting is a descendant). Second, by taking advantage of the multidimensional classification scheme, the items to be classified under "15th century Florentine paintings" will be classified under Location>Florence, Time>15th century, and Art>Painting instead. The extensional inference rule establishes a relationship between Florence, 15th century, and Painting, and the compound concept can be recovered by zooming on Florence, then on 15th century, and finally on Painting, or any permutation of these concepts since concept composition is commutative. In a conventional classification scheme, such as Dewey (1997) indexing, in which every item is classified under a single concept, we will need to explicitly define a number of different concepts equal to the Cartesian product of the terminals in the three taxonomies. Such a combinatorial growth either results in extremely large conceptual taxonomies or in a gross conceptual granularity (Sacco, 2000). In addition, the dynamic taxonomy approach makes it simple to focus on a concept, such as 15th century, and immediately see all related concepts such as literature, painting, politics, and so forth, which are recovered through the extensional inference rule. In the compound concept approach, these correlations are unavailable because they are hidden inside the concept label.

Additional advantages include the uniform management of heterogeneous items of any type and format, easy multilingual access, and easy integration with other retrieval methods.

Related Areas

Dynamic taxonomies directly derive from the work on the Fact Model (Sacco, 1988), the first semantic data model to include standard inference capabilities based on the conceptual schema itself rather than on external Prolog-like rules. In the Fact Model, relationships among entities (facts) are expressed as irreducible relations (Falkenberg, 1976): one of the standard inference rules in the model (called fact subsumption) states that given a fact F on entities E1, …, En, F is subsumed by all the facts defined on a subset of these entities. This means that, for instance, F(E1, E2) is a generalization of F(E1, …, En), in which E3, …, En are treated as 'don't cares'. In addition, F(E1, E2) exists if there exists at least one fact referencing both entities and at least one tuple in which these entities are not null. If the classification of an item in dynamic taxonomies is seen as a tuple in a fact which references all the concepts in the taxonomy, the extensional inference rule is derived immediately.

Dynamic taxonomies have obvious connections with Description Logic (Baader, 2003), especially in the interpretation of concepts as sets of instances. Since the model is able to dynamically reconstruct all the combinations of concepts, it can be seen as a device to interactively build and explore hypercubes, in a way applicable to OLAP techniques for databases (see Chaudhuri & Dayal, 1997).

Some of the guidelines for the construction of the taxonomy are similar to basic faceted classification (Ranganathan, 1965; Hearst, 2002). Although some researchers use the term faceted classification instead of dynamic taxonomies, we believe it to be a misnomer because: (a) faceted classification only addresses conceptual modeling and very basic concept composition—conceptual summaries, reduced taxonomies, and guided navigation are totally absent; and (b) faceted classification is a special case of the more general multidimensional classification on which dynamic taxonomies are built.

Finally, agent-based architectures based on user profiles (see Ardissono, 2002, as an example) are a contender for recommender systems and product selection. However, they suffer for a number of important shortcomings with respect to dynamic taxonomies. First, they usually try to acquire knowledge on the user through lengthy dialogs, which are usually perceived as boring and intrusive, and at the same time, often fail to capture a sufficient amount of information. Second, it is often quite difficult to explain to the user why a certain solution was found and which alternatives exist: in short, the properties of selected candidates are not as transparent as they are in dynamic taxonomies.

Applications

Although dynamic taxonomies have an extremely wide application range, the main industrial application is currently e-commerce. Assisted product selection is a critical step in most large-scale e-commerce systems (Sacco, 2003), and the advantages in interaction are so significant as to justify the restructuring of well-established e-commerce portals: current examples include Yahoo, Lycos, BizRate, and so forth.

An interesting application area is multimedia databases, where dynamic taxonomies can be used to integrate access by conceptual metadata and access by primitive multimedia features (color, texture, etc.) into a single, coherent framework (Sacco, 2004). Among other application areas are news archives, encyclopedias, legal databases, multilingual portals, general-purpose search engines, e-auctions, CRM systems, human resources management, medical guidelines (Wollersheim & Rahayu, 2002), and diagnostic systems. Dynamic taxonomies seem especially important as a tool for accessing laws and regulations, and consequently quite relevant for e-government.

A number of Web-based commercial systems based on dynamic taxonomies exist. These include Knowledge Processors, Endeca, i411, and Siderean Software.

FUTURE TRENDS

Five broad areas need further investigation:

1. Extensions to the Model: Dynamic taxonomies assume a Boolean classification. In some practical cases, a fuzzy (Zadeh, 1965) classification, in which a document can be classified under several concepts with different probabilities, can be more appropriate (Sacco, 2004).
2. Centralized, Distributed, Federated Architectures: Effective systems based on dynamic taxonomies must perform the zoom operation and the subsequent reduction of the corpus taxonomy in real time. A slower execution would severely impair the sense of free exploration that the user of dynamic taxonomy systems experiences. Commercial database systems do not achieve a sufficient speed on large to very large information bases, so that special data structures and evaluation strategies must be used (Sacco, 1998). Distributed and federated architectures need also to be investigated since centralized architectures are not always appropriate, because of organization needs and performance and reliability bottlenecks.
3. Guidelines for Effective Conceptual Schema Design: The design of effective dynamic taxonomies obviously plays a critical role in practical applications. Sacco (2000) indicates a number of general guidelines for the construction of dynamic taxonomies schemata, which take into account the fact that dynamic taxonomies are able to summarize concepts related to the current focus. Further research is needed to determine more stringent and specific guidelines.
4. New Application Areas and Environments: Dynamic taxonomies have an extremely wide application range, and the application areas listed above are but an initial sample. For instance, because of quick convergence, dynamic taxonomies seem the ideal access method for low-resolution wireless devices, especially when a taxonomy design that minimizes breadth is used.
5. Human Factors Both in General and in Connection with Specific Application Areas: A critical human factor issue is the presentation and manipulation of the taxonomy, where several alternatives exist (as an example, see Yee et al., 2003, vs. Sacco, 2000, 2004). With respect to specific application areas, dynamic taxonomies may need adaptation or complementary schemes (Sacco, 2003).

CONCLUSION

Exploratory browsing based on dynamic taxonomies applies to most practical situations and search tasks in knowledge management: an extremely wide application range going from multilingual portals, to general-purpose search engines, e-commerce, e-auctions, CRM systems, human resources management, and so forth. In this context, dynamic taxonomies represent a dramatic improvement over other search and browsing methods, both in terms of convergence and in terms of full feedback on alternatives and complete guidance to reach the user goal. For these reasons, we believe them to be a fundamental complement of traditional search techniques, and in fact, systems and Web sites implementing this paradigm are rapidly growing in number.

REFERENCES

Ardissono, L., Goy, A., Petrone, G., & Segnan, M. (2002). Personalization in business-to-customer interaction. *Communications of the ACM, 45*(5), 52-53.

Baader, F., Calvanese, D., McGuinness, D., Nardi, D., & Patel-Schneider, P. (Eds.). (2003). *The description logic handbook.* Cambridge: Cambridge University Press.

Blair, D.C., & Maron, M.E. (1985). An evaluation of retrieval effectiveness for a full-text document-retrieval system. *Communications of the ACM, 28*(3), 289-299.

Chaudhuri, S., & Dayal, U. (1997). An overview of data warehousing and OLAP technology. *ACM SIGMOD Record, 26*(1), 65-74.

Dewey, M., Mitchell, J.S., Beall, J., Matthews, W.E., New G.R., & Matthews, Jr., W.E. (Eds.). (1997). *Dewey decimal classification and relative index* (21st Ed.). OCLC.

Falkenberg, E. (1976). Concepts for modelling information. In G.M. Nijssen (Ed.), *Modelling in database management systems* (pp. 95-109). Amsterdam: North-Holland.

Groenbaek, K., & Trigg, R. (Eds.). (1994). Hypermedia. *Communications of the ACM, 37*(2).

Hearst, M. et al. (2002). Finding the flow in Web site search. *Communications of the ACM, 45*(9), 42-49.

Ranganathan, S.R. (1965). The colon classification. In S. Artandi (Ed.), *Rutgers series on systems for the intellectual organization of information* (vol. 4). Piscataway, NJ: Rutgers University Press.

Sacco, G.M. (1987). Navigating the CD-ROM. *Proceedings of the International Conference on Business of CD-ROM.*

Sacco, G.M. (1988). The fact model: A semantic data model for complex databases. *Information Systems, 13*(1), 1-11.

Sacco, G.M. (1998). *Procedimento a tassonomia dinamica per il reperimento di informazioni su grandi banche dati eterogenee.* Italian Patent 01303603; also U.S. Patent 6,763,349.

Sacco, G.M. (2000). Dynamic taxonomies: A model for large information bases. *IEEE Transactions on Knowledge and Data Engineering, 12*(2), 468-479.

Sacco, G.M. (2002). *Analysis and validation of information access through mono, multidimensional and dynamic taxonomies.* Technical Report, Department of Informatics, University of Torino, Italy.

Sacco, G.M. (2003). The intelligent e-sales clerk: The basic ideas. In H. Krueger & M. Rautenberg (Eds.), *Proceedings of INTERACT'03, the 9th IFIP TC13 International Conference on Human-Computer Interaction* (pp. 876-879).

Sacco, G.M. (2004). Uniform access to multimedia information bases through dynamic taxonomies. *Proceedings of the IEEE 6th International Symposium on Multimedia Software Engineering,* Miami, (pp. 320-328).

Schmeltz Pedersen, G. (1993). A browser for bibliographic information retrieval, based on an application of Lattice Theory. *Proceedings of the 1993 ACM SIGIR Conference* (pp. 270-279).

Straube, D.D., & Ozsu, M.T. (1990). Queries and query processing in object-oriented database systems. *ACM Transactions on Information Systems, 8*(4), 387-430.

van Rijsbergen, C.J. (1979). *Information retrieval.* London: Butterworths.

Wollersheim, D., & Rahayu, W. (2002). Methodology for creating a sample subset of dynamic taxonomy to use in navigating medical text databases. *Proceedings of the IDEAS 2002 Conference*, Edmonton, Canada (pp. 276-284).

Yee, K.-P., Swearingen, K., Li, K., & Hearst, M. (2002). Faceted metadata for image search and browsing. *Proceedings of ACM CHI 2002*.

Zadeh, L. (1965). Fuzzy sets. *Information Control, 8*, 338-353.

Chapter 4.16
Effects of Knowledge Management on Electronic Commerce:
An Exploratory Study in Taiwan

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ABSTRACT

The Internet-enabled e-commerce field provides capabilities for firms in all sectors to reach global buyers and suppliers. Knowledge management provides frameworks to manage intellectual capital as a valuable organizational and strategic resource. Current literature on e-commerce and knowledge management primarily emphasizes the benefit of knowledge management for innovative e-commerce operations. Do knowledge management practices significantly benefit electronic commerce? If so, does the relationship work in the other direction? Does a firm's e-commerce applications significantly benefit knowledge management practices, as well? To test these exploratory propositions, empirical data were collected from companies in a variety of industries in Taiwan, a country emphasizing e-commerce initiatives. The results revealed significant relationships between the way businesses implement electronic commerce projects and how they experiment with knowledge management concepts, as well as interesting benefits and difficulties in implementation. These relationships were found to operate in both directions, offering reinforcing effects as well as connections.

INTRODUCTION

Internationally, Internet technology is an integral component of business strategy. Most firms use electronic commerce to reach customers at home and abroad. E-commerce, when properly linked with business processes and aligned with an organization's culture, aids a firm's strategic growth (Ahadi, 2004; Piris, Fitzgerald & Serrano, 2004). These initiatives can lead to important performance gains (Green & Ryan, 2005). Another global imperative is the widespread recognition of the value of intellectual capital as a major source of sustainable competitive advantage (Marr, Schiuma & Neely, 2004). To avoid basing competitive strategy on price discounting alone, a company continuously must engage in acquiring and updating the knowledge base. According to Porter (2001), intellectual assets embodied in the total business system are then difficult to duplicate.

Thus, these two developments of knowledge management and e-commerce would seem to supplement each other (Bose & Sugumaran, 2003; Fahey, Srivastava, Sharon & Smith, 2001). Knowledge management provides the mechanism for firms to keep up with innovative activities (Bakhru, 2004; Trethewey & Corman, 2001). As e-commerce information flows freely and sites are easy and inexpensive to duplicate, innovations have an increasingly shorter life span. The integration of major business processes brought about by e-commerce provides a wealth of data and information that can fuel knowledge management (Kocharekar, 2001). Yet, most discussions in the literature are largely conceptual in nature (Holsapple & Singh, 2000).

Inquiries that examine these global issues, based on actual data, are needed to obtain more insight into the relationship and directionality between the two management themes. The purpose of this study is to correct this deficiency in the literature by exploring these relationships. Thus, the primary research question is: Do knowledge management practices significantly benefit electronic commerce? If so, does the relationship work in the other direction? Does a firm's e-commerce applications significantly benefit knowledge management practices, as well? To test these exploratory propositions, empirical data were collected from companies in a variety of industries in Taiwan. Taiwan was chosen due to its aggressive emphasis on e-commerce initiatives.

The paper first will briefly review the existing literature on both knowledge management (KM) and electronic commerce (EC) individually and then will present current literature on the linkages or supplementary relationships between the two topic areas. The paper links this literature to the paper's research propositions. Next, the case of Taiwan, a global EC leader, is discussed, along with the questionnaire development and subsequent data collection and analysis. The implications for practice call for future research in other countries in order to validate these exploratory research findings.

LITERATURE REVIEW

Knowledge Management

KM has captured increased attention in today's global business environment, because it views intellectual capital as manageable and suggests frameworks to help companies utilize this valuable strategic resource (Brand, 1998; Child, 2002; Kim & Mauborgne, 1999). KM is a set of business processes through which valuable knowledge is identified, collected/created, organized/stored, distributed, managed, and applied to problems or projects (Child, 2002; Davenport & Prusak, 2000; Grover & Davenport, 2001; Kim & Mauborgne, 1999; Leseure & Brookes, 2004; Pan & Scarbrough, 1998; Zack, 1999a).

Early discussions of KM practices range from a human-oriented to a technology-driven point of view. At one extreme of the continuum is the view of knowledge as completely unmanageable and KM as managing knowledge as human networks (Brand, 1998; Porter, 2001; Savary, 1999; Storck & Hill, 2000). Some researchers, however, view KM as an expansion of traditional data and information management. This latter view suggests a holistic approach (joining social and technological factors) in order to achieve performance expectations (Davenport & Prusak, 2000; Koch, Chae & Guo, 2002; Georgopoulos, Koulouriotis & Emiris, 2004; Soo, Devinney, Midgley, Diakoulakis & Deering, 2002).

Researchers argue that organizational knowledge can be managed without an explicit definition of the knowledge itself. Rather, the focus should be on measuring its business processes (i.e., problem solving and decision making) and the innovative outcomes (Grover & Davenport, 2001; Soo, Devinney, Midgley & Deering, 2002). Various researchers (see Ahn & Chang, 2004; Castanho, 2004; Diakoulakis, Georgopoulou, Koulouriotis & Emiris, 2004; Holsapple & Joshi, 2004; Wang & Ariguzo, 2004) have studied knowledge management and worked toward a better understanding of the topic as well as moved toward model development.

KM is emphasized in the computer information systems community and is continuously gaining interest in industries, enterprises, and government (Ahn & Chang, 2004; Davenport & Prusak, 2000). Data and knowledge are available in various forms, and decision makers combine different types of data and knowledge (Mataxiotis, Ergazakis, Samouilidis & Psarras, 2004; Woods, 2004). While the research cites IT issues, artificial intelligence, and EC, most experts agree that the true goal of KM is to establish a unified, global framework (Stankosky, 2004). Although technology is not a replacement for knowledge, the gap between the two must be bridged (Spiegler, 2003).

There are three major areas of concern characterizing an organization's KM program: (1) the choice of implementation strategy (e.g., system-oriented vs. individual-oriented and top-down vs. bottom-up); (2) the set of objectives expected to be achieved (determined by such factors as top managers' support and involvement, the nature of the industry in which the organization operates, its existing information technology infrastructure, and the organizational culture) (Zack, 1999a, 1999b); and (3) critical successful factors.

Mudambi and Navarra (2004) studied multinational subsidiaries' knowledge flows in the United Kingdom and found support for a more creative role for knowledge intensity. Gerstlberger (2004) studied companies in Upper Austria, Germany, and the Silicon Valley in the U.S. and found that regional innovative systems were important for knowledge sustainability.

Electronic Commerce

E-commerce includes business-to-consumer (B2C), business-to-business (B2B), and internal business via an Intranet (Kalakota & Whinston, 1996a). While the expectation for the commercial value of Internet technologies was widely touted during the end of the last century, the sudden collapse of dot-com companies in the spring of 2000 drove many to the other extreme of the expectation continuum. Recent observations have demonstrated that, when used properly, the Internet can become the technological foundation of an innovative international business strategy. It has been recognized generally that how the Internet is incorporated in the value-creating business strategy, rather than the Internet itself, enhances a company's competitive advantage (Barua, Konanna, Whinston & Yin, 2002; Feeny, 2001; Fingar & Aronica, 2001; Garbi, 2002; Jih, 2002; Lee & Whang, 2001; Prusak & Liam, 1998; Wigand, 1997).

The Internet provides companies of all sizes and in all industries with a convenient, affordable communication infrastructure that is not limited by time and distance. Internet transactions include the purchase of information products (i.e., software, CDs, books) to physical products (i.e., automobiles and groceries) (Child, 2002; Feeny, 2001; Turban, Lee, King & Chung, 2000). Internet technologies have enabled innovative companies, such as Tesco, e-Bay, Rosenbluth International, Dell, and Amazon.com, to outperform their competitors. As companies streamline their internal and external business processes, the distinction between the old economy and the new economy continues to fade.

Researchers have analyzed EC business models from many different perspectives and frameworks (Barua, Konanna, Whinston & Yin, 2002; Hogue, 2000; Kalakota & Whinston, 1996b; Mahadevan, 2000; Turban, Lee, King & Chung, 2000). EC has become important to countries around the globe. Salman (2004), for example, studied EC for competitive advantage in developing countries, concentrating on Bangladesh. In their study of e-tourism in Greece, Buhalis and Deimezi (2004) found EC to have a great potential for the country and confirmed how EC has revolutionized the travel industry, in particular.

Linkages Between EC and KM

EC Supports KM

The way companies implement KM concepts often is facilitated by their capabilities in implementing EC applications. The implementation of their EC applications also can benefit from experience acquired from their KM practices. This reinforcing effect results from the following seven characteristics shared by the two management paradigms. Both (1) use the Internet and their related technologies (Grover & Davenport, 2001); (2) emphasize intangible assets; (3) must be tightly integrated with major business processes; (4) are innovation-minded (Srinivasan, Lilien & Rangaswamy, 2002); (5) lack commonly accepted operational performance indicators and are hard to justify (Soo, Devinney, Midgley & Deering, 2002); (6) have strategic significance (Davenport & Prusak, 2000; Zack, 1999a, 1999b); and (7) govern EC applications and KM implementations, to a certain degree, by the principle of network economies (Brand, 1998; Pan & Scarbrough, 1998; Savary, 1999).

Specifically, EC supports KM in both technology and content. EC applications must be developed with the foundation of an information architecture. Hogue (2000) identified nine functional components of one such EC process architecture: profiling, personalization, search management, content management, workflow management, collaboration and trading, event notification, catalog management, and payment. It is evident that the functional components for EC applications also play an important role in KM practices, as evidenced by the first six of the nine EC components in the Hogue model. In the KM field, Turban, Aronson, and Liang (2005) emphasize the essential role of information technology in KM implementations. In particular, three categories of information technology are instrumental: knowledge discovery (e.g., data warehousing and data mining), knowledge distribution (e.g., collaborative software), and knowledge application (e.g., expert systems and intelligent agent). Most of these technologies, such as expert system and intelligent agent, have helped EC companies to add a wide variety of customization capabilities to EC applications. The supporting role of EC for KM is evident.

EC applications also support KM practices by providing valuable customer knowledge to help better focus the KM program. Focusing on customer knowledge allows a KM program to be effective in accomplishing its mission and efficient in the use of organizational resources. The importance as well as the dimensions of customer knowledge are addressed by Glosch (2000), Bose and Sugumaran (2003), Jarvenpaa and Todd (1997), and Plessis and Boon (2004). EC Web sites constantly collect a massive amount of customer knowledge through daily operations. These knowledge contents represent valuable resource input for KM programs.

Alvesson (2004) found that key knowledge-intensive firms are using EC in their business models and include IT, management consulting, advertising, and life sciences. He further agrees that KM is, indeed, a core competency. The increased sense of urgency for the institutionalization of comprehensive knowledge management programs is driven by EC. A well-designed KM infrastructure facilitates sharing of knowledge and reduces operating cost, improves staff productivity, and increases the knowledge base and expertise sharing (Bose & Sugumaran, 2003). Spiegler (2003) states that the idea of technology is to represent the means and the knowledge to the end as well as to support the EC process. He agrees that methods for generating knowledge are assisted by using technology or EC.

KM Supports EC

Electronic commerce is challenging and is only sustainable for global companies who continue to innovate and strategically use acquired knowledge. Wenger (2004) agrees that if knowledge is a strategic asset, it must be managed. For example, the value-added content in Web site design has been recognized as an important factor in influencing online shoppers' perceptions as well as their behaviors (Jarvenpaa & Todd, 1997; Wolfinbarger & Gilly, 2002).

True value-added content of an EC Web site only can be produced and sustained through a viable knowledge management program. Huosong, Kuanqu, and Shuqin (2003) agree that, while KM has been studied, our understanding of how the design of a KM system affects both its use and definition is still limited. Malhotra (2000) confirms that knowledge creation is relevant to both e-business and EC.

KM Supports EC in Various Forms

Singh, Furrer, and Ostinelli (2004) studied Web standardization in Italy, India, the Netherlands, Spain, and Switzerland, and found that knowledge of local cultural preferences was important for Web customization. In Brazil, Tigre and Dedrick (2004) studied local cultural knowledge for EC adaptation and found that local forces were important for driving EC diffusion. Plessis and Boon (2004) studied e-business in South Africa and found that knowledge management is a prerequisite for e-business and its increasing customer-centric focus and is an integral part of both customer relationship management and e-business.

Synergy in Both Directions

KM-to-EC and EC-to-KM. Gathering and using customer knowledge and feedback serves to link KM and EC (Blosch, 2000; Bose & Sugumaran, 2003). The potential synergy between KM and EC has been noted in both the information systems and the marketing literature along three dimensions: process impact, community and content, and system architecture (Holsapple & Singh, 2000; Salazar, Hackney & Howells, 2003). The process-impact point of view, in particular, stresses the increasing demand for in-depth knowledge in implementations of e-business processes and views KM as playing a vital role in change management. Fahey, Srivastava, Sharon & Smith (2001) suggest that KM is valuable in evaluating the what, how, and why aspects of e-business operations. Through the development of e-business-focused knowledge, organizations can evaluate the type of work performed in the global e-business environment, understand how they are doing it, and determine why certain practices in companies are likely to change in the future.

In the implementation of a KM solution in Greek banks, Samiotis, Poulymenakou, and

Doukidis (2003) found support for KM in the newly employed and strategically important e-banking role, while Bose and Sugumaran (2003) found a U.S. application of KM technology in customer relationship management, particularly for creating, structuring, disseminating, and applying knowledge. Rowley (2002) agrees that such customer knowledge is an important e-business opportunity, since customers in the digital economy depend on knowledge management and the accompanying organization's knowledge management paradigm.

Recent developments in information technology — the Internet, enterprise resources planning systems, and KM — are all necessary for business survival (Soliman & Youssef, 2001). However, the new business models created by e-business are changing operations. But most agree that it has not been integrated well with internal knowledge management initiatives. Fahey, Srivastava, Sharon, and Smith (2001) stress that, with the development of e-business, focused knowledge organizations are needed to enhance customer relationship management, supply chain management, and product development. The authors also emphasize the central role of knowledge management in managing e-business changes occurring in organizations. Warkentin, Bapna, and Sugumaran (2001) studied e-knowledge networks and found them key in inter-organizational collaborative e-business, thus linking KM and EC.

KM plays a role in customer retention with value-added service through product-related knowledge and support of the online community. Faced with a great array of vendor choices, customers often are attracted by the Web sites that contain relevant, well- organized information and knowledge relating to product quality and usage. The rich knowledge information and knowledge content, according to Wolfinbarger and Gilly (2001), represents an important motivating factor by providing online shoppers with freedom, control, and even fun. Williams and Cothrel (2000) argue for the importance of the online community in the Internet-centered business world and highlight the important role of experience sharing in managing the online community. Finally, on the system architectural dimension, Kocharekar (2001) contends that both KM and EC represent the next movement beyond ERP systems and must converge to a commerce characterized by knowledge-intensive activities, which they term knowledge commerce or K-Commerce.

Based on our literature review on KM and EC and their initial linkages, we propose that:

EC facilitates the practices of KM, whereas KM guides and supports EC.

The reasoning behind this proposition is reiterated as follows. Although experience suggests that traditional wisdom should not be ignored in running EC businesses, there is also an abundance of evidence indicating that innovative thinking is critical to conducting business via the Internet. Facing a massive amount of information, customers' attentions will be drawn to the Web sites that offer innovative values. KM supports EC by enabling a company to put its entire organizational knowledge base behind such major business processes as new product development, customer service, and supply chain management. The infrastructure constructed for EC applications also provides valuable mechanisms for the implementation of KM programs.

The literature also shows that successful EC operations must be guided and aligned with business strategy, backed by fully integrated business processes and work flows, and built around a consistent customer-centric system of interactions. This requires a great deal of innovative capability and learning capacity, which only can be achieved with an effective, ongoing knowledge management program. The characteristics shared by EC and KM suggest existence of synergy between the two fields. To test this linkage, we chose to examine the relationship between the two fields in terms of the basic aspects of each, considering B2B and B2C EC applications as well as strategy, objectives, and critical success factors. Thus, the following research propositions were developed:

P1: EC applications do not significantly affect KM practices.
- P1.1: EC applications do not significantly affect the choice of KM implementation strategies.
- P1.2: EC applications do not significantly affect the objectives of KM initiatives.

P2: KM practices do not significantly affect the applications of EC.
- P2.1: The choice of KM implementation strategy does not significantly affect applications of EC.
- H2.2: Critical success factors of KM initiatives do not significantly affect applications of EC.

RESEARCH METHODOLOGY

The first step to validate our research proposition regarding the mutually reinforcing effect between KM and EC is to test the correlation between the two. For this purpose, a cross-sectional survey was administered to business managers.

Taiwan

Taiwan was selected as the site for this exploratory study for several important reasons. Among other major initiatives, EC has been designated by the government of Taiwan as an important area of investment to stimulate national economic vitality and to enhance competitiveness. In the second quarter of 1999, the Ministry of Economic Affairs launched a multi-year project to promote EC applications in 40 industries identified as having the best potential to stimulate long-term national economic development (http://www.ec.org.tw). A primary project objective is to develop Taiwan into an Asia-Pacific regional commercial center. Both B2C and B2B EC applications are included in the promotional campaign. These government-funded promotions include research support, training, systems development, and a national innovative projects contest. In academia, a variety of research projects have been sponsored by the National Science Council, and numerous industrial associations in Taiwan examine various aspects of EC applications. Based on a field survey, Jih (2002) found that a variety of benefits has been realized by companies in Taiwan who have actively adopted EC.

Taiwan recovered more quickly than other Asian nations from the 1997-1998 financial crises that hit Asian markets and experienced only a brief period of slow growth. Currently, Taiwan has a solid economic and financial foundation due to its economic transformation from a labor-intensive environment to a capital and technology-intensive environment. This export-oriented economy has grown at a 5% to 6% yearly rate, and this growth, in part, is due to the continuous development of a knowledge-based economy (Tang, 2000; Wang, Scherban & Bonnici, 2005). Taiwan now exports twice as much to China as to the U.S. after decades of relying only on the American market, largely due to their increase in the production of computer chips, laptop computers, and notebooks (Bradsher, 2004).

Recognizing the importance of continuous innovation in such major areas as new product development, production process streamlining, and quality assurance, many Taiwanese companies have attempted to implement forms of KM programs in their organizations. Many manufacturing firms in Taiwan play an important upstream role in global supply chains. These companies understand that they must continually improve their production cost, quality, delivery, and service. The service industries within the domestic Taiwanese market also face competition from global players with scale advantages (Child, 2002). World Trade

Organization membership means that almost every company in Taiwan will face unprecedented, larger competitors. Taiwan, a small island nation, is a major exporter with little domestic demand. Thus, EC levels the playing field for the nation. Its commerce must be with international partners, and most of these transactions depend on EC as their means of competition.

Survey Instrument

The questionnaire was written in Chinese and contained items designed to address issues related to EC applications, KM practices, the benefits realized, and the difficulties experienced in applying the concepts. The questionnaire was pilot-tested with a convenience sample of managers to ensure validity and reliability. Some questions were revised for clarity and wording, based on the feedback obtained from the pilot test; the companies involved in the pilot testing were excluded from the final results. The data were collected in 2002 and 2003.

In designing the questionnaire, the EC applications in three categories (business-to-business, business-to-consumer, and intra-organizational EC activities) were considered, following the original definition of Kalakota and Whinston (1996b). The following three macro-level aspects of KM practices also were used in the study: KM strategies, KM objectives, and KM critical success factors. Each construct was measured with multiple questions. Except for questions about the respondents' demographic background and company information, all questions used a 7-point Likert-type scale to collect perceptual data, with 7 representing "strongly agree" and 1 representing "strongly disagree." Figure 1 is a graphical depiction of the research proposition and the study's conceptual framework. The EC and KM components, which serve as the basis for the survey items, are summarized in Table 1. The questionnaire consisted of four questions for B2B applications, five questions for B2C applications, and three questions for intranet applications. For KM implementation practices, there were two questions on KM strategies, 13 on KM objectives, and 10 on KM critical success factors. In addition, 15 benefits questions and 11 difficulty items were included to advance understanding of KM implementations.

For KM strategies, companies were asked to identify the relative emphasis (as a percentage) of system-oriented (technology view) vs. personal-oriented (human resource view) and top-down (revolution approach) vs. bottom-up (evolution approach) KM implementation strategies. Examples of survey questions are included in Table 2.

Figure 1. Conceptual framework

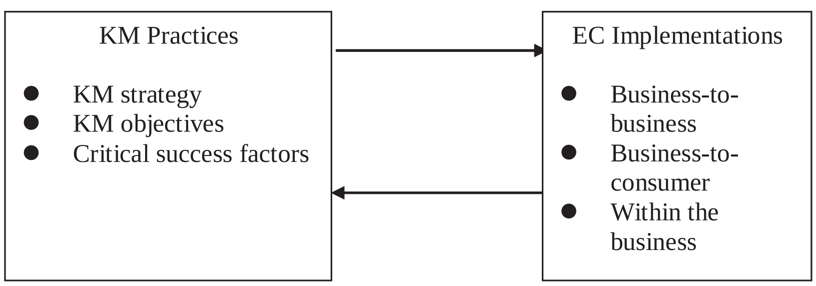

Table 1. Summary of research variables

Research Variables		Definition
EC Activities	Business-to-Business EC Activities	• Electronic financial transaction • Knowledge dissemination and sharing • Workgroup discussion • Workflow integration
	Business-to-Consumer EC Activities	• Organizational information dissemination • Online transaction • Product/Service information inquiry • Customer service • Online advertising
	Intra-organizational EC Activities	• Information dissemination and sharing • Workgroup discussion • Workflow integration
KM Activities	KM Strategies	• Systems approach vs. Individual approach • Top-down vs. bottom-up approach
	KM Objectives	• Increasing organizational knowledge repository and value • Establishing knowledge network • Improving efficiency of knowledge usage • Facilitating organizational innovation • Promoting organizational learning
	Critical Success Factors for KM	• Linkage with overall organizational performance • Technological and organizational infrastructure • Flexible knowledge organization structure • Organizational culture enables knowledge sharing • Clear and specific objectives • Incentive measures • Multiple knowledge transfer channels • Top management support

Data Collection and Analysis

A total of 221 questionnaires were mailed to the chief information officers of a variety of companies in Taiwan. The companies were selected, based on their publicly reported EC and KM activities and their positions as recognized leaders in the application of EC and KM concepts within key industries in Taiwan. They were categorized into financial service institutions, information technology, electronics manufacturing, and other industries (representing pharmaceutical, management consulting, and retail chains). Sixty-three questionnaires were returned, representing an effective response rate of 28.5%. Information technology representatives had the highest re-

Table 2. Sample survey items (All on a 7-point Likert-type scale with 1 as Strongly Disagree to 7 as Strongly Agree)

EC (B2B):
- Our financial transactions with upstream and downstream business partners are all conducted on WWW and/or EDI.
- We exchange information, knowledge, and experience with business partners on WWW and/or EDI.
- We use WWW and/or EDI to communicate and collaborate with our business partners.
- We use computer networks, including the Internet, to integrate with business partners our work flows.

EC (B2C):
- We provide company and products/ services information on our website.
- We conduct product and service transactions online.
- We provide online search capability for customers' information inquiry.
- We offer online customer service and inquiry capabilities.
- We advertise and promote our products and service online.

EC (Intranet):
- We encourage knowledge and experience sharing among employees using computer networks.
- We provide networking capabilities for employees to communicate with one another and to engage in group discussions.
- We attempt to integrate our workflows using Internet technologies.

KM Strategy:
- Please indicate the relative emphasis on the two knowledge management strategies of your company:
  System-driven: _____ %
  Personally oriented: _____%
  (Please note the two numbers should total 100 %.)
- Please indicate the relative emphasis on the following two knowledge management strategies of your company:
  Top-down strategy: _____ %
  Bottom-up strategy: _____%
  (Please note the two numbers should total 100 %.)

KM Objectives:
- Our objective for knowledge management implementation is to create electronic databases, digital knowledge bases, document bases, and other digital media so they are can be conveniently accessed by our employees.
- Our objective for knowledge management implementation is creating valuable knowledge repositories in electronic forms.
- Our objective for knowledge management implementation is to strengthen our innovation
- Our objective for knowledge management implementation is to uncover knowledge owned by our employee so it can be utilized more.

KM Critical Success Factors:
- Our knowledge management initiatives are aligned with our overall business strategy.
- Knowledge management is viewed as a long term organizational effort rather than just a short-term and one-time endeavor.
- A flexible organization structure is employed to promote knowledge management efforts, such as an interdepartmental km team.
- We have a clear definition for knowledge to distinguish it from data and information.

Table 3. Sample distribution

	Financial Service Institutions	Information Technology Industry	Electronics Manufacturing Industry	Other Industries	Total
Questionnaires Mailed	102	19	50	50	221
Questionnaires Received	37	13	17	11	78
Effective Questionnaires	31	10	14	8	63
Effective Questionnaire Return Rate	30.4%	52.6%	28%	16%	28.5%

Table 4. Reliability measures of the research constructs and the questionnaire

	Cronbach's α	**Question Category**	**Number of Questions**	**Cronbach's α**
E-Commerce	0.94	B-B EC	4	0.8682
		B-C EC	5	0.9775
		Intranet	3	0.9380
Knowledge Management	0.9792	KM Objectives	13	0.9832
		KM CSF_	10	0.9762
		Current Implementations	26	0.9592
Entire Questionnaire		0.9795		

sponse rate (52.6%) — an understandable result, given the progressive nature of this industry in Taiwan. A follow-up interview was conducted with a small number of these companies to obtain anecdotal and supplementary information to augment the quantitative data. The distribution of the respondents is summarized in Table 3.

Statistical analysis was used to analyze the collected data. First, descriptive statistics were obtained for each variable. The correlation between EC applications and KM objectives and between EC applications and KM critical success factors then were analyzed using Pearson Product-Moment Correlations. A one-way analysis of variance was conducted to examine the impact of KM implementation strategy on EC applications and the difference of KM implementation strategies among different industries. In addition, the internal consistency of the questionnaire (measured by the Cronbach's alpha coefficient) was examined to ensure survey reliability. Table 4 shows each individual construct has a Cronbach's α coefficient of at least 0.8682, and Cronbach's alpha for the entire questionnaire is 0.9795. The questions for perceived benefits from KM implementations and for the difficulties encountered also were analyzed. Cronbach's alpha for the former is 0.9827, and the latter is 0.9204, both indicating high degrees of reliability.

SURVEY RESULTS

Since the effective respondents all had EC and KM programs, the distribution of their sizes (as measured by the number of employees and annual sales) was examined to determine if size had a significant influence. Although there were 23 companies (36.5%) with 1,000 or more employees, there were also 28 companies (44.4%) with 300 or fewer employees. The largest revenue category was represented by 19 responding companies with annual sales of $800 million USD or more. The second category was represented by the companies with annual sales between $40 million and $134 million USD. Although larger companies had more resource support for applications of EC and KM, smaller companies also were actively engaged in these activities. In fact, follow-up interviews revealed that smaller companies hoped EC and KM applications would help them compete more effectively within their respective industries.

Effects of EC Applications on KM Practices

The possible effects of EC applications on KM strategies were examined by obtaining the Pearson product-moment correlation coefficient between EC applications and KM practices. Each EC application type was used as an independent variable, and each knowledge strategy type as a dependent variable. As summarized in Table 5, the system's approach is positively correlated, and the individual approach is negatively correlated with B2B EC applications. The fact that these are the only

Table 5. Correlations between EC implementations and KM strategies

	B-to-B EC	B-to-C EC	Intranets
Systems Approach	0.461*	0.121	0.178
Individual Approach	-0.461*	-0.121	-0.178
Top-down Approach	-0.101	-0.126	-0.018
Bottom-up Approach	0.101	0.126	0.018

** Level of significance < 0.01*

Table 6. Correlations between EC implementations and KM objectives

	B-to-B EC	B-to-C EC	Intranets
Increasing organizational knowledge and value	0.448*	0.669*	0.668*
Establishing knowledge network	0.427*	0.607*	0.578*
Improving efficiency of knowledge usage	0.428*	0.697*	0.617*
Facilitating organizational innovation	0.458*	0.710*	0.676*
Promoting organizational learning	0.383*	0.690*	0.675*

** Level of significance < 0.01*

Table 7. Correlation between CSFs for KM and EC applications

	B-to-B EC	B-to-C EC	Intranets
Linkage with overall organizational performance	0.364**	0.563**	0.579**
Technological and organizational infrastructure	0.275*	0.420**	0.503**
Flexible KM organization structure	0.377**	0.494**	0.622**
Organizational culture enables knowledge sharing	0.283*	0.465**	0.525**
Clear and specific objectives	0.318*	0.559**	0.584**
Incentive measures	0.2 37	0.446**	0.460**
Multiple knowledge transfer channels	0.326**	0.536**	0.551**
Top management support	0.347**	0.685**	0.598**

** Level of significance < 0.05; ** Level of significance < 0.01*

significant correlation coefficients (at the 1% level) may be explained by the experimental nature of EC (especially B2C EC) and KM activities. The system's approach places more emphasis on the use of information technology in implementing KM projects, whereas the individual approach views human interaction as the more important information technology. Both the degree and the direction of the correlation coefficients indicate that key aspects of EC applications and KM implementation strategies (system vs. individual) are significantly correlated.

When EC activities are correlated with KM implementation objectives, the correlation coefficients are significant at the 1% level (See Table 6). The degrees of EC implementations are positively correlated with the importance placed on each KM objective. It appears that these companies have an understanding of the strategic value of KM to their organizations and an expectation that EC applications will facilitate successful implementations of KM. In summary, some EC applications do facilitate KM practices. Therefore, Proposition 1 is rejected.

The data from Taiwan about the effects of EC applications on KM practices indicate that KM practices benefit from EC application. This facilitating effect is especially obvious in fulfilling KM objectives — all EC application types have a significantly positive impact on both the efficiency and effectiveness of KM programs. The technological infrastructure and business processes designed for EC operations, such as the Web-based user interface, product/service customization, and online community, also facilitate important aspects of knowledge management (e.g., knowledge acquisition, knowledge flow, and knowledge application. The facilitation effect is discussed by Alvesson (2004) and Rowley (2002). Buhalis and Deimezi (2004) also reported similar findings in their study about the travel industry in Greece. Kankanhalli, Tanudidjaja, Sutanto, and Tan (2003) shared this observation by attributing part of the KM program's implementation success at British petroleum, Buckman Laboratories, and Shell to the capabilities of their EC-enabled information technologies. As a matter of fact, the majority of technological tools discussed in the KM literature are associated with some types of EC applications (Holsapple, 2004). Although successful KM implementation does not depend solely on EC technology, the technological tool is essential in order to smoothly implement the KM program.

Effects of KM Practices on EC Applications

A one-way analysis of variance (ANOVA analysis) was used to determine the effects of KM practices on EC applications using each EC application as the dependent variable and KM strategies as the independent variables. The B2B EC is the only variable affected significantly by the choice of systems approach vs. individual approach to KM implementation (F-value: 9.257, level of significance < 1%). Thus, the choice of KM implementation strategy does significantly affect some aspect of EC application; namely, B2B EC.

When each type of EC application was used as the dependent variable with critical success factors for KM implementation as the independent variables, the result of Pearson Product-Moment Correlation analysis shows that all correlation coefficients pass the test at either the 1% or 5% level of significance. The highest correlation relationship is found between Intranets and flexible KM organization structures. Thus, the more flexible the organization structure for KM, the more likely that company-owned Intranets would be utilized. It is also worth noting that the degree of Intranet usage has higher correlations (with all but one KM variable) than the other two types of EC applications (B2B and B2C). This is an understandable phenomenon, given the current similar internal orientation of both intranet and KM applications. The second component of Proposition 2 (H2.2: Critical successful factors of KM initiatives do not significantly affect applications of EC) is rejected.

EC is emerging rapidly as a competitive paradigm in today's globalized business environment. The companies in Taiwan understand this trend and actively engage in integrating EC in their business models. The key to succeeding in EC applications is to provide attractive customer value (effectiveness) at affordable cost (efficiency). Both effectiveness and efficiency of EC applications can be enhanced by KM. This finding is shared by Singh, Furrer, and Ostinelli (2004) in their report on Web standardization in several European nations, by Tigre and Dedrick (2004) in their study regarding using local cultural knowledge for EC adaptation in Brazil, and by Plessis and Boon (2004) in the study in South Africa. In addition, stories abound in Fortune 500 companies about how innovative EC applications derive enormous business value from aggressive KM implementation (Holsapple, 2004).

Perceived Benefits from KM Implementations

Qualitative understanding of the future of KM in Taiwan was addressed by 15 items in the questionnaire. The means and the standard deviations, as well as the rankings, are summarized in Table 8. The top five benefit items are (1) improvement of organizational capability in responding to environmental change; (2) improvement of overall productivity; (3) improvement of overall performance; (4) timely monitoring of competition; and (5) enhancement of organizational innovative capability. It is interesting to note the breadth of the top 10 benefit items: capability to respond to change; productivity and performance improvement; relationship improvement (customer, supplier, and employee); and product quality improvement. Companies appear to have a good understanding that successful KM requires a broad view of value assessment. This is a sound beginning, since it requires an extensive period of time for a company to reap the long-term benefits from a KM investment. These findings are consistent with those reported in the KM literature.

Table 8. Benefits realized from KM initiatives

Rank	Benefit from KM Initiatives	Mean	Standard Deviation
1	Improvement of organizational capability in responding to environmental change	4.92	1.35
2	Improvement of overall productivity	4.90	1.52
3	Improvement of overall performance	4.86	1.62
4	Timely monitoring of competition situations	4.83	1.62
5	Enhancement of organizational innovative capability	4.81	1.48
5	Enhancement of customer satisfaction	4.81	1.62
6	Quicker response to market demand variation through production adjustment or marketing planning change	4.79	1.60
7	Improvement of product quality	4.78	1.53
8	Improvement of relationship with suppliers and customers	4.75	1.44
9	Improvement of employee satisfaction	4.73	1.61
10	Increase of sales volumes	4.63	1.37
11	Reduction of operational costs	4.51	1.53
11	Increase of profitability	4.51	1.51
12	Reduction of maintenance costs	4.41	1.42
13	Reduction of product/service development costs	4.38	1.56

PERCEIVED DIFFICULTIES ENCOUNTERED IN KM IMPLEMENTATIONS

On a 7-point Likert-type scale, the six difficulty items with difficulty averages above 4, as reported by respondents are (1) difficulty in knowledge flow due to lack of interdepartmental coordination; (2) lack of top management support; (3) weak consensus on the value of knowledge to the organization; (4) lack of innovative capability and motivation to innovate; (5) lack of incentive to encourage knowledge sharing; and (6) lack of clearly defined communication mechanisms across departments. Organizational and human factors ranked higher than technological factors, a confirmation of the observation reported in KM literature about the importance of organization culture for KM implementation (Brand, 1998; Davenport & Prusak, 2000; Koch, Paradice, Chae & Guo, 2002; Pan & Scarbrough, 1998; Storck & Hill, 2000). The finding suggests that, while companies have a clear understanding of the strategic value of knowledge, it is difficult for them to develop momentum. Nonetheless, the fact that the highest degree of difficulty is only 4.62 indicates that companies do not feel hopeless about coping with these challenges.

SUMMARY AND CONCLUSION

The business environment today requires companies to continually offer new and improved products or services, trim operational costs, shorten delivery time, increase quality, provide

Table 9. Difficulties experienced in KM implementations

Rank	Difficulties Encountered	Mean	Standard Deviation
1	Difficulty in knowledge flow due to lack of inter-departmental coordination	4.62	1.47
2	Lack of top management support	4.44	1.64
3	Weak consensus on the value of knowledge to the organization	4.33	1.51
4	Lack of innovative capability and motivation to innovate	4.30	1.53
5	Lack of incentive to encourage knowledge sharing	4.16	1.45
6	Lack of clearly defined communication mechanisms across departments	4.11	1.48
7	Employee resistance to sharing knowledge	3.94	1.60
8	Lack of clearly defined objectives for KM	3.92	1.51
9	Lack of trust between employee and management	3.76	1.51
10	Lack of hardware equipment to implement KM projects	3.49	1.74
11	Lack of proper software to implement KM projects	3.46	1.68

value-added customer services, and quickly adapt to unexpected changes. To cope effectively with these multi-faceted challenges, companies must engage diligently in activities that are capable of transforming their businesses into intelligent-acting organizations (Wiig, 1994, 1995). EC represents a promising avenue by enabling companies to interact directly with customers and integrate efforts of supply chain members (Keeny, 1999). The improved innovative capacity resulting from a thorough execution of KM strategies helps companies to establish and sustain competitive advantage by providing unique, attractive customer values (Zack, 1999a, 1999b).

The literature reviewed suggests that there is a significant relationship between how companies apply EC and how they practice KM in their operations. Our empirical study confirms this proposition. More specifically, the choice between systems-oriented and individual-oriented KM implementation strategies is affected by the B2B EC and vice versa. Each of the of KM implementation objectives is significantly affected by each of the three types of EC applications, and each of the three types of EC applications is significantly affected by all but one KM critical success factor.

Two important implications for information systems professionals and EC managers can be drawn from the findings of this study. First, although information technology does not guarantee success of either EC applications or KM implementations, it does represent an essential component, since it provides the technological infrastructure. The information technology infrastructure must be aligned properly with business strategy and business processes in order to create synergies. Only with a high degree of synchronized efforts can a company perform competitively in an open environment. Taiwan is not unique in the pressures for global expansion and increased need for market development. Taiwan's recent success in manufacturing computer-related hardware and software is a natural fit to the need for EC applications and KM implementations.

Second, the investments in EC applications and KM implementations are complementary. As noted in the Taiwanese example, the hardware and software tools acquired for EC applications can be useful for the promotion of KM activities. EC applications are guided and supported by an active KM program. The companies in Taiwan, as demonstrated in this study, are similar to companies in other parts of the world with regard to the facilitation effect of EC on KM. The enabling and support effect of KM on EC and the synergistic effect between EC and KM in Taiwan also are evident in companies throughout the world. These findings add to and extend the EC and KM research by providing empirical evidence obtained in Taiwan.

The contributions of this study are largely exploratory. It is the first study to attempt to empirically test the directional linkage or correlation between KM and EC. Other literature has alluded to the relationship but has not attempted to validate its presence. Since the subjects for this research were Taiwanese businesses operating in a global business environment, the study has global relevance. However, it is limited to one country. Other limitations of the research are the questionnaire design, which was limited to subjective judgment, and variable response rates. Future research should work to overcome these limitations.

Three directions for future research are suggested. The first direction extends the scope of coverage by including additional forms of EC application (such as customer-to-business) and other KM practice items (e.g., knowledge acquisition methods). The second direction should examine in-depth relationships between EC and KM. For example, an interesting research issue might be how communities of practice support EC operations. The third direction involves collecting primary data from companies in the U.S. and internationally in order to further validate the research propositions, explore additional relationships, make cross-cultural comparisons, and establish further global linkages between these two important management themes.

REFERENCES

Ahadi, H.R. (2004). An examination of the role of organizational enablers in business process reengineering and the impact of information technology. *Information Resources Management Journal, 17*(4), 1-19.

Ahn, J-H. & Chang, S-G. (2004). Assessing the contribution of knowledge to business performance: The KP3 methodology. *Decision Support Systems, 36*(4), 403-414.

Alvesson, M. (2004). *Knowledge work and knowledge-intensive firms.* Oxford: Oxford University Press.

Bakhru, A. (2004). Managerial knowledge to organizational capability: New e-commerce businesses. *Journal of Intellectual Capital, 5*(2), 326-336.

Barua, A, Konana, P.K., Whinston, A.B., & Yin, F. (2001). Managing e-business transformation: Opportunities and value assessment. *Sloan Management Review, 43*(1), 36-44.

Blosch, M. (2000). Customer knowledge. *Knowledge and Process Management, 7*(4), 265-268.

Bose, R. & Sugumaran, V. (2003). Application of knowledge management technology in customer relationship management. *Knowledge and Process Management, 10*(1), 3-17.

Bradsher, K. (2004, December 13). Taiwan watches its economy slip to China. *New York Times*, p. C7.

Brand, A. (1998). KM and innovation at 3M. *Journal of KM, 2*(1), 17-22.

Buhalis, D. & Deimezi, O. (2004). E-tourism developments in Greece: Information communication technologies adoption for the strategic management of the Greek tourism industry. *Tourism and Hospitality Research, 5*(2), 103-130.

Castanho, M.A.R.B. (2004). What do college life sciences students need to know about knowledge management. Journal of Biological Education, 38(2), 85-89.

Child, P.N. (2002). Taking Tesco global. *The McKinsey Quarterly, 3.*

Davenport, T.H. & Prusak, L. (2000). *Working knowledge: How organizations know what they know.* Boston: Harvard Business School Press.

Diakoulakis, I.E., Georgopoulos, N.B., Koulouriotis, D.E., & Emiris, D.M. (2004). Towards a holistic knowledge management model. *Journal of Knowledge Management, 8*(1), 32-46.

Fahey, L., Srivastava, R., Sharon, J.S., & Smith, D.E. (2001). Linking e-business and operating processes: The role of knowledge management. *IBM Systems Journal, 4*0(4), 889-907.

Feeny, A. (2001). Making business sense of the e-opportunity. *Sloan Management Review, 42*(2), 41-51.

Fingar, P. & Aronica, R. (2001). *The death of E and the birth of the real new economy.* Tampa, FL: Meghan-Kiffer Press.

Garbi, E. (2002). Alternative measures of performance for e-companies: A comparison of approaches. *Journal of Business Strategies, 19*(1), 1-17.

Gerstlberger, W. (2004). Regional innovation systems and sustainability: Selected examples of international discussion. *Technovation, 24*(9), 749-758.

Green, A. & Ryan, J.J.C.H. (2005). A framework of intangible valuation areas (FIVA): Aligning business strategy and intangible assets. *Journal of Intellectual Capital, 6*(1), 43-53.

Grover,V. & Davenport, T.H. (2001). General perspectives on KM: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Hoffman, D.L. & Novak, T.P. (1997). A new marketing paradigm for EC. *The Information Society, 13*, 43-54.

Hogue, F. (2000). *E-enterprise: Business models, architecture, and components.* Cambridge, MA: University Press.

Holsapple, C.W. (Ed.). (2004). *Handbook of knowledge management.* Berlin: Heiderberg-Springer.

Holsapple, C.W. & Joshi, K.W. (2004). A formal knowledge management ontology: Conduct, activities, resources and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-605.

Holsapple, C.W. & Singh, M. (2000). Toward a unified view of electronic commerce, electronic business, and collaborative commerce: A knowledge management approach. *Knowledge and Process Management, 7*(3), 151-164.

Huosong, X, Kuanqi, D., & Shuqin, C. (2003). Enterprise knowledge tree model and factors of KMS based on E-C. *Journal of Knowledge Management, 7*(1), 96-106.

Jarvenpaa, S.L. & Todd, P.A. (1997). Consumer reactions to electronic shopping on the World Wide Web. *International Journal of Electronic Commerce, 1*(2), 59-88.

Jih, W.J.K. (2002). Effects of EC implementations in Taiwan. *Journal of Computer Information Systems,* 56-62.

Kalakota, R. & Whinston, A.B. (1996a). *Electronic commerce: A manager's guide.* New York: Addison-Wesley.

Kalakota, R. & Whinston, A.B. (1996b). *Frontiers of EC.* New York: Addison-Wesley.

Kankanhalli, A., Tanudidjaja, F., Sutanto, J., & Tan, B.C.Y. (2003). The role of IT in a successful knowledge management initiatives. *Communication of the ACM, 46*(9), 69-73.

Keeny, R.L. (1999). The value of Internet commerce to the customer. *Management Science, 45*(4), 533-542.

Kim W.C. & Mauborgne, R. (1999). Strategy, value innovation, and the knowledge economy. *Sloan Management Review, 40*(3), 41-54.

Koch, H., Paradice, D., Chae, B., & Guo, Y. (2002). An investigation of KM within a university IT group. *Information Resources Management Journal, 15*(1), 13-21.

Kocharekar, R. (2001). K-commerce: Knowledge-based commerce architecture with convergence of e-commerce and knowledge management. *Information Systems Management,* 30-35.

Lee, H.L. & Whang, S. (2001). Winning the last mile of e-commerce. *Sloan Management Review, 42*(4), 54-62.

Leseure, M.J. & Brookes, N.J. (2004). Knowledge management benchmarks for project management. *Journal of Knowledge Management, 8*(1), 103-116.

Mahadevan, B. (2000). Business models for Internet-based e-commerce: An anatomy. *California Management Review, 42*(4), 55-69.

Malhotra, Y. (2000). Knowledge management for e-business performance: Advancing information strategy to "Internet time" information strategy. *The Executive's Journal, 16*(4), 5-16.

Marr, B., Schiuma, G, & Nelly, A. (2004). Intelectual capital: Defining key performance indicators for organizational knowledge assets. *Business Process Management Journal, 10*(5), 551-569.

Mataxiotis, K., Ergazakis, K., Samouilidis, E., & Pgarras, J. (2004). Decision support through knowledge management: The role of the artificial intelligence. *International Journal of Computer Applications in Technology, 19*(2), 101-119.

Mudambi, R. & Navarra, P. (2004). Is knowledge power? Knowledge flows, subsidiary power and rent-seeking within MNCs. *Journal of International Business Studies, 35*(5), 385-406.

Pan, S.L. & Scarbrough, H. (1998). A socio-technical view of knowledge-sharing at Buckman Laboratories. *Journal of KM, 2*(1), 55-66.

Plessis, M. & Boon, J.A. (2004). Knowledge management in e-business and customer relationship management: South Africa case study findings. *International Journal of Information Management, 24*(10), 73-85.

Piris, L. Fitzgerald, A.S. (2004). Strategic motivators and expected benefits from e-commerce in traditional organizations. *International Journal of Information Management, 24*(6), 489-499.

Porter, M. (2001). Strategy and the Internet. *Harvard Business Review*, 63-78.

Prusak, L. & Liam, F. (1998). The eleven deadliest sins of KM. *California Management Review, 40,* 265-276.

Rahman, B. (2004). Knowledge management initiatives: Exploratory study in Malaysia. *Journal of the American Academy of Business, 4*(1/2), 300-335.

Rowley, J.E. (2002). Reflections on customer knowledge management in e-business. *Qualitative Market Research, 5*(4), 268-280.

Salazar, A., Hackney, R, & Howells, J. (2003). The strategic impact of Internet technology in biotechnology and pharmaceutical firms: Insights from a knowledge management perspective. *Information and Technology Management, 2*(2-3), 289-301.

Samiotis, K., Poulymenakou, A., & Doukidis, G. (2003). Understanding knowledge management interventions: Evidence from supporting (e-) banking activities. *Knowledge and Process Management, 10*(3), 175-191.

Savary, M. (1999). KM and competition in the consulting industry. *California Management Review, 41*(2), 41-52.

Singh, N., Furrer, O., & Ostinelli, M. (2004). To localize or to standardize on the Web: Empirical evidence from Italy, India, Netherlands, Spain, and Switzerland. *Multinational Business Review, 12*(1), 69-87.

Soliman, F. & Youssef, M. (2001). The impact of some recent developments in e-business on the management of next generation manufacturing. *International Journal of Operations & Production Management, 21*(5/6), 538-549.

Soo, C., Devinney, T., Midgley, D., & Deering, A. (2002). KM: Philosophy, processes, and pitfalls. *California Management Review, 44*(4), 129-150.

Spiegler, I. (2003). Technology and knowledge: Bridging a "generation" gap. *Information & Management, 40*(6), 533-539.

Srinivasan, R., Lilien, G.L., & Rangaswamy, A. (2002). Technological opportunism and radical technology adoption: An application to e-business. *Journal of Marketing, 66*(3), 47-60.

Stankosky, M. (2004). Tackling a unified KM framework. *KM World, 13*(1), 1-19.

Storck, J. & Hill, P.A. (2000). Knowledge diffusion through "strategic community." *Sloan Management Review, 41*(2), 63-74.

Tang, F. (2000). *Taiwan to become a knowledge-based economy within 10 years*. Retrieved from http://www.thenews.com

Tigre, P.B. & Dedrick, J. (2004). E-commerce in Brazil: Local adaptation of a global technology. *Electronic Markets, 14*(1), 36-47.

Trethewey, A. & Corman, S. (2001). Anticipating k-commerce. *Management Communication Quarterly, 14*(4), 619-628.

Turban, E., Aronson, J.E., & Liang, T.P. (2005). *Decision support systems and intelligent systems*. New Jersey: Prentice-Hall.

Turban, E., Lee, J., King, D., & Chung, H.M. (2000). *EC: A managerial perspective.* New Jersey: Prentice-Hall.

Wang, L.K., Scherban, D.M., & Bonnici, J. (2005). International business: Taiwan's edge in the Asian financial crisis. *Journal of American Academy of Business, 6*(1), 143-150.

Wang, S. & Ariguzo, G. (2004). Knowledge management through the development of information schema. *Information & Management, 41*(4), 445-456.

Warkentin, M., Bapna, R., & Sugumaran, V. (2001). E-knowledge networks for inter-organizational collaborative e-business. *Logistics Information Management, 14*(1/2), 149-162.

Wenger, E. (2004). Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice. *Ivey Business Journal Online*.

Wigand, R.T. (1997). EC: Definition, theory, and context. *The Information Society, 13*(1)-16.

Wiig, K.M. (1994). *KM: The central management focus for intelligent-acting organizations*. Arlington, TX: Schema Press.

Wiig, K.M. (1995). *KM methods: Practical approaches to managing knowledge.* Arlington, TX: Schema Press.

Williams, R. & Cothrel, J. (2000). Four smart ways to run online communities. *Sloan Management Review, 41*(4), 81-91.

Wolfinbarger, M., & Gilly, M.C. (n.d.). *comQ: Dimensionalizing, measuring and predicting quality of the e-retail experience.* Retrieved from http://www.crito.uci.edu

Wolfinbarger, M. & Gilly, M.C. (2001). Shopping online for freedom, control, and fun. *California Management Review, 43*(2), 34-55.

Woods, E. (2004). KM past and future: Changing the rules of the game. *KM World, 13*(1), 12-14.

Zack, M.H. (1999a). Developing a knowledge strategy. *California Management Review, 41,* 25-145.

Zack, M.H. (1999b). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 4.17
Knowledge Intermediation

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INTRODUCTION

Since knowledge is increasingly regarded as the central source of competitive advantage, a "cognitive" interpretation of business activities becomes vital. With regard to this, the flourishing field of knowledge management (KM) provides useful insights into approaches to a systematic and explicit management of knowledge. Furthermore, the development of Internet technologies raises expectations of new opportunities to acquire, process, and distribute knowledge. Little research has, however, been done on the new businesses that may originate from a combination of KM practices and the use of new technologies. In particular, since the activities of knowledge creation and sharing are not bound to the single organisation, there is room for the development of innovative services that enable a "knowledge-based use" of network technologies such as the Internet. In fact, an increasing number of examples of innovative "knowledge-intensive" firms based on the Web can be found, but there is the need for better understanding of the contents and issues associated with such emerging ventures.

This article focuses on the business of "knowledge intermediation" via the Web, that is, the provision of technology-based services designed to support knowledge flows between organisations. In detail, the aims are: (1) to explore the development of a new business model that combines the use of information and communication technologies with a KM capability; (2) to suggest preliminary classifications; and (3) to highlight possible economic opportunities and problems as well.

BACKGROUND

As the day-by-day practice shows, it is very unlikely that the single firm can own or internally generate all the knowledge assets required for the business (Quintas, Lefrere, & Jones, 1997; Bolisani & Scarso, 2000). As a consequence, companies are increasingly realising that their knowledge resources derive in significant part from the system of interorganisational relationships established with customers, vendors, business partners, institutions, and even competitors. Such knowledge networks (i.e., formal or informal agreements to share knowledge, explore innovations, and exploit new ideas, Millar, Demaid, & Quintas, 1997; Pyka, 1997, 2002; Warkentin, Sugumaran, & Bapna, 2001; Peña, 2002) constitute a basic and distinctive feature of the current knowledge-based economy.

Until now, most of the literature on KM has focused on knowledge generated, transferred, and used within a single organisation, while little work has been done to understand how to manage knowledge across organisations (Parise & Henderson, 2002; Spring, 2003). Hence, it is necessary to analyse whether and how the principles and approaches elaborated in "traditional" KM have to be reframed to perform knowledge network management (Seufert, von Krogh, & Bach, 1999). This sort of "extended KM" clearly raises more problematic issues than managing knowledge within the single firm. For instance, attempts to communicate meanings may be difficult due to the lack of common goals, languages, values, and mental schemes. As a matter of fact, a cognitive distance or gap may separate knowledge sources and users, which makes the sharing of useful knowledge difficult. Furthermore, reciprocal trust is needed, since a knowledge exchange may be easily exposed to the risk of opportunistic behaviours. Also, the effective "functioning" of a knowledge network involves the subdivision of "cognitive tasks" and KM competencies among the participants. Finally, an adequate technological infrastructure may be required to handle the large amounts of contents scattered in a wide context.

For this reason, new kinds of "mediating services" can be of great use: to fill the cognitive gap between players; to facilitate the flowing of knowledge inside the network (Spring, 2003); to act as "organizational translators" (Teece, 1998) between different interests, values, and culture of interconnecting partners; to implement and manage Internet-based interorganisational KM systems; to build network trust, and so forth. There is already evidence of companies providing such innovative services (see Bolisani, Di Biagi, & Scarso, 2003). The purpose here is to verify whether a "KM viewpoint" can be of help to describe more formally the new businesses of knowledge intermediation that we will name "knowledgemediary" (KMY). In particular, their distinctive features, key competences, and critical managerial issues are illustrated and discussed.

CONCEPT DEFINITION

To better specify the notion of knowledgemediary, it is useful to briefly recall its antecedents.

Knowledge-Intensive Business Services (KIBS)

The term KIBS was introduced to define business service firms providing knowledge-intensive, technology-based services with a high level of supplier-user interaction, generally produced by employing a highly qualified labour force (Nählinder, 2002). KIBS play the crucial role of both creating knowledge for (or together with) their customers, and assisting the circulation of knowledge from one firm to another. This knowledge brokering function is generally a byproduct of their work, that mainly consists in "solving problems for the clients." A growing number of studies about KIBS highlights the relevant contribution given by such services in the present economic systems (OECD, 1997; Roberts, Andersen, & Hull, 2000; Nählinder, 2002), as well as their special features, that is, they are innovative, act as vehicles of innovation, and connect firms, thus performing the function of "cognitive interface" between different business partners. Miles (1996) proposes a useful distinction between "traditional" KIBS (e.g., classical consulting services) and T-KIBS (i.e., services that concern or are based on the use of information and communication technologies, including Internet-based applications). Our notion of KMY has its roots inside the T-KIBS category.

Intermediation and Internet Applications

As mentioned, KMY services imply a mediating capability by their very nature, since they act in the middle of an interorganisational context. It is, however, necessary to specify the particular kind of intermediation that can be of interest here.

First, it is important to note that even the activity of intermediaries in traditional trade (e.g., identification of demand needs; information on products and suppliers; comparisons; market intelligence; distribution of information on products; customer targeting; demand orientation, etc.) involves cognitive contents (Sarkar, Butler, & Steinfield, 1995). In substance, a significant part of the value added by an intermediary consists of "bridging" over the cognitive gap between buyers and sellers, thereby facilitating the exchange of knowledge for settling transactions. Such cognitive implications of the intermediation activity also are underlined by the economic theories. For instance, according to the transaction costs theory, the choice between in-house direct sale and use of external intermediaries is based on the complexity, specificity, and uncertainty of economic exchanges (Rangan, Menezes, & Maier, 1992), that is on the cognitive aspects of a transaction. Also, in the principal-agent theory, agents are delegated to assist principals with their economic counterparts, in order to reduce the decisional complexity produced by knowledge shortages (Pratt & Zeckhauser, 1985). Another important problem concerns the quality of information exchanged by trading partners, and the signalling (transferring) mechanisms employed for this (Choi, Stahl, & Whinston, 1997).

The cognitive connotation of intermediation raises peculiar issues for Internet-based businesses. In fact, although the huge amount of information available on the Web extends the cognitive capabilities of the surfers, the growing size and complexity of the cyberspace and the resulting "information overload" effect makes its exploitation very difficult. In such context there may be the need for "knowledge mediators," capable of assisting the users in the management of online sources. Indeed, theoretical arguments and empirical observations show that the diffusion of Internet applications generally implies the development of new forms of intermediaries (Sarkar, Butler, & Steinfield, 1995), such as infomediaries (online firms specialising in online customer profiling and analysis of navigation traces), cybermediaries (online companies that specialise in electronic transactions such as Web malls, comparison sites, credit card clearing services, etc.), and so on.

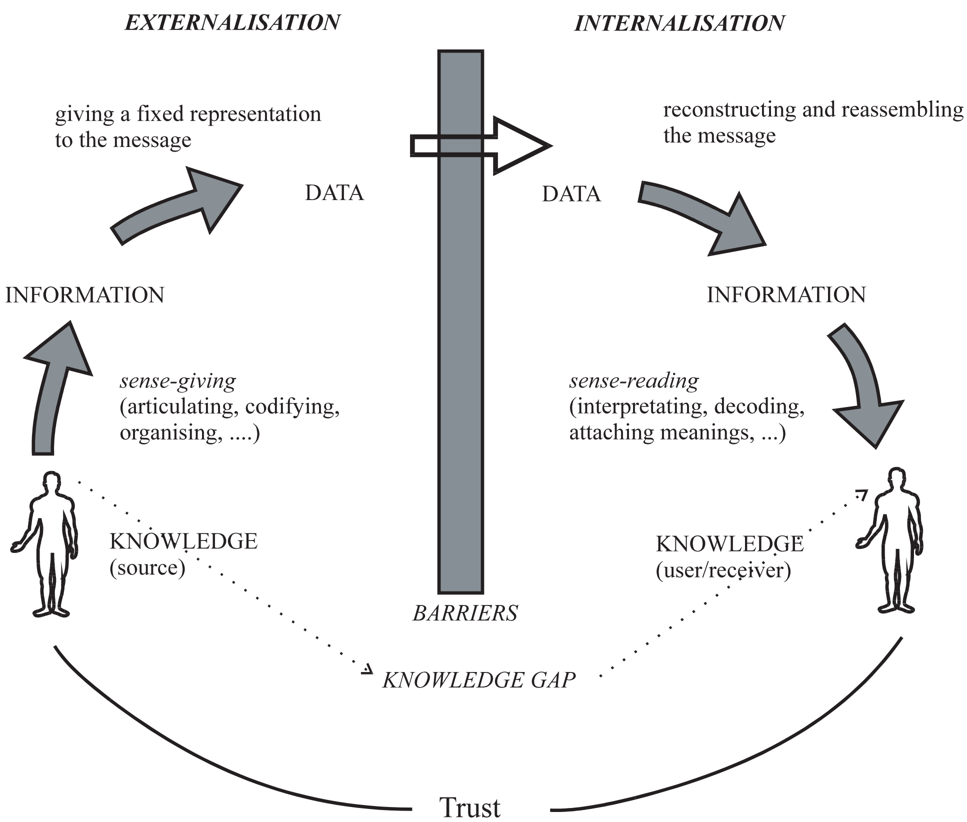
Knowledge Mediators in KM Processes

The notion of "knowledge mediator" is also relevant to the literature of KM. For instance, the resort to "domain experts" is recommended for a corporate Web portal, in order to facilitate the extraction of knowledge from internal sources and its delivery to end users (Mack, Ravin, & Byrd, 2001). The presence of a "knowledge broker" is often suggested for the good functioning of knowledge exchanges (e.g., the concept of "knowledge markets," Davenport & Prusak, 1998; Markus, 2001; Matson, Patiath, & Shavers, 2003; Kafentzis, Mentzas, Apostolou, & Georgolios, 2004). The task here consists of assisting sources and recipients to match their different interpretative contexts, translating meanings and values, and supporting the whole knowledge transfer process.

Knowledge Transfer Process

To better understand the role played by a knowledge mediator, we can refer to a representation of the knowledge transfer process (Hendriks & Vriens, 1999; Tuomi, 2000; Garavelli, Gorgoglione, & Scozzi, 2002). Figure 1 depicts the particular case of knowledge transferred through electronic communication. A piece of knowledge content must be first externalised (i.e., converted in the appropriate format, language, and data), transmitted, and then internalised (i.e., understood and assimilated by the receiver¾cf. Sharratt & Usoro, 2003). The success of this process requires: an "interpretative context" (or background) shared by the interconnecting partners; a mutual interest in transferring knowledge; and established "trust" (i.e., the parties should not doubt the quality of the knowledge transferred and its use). Such conditions can be better satisfied thanks to the action of a knowledge mediator, who can assist

Figure 1. The knowledge transfer process (adapted from Hendriks & Vriens, 1999)



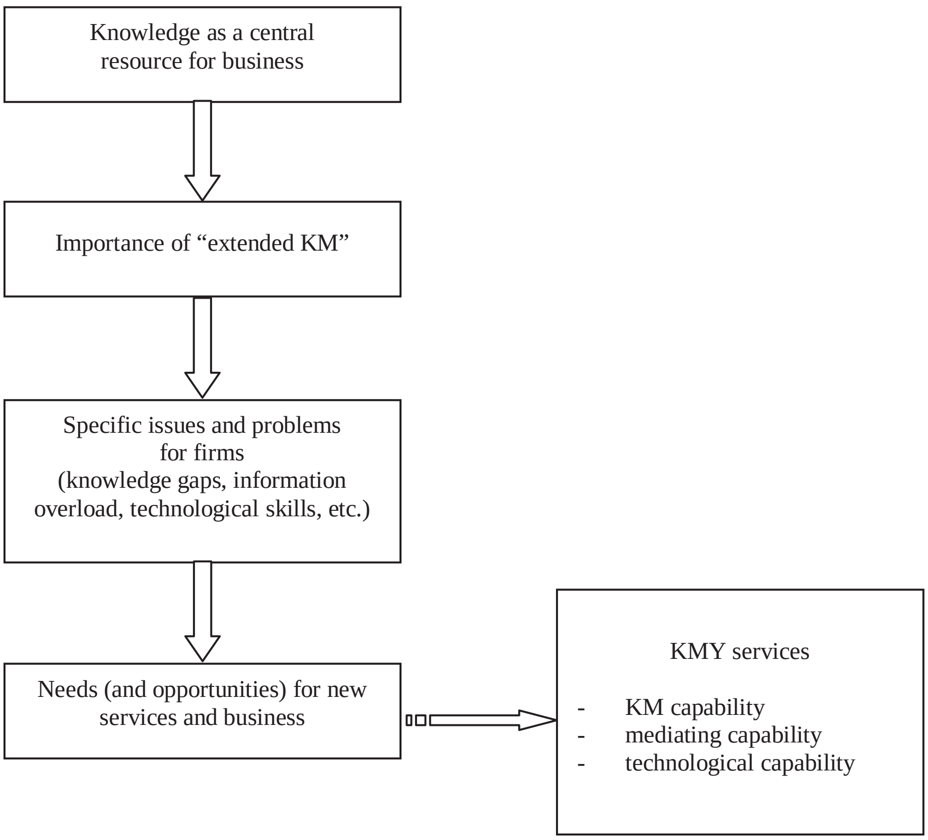
or perform the externalisation/internalisation processes and help generate trust. In addition, the mediator might deal with the development and management of the technical infrastructure that underpins the transfer process.

Conceptual Roots of KMY Services

The following points represent the conceptual roots of the kind of firms that we named KMY (Figure 2). To summarise, the recognition of knowledge as a core resource for business and the increasing resort to external competencies explains the growing importance ascribed to "extended" KM processes. However, since a single firm may encounter several problems in accessing external sources and managing knowledge relations, this may open opportunities for innovative intermediating services that combine different services and capabilities:

- solving knowledge-intensive problems and applying extended KM ("KM capability")
- acting as an interface between knowledge sources and users, thus favouring knowledge exchanges ("mediating capability")
- designing and/or using information and communication technologies as a fundamental support of its activities ("technological capability")

Figure 2. Conceptual roots of KMY services



The practical foundations of the services provided by a KMY can be associated to the following aspects:

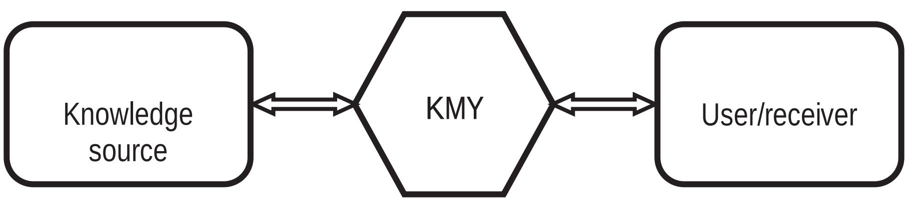
- a basic competence in managing knowledge transfer between firms/organisations, for example, to identify knowledge needs of the users, to research and select sources and knowledge contents, to perform processes of codification/de-codification, and so forth
- the capability of selecting the most adequate solution for settling a knowledge transaction in accordance to the specific circumstances of application (namely, nature of players involved, kind of knowledge exchanged, property rights, legal implications, payments, etc.)
- and, finally, the capability of using and integrating the technology into the KM processes

It is worth noting that such services can be provided by completely new startups but also by existing companies that can create departments specialising in KMY activities. Indeed, the focus of some existing companies (as in the case of consulting firms, or even media groups) is information or knowledge transfer. However, even in this case, the novelty is that KMY services represent the evolution and enrichment of traditional activities, thanks to the organic integration of KM competencies, mediating capabilities, and the advanced use of new technologies.

To specify in more detail the possible features of a KMY service, we outline a framework and propose a reference taxonomy, by considering a typical situation denoted by the presence of: the user (typically a business user: firm, professional, etc.); a source, that provides or sells knowledge (other firms, university departments, research centres, etc.); and a KMY. For this purpose, we also refer to a scheme of a knowledge transaction (Figure 3), that is, a situation where economic players exchange knowledge contents with one another, by means of KMY services. The notion of transaction is essential to analyse the economic value of knowledge exchanges used in business processes.

Similarly to other economic exchanges, a knowledge transaction implies the transfer of a kind of goods (i.e., knowledge) from a source to a receiver, and a flow of payments. Clearly, there are peculiar aspects that should be considered when knowledge is the object of economic exchange. While in a traditional transaction, it is the buyer that makes a payment in favour of the seller (and, in addition, the intermediation service is paid by one or both parts); in the case of a knowledge transaction, it may be less clear who pays for what. For instance, in some cases knowledge sources can be "free," and the user can be asked to pay for the intermediation service (e.g., the research

Figure 3. Knowledge transaction by means of KMY services



activity performed by the KMY). Another important issue regards pricing. Since knowledge is typically an experience good (i.e., its value can be estimated after acquisition and use), it is very difficult to establish a market price, and consequently the pricing of KMY services also is harder. Other special questions concern the property rights protection, namely the attempts to avoid opportunistic behaviour associated with the exchange of knowledge.

All things considered, our analytical framework consists of six dimensions.

a. Knowledge flows:
   - knowledge asked or researched by the users
   - knowledge delivered by the source (not necessarily on demand)
   - knowledge that represents an additional (and original) contribution of the KMY

b. Knowledge forms and contents:
   - tacit vs. explicit knowledge components: referring to the knowledge transfer process, the explicit component can be more easily "de-contextualised" and transferred in formal modes, while the tacit component is tightly connected to the interpretative framework shared by the parties involved in the transfer process
   - range and scope of knowledge, for example, multidisciplinary vs. specialised knowledge
   - object of knowledge, for example, know-about, know-how, know-why, know-who, know-with

c. KM process implied in delivering KMY services:
   - acquisition (identifying and cataloguing sources, analysing nature and formats of knowledge, etc.)
   - selection (choice of the specific knowledge contents to be transferred in relation to the specific uses)
   - internalisation (assistance to users in the assimilation of knowledge)
   - externalisation and distribution (assistance to sources in the delivery of knowledge)

d. Service structure and competencies needed:
   - organisational-managerial component: KM competencies (see point c), knowledge of the sector/market where the KMY operates, capability of managing interorganisational network relations, and intermediation skills
   - technical components: tools used to support interorganisational KM processes in an Internet environment, as well as the skills to select, configure, and use them

e. Management of knowledge transactions: When knowledge is the object of an economic exchange, the transaction raises specific questions in relation to the transfer, protection, and replication of the property rights. It also should be analysed what service of knowledge transfer is paid for. More generally, the issues involved are:
   - mechanisms used for the economic exchange (formats, times, contracts, etc.)
   - mechanisms used for payments
   - duration of the transactional relations (e.g., spot, repetitive, or project-based relation)

f. Model and structure of relations established by the KMY:
   - bilateral relations with a single user or source (i.e., KMY as a sort of "private consultant")
   - relations with multiple and indistinct sources and users, with players belong-

ing to a specific sector, value chain, or business community

EMPIRICAL INVESTIGATIONS

Despite their novelty, various examples of KMYs can be found in the business arena. Here, the features of some emergent categories or models are described, just as they were identified on the basis of an empirical exploration of the current experience in the field (see Bolisani, Di Biagi, & Scarso, 2003).

- Mediator: Its main role is to activate knowledge flows from sources to users. Examples include KMY services for professional consulting. The clients submit queries that are interpreted by the KMY, that also selects the appropriate professional, and takes care of the correct transmission of the answer as well as payment execution, and so forth. Other examples are human-based search engines, that is, services that provide assistance in information retrieval through the Net. In this case, users formulate complex queries interpreted by the KMY operators that also search on the Net and provide possible answers. Thus, the mediator model focuses on the management of "know-who" knowledge (i.e., knowledge of the possible sources and of their "quality" or reliability). Accordingly, the "reputation" that the KMY builds is crucial. Another key issue is the KM process of interpretation/de-contextualization of queries, which is vital especially considering that the entire relation occurs on the Internet with no face-to-face interactions.
- Facilitator: Its key function is to build appropriate environments for knowledge transfer, by identifying the optimal mechanisms or technology (i.e., a database, a document exchange, an online form, etc.), by processing codification/de-codification, and so on. A typical example is that of "job seeking" online services: The KMY performs a collection, selection, and presentation of job ads that are classified in a common format to facilitate retrieval. It is crucial for facilitators to have a "standard" process of collection, de-contextualization, and presentation of knowledge contents from heterogeneous sources to undifferentiated users. All this raises peculiar issues, such as the selection, explication, and standardisation of knowledge contents to be presented through a common interface (e.g., a Web portal). While knowledge coming from sources can be the "know-about" type, the added contribution of the KMY service is essentially a "know-with" component (i.e., how to connect different contents).
- Aggregator: This KMY service performs preliminary recognition and mapping of knowledge sources for a specific business community or market; knowledge contents are then made available to the users on demand. Examples are "vortal" (vertical portal) services, supplying market and technical information for specific business communities. The "aggregator" model refers to a common situation: a multiplicity of heterogeneous sources, and several potential users belonging to the same business community. The highly specific knowledge contents, which also can have heterogeneous formats, must be aggregated and collected for the community. The added service of the aggregator rests on the capability of selecting and reformulating contents that "may be" of interest for the users, which requires high competence of the business sector. In addition, the contents collected have to be

converted and proposed in the appropriate form.

- Manager: This is the most complex model of KMY, since it combines many of the services described. Examples can be the online services for virtual business communities, or for communities of practice. In this case, an Internet-based platform for "knowledge sharing" is provided to all the firms and professionals serviced. This sort of Web portal, reserved to registered users, is based on a "flexible" system for sharing all the documents and contents needed. Since the mediating role of the KMY and the business relations between the users are closely intertwined, the kind of knowledge that the KMY has to manage is highly specific, but at the same time requires extreme flexibility to manage exceptions and innovations.

CONCLUSION AND FUTURE TRENDS

The main point here is that the practical transition toward the knowledge economy implies the implementation of new businesses that combine the explicit management of knowledge with an advanced use of Internet-based technologies. To investigate such issue, we attempted to introduce new approaches to the analysis of online business models by integrating "classical" themes of e-commerce (i.e., the characteristics of online transactions and the role of intermediation) with the emerging discipline of KM. The definition of KMY is strictly functional to this purpose, and is used to analyse new businesses of online intermediation by considering their role in KM processes in an explicit and direct way. Clearly, one limitation is that the empirical evidence is still insufficient to draw a conclusion. Actually, any new study of emerging business models necessarily suffers from scarce empirical confirmations. In any case, our early findings (see Bolisani, Di Biagi, & Scarso, 2003) apparently show that the perspective adopted could be promising.

Although the approach proposed here has descriptive aims, the findings also can provide useful insights into practical managerial aspects of new business implementation. In particular, the classifications of business models previously discussed, and the evaluation of the specific opportunities and problems associated with each specific KMY feature, can be of use for the implementation of new services based explicitly on KM practices and Internet technologies.

Having said that, there is still work to do to transform the analysis into a more complete subject of research. In particular, the transactional nature of KMY services should be investigated more thoroughly, with direct reference of knowledge as the object of economic exchange. As regards managerial guidelines, an important issue concerns the practical implementation of an online strategy for a KMY service. There is especially the need to integrate a descriptive or analytical approach (that can be useful to make classifications or illustrate problems) to more normative prescriptions.

REFERENCES

Bolisani, E., Di Biagi, M., & Scarso, E. (2003). Knowledge intermediation: New business models in the digital economy. *Proceedings of the 16th Bled eCommerce Conference* (pp. 987-999).

Bolisani, E., & Scarso, E. (1999). Information technology management: A knowledge-based perspective. *Technovation, 19,* 209-217.

Choi, S., Stahl, D.O., & Whinston, A.B. (1997). *The economics of electronic commerce.* Indianapolis: MacMillan.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Garavelli, A.C., Gorgoglione, M., & Scozzi, B. (2002). Managing knowledge transfer by knowledge technologies. *Technovation, 22*, 269-279.

Hendriks, P.H.J., & Vriens, D.J. (1999). Knowledge-based systems and knowledge management: Friends or foes? *Information & Management, 35,* 113-125.

Kafentzis, K., Mentzas, G., Apostolou, D., & Georgolios, P. (2004). Knowledge marketplaces: Strategic issues and business models. *Journal of Knowledge Management, 8*(1), 130-146.

Mack, R., Ravin, Y., & Byrd, R.J. (2001). Knowledge portals and the emerging digital knowledge workplace. *IBM Systems Journal, 40*(4), 925-954.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 27-93.

Matson, E., Patiath, P., & Shavers, T. (2003). Stimulating knowledge sharing: Strengthening your organization's internal knowledge market. *Organizational Dynamics, 32*(3), 275-287.

Miles, I. (1996). *Innovation in services: Services in innovation*. Manchester, UK: Manchester Statistical Society.

Millar, J., Demaid, A., & Quintas, P. (1997). Trans-organizational innovation: A framework for research. *Technology Analysis & Strategic Management, 9*(4), 399-418.

Nählinder J. (2002). *Innovation in knowledge intensive business services. State of the art and conceptualisations.* ISRN Liu–Tema-T-WP-244-SE, June.

OECD (1997). *Statistics on value added and employment, services.* Paris, OECD.

Parise, S., & Henderson, J.C. (2001). Knowledge resource exchange in strategic alliance. *IBM Systems Journal, 40*(4), 908-924.

Peña, I. (2002). Knowledge networks as part of an integrated knowledge management approach. *Journal of Knowledge Management, 6*(5), 469-478.

Pratt, J.W., & Zeckhauser, R.J. (Eds.). (1985). *Principals and agents. The structure of business*. Boston: Harvard Business School Press.

Pyka, A. (1997). Informal networking. *Technovation, 17*, 207-220.

Pyka, A. (2002). Innovation networks: From the incentive-based to the knowledge-based approaches. *European Journal of Innovation Management, 5*(3), 152-163.

Quintas, P., Lefrere, P., & Jones, G. (1997). Knowledge management: A strategic agenda. *Long Range Planning, 30*(3), 385-391.

Rangan, K.V., Menezes, M.A.J., & Maier, E.P. (1992). Channel selection for new industrial products: A framework, method, and application. *Journal of Marketing, 56*, 69-82.

Roberts, J., Andersen, B., & Hull, R. (2000). In B. Andersen, J. Howell, R. Hull, I. Miles, & J. Roberts (Eds.) *Knowledge and innovation in the new service economy* (pp. 10-35). Cheltenham, UK: Edward Elgar.

Sarkar, M.B., Butler, B., & Steinfield, C. (1995). Intermediaries and cybermediaries: A continuing role for mediating players in the electronic marketplace. *Journal of Computer Mediated Communication, 1*(3).

Seufert, A., von Krogh, G., & Bach, A. (1999). Towards knowledge networking. *Journal of Knowledge Management, 3*(3), 180-190.

Sharratt, M., & Usoro, A. (2003) Understanding knowledge-sharing in online communities of practice. *Electronic Journal on Knowledge Management, 1*(1), 187-196.

Spring, M. (2003). Knowledge management in extended operations networks. *Journal of Knowledge Management, 7*(4), 29-37.

Teece, D.J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review, 40*(3), 55-79.

Tuomi, I. (2000). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems, 16*(3), 103-117.

Warkentin, M., Sugumaran, V., & Bapna R. (2001). E-knowledge networks for inter-organizational collaborative e-business. *Logistics Information Management, 14*(1/2), 149-162.

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Chapter 4.18
An Investigation to an Enabling Role of Knowledge Management Between Learning Organization and Organizational Learning

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ABSTRACT

This chapter is an exploratory investigation of the relationship and interaction between the learning organization and organizational learning in terms of an enabling role of knowledge management. In the severe and dynamic business environment, organizations should respond quickly to their rivals and environment by transforming into a learning organization. A learning organization could provoke innovation and learning through its structure, task and process redesigns, and evermore adapt gradually toward the eventual goal of organizational learning. Therefore, the dynamic process between the learning organization and organizational learning is an important issue of current knowledge management and practice — that is, the enabling role of knowledge management could enhance the interaction between learning organization and organizational learning. Furthermore, the authors will explore the relationship and interaction between the learning organization and organizational learning in terms of knowledge management processes in business. Two cases, TSMC and Winbond, the semiconductor and high-tech firms in Taiwan, will be studied to illustrate the findings and insights for the study and the chapter.

INTRODUCTION

Today a "Third Industrial Revolution" is under way; knowledge will replace land and a firm's resources as important asset (Thurow, 1999). Even Drucker (1993) argues that in the new economy, knowledge is not just another resource alongside the traditional factors of production — labor, capital and land — but is the only meaningful resource today. Tangible assets will be decreased or consumed because of use, but intangible assets — knowledge, information and technology will grow through sharing and application. In many industries, firms could sustain their competitive advantage if their abilities for learning and evolution are faster than their competitors. Thus, organizations should learn to survive in the fast-changing and intensely competitive environment, continually redesigning themselves into learning organizations (Daft, 1998).

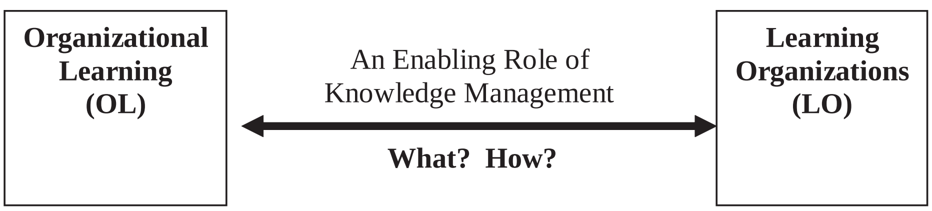
Knowledge is a limitless resource in the knowledge-based economy, therefore, organizations should learn, store, transfer and apply knowledge to add value or gain competitive advantage (Sveiby, 1997). Knowledge management refers to identifying and leveraging the collective knowledge within the organization to help in competing (von Krogh, 1998). But in a severe and dynamic environment, organizations should respond quickly to their rivals and their environment by transforming into a learning organization, an organic and flexible company, to foster knowledge flow and sharing among the departments and task groups. A learning organization could provoke innovation and learning through its structure, task and process redesigns, and adapt gradually toward the eventual goal of organizational learning. Therefore, the dynamic process between the learning organization and organizational learning is an important issue of current knowledge management and practice — that is, an enabling role of knowledge management could change the interaction between the learning organization and organizational learning. But what is and how does knowledge management play this enabling role? The research question can be depicted as shown in Figure 1.

This study will try to find the relationship and interaction between the learning organization and organizational learning in terms of an enabling role of knowledge management. We hope to provide some new insights for firms as they translate their organizations into learning organizations and implement knowledge management practices to provoke organizational learning.

LEARNING ORGANIZATION

Learning organizations can be described as places where people continually expand their capacities to create the results they truly desire,

Figure 1. The dynamic process and interaction between OL and LO



where expansive and new patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together (Senge, 1990). It also can be defined as one in which everyone is engaged in identifying and solving problems, enabling the organization to continuously experiment, change, and improve, thus increasing its capacity to grow, learn, and achieve its purpose (Daft & Marcic, 1998). Most definitions focus on the importance of acquiring, improving, and transferring knowledge, facilitating individual and collective learning, integrating and modifying behaviors and practices of the organization as a result of the learning (Appelbaum & Reichart, 1998; Ellinger, Ellinger, Yang, & Howton, 2002).

Learning organizations are also generally described as being market-oriented; having an entrepreneurial culture as well as a flexible, organic structure; and having facilitative leadership (Lundberg, 1995; Luthans, Rubach, & Marsnik, 1995; Slater & Narver, 1995; Watkins & Marsick, 1996). When the environment is complicated and dynamic, organizations need to create, validate and apply new knowledge into their products, processes and services for eventual value-adding (Bhatt, 2001). Learning organizations take action, reflect and adjust course as they seek to enhance the speed and effectiveness by which they learn how to change (Rowden, 2001).

A learning organization could facilitate the learning of all of its members and continuously transform itself (Hawkins, 1991; Pedler, Boydell, & Burgoyne, 1988). It also improves its knowledge and understanding of the environment over time by facilitating and making use of the learning of individual members (Galer & Kees, 1992). After all, Garvin (1993) argued that a learning organization is an organization skilled in creating, acquiring and transferring knowledge, and modifying its behavior to reflect new knowledge and insights.

ORGANIZATIONAL LEARNING

Nevis, DiBella and Gould (1995) defined organizational learning as the capacity or processes within an organization to maintain or improve performance based on experience. Organizational learning occurs when workers act as learning agents for the organization, responding to changes from the internal and external environments by detecting and correcting errors and embedding the results of their inquiries in private images and shared maps of the organization. Organizational learning is at the heart of continuous improvement today. While companies learn, the crucial and key point is to learn fast enough to sustain the competitive advantage (De Geus, 1988). How effectively an organization learns can dictate whether it will improve, and how fast, or if it is destined to lose ground to competitors who can and do learn (Lynn, 1998). The abilities to continuously learn, adapt and improve on its capabilities are all key elements to gain competitive advantage.

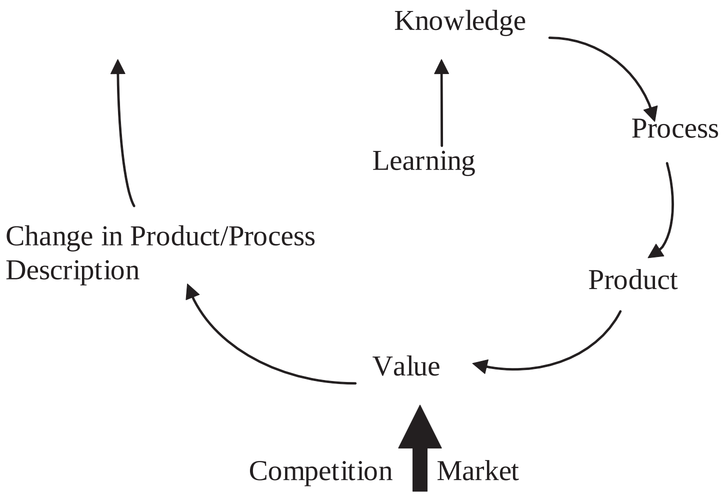
Continuous learning is essential for surviving in dynamic and competitive environments, but the key to gain competitive advantage is the method and speed of learning (De Geus, 1988; Garvin, 1993; Nonaka, 1991; Popper & Lipshitz, 2000; Senge, 1990; Lennon & Wollin, 2001). Argyris and Schon (1978) proposed three processes of organizational learning: (1) Single-loop learning: individuals respond to errors by modifying strategies and assumptions within constant organizational norms, (2) Double-loop learning: the response to detected error takes the form of joint inquiry into organizational norms themselves, so as to resolve their inconsistency and make the new norms more effectively realizable, (3) Deutero-learning: workers learn about previous contexts for learning, and reflect on and inquire into previous contexts for learning. They also reflect on and inquire into previous episodes of organizational learning or failure to learn. They discover what they did that facilitated or inhibited learning and then they invent new strategies for learning.

Kanevsk and Housel (1999) argued that corporate success largely rests on the ability to translate learning from these changes into knowledge that will result in new or modified products. Learning is a critical element ensuring that a corporation makes the necessary adjustments to the new market by continuing to produce valuable products. Hence, the organization must track the effectiveness with which corporations change learning into knowledge that is valuable to customers. A "Learning-Knowledge-Value Spiral" illustrates the process of transforming learning into value (Kanevsk & Housel, 1999), as shown in Figure 2. Any company has to understand that learning from the market must be translated into knowledge that can be applied to its production processes, resulting in changes to its product or service. This "learning to knowledge to new value" cycle must spiral upwards if any company is to flourish, not to mention to survive at all.

An organization can't create knowledge on its own without the initiative of the individual and the interaction that takes place within the group. But, having an insight or a hunch that is highly personal is of little value to the company unless the individual can convert it into explicit knowledge to be shared with others in the company (Nonaka & Takeuchi, 1995). In terms of the process of activity, organizational learning is the social process from individual, group, to the whole organization — that is, organizational learning begins with the individual to affect the groups or departments, and then extends to the organization (Dodgson, 1993). It is not organizational learning if it can't shape any force to affect the organization (Lu, 1996).

But what's the relationship between the learning organization and organizational learning? Organizational learning means activities or processes of learning in organizations, while a learning organization is an ideal form of organization that successfully practices all of these

Figure 2. A learning-knowledge-value spiral



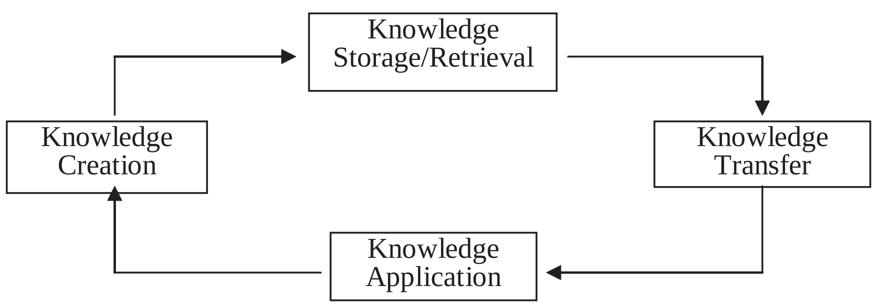
Source: Kanevsk and Housel (1999)

activities (Örtenblad, 2001). Popper and Lipshitz (2000) pointed out that learning organizations are organizations that have embedded institutionalized learning mechanisms into a learning culture. Marquardt (1996) notes that learning organizations focus on the "what" — the characteristics, principles, and systems of an organization that produces and learns collectively, while organizational learning refers to the "how" — the proficiencies and processes of knowledge development. Organizational learning is a concept used to describe certain types of activity that take place in an organization, and the learning organization refers to a particular type of organization in and of itself (Tsang, 1997; DiBella, 1995; Elkjaer, 1999; Finger & Bürgin Brand, 1999; Lundberg, 1995). DeBella and Nevis (1997) argued that a learning organization is a systems-level concept; it has been characterized as having the capability to adapt to changes in its environment and to respond to lessons of experience by altering organizational behavior. In contrast, organizational learning is a term used to describe certain types of activities or processes that may occur at any one of several levels of analysis or as part of an organizational change process. Thus it's something that takes place in all organizations, whereas the learning organization is a particular type or form of organization in and of itself. In summary, learning organizations focus on learning at the organization level, but an organization will learn when the organizational knowledge is out of date, incorrect, or insufficient, and then feedback the learning to the organization. Therefore, we could demonstrate that there exists an interactive relationship between the learning organization and organizational learning.

KNOWLEDGE MANAGEMENT AS AN ENABLING ROLE

Knowledge management is concerned with systematic, effective management and utilization of an organization's knowledge resources (Demarest, 1997). It consists of the creation, storage, arrangement, retrieval and distribution of an organization's knowledge (Demarest, 1997; Saffady, 2000). Alavi and Leidner (2001) classified the processes of knowledge management into four steps: knowledge creation, knowledge storage/retrieval, knowledge transfer and knowledge application, representing a detailed process view of organizational knowledge management with a focus on the role of Information Technology. This systematic framework is shown as Figure 3.

Figure 3. Four processes of knowledge management



Modified from Alavi and Leidner (2001)

Knowledge Creation

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge (Pentland, 1995). In today's rapidly changing environment, organizations have to focus on the creation of knowledge to prevent existing knowledge from obsolescing quickly. When organizations innovate, they do not simply process information from the outside in, but solve existing problems and adapt to the dynamic environment. They actually create new knowledge and information, from the inside out, in order to redefine both problems and solutions and, in the process, to recreate their environment (Nonaka & Takeuchi, 1995). New knowledge is a necessary raw material for innovation and the creation of knowledge, both are closely tied to new products and services (Hauschild, Licht, & Stein, 2001). When a firm starts to develop new products or services, or when organizational knowledge is antiquated or insufficient, a firm could innovate and create new knowledge by organizational learning activities to face the challenges.

Knowledge Storage/Retrieval

While new knowledge is developed by individuals, organizations play a critical role in articulating and amplifying that knowledge (Nonaka, 1994). The storage, organization, and retrieval of organizational knowledge are referred to as organizational memory (Stein & Zwass, 1995; Malhotra, 2000). Organizational memory includes knowledge residing in various component forms, including structured information stored in electronic databases, written documentation, expert systems, documented organizational procedures and processes and tacit knowledge acquired by individuals and networks of individuals (Tan, Teo, Tan, & Wei, 1999).

The individual's knowledge is not equal to the organizational knowledge. The organizational knowledge is of company-level and it should be identified or shared by the members and correlated to a knowledge system (Lu, 1996). Hence, to translate to a learning organization that is full of knowledge, there should be a mechanism and system to store the knowledge for the further application. The strategy for knowledge management should reflect the firm's competitive strategy: how it creates value for customers, how that value supports a business model, and how the organization's people deliver on the value. Two strategies are being used for storing knowledge (Hansen, Nohria, & Tierney, 1999):

1. Codification: Provide high-quality, reliable, and fast information-systems implementation by reusing codified knowledge;
2. Personalization: Provide creative, analytically rigorous advice on high-level strategic problems by channeling individual expertise.

Knowledge Transfer

The distribution and transfer of knowledge is an important process in knowledge management (Alavi & Leidner, 2001; Huber, 1991). Knowledge should be shared and generalized within the organization. In addition, generalization occurs not only when single ideas are moved, but also when the entire process of moving ideas becomes institutionalized within an organization (Yeung, Ulrich, Nason, & von Glinow, 1999). The institutional process embedded in a firm and the capability of generalizing ideas consistently are important elements to meet the real goal of knowledge management.

Organizations should provide several ways and mechanisms to transfer and distribute knowledge to ensure unrestricted transferring. For example, knowledge that is more or less explicit can be embedded in procedures or represented in documents and databases and then transferred accurately. But, transfer of tacit knowledge generally requires extensive personal contacts (Davenport & Prusak, 1998). Hung (2001) found that two approaches facilitate the efficiency of knowledge transfer among employees:

1. Systematic mechanism: refers to the centralized management that stores the knowledge in the institutional systems built upon information and network technology and disseminating the knowledge through the network.
2. Socialized mechanism: refers to an extensive notion, including many heterogenous ways of social interaction, such as the learning community, virtual community, yellow page (of specialists), institutional community, knowledge intermediary within a company, and a speech or conference outside a company.

Knowledge Application

Knowledge application means making knowledge more active and relevant for firms in creating value, since organizational knowledge needs to be employed into a company's products, processes and services (Bhatt, 2001; Demarest, 1997). The source of competitive advantage resides in the application of the knowledge rather than in the knowledge itself (Alavi & Leidner, 2001). Using knowledge more powerfully than your competitors is a key to battling it out in the global information era (Prokesch, 1997). Employees use all available resources, including the corporate knowledge base, to improve their chances of reaching the goals of the organization (Hauschild et al., 2001). Learning from the experience of others and reusing materials that have been effective elsewhere improves the quality and speed of problem solving (Cross & Baird, 2000). Knowledge should be really used to create value for the company and when it is applied, the company can judge the validity and suitability. Knowledge application is essential when the organization transforms into a learning organization and helps the organization to retain correct and valuable knowledge.

RESEARCH METHOD

Case Selection and Data Collection

This case study is applied to illustrate how high-tech firms implement knowledge management practices to transform themselves into learning organizations. The case selection is very important in this study and should be guided by principles (Yin, 1994). Kofman and Senge (1995) suggested that a learning organization should be grounded in three foundations: a culture based on transcendent human values of love, wonder, humility and compassion; a set of practices for generative conversation and coordinated action; and finally, a capacity to see and work with the flow of life as a system. Two cases, Taiwan Semiconductor Manufacturing Corporation (TSMC) and Winbond, have been selected, because of their reputation for their knowledge management practices, to illustrate the different enabling roles of knowledge management in the interaction between learning organizations and organizational learning. TSMC is the world's largest and most successful dedicated independent semiconductor foundry. Winbond is the largest integrated circuit (IC) supplier in Taiwan's IC industry. In addition, the Chief Knowledge Officer (CKO) of the firms promises to provide case interviews. Also, case data collection from multiple evidence resources, company profiles and internal documents is to control the construct validity of the study, and the chain of evidence is found to keep track of the processes of implementing knowledge management in TSMC and Winbond. Besides, data and content from the firm's web site and knowledge portal is collected and analyzed systematically.

Case Illustration: TSMC and Winbond

TSMC: Company Overview

TSMC, founded in 1987 and located in the Hsin-Chu Science-Based Industrial Park of Taiwan, is listed on the New York Stock Exchange (TSM). As the first "pure play" foundry company, TSMC has experienced strong growth by being a true partner with its customers by designing and manufacturing IC products for them. The evolution of advanced IC technology over the past decade has been so rapid that it has changed the ways that companies do business. Demands for faster time-to-market and design cycle have increased, as well as demands for higher speed and product quality. These are some reasons companies around the world turn to TSMC as their manufacturing partner. TSMC puts more resources into its manufacturing facilities and capacity than nearly anyone else. It continues to be the trusted source for a global collection of innovative and savvy businesses, large and small, who appreciate their steadily increasing manufacturing capacity and consistent volume production levels. TSMC enhances its ability to serve its customers by operating, expanding and developing many new facilities as we enter into the new decade:

- Nine 8-inch wafer Fabs in full operation (Fabs 3, 4, 5, 6, 7A, 7B, 8A, 8B, plus WaferTech).
- One 8-inch wafer Fab facility through our TSMC affiliate-Vanguard International Semiconductor Corporation.
- Ground-breaking for the company's two initial 12-inch wafer fabs took place in late 1999 in Hsin-Chu Science-based Park and Tainan Science-based Industrial Park.
- A joint venture with Philips Semiconductor and with Singapore's EDB Investments (SSMC) will also bring increased capacity in the coming years.

TSMC: Knowledge Management Practices

1. Knowledge Creation: TSMC maintains a stable relationship with their customers, has extended their production, innovated their service in eFoundry via the Internet, owns the most advanced process technologies and leads the market. One of the main reasons for its growth is the investment in the innovation of production technologies and the development of value innovation ability that enables TSMC to be the leader. To be more competitive, TSMC has concentrated its attention on the modification and the coordination of various technologies to decrease production costs, reduce its defect rate, cut down the product cycle time, and improve productivity (Hung, 2001). TSMC is not only devoted to technical innovation but also to the innovation of customer service. Morris Chang, the TSMC chairman, announced that TSMC is a customer-oriented service business and he stressed the importance of service innovation. In July 2000, TSMC proposed the idea of eFoundry that allows their customers to be served via the Internet. The vision of eFoundry is to offer the best services for customers; that they can gain benefits from eFoundry without paying a lot for establishment and management. TSMC offers customers a highly integrated supply chain management system with reliability, security, speed and transparency through strategic use of Information Technology. This innovative strategy has enabled TSMC to maintain its superior position and more competitive edge. TSMC continues to boost its learning capabilities and create new knowledge, such that its organizational

learning occurs not necessarily because of the shortage of knowledge, but out of the desire to maintain its superior market position. As we found, knowledge creation plays a key role as TSMC engages in organizational learning.

2. Knowledge Storage/Retrieval: Dr. Tsai, the President and Chief Operating Officer, drives the knowledge management activities in TSMC and founded eight technical boards that are categorized according to the processes in the semiconductor industry. The workers have to join relevant technical boards to share information and knowledge. The manager of IC Design, Dr. Kao, indicates that TSMC should translate the records of the best machines, equipment and technical processes into know-how that can be shared, and then transfer that knowledge to the new foundry. He said that, "The best knowledge of building foundries in the world was filed in our technical board." Any employee in any foundry can share best techniques and knowledge with others on the technical board. The technical board checks and reviews records in which the experience of work will be encoded, stored and shared. As the evidence shows, TSMC pays much attention to knowledge storage and retrieval.
3. Knowledge Transfer: TSMC promotes two approaches for knowledge transfer (Hung, 2001): (a) Sharing: The experiences of engineers are codified and stored in the knowledge system. As the production process can be scientifically measured, it's easy to translate processes into explicit knowledge and to accumulate it. Besides the technical knowledge, information about decision-making is also stored in the Documentation Center after review by the managers. Then, that information can be shared and referred to by the relevant workers. (b) Collaboration: TSMC builds communities among the departments to help the knowledge demander track the knowledge provider and ask for support. This is a social mechanism in which all workers can seek support from those experienced workers through the TSMC Yellow Pages. The effect of knowledge transfer in such a dynamic sharing mechanism is better than the static knowledge system. Through the combination of an active knowledge network and static knowledge system, working knowledge is shared continuously. Sharing and collaboration improve the knowledge transfer in TSMC and help to create more new knowledge. It also enables the positive cycle of knowledge creation, storage and transfer.
4. Knowledge Application: TSMC's employees are urged to apply knowledge to their work and benefit from doing so. Owing to efficient knowledge management, TSMC grew rapidly in the past 12 years and there are five new factories still in the process of construction. Moreover, factories in Singapore and Boston are now in the planning stage. As for process technology, TSMC developed 0.18 micron logic, copper process technology and the embedded process technology applied in sys-on-a-chip. TSMC provides support to the process technology and design of semiconductor to satisfy customers' needs. The primary process technology is 0.35 micron, but it will increase that technology from 0.25 micron to the advanced 0.18 micron at the same time that it goes into mass production. Now, TMSC has also started to test 0.15 micron and plans 0.13 micron process technology for mass production on its schedule. The advanced process technologies significantly cut down the production costs, so that TSMC has made more profit and gains competitive advantage in the world.

The ability of continuous improvement, learning and innovation leads to high efficiency in integrating and coordinating the varied process technologies, and reduces the production cost, while achieving high product quality, low defect rate and short cycle time. The main reason for TSMC superiority is its concentration on technological evolution and innovation of new knowledge and process technology. In addition, TSMC provides the standard circuit component-base and intellectual property (IP) for customers to strengthen their design service abilities.

Winbond: Company Overview

Winbond Electronics Corporation, established in 1987 in the Hsinchu Science-based Industrial Park, Taiwan, is the largest brand name IC supplier in search of excellence in process technology, worldwide marketing networks and wafer processing. After 14 years of growth and accumulation of bountiful assets in products and technologies, Winbond has started to design, develop and market its own products under its brand name and aims at a broad range of product lines to meet the demands of the information industry and satisfy customers' needs. The products include PC and peripheral ICs, micro-based consumer ICs, Network Access ICs, Memory ICs, etc. Winbond, on the average, invests more than 10% of annual revenues into R&D and has built on its extensive technical knowledge and technological experiences. For the past few years, Winbond investment in R&D has yielded substantial growth in technology and helped it to forge strategic alliances, combining R&D with leading global companies. R&D centers have been set up in China and the United States, both tasked with aggressively absorbing new market trends. Winbond's depth in design IP, combined with skilled production capability, allows the company to effectively leverage its efforts to a number of growing markets.

Winbond: Knowledge Management Practices

1. Knowledge Creation: Since 1991, Winbond has been honored by receiving the R&D Investment Award from the Hsinchu Science-Based Park. The company has a long history of knowledge management and patent production worldwide—already surpassing 1,000 patents. In 1998, the company made the top 300 American Patents list. In 1999, Winbond became the winner of the Gold Medal of National Invention by the Bureau of IP, the Ministry of Economic Affairs. Winbond has been named "Outstanding Electronics Component Supplier" for two years in a row and was also selected as the best performing manufacturing company in Taiwan. Dr. Tauso, the manager of knowledge management, implied that the company does emphasize the storage, transfer and application of knowledge rather than the creation of knowledge. But it does not mean that Winbond ignores the importance of knowledge creation. In fact, Winbond is checking and counting its intangible assets first and foremost. As the knowledge is refined, shared and applied, if the knowledge is incorrect, out of date, or not suitable for use, it might force the company to engage in another wave of organizational learning based on the knowledge creation.
2. Knowledge Storage/Retrieval: With the speedy change in the electronics industry, Winbond tends to collect and check the knowledge, then store it in Winbond's knowledge bank after the investigation and refinement by the technical board. To make the knowledge more accessible to workers, Winbond uploads it to the Intranet, so that workers may obtain the knowledge and experience online easily. As the invention of IC is highly specialized in varied

fields of knowledge, the invention of new products design needs clear standard interfaces and technical definitions within the IC framework. Hence, it's easy to transfer an individual's knowledge to codified knowledge, and accumulate it systematically. This crucial knowledge is standardized and stored in Winbond's knowledge systems for those who would request it.

The knowledge systems comprise patents databases, learning materials and technical information, etc. Technical information is subdivided into debug/design reports, IP code and IP Map. Furthermore, to prevent knowledge from being stolen, there is a security mechanism. Some IP and debug/design contents are designed to be online training courses to reduce the training time for newcomers. Most patent information is classified into company patent and market patent information provided for administrators and executives to reference when making decisions. The evidence shows that Winbond pays much attention to knowledge storage/retrieval.

3. Knowledge Transfer: Winbond's technical information and learning materials are explicit knowledge for workers to obtain knowledge and peers' experience through the Intranet immediately. Moreover, senior engineers' experiences can be also transferred to the new employees through IP Map or Yellow Pages, when they are vague about the knowledge or going to check it out. The knowledge department plays the role of mediating for workers to search for the knowledge source. As to knowledge that is unclear or value undefined, Winbond provides an online forum to facilitate sharing that implicit knowledge. This online forum is divided into two kinds — public and nonpublic with some confidential issues reserved for qualified members only. The main purpose of the Knowledge Management Center is to increase the volume and value of organizational knowledge and to spread knowledge throughout the firm. As the knowledge management practices in Winbond imply, it plays a significant role in knowledge storage/retrieval and knowledge transfer.
4. Knowledge Application: Winbond set up the Knowledge Management Center to advance product technology and improve the performance of service innovation on its core competence by applying the knowledge. But during transformation to a learning organization, Winbond emphasizes more of the practice of knowledge application to gain competitive advantage in the IC battle. According to the statistics in the Knowledge Management Center, most engineers encountered similar problems in their work before, but now engineers need not waste time in solving the same problems or recommitting the same errors due to the functions of the center, which has reduced their products' defect rate to 2~3% and cut the cycle time down to 75%. The evidence implies that Winbond takes advantage of organizational knowledge to improve the quality of products, lower defect rate and decrease cycle time of production, and utilizes organizational knowledge to lead the firm.

Case Reasoning and Discussion

TSMC's technology innovation is the wellspring of its growth and is vital to all sectors from strategic planning to management of technology and production. TSMC regards employees and shareholders as important constituents and its goal is to provide better salary and benefit packages for employees. TSMC has implemented an open-style management system designed to keep all lines of communication free in the working environment, and employees are instructed to treat each other sincerely, honestly and cooperatively.

Winbond's human resource is an important asset for company to go from strengths to high quality. It provides suitable working conditions, munificent salaries and bonuses for its employees. In addition, Winbond provides 1,200 training programs and more than 20 Web-based training courses for employees to pursue further upgrades and learning. The continuous-learning culture in Winbond has been established and, furthermore, it also set up many channels (like IP Map, Expert Yellow Pages) for workers to solve their problems or seek help based on the Knowledge Portal.

TSMC and Winbond, famous high-tech companies in the world, put knowledge management into practice and the way they learn, providing many consultations and references due to making efforts to transform into learning organizations. Such dynamic interaction between the learning organization and organizational learning is an important issue for the academic and in practice. This study would provide practical implications and insights for business and research.

Insights from Case Study

With the stiff global competition, high-tech companies face the challenge of shorter product life cycles, the rapid depreciation of tangible assets and the transience of employees. It is essential for firms to put knowledge management into practice positively and actively. Based on the literature and

Table 1. The comparison of case studies: TSMC vs. Winbond

Item comparison	*TSMC*	*Winbond*
Industry	"pure" foundry company	IC design and manufacturing
Enabling role of KM (Knowledge Management)	Focus more on knowledge creation, comparatively (on knowledge innovation)	Focus more on knowledge storage/retrieval, comparatively (on knowledge checking)
Organizational type toward KM	Foster the organizational learning aggressively	Foster move toward a learning organization gradually
KM Mechanism	8 Technical boards; Sharing and Collaboration	KM department and KM Center / IP code and IP map
The KM Agent	The President (Dr. Tsai)	The KM Manager (Dr. Tauso)
KM Strategy	Facilitate faster design cycle, time-to-market and the high quality of product/service	Facilitate checking and counting the intangible asset of IC know- ledge by refinements
Key success factor (KSF)	Technology innovation based on knowledge innovation	Knowledge refinements based on knowledge storage/retrieval
Competitive Advantage via KM practices	Toward customer-oriented service business via the eFoundry with advanced process technologies	Low defect rate and short cycle time to cut down IC product cost. Reduce training cost and keep experience value-added

cases studies of TSMC and Winbond, the authors offer the following insights for managers or readers seeking to develop the enabling role of knowledge management in their companies. Table 1 shows the comparison of the case studies in terms of an enabling role of knowledge management and the organization.

Insight 1. There exists empirically an interactive and recurring relationship between the learning organization and organizational learning. The former is an organization that fills with knowledge and embeds an institutionalized learning mechanism into the learning culture. This type of organization will continue learning to create new knowledge to gain or sustain its competitive advantage. The learning results and accumulated knowledge will modify the organization itself. This feedback continuously transforms the learning organization.

Insight 2. When organizations transform to learning organizations, the processes of knowledge storage/retrieval, transfer and application play more important roles in the knowledge management process because knowledge must be stored in the organization, and then transferred to people who need to apply that knowledge in productivity. Gradually, as learning organizations continue learning, knowledge creation becomes more important than other factors in the process of knowledge management. This is an interaction between organizational learning, with emphasis on knowledge creation, and the learning organization, with emphasis on knowledge storage/retrieval, transfer and application, in terms of an enabling role of knowledge management.

Insight 3. The strategies for knowledge management and practices differ because of different implementation stages or the nature of the company. For example, Winbond doesn't focus mainly on creating knowledge but on checking and reviewing the existent intangible assets; while TSMC does make much effort to create more technology knowledge in order to safeguard its leading advantage in the world.

Knowledge management for firms should refer to the source of competitive advantage or "dynamic capabilities," emphasizing the dynamic character of the environment and capabilities of appropriately adapting, integrating and reconfiguring internal and external organizational skills, resources and competencies. This study suggests that the competitive advantage of firms lies in their managerial and organizational processes, where processes include the routines and patterns of current practice, learning, the endowments of technology and intellectual property. As the cases show, TSMC and Winbond's timely response and rapid development of product innovation, coupled with the enabling role of knowledge management to effectively coordinate and redeploy internal and external competences of knowledge-based innovation, requires careful analysis of various kinds of knowledge. The results indicate there is an interactive relationship between the learning organization and organizational learning. Organizational learning emphasizes mainly knowledge creation, but the learning organization mainly emphasizes knowledge storage/retrieval, transfer and application, in terms of the enabling role of knowledge management. Therefore, firms should transform themselves into learning organizations to foster organizational learning by implementing knowledge management practices in order to gain or sustain a competitive advantage in the knowledge-based economy.

CONCLUSION AND SUGGESTION

This chapter depicts the relationship and interaction between the learning organization and organizational learning in terms of the enabling role of knowledge management in business, However, the result of this case study is difficult to infer from two cases and the generalization of the findings is limited to these contexts (Yin, 1994). But two cases, TSMC and Winbond, are studied to suggest that the enabling role of knowledge management plays the dynamic relationship between the two constructs — the learning organization and organizational learning. Future research may apply the quantitative methods to study the solid relationships between the learning organization and knowledge management, and organizational learning and knowledge management, respectively.

The practical implication of the chapter would be helpful to certain high-tech industries. For example, an enabling role of knowledge management could provoke the emphases on the importance of knowledge creation for the turbulent environment; otherwise, on the importance of knowledge storage/retrieval, transfer and application for the static environment. Firms would define their organizational status and starting point to foster implementation of knowledge management practice based on their goals. Therefore, the interchange transformation of organizational learning and the learning organization should be dynamic adaptation systematically.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Appelbaum, S. H., & Reichart, W. (1998). How to measure an organization's learning ability: The facilitating factors – Part II. *Journal of Workplace Learning, 10*(1), 15-28.

Argyris, C., & Schon, D. (1978). *Organizational learning: A theory of action perspective.* Addison-Wesley Publishing.

Bhatt, G. D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-75.

Cross, R., & Baird, L. (2000, Spring). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 69-78.

Daft, R., & Marcic, D. (1998). *Understanding management*. Ft. Worth, TX: Dryden Press.

Daft, R. L. (1998). *Organization theory and design*. South-Western College Press.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Harvard Business School Press.

De Geus, A. P. (1988, March/April). Planning as learning. *Harvard Business Review, 66*, 70-74.

DeBella, A. J., & Nevis, E. C. (1997). *How organizations learn.* Jossey-Bass Publishers.

Demarest, M. (1997). Understanding Knowledge Management. *Long Range Planning, 30*(3), 374-384.

DiBella, A. J. (1995). Developing learning organizations: A matter of perspective. *Academy of Management: Best Papers Proceedings*, 287-290.

Dodgson, M. (1993). Organizational learning: A review of some literatures. *Organization Studies,* 375-394.

Drucker, P. F. (1993). *Post-capitalist society*. Oxford: Butterworth Heinemann.

Elkjaer, B. (1999). In search of a social learning theory. In M. Easterby-Smith, J. Burgoyne, & L. Araujo (Eds.), *Organizational learning and the learning organization: Developments in theory and practice* (pp. 75-91). London: Sage.

Ellinger, A. D., Ellinger A. E., Yang, B., & Howton, S. W. (2002). The relationship between the learning organization concept and firms' financial performance: An empirical assessment. *Human Resource Development Quarterly, 13*(1), 5-21.

Finger, M., & Bürgin Brand, S. (1999). The concept of the learning organization applied to the transformation of the public sector: Conceptual contributions for theory development. In M. Easterby-Smith, J. Burgoyne & L. Araujo (Eds.), *Organizational learning and the learning organization: Developments in theory and practice* (pp. 130-156). London: Sage.

Galer, G., & Kees, H. (1992). The learning organization: How planners create organization learning. *Marketing Intelligence and Planning*, 5-12.

Garvin, D. A. (1993). Building a learning organization. *Harvard Business Review,* 78-91.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March/April). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

Hauschild, S., Licht, T., & Stein, W. (2001). Creating a knowledge culture. *The McKinsey Quarterly, 1,* 74-81.

Hawkins, P. (1991). The spiritual dimension of the learning organization. *Management Education and Development, 22*(3), 172-187.

Huber, G. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Hung, K. Y. (2001). *Knowledge management mechanisms and enterprise's innovation ability: An exploratory study to build a positive research model*. Unpublished doctoral dissertation, Graduate Institute of Business Administration, National Taiwan University.

Kanevsky, V., & Housel, T. (1999). The learning-knowledge-value cycle. In G. von Krogh, J. Roos, & D. Kleine (Eds.), *Knowing in firms* (pp. 269-284). Corwin Press.

Kofman, K., & Senge, P. M. (1993). Communities of commitment: The heart of learning organizations. *Organizational Dynamics, 22*(2), 5-24.

Lennon, A., & Wollin, A. (2001). Learning organizations: Empirically investigating metaphors. *Journal of Intellectual Capital, 2*(4), 410-422.

Lu, W. S. (1996). *A theoretical inquiry into organizational learning.* Unpublished doctoral dissertation, Graduate Institute of Public Administration National Chengchi University, Taiwan.

Lundberg, C. C. (1995). Learning in and by organizations: Three conceptual issues. *International Journal of Organizational Analysis, 3*(1), 10-23.

Luthans, F., Rubach, M. J., & Marsnik, P. (1995). Going beyond total quality: The characteristics, techniques and measures of learning organizations. *International Journal of Organizational Analysis, 3*(1), 24-44.

Lynn, G. (1998). New product team learning: Developing and profiting from your knowledge capital. *California Management Review, 40*(4), 15-26.

Malhotra, Y. (2000). Knowledge management & new organization forms: A framework for business model innovation. *Information Resources Management Journal, 13*(1), 5-14.

Marquardt, M. J. (1996). *Building the learning organization: A systems approach to quantum improvement and global success.* New York: McGraw-Hill.

Nevis, E. C., DiBella, A. J., & Gould, J. M. (1995, Winter). Understanding organizations as learning systems. *Sloan Management Review*, 73-85.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review, 69*(9), 96-104.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). The knowledge-creating company. Oxford University Press.

Örtenblad, A. (2001). On differences between organizational learning and learning organization. *The Learning Organization, 8*(3), 125-133.

Pedler, M., Boydell, T., & Burgoyne, J. (1988). *Learning company project report.* Train Lund, Sweden.

Pentland, B. T. (1995). Information systems and organizational learning: The social epistemology of organizational knowledge systems. *Account, Management and Information Technologies*, 1-21.

Popper, M., & Lipshitz, R. (2000). Organizational learning: Mechanisms, culture, and feasibility. *Management Learning, 31*(2), 181-196.

Prokesch, S. E. (1997, September/October). Unleashing the power of learning: An interview with British Petroleum's John Browne. *Harvard Business Review*, 5-19.

Rowden, R. W. (2001). The learning organization and strategic change. *SAM Advanced Management Journal*, 11-24.

Saffady, W. (2000). Knowledge management: An overview. *Information Management Journal, 34*(3), 4-8.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization.* New York: Doubleday.

Slater, S. F., & Narver, J. C. (1995). Market orientation and the learning organization. *Journal of Marketing, 59*, 63-74.

Stein, E. W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Sveiby, K. E. (1997). *The new organizational wealth: Managing & measuring knowledge-based assets.* Berrett-Koehler.

Tan, S. S., Teo, H. H., Tan, B. C., & Wei, K. K. (1999). Developing a preliminary framework for knowledge management in organizations. In *Proceedings of the Fourth Americas Conference on Information Systems,* Baltimore (pp. 629-631).

Thurow, L. C. (1999). *Building wealth: The new rules for individuals, companies, and action in a knowledge based economic.* Harper Business Press.

Tsang, E. W. K. (1997). Organizational learning and the learning organization: A dichotomy between descriptive and prescriptive research. *Human Relations, 50*(1), 73-89.

von Krogh, G. (1998). Care in knowledge creation. *California Management Review, 40*(3), 133-153.

Watkins, K. E. & Marsick, V. J. (1996). *In action: Creating the learning organization.* Alexandria, VA: American Society for Training and Development.

Yeung, A. K., Ulrich D. O., Nason, S. W., & von Ginow, M. A. (1999). *Organizational learning capability.* New York: Oxford University Press.

Yin, R. K. (1994). *Case study research design and methods* (2nd ed.). Thousand Oaks, CA: Sage.

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Chapter 4.19
Integrating Knowledge, Performance, and Learning Systems

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INTRODUCTION AND BACKGROUND

Considerable effort has been devoted recently to development of systems or platforms that manage the learning, performance, or knowledge delivered to students and employees. These systems are generically labeled learning management systems (LMS), learning and content management systems (LCMS), performance support systems, and knowledge management systems (Rockley, 2002). Organizations increasingly use content management systems to deliver content objects to employees on a just-in-time basis to support knowledge and performance requirements (Rosenberg, 1999).

While systems are developed that efficiently manage learning, knowledge, or performance, it seems desirable to consider how integration of each of these areas into a single system would benefit organizations. A major challenge to developing such systems has been the degree to which they are interoperable and the components within each are reusable. Reuse of data or information for learning or performance solution development is considered the primary driving force behind the movement toward object-based architectures for such systems (Douglas & Schaffer, 2002; Schaffer & Douglas, 2004).

Ideas for integrating different sources of support for individuals and making its construction more cost effective have begun to take shape. Some efforts have focused on reusable and interchangeable (between different delivery systems) content objects, such as the U.S. Department of Defense Advanced Distributed Learning initiative (http://www.adlnet. org). A big challenge in development of support is the lack of a pedagogical model that takes advantage of object-based architectures while promoting collaboration and knowledge capture and sharing. A significant move in this direction has been outlined by Collis and Strjker (2003) who view the learner as a contributor of knowledge that may be captured and stored for reuse by future learners or course designers. An expansion of this idea, focused on in this article, is the reuse of the contributions of various members of a design and development team. This includes artifacts, decisions, and rationales related to activities such as the analysis of needs, identification of metrics, and identification of causes and possible solutions to workplace problems. This approach essentially attempts to link the analysis and design processes related to initial development of solutions with the ongoing adaptation and evaluation of the solutions in practice.

MOVING FROM E-LEARNING TO E-PERFORMANCE DEVELOPMENT

Advances in technology have made integration of various types of information for the purpose of just-in-time learning and performance development more viable (Greenberg & Dickelman, 2000). The Internet and World Wide Web, along with various authoring tools, have facilitated development of digital materials that are easily accessible by learners and performers. The technology that has lagged is the pedagogy and design thinking and strategies required to make all of this digital information reusable and targeted toward adding value (Clark & Meyer, 2002). Structured training or learning experiences do not always translate into better performance, and, given the fast changing nature of modern organizations, workers need to access critical and specific knowledge and performance support exactly when they need it. The traditional training approach relies on acquisition of knowledge in the hope that it will be useful and be remembered when needed. Unfortunately, much of this knowledge acquisition is explicit and context-specific and does not often transfer well to problem-solving situations (Smith, 2002).

Software development has for a number of years progressed toward embedding knowledge acquisition in context rather than rely up-front on training courses. This is evident through context-sensitive help, task-oriented help, task automation, and task wizards. For example, an LMS will often support a particular task such as entering a new course or adding new students to a course. Furthermore, content management systems are becoming object-based and will allow learners and designers to actively "pull" learning content on an as-needed basis. The development of tools to support the selection of content and to guide this kind of designing "on-the-fly" is also on the rise, as the new wave of user support tools are designed with an object-oriented architecture in mind (Spector, 2001).

Integrating knowledge, performance, and learning within a single system requires thinking of both the whole and the parts. The learners and performers who use the system will interact with an interface that is integrative and allows them to filter and select information most important to them (Gery, 1991). The kinds of information made more readily available to a particular user should be determined by their job role, function, performance objective, and organizational goal. Visual modeling tools are proposed as one way to aid in such integration during problem analysis. Such tools may allow collaborators to construct system models that identify key requirements and subsystems. The veracity of the models is tested as collaborators with multiple perspectives on the system provide feedback and revisions to the model. Subsequent KPL solutions developed from these models would thus more accurately reflect actual workplace situations, constraints, resources, and interactions.

An integrated KPL system would support learners and performers as they (1) access and construct knowledge; (2) perform a specific task; and (3) learn about a topic or objective. Such a system may take many forms. A knowledge management system may essentially be a digital library of artifacts such as manuals, guides, and company records that are stored in a database for retrieval on an as-needed basis. More recently, such systems support collaboration that builds and promotes sharing of knowledge across learners, roles, or organizations through the use of tools such as discussion forums and online white boards (Greenberg & Dickelman, 2000; Shadbolt & Wielenga, 1990).

Performance support systems are typically role or job related and guide performers as they perform specific tasks. An example of performance support could be an electronic job aid with procedures for calibrating a monitoring device in a chemical facility. These kinds of systems purport to offer users a greater level of simplicity and efficiency as they seek to manage courseware, knowledge, and performers. Blended solutions incorporating online knowledge building and learning activities, workplace performance support, and face-to-face classroom learning experiences are powerful examples of how knowledge, performance, and learning integration can be accomplished in a collaborative manner. Collis, Waring, and Nicholson (2004) describe a project at Shell in which workers collaborate online in preparation for classroom activities. Collaboration is supported by a LCMS where contributions are stored in a repository and may be accessed by other learners or by facilitators for classroom use. Participants learn at their own workplace and are able to improve individual and organizational performance as a result of online participation in discussions with other Shell employees across the world.

OBJECTS AND THE CONTENT REPOSITORY

Object thinking, dividing knowledge into discrete granular chunks, represents the next step in the progression toward increasing reuse potential within a KPL system. Object thinking should not be constrained to end products, for example, learning objects used in courses; it also applies to analysis and design knowledge (Due, 2002). By integrating object thinking into analysis, a higher level of reusability as well as adaptability, interoperability, and durability may be achieved (Schaffer & Douglas, 2004). An object approach with a results focus (i.e., each object relates to a specific result required on a job) applied throughout the development process can make it easier to obtain, develop, and implement the solutions to organizational problems or opportunities.

What is an Object?

Gibbons, Nelson, and Richards (2002) refer to a learning object, educational object, knowledge object, intelligent object, or data object as an instructional object. However, since the focus of this framework is problem solving, any learning, performance, knowledge, or instructional object is referred to as a sharable content object (SCO), taken directly from SCORM (n.d.) version 1.2.

The SCORM defines an SCO as "a set of representations of media, text, images, sounds, web pages, assessments objects, or other pieces of data that can be delivered to a Web client" (SCORM, n.d.). A single representation, according to SCORM 1.2, is called an asset. A single asset is unusable in an educational/performance setting, but by conjoining these assets, a shareable content object is created. A set of shareable content objects is referred to as content aggregation. Content aggregation consists of "a map (content structure) that can be used to aggregate learning resources into a cohesive unit of instruction, to apply structure, and to associate learning taxonomies" (SCORM, n.d.).

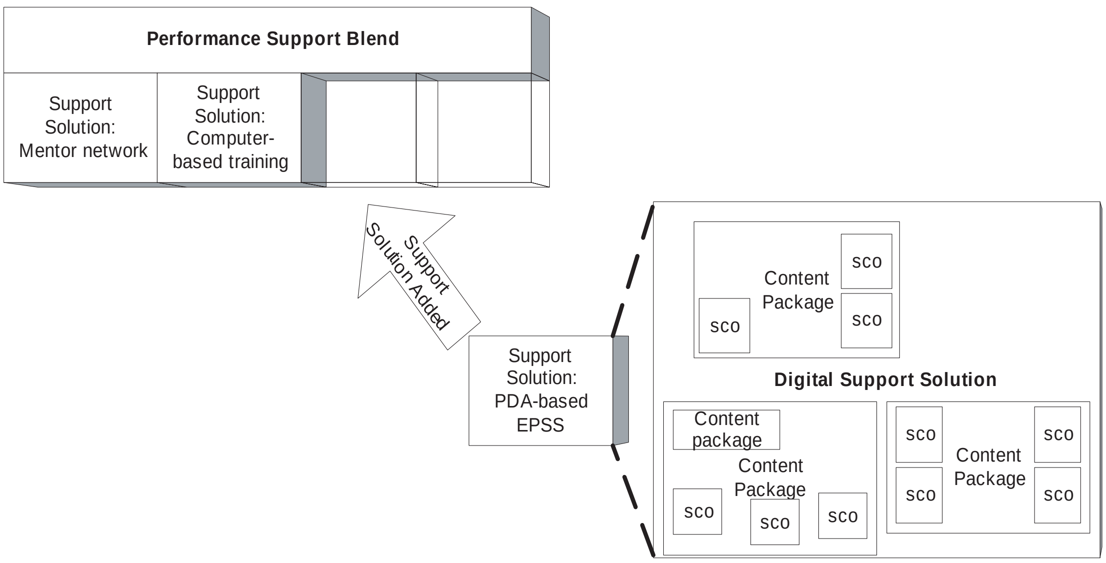
For an object to be SCORM compliant, it must meet specific criteria. Any object developed for performance/instructional purposes must be accessible, interoperable, durable, and reusable. "Without them [the criteria], anyone with a significant investment in either content or a learning system is locked in to that particular content or system" (Robson, 2001).

To ensure that the criteria exist within an object, metadata is tagged to each asset, SCO, and/or content aggregate. Metadata is tagged to an asset, SCO, and content aggregate to ensure that during the process of content creation, the information within each is reusable as well as discoverable. By integrating

The basic asset level is combined into SCOs, the SCOs into packages, and the packages into digital support solutions. Currently, the thinking around SCOs and packages is for them to be delivered in traditional training courses accessed through an LMS or documents accessed through a content or knowledge management system. In a KPL system, the idea is to have all digital support blended together and organized by the particular performance goals people have to achieve in their employment.

Figure 1 illustrates the manner in which SCO's may be packaged to create customized performance support solution packages. In the example shown, a personal digital assistant-based (PDA) support system is developed and slotted together with other solutions available to support a particular role. Examples of other support solutions shown in Figure 1 include a mentor network, which provides a collaborative community for support and knowledge development in a particular performance role, and computer-based training which is specific, structured instructional activities. These are just some of the many possible forms of support that could be developed to support a particular performance role.

Figure 1. Example of performance support solution blend



Why are Important Objects Within the Framework?

The reasons for using objects are simple: they enhance the resulting solution package by defining the separate components of problem-solving knowledge, provide methods for standardization, and offer potential economic advantages through reuse.

There has been a growing emphasis on objects within the fields of instructional design and performance technology. Peters (1995) states:

objects enabled by [an] emergent artifact of digital libraries will be much more like 'experiences' than they will be like 'things,' much more like 'programs' than 'documents,' and readers will have unique experiences with these objects in an even more profound way than is already the case with books, periodicals, etc.

This statement leads Gibbons, Nelson, and Richards (2002) to suggest the need for "model components that can be brought together in various combinations to create the environments and systems" to represent a variety of problems. A contribution-oriented approach to using artifacts and objects to represent problems supported by visual modeling tools goes a long way toward experiencing problems as opposed to simply categorizing and storing them. Furthermore, a comprehensive framework combining an analysis, design, and object orientation in a sequential process would allow such problem representation. Collaborative approaches to the development of objects enable the users/learners to continually reflect upon and evaluate the usefulness of objects. Repositories of analysis and design knowledge provide analysis and design teams with support throughout their respective processes. A content object repository has the potential to provide learner-designers with solution packages that match the recommended solutions identified during analysis. The representation of problems as a result of collaborative and systematic analysis ensures that resulting objects created through design and development processes may be evaluated following use.

Repositories

The purpose of repositories is to support problem solvers, designers, or learners by providing a centralized location for the storage and reuse of standard artifacts and objects. An artifact generally refers to any template, documentation, data, visual model, or component of a visual model that can be accessed and used during any phase of an analysis and design process, for example. We envision that interlinked artifacts will exist for various levels of performance (organizational, process, and individual). For example, an object could contain specifications for the support requirements of a specific task, which will enable early identification of content objects that may be useful in the construction of customized solutions related to performance of that task.

The purpose of a repository is to allow creation of an easier, adaptable, and reusable analysis, design, and development process. This process would also support the collaborative development of organizational problem-solving capacity and ultimately link to the identification of solutions. Creating a common standard for artifacts and objects will enable the sharing of information about common performance problems or opportunities across different organizations. Tools such as groupware and visual modelers support teams as they create shareable objects. As contributions to a repository are reused, they may also be evaluated, revised, or replaced depending on utility and perceived value by members of the community.

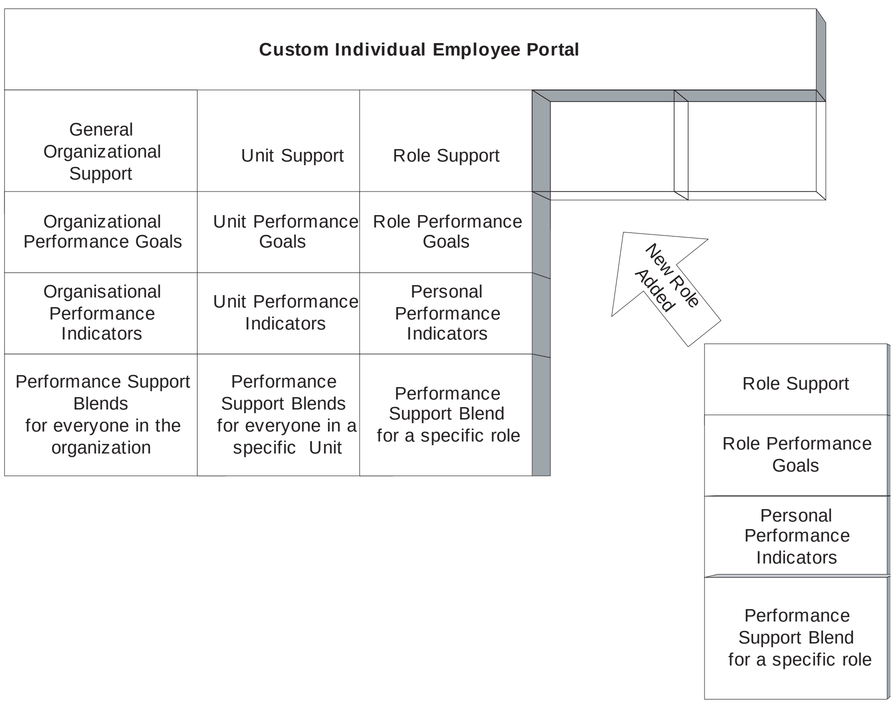
SYSTEM DEVELOPMENT

In system and object development, there are two parallel tasks. Initially, at the systems level for each solution selected, design teams must decompose the system into subsystems (e.g., a course unit in the case of a training system), distribute the objects to the subsystems, and create the packaging and sequencing structure to bind the objects together. Second, for those analysis objects not matched against pre-existing objects, teams must design and develop content, package it into a SCORM compliant object, and submit a copy to the repository. Figure 2 illustrates how these packages and sequencing structures might be bound to create support solutions.

Decomposing the system into subsystems is critical if aligning the results of KPL systems across individual, functional, and organizational levels is desired. For example, in Figure 2, a custom individual employee (student) portal is modeled that illustrates the emphasis on roles that a problem solver in an organization would play rather than using the traditional job title to identify required performance. Roles often cut across traditional job title designations and may be performed by many different employees. Consider the many roles related to a formal title such as manager. Roles often include budgeting, staffing, developing people, proposing projects, and so on. These roles may be performed by many other employees in various job titles across an organization in much the same way.

Organizations that are continuously developing their capacity to solve problems, that is, learning organizations, are able to store and share relevant knowledge, performance, and learning support related to each of these roles. Figure 2 illustrates how goals, indicators of success in achieving goals, and related support are aligned across the organization, unit (department, function), and individual levels. A new role is shown as it is added to a particular employee's portal. This employee has likely assumed this role as part

Figure 2. A model for the services provided by a performance support portal



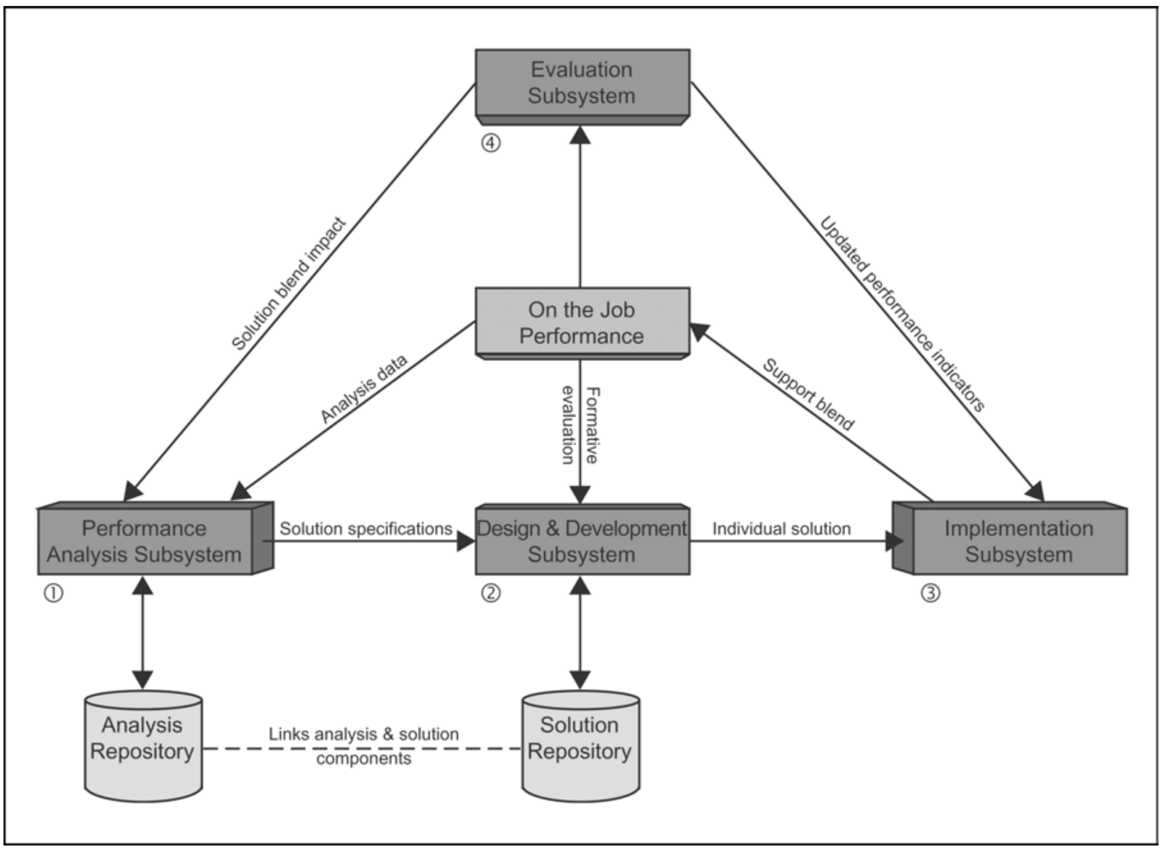
of changing job requirements or as a member of a problem-solving team.

INTEGRATING THE SILOS

There is still a training-oriented bias within the standard setting community in that objects are conceived as learning objects. The main solution considered is computer-based training delivered through a learning management system. As noted in the introduction, the trend is toward thinking in terms of integrated solutions rather than being fixated on the training solution that assumes a knowledge or skill gap for the performer. This not only requires research into how problems are analyzed and solutions are selected, it also requires a reconsideration of how solutions are delivered and managed.

If we look at the way support solutions are currently delivered, we see a lack of integration with systems often developed and delivered independently in silos. Such silos often require that learners and performers discover, integrate, and synthesize the resources that are available to support them. This can lead to usability problems, as users have to contend with a variety of different systems with different interface designs. There may also be reduced utility in some of the systems due to the redundant, irrelevant, inadequate

Figure 3. A model for a comprehensive organizational support system incorporating reuse



information. Learning management systems solve some of these problems for online learning, but they do not solve the problem for performance support in general.

A KPL is conceptualized as a dynamic performer/learner-defined system that links to a database of packaged KPL support systems. Performers using personal digital assistants, wearable computers, or desktop PCs can access available system and subsystem packages. Performance managers or instructors can create a customized performance support environment for a particular individual based on the roles they will perform or tasks to be completed. We would envisage the possibility for a certain amount of resequencing and packaging of systems within this environment. In addition to providing customized access to available performance support systems, the management system should act as a collection point for evaluation information concerning the systems use.

Figure 3 presents an initial model for how a KPL organizational support system might work. The model features two types of repositories. At the top is the reusable analysis knowledge repository which supports problem solvers by providing access to previous problem cases. These cases are linked to objects that may be useful in solving the current problem. Another repository, the reusable solution repository, supports solution developers by linking them to potentially useful objects that are related to the problem identified in the analysis.

The core of the model is on-the-job performance or, in the case of a learning environment, learning goals or problems. Analysis of performance roles or specific goals results in solution recommendations to close gaps between desired and actual role performance. The performance support development system locates reusable solutions if any exist or supports the design and development of SCOs to be packaged into a performance support system. This system is then made available to the performer via the performance support portal. This portal would automatically be made available to any performer with the responsibility of performing that role.

A key element of this model is the connection between on-the-job performance, performance evaluation, and the performance support portal. Indicators of successful performance as related to the performance support for a given role is constantly fed back to the performer. The evaluation subsystem is a key to continuously improving the quality and fidelity of the objects created within this model. Data from actual performance is relayed through the evaluation system to the performer and to the analysis team. Evaluation data is a key ingredient to successful integration of KPL systems since it allows for determination of the effect of a particular type of support system on individual and organizational effectiveness. Over time, patterns of particularly successful solutions may be quickly identified and made accessible to performers automatically. An automated system could monitor patterns of access and use, and automatically generate and administer questionnaires to gather qualitative data from performers when certain patterns are detected.

CONCLUSION AND FUTURE TRENDS

An outline of a new model for the IT systems support for the collaborative development and delivery of KPL management systems has been presented. The unifying strands of the framework are that it be performance, learning, and object oriented. The role of the KPL system is currently taken by learning management systems (LMS) or content management systems (CMS), and many of these systems are facilitating the technical aspect of learning objects; however, they are still rooted in the thinking that formal courses are the main solution to learning and performance problems and that objects are created by content experts. A reusable object and performance orientation should run through an entire support system from its initial conception to its delivery to the end users and the evaluation of its impact of the organization. Within this orientation is a contribution focus that supports the development of reusable objects by analyzers, designers, developers, and performers within the system. These contributors are supported in their efforts by tools such as discussion forums, other groupware, and visual modeling software that are integrated with object repositories.

REFERENCES

Brennan, M., Funke, S., & Anderson, C. (n.d.). *The learning content management system: A new elearning market segment emerges.* Retrieved May 6, 2005, from http://www.trainingfoundation.com/tfimages/ftp/IDCLCMSWhitePaper.pdf

Clark, R., & Mayer, R. (2002). *E-learning and the science of instruction.* San Francisco: Jossey-Bass.

Collis, B., Waring, B., & Nicholson, G. (2004). Learning from experience, for experienced staff. In M. R. Simonson (Ed.), *Proceedings of Selected Research and Development Paper Presentations AECT, 1.*

Collis, B., & Strjker (2001). New pedagogies and re-usable learning objects: Toward a new economy in education. *Journal of Educational Technology Systems, 30*(2), 137-157.

Douglas, I., & Schaffer, S. P. (2002). Object-oriented performance improvement. *Performance Improvement Quarterly, 15*(3), 81-93.

Due, R. T. (2002). *Mentoring object technology projects.* Upper Saddle River, NJ: Prentice Hall PTR.

Gery, G. (1991). *Electronic performance support systems.* Boston: Weingarten.

Gibbons, A. S., Nelson, J., & Richards, R. (2002). The nature and origin of instructional objects. In D. A. Wiley (Ed.), *The instructional use of learning objects* (pp. 25-58). Bloomington, IN: AIT/AECT.

Greenberg, J., & Dickelman, G. (2000, July). Distributed cognition: A foundation for performance support. *Performance Improvement,* 18-24.

Peters, P. E. (1995, July-August). Digital libraries are much more than digitized collections. *Educom Review, 30*(4) Retrieved May 6, 2005, from http://www.educause.edu/pub/er/review/reviewArticles/30411.html

Robinson, D., & Robinson, J. (1995). *Performance consulting: Moving beyond training.* San Francisco: Berrett-Kohler.

Robson, R. (2001). *All about learning objects.* Retrieved May 6, 2005, from http://www.edu works.com/LOTT/tutorial/learningobjects.html

Rockley, A. (2002). *Managing enterprise content: A unified content strategy.* New Riders.

Rosenberg, M. (2000). *Strategies for delivering knowledge in the digital age.* New York: McGraw-Hill.

Schaffer, S. P., & Douglas, I. (2004). Performance support for performance analysis. *TechTrends, 3*(2), 34-39.

SCORM. Version 1.2. Retrieved May 6, 2005, from http://www.adlnet.org/

Shadbolt, N., & Wielinga, B. (1990). Knowledge based knowledge acquisition: The next generation of support tools. In B. Wielinga, J. Boose, B. Gaines, G. Schreiber, & M. Van Somerau (Eds.), *Current trends in knowledge acquisition.* Washington, DC: IOS Press.

Spector, M. (2002). Knowledge management tools for instructional design. *Educational Technology Research and Development, 50*(4), 37-46.

Smith, D. (2002). Real-world learning in the virtual classroom: Computer-mediated learning the corporate world. In E. Rudestam & J. Schoenholtz-Read (Eds.), *Handbook of online learning: Innovations in higher education and corporate training.* Thousand Oaks, CA: Sage.

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Chapter 4.20
Working and Learning in Interdisciplinary Project Communities

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INTRODUCTION AND BACKGROUND: CREATING KNOWLEDGE IN INTERDISCIPLINARY PROJECT TEAM SITUATIONS

Designing a product or service does not form a complete and coherent body of knowledge that can be precisely documented or even articulated by a single individual. Rather, it is a form of knowing that exists only through the interaction among various collective actors (Gherardi & Nicolini, 2000). Existing literature (Kanter, 1988; Nonaka, 1994) has highlighted a need for the development of a diverse workforce if knowledge creation is to be promoted and sustained. This literature suggests that a diverse set of resources (experts with different backgrounds and abilities) provides a broad knowledge base at the individual level, offering greater potential for knowledge creation.

Sahlin-Andersson (1998) viewed projects as local arenas for knowledge creation, as individuals possessing different experience and skills work together to solve a common task within a limited timeframe. Through collaboration, new technical knowledge and knowledge for organizing the project are developed over time. March et al. (1991) argued that organizations learn from experience to improve future performance. By the same token, projects can be used as a medium for organizational learning, where knowledge and experience gained in one project can be transferred and utilized in the next. This strategy does not aim solely to save time and money, but also to avoid "reinventing the wheel", which is something that occurs frequently in every new project. Penrose (1959) argued that utilizing and employing experience and the knowledge thus created makes an organization grow.

Conceptually, a team can be viewed as a socially constructed phenomenon or linking mechanism that integrates individuals and organizations (Horvath et al., 1996). A multidisciplinary team is defined by Nonaka and Takeuchi (1995) as "a self-managed, self-organised team in which members from various functional departments, and/or areas of expertise, work together to accomplish a common goal" (p. 85). The primary goal of the multidisciplinary composition (see Figure 1) is to marry diverse bodies of knowledge in a way that forces out a synergistic knowledge outcome that is innovative, contextualized, difficult to imitate, and, as such, has strategic value. For the most part, project team tasks are nonrepetitive in nature and involve the application of considerable knowledge, judgment, and expertise.

The advantage of adopting multidisciplinary project teams is that they are quicker in integrating the expert knowledge of different functions, for example, design, construction, property management, marketing, and so forth. Cross-functional project teams with mutual accountability and collective work products have been found to decrease development time and increase product quality (Van de Ven, 1986; Wheelwright & Clark, 1992). Multidisciplinary project teams create a "task culture", facilitating close linkages and direct personal contacts between different functions (Cohen & Levinthal, 1990). These close connections are necessary, as new product development by its very nature includes uncertainty about the potential market response and about new technology (Henke, Krachenberg & Lyons, 1993). The multidisciplinary project team can be viewed as an unusual team arrangement primarily because it is composed of professionals from various disciplines who take pride in their fields of expertise. They are committed to the basic assumptions of their paradigms, and they perceive their roles in the team as representing their knowledge bases in the best possible way.

Figure 1. A multidisciplinary composition of team members with diverse knowledge, judgment, and expertise

KNOWLEDGE SHARING IN PROJECT TEAMS

To enhance competitiveness and meet organizational goals, organizations need to ensure that people share both tacit and explicit knowledge. The increased sharing of knowledge raises the likelihood of new knowledge being created, tending to support valuable innovation (Nonaka & Takeuchi, 1995). Though organizations can codify some of the knowledge people use, it is easy to find cases or examples that do not fit the codified knowledge of the organization. This unarticulated knowledge requires communication among people in the organization. Orr (1996) found that photocopier technicians often searched for solutions beyond their manuals. He explained that "the expertise vital to such contingent and extemporaneous practice cannot be easily codified" (p. 2). When documentation proves insufficient, people need to access each other's experience to solve more difficult problems. Orr showed how technicians sometimes use narrative to recount each other's experience. Technicians might use breakfast or lunch meetings to share knowledge. Other accounts of knowledge sharing demonstrate how workers use computer-mediated communication. For example, Constant, Sproull, and Kiesler (1996) showed how people use a computer-mediated network to seek help and advice. Similarly, Hargadon and Sutton (1997) explained how product designers search for knowledge by sending out pleas for help via electronic mail. In both cases, communication is the key to sharing knowledge.

Knowledge sharing relies on reaching a shared understanding of the underlying knowledge, in terms of not just the content but also the context of the knowledge, or "Ba", to use Nonaka and Konno's (1998) term. Exchanging information represents only a partial view of knowledge sharing activity. The essence lies in unveiling and synthesizing paradigmatic differences through social interaction.

Many definitions of the word *paradigm* exist. Neufeldt and Guralnik (1988) defined it first as "a pattern, example, or model" and second as "an overall concept accepted by most people in an intellectual community…because of its effectiveness in explaining a complex process, idea, or set of data" (p. 979). Kuhn (1970, p. 181), who popularized the term, provided two definitions for a paradigm. In the primary sense of the word, a paradigm is a "disciplinary matrix", the ordered elements of which are held by the practitioners of a discipline. According to this definition, a paradigm includes symbolic generalizations (laws and definitions), shared beliefs, and shared values. In an alternate use, Kuhn (1970, p. 187) defined paradigms in a more circumscribed manner as "exemplars" or "shared examples". More recent work by Boland and Tenkasi (1995) indicated the use of the concept of "perspective taking" and "perspective making" to resolve paradigmatic differences through appreciating individuals' different paradigms. By synthesizing the various definitions and insights, a paradigm as used in this chapter, is defined as a team perspective or belief which is collectively constructed and accepted by members of the team. This definition reflects the perspective of social construction as well as the opportunity for paradigmatic differences to be resolved through social interaction between members in collective settings, such as teams or organizations.

Knowledge sharing is not constrained to exchanges among and across the employees of a company. It can occur between employees and customers, or between organizations or firms in entirely different industries (von Hippel, 1988). Some of the very important knowledge identified in a survey among knowledgeintensive businesses includes customer, competitor, and product knowledge (Skyrme & Amidon, 1997). The more knowledge is shared about the needs of current and potential customers among project team members, the better they may understand realistic customer requirements. With such knowledge, greater value for customers may be created because the resultant products may better satisfy customer needs and expectations. Accordingly, they may have a better chance of success in the marketplace. In the same vein, shared competitor knowledge could be helpful in developing products ahead of market requirements (getting products to market ahead of competitors, developing products on schedule). It could yield high value to customers (extending a product's success in the marketplace), possibly improving product performance (better overall product performance than that of competitors). In addition, shared product knowledge (product advantages, disadvantages, strengths, history, and technologies) may be important in improving development productivity (reducing development costs) and production costs (reducing overall production costs).

It is clear that sharing diverse knowledge can enhance problem solving as well as create the culture required for knowledge creation. Communication is the key to knowledge sharing. Knowledge sharing is regarded as a combination of processes sharing and using knowledge directly without language (socialization) and with language (externalization).

KNOWLEDGE INTEGRATION IN TEAM SITUATIONS

More information and knowledge are not always the answer. What may be needed is to better integrate the information and knowledge already available within the team. According to Weick (1995):

more information will not help them. What will help them is a setting where they can argue, using rich data pulled from a variety of media, to construct fresh frameworks of action-outcome linkages that include their multiple interpretations. The variety of data needed to pull off this difficult task is most available in variants of the face to face meeting. (p. 86)

In a new product context, Hayes, Wheelwright, and Clark (1988) suggested that members of new product development teams should have a basic knowledge of other functions in addition to an in-depth knowledge of their own specialty. It is suggested that "specialists are inventors; generalists are innovators" (Galbraith, 1982, p. 22) and that people who are willing to cross functional or other boundaries are likely to be more innovative (Kirton, 1988), or to be able to resolve conflicts because of their ability to see both sides (Gregory, 1983). Nonaka and Takeuchi (1995) alluded to generalism when they talked about Japanese firms' support of "information redundancy" or knowledge overlap between people. Although the use of the term *redundancy* might seem to denote inefficiency, it might in fact turn out to be effective in an innovation situation. This positive effect of knowledge overlap may explain the positive association between the use of job rotation and new product success found in a number of product development studies (Souder, 1981; Wiebecke, Tschirky & Ulich, 1987). Wiebecke et al. (1987) proposed that job rotation promotes an understanding of the work of other functions and facilitated cross-functional "bilingualism". Souder (1981) found that in all the cases where "equal partners" harmony, associated with product success, was attained between marketing and research and development (R&D), the marketing personnel were all technically trained, most having worked in R&D previously. Cross-functional skills learned in job rotation may facilitate the combination of existing knowledge to produce new knowledge. Having considered the importance of integrating knowledge in team situations, the following section will focus on tensions in the process.

Following the above discussion, knowledge integration is defined as a collective process of synthesizing different knowledge and paradigms through the social interaction of team members/stakeholders in order to facilitate the construction of new knowledge or combine existing knowledge.

A project in which a multidisciplinary team is involved can be described as a transformation process, superimposed on the regular or cycled activities of an organization (Beale & Freeman, 1991). In this regard, a project becomes part of a wider venture (Beale & Freeman, 1991), the first part of which is the production of a product or service followed by an operating cycle. The project therefore takes place within a complex corporate, legal, financial, and regulatory environment (Fox, 1984). This environment leads to a number of parties having a stake in the project, from internal departments to external regulatory bodies and customers, since the project decisions have a potential impact on all stakeholders (Cleland, 1986).

As Grant (1996) indicated, competitive advantage does not evolve from knowledge, per se, but from the integration of such knowledge as facilitates the construction of new knowledge. The diversity of the specialized knowledge involved in the integration process determines its difficulty. Hence, the uniqueness of multidisciplinary teamwork is in its potential to integrate different bodies of knowledge into a new synergy. From an organizational standpoint, the prime purpose of the multidisciplinary team is to function as a knowledgeable entity engaged in creating new knowledge. In other words, the function of a project team is to convert knowledge inputs into new products and processes, bringing together participants with expertise in the right specialized knowledge domains and skills necessary to integrate and coordinate the knowledge of diverse participants. With these paradigms of divergent thinking, basic assumptions, and the "professional egos" (Dougherty, 1992) held by team members, this difference of opinion is likely to challenge invalid assumptions and bring more information and knowledge to bear on issues; it may also neutralize tendencies toward "groupthink" (Janis, 1982).

LEARNING AND PROJECT COMMUNITIES

The metaphor of projects as learning experiments for the company embraces an awareness of the importance of both exploration and exploitation of knowledge in organizations (Burgelman, 1991; March, 1991). To see an individual project as an experiment means that new knowledge is created and explored among project participants. The project knowledge and experience gained from earlier or current projects can be used to create new knowledge to suit current situations or problems. Projects, as a form of organizing work, can be one way to explore new knowledge, project-related as well as operational. During participation in a project, team members, through their engagement in the learning process, gain new experience and knowledge that could be used to solve problems. Furthermore, this knowledge and experience could be useful for other projects. In that sense, a project can be viewed as a learning experiment for the companies involved (Drew & Smith, 1995).

In project-oriented companies, learning from projects is the key to building strategic competitive advantage. During a project's existence, a number of decisions are made. Every decision involves a degree of uncertainty. Packendorff (1995), for example, argues that the problems or mistakes that cause this uncertainty are often of a similar character. Yet it is not clear whether this is a global generalization or whether it depends on the sector or stage of an industry's life cycle. Nevertheless, experience to date has shown that once experience is gained in a project, knowledge is created that may be reapplicable. The basic hypothesis of the project learning approach is that learning from projects can reduce the uncertainties that might lead to inefficiencies. The use of project experiences and their integration into the organization to expand the body of knowledge are important and valuable cornerstones in a project learning approach. Ensuring that people pass on their experience to others is one of the greatest challenges for an organization and its organizational memory (Morris, 1994). However, learning and projects are not a natural combination (Bartezzaghi, Corso & Verganti, 1997) since conflicts of a basic logical character are involved. These conflicts comprise the time aspect, the task orientation, the team structure, and the transitional culture of projects (Lundin & Söderholm, 1995).

To carry out their project work effectively, project team members need to develop the ability to manage across boundaries. If learning is assumed to be social, learning is engagement in practice and dealing with boundaries (Wenger, 1998). Project-based organizations offer an excellent opportunity to engage in learning and to acquire reflective habits that transcend the boundaries of projects. Learning is supported not only by the nature of single projects, but also by the web of relationships that is created in project management organizations.

Membership in projects is temporary and thus offers individuals the opportunity to belong to multiple communities. In project-based organizations, there are a large number of weak ties that help diffuse knowledge and practices (Granovetter, 1973). In the majority of organizations, project members maintain their links with their primary organizations (to which they will return upon the completion of the project). Membership in multiple existing teams contributes to the creation of informal webs of people who act as knowledge brokers (Wenger, 1998). Project-based organizations thus enable the continuous building and cultivation of relationships, nurturing the development of communities of practice (Brown & Duguid, 1999). Communities of practice are natural internal mechanisms where ideas and practices spread in work settings, although they tend to exist outside the boundaries of the formal hierarchy (Wenger & Snyder, 2000). Project-based organizations may grow into constellations of interrelated communities of practice, offering a web of mutual support for cultivating reflective practices. When projects share members, they are bound together and become embedded in the same social network (Granovetter, 1973). The recursive interaction among projects creates social networks of mutual assistance. Project-based learning looks to augment the natural workings of such social networks and communities of practice as already exist.

When a project is completed, the members either return to their functional units or organizations or move on to the next project, which makes project teams unique from any other organizational arrangement. In addition, it is not uncommon for individual team members to be members of several teams simultaneously (Henke et al., 1993).

CONCLUSION AND FUTURE TRENDS

Designing a service or product requires the collaborative interaction of individuals from different professional backgrounds. Their diverse expertise represents different interests and issues. These different experiences, mental models, and motivations can be expressed only partly in explicit language. Thus, socialization is a valuable mode of sharing knowledge in teams without language through imitation, observation, and sharing experience face-to-face. Nonaka (1994) emphasized that socialization was also an important way to further trust between partners. Saint-Onge (1996) referred to socialization as a way of creating a sufficient level of congruence to enable individuals to understand each other and work together toward their common goals from different perspectives. Social constructionists regard language as coordination of action (Burr, 1995) and therefore a fundamental tool in knowledge creation. The commonly employed tool in externalization is dialogue. Dialogue triggers the unconscious elements of knowing and not-knowing, as well as revealing gaps in knowledge compared to what the community knows (Ayas, 1996).

An important aspect of knowledge integration is the willingness to combine knowledge from within and outside the team. The more differentiated the knowledge inputs needed in a task, the higher the knowledge diversity and the greater the scope for knowledge integration. Design, involving art, engineering, finance, and business, is a process of knowledge integration, and a product's design emerges from the collaboration of project participants and stakeholders. Leonard-Barton (1995) viewed the creation of new knowledge as occurring by combining previously unconnected elements or by developing ways of combining elements previously associated.

In project-intensive companies, learning from projects is the key to building strategic competitive advantage. During a project's existence, a number of decisions are made. Every decision involves a degree of uncertainty. However, the problems or mistakes that cause this uncertainty are often of a similar character (Packendorff, 1995). Penrose (1959) argued that utilizing and employing the experiences and knowledge created makes an organization grow. Takeuchi and Nonaka (1989) found that learning could potentially occur within a project team along two dimensions: across different levels (individual, team, and organizational) and across multiple functions or disciplines.

Project team members have to incorporate new knowledge into their understanding in order to solve the technical challenges they face. Thus, learning is inherent in the work they do (Mohrman, Mohrman, & Cohen, 1995). In the role of reflecting expert (Schön, 1987), one is expected, like the technicalrational practitioner, to "know one's business", to possess the relevant know-how. However, one need not know everything, let alone have all the answers. One recognizes that others, too, possess relevant knowledge and that people can learn from each other, gaining insights that result in good solutions. New learning is created through the transformation of experiences, but that learning is not leveraged before an understanding of the experience and task is established (Kolb, 1984). Learning has to be linked to a change in an individual's interpretation of events and actions (von Krogh & Roos, 1996).

Membership in projects is temporary and thus offers individuals the opportunity to belong to multiple communities. In project-based organizations, there are a large number of weak ties that help diffuse knowledge and practices (Granovetter, 1973). Crossteam learning or interteam learning can occur when teams share their internal approaches with one another. Collective learning can be considered a vital mechanism (Huber, 1991) and a final product of knowledge creation (Senge, 1990).

REFERENCES

Ayas, K. (1996). Design for learning and innovation. *Long Range Planning, 29*(6), 898-901.

Bartezzaghi, E., Corso, M., & Verganti, R. (1997). Continuous improvement and inter-project learning in new product development. *International Journal of Technology Management, 14*(1), 116-138.

Beale, P., & Freeman, M. (1991). Successful project execution: A model. *Project Management Journal, 22*(4), 23-29.

Boland, R., & Tenkasi, R. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, J. S., & Duguid, P. (1999). Organizing knowledge. *Reflections: The SoL Journal, 1*(2), 28-44.

Burgelman, R. A. (1991). Intraorganizational ecology of strategy making and organizational adaptation: Theory and field research. *Organization Science, 2*, 239-262.

Burr, V. (1995). *An introduction to social constructionism*. London: Routledge.

Cleland, D. I. (1986). Project stakeholder management. *Project Management Journal, 17*(4), 36-44.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organization Science, 7*(2), 119-135.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization Science, 3*(2), 179-202.

Drew, S. A. W., & Smith, P. A. C. (1995). The learning organization: "Change proofing" and strategy. *The Learning Organization, 2*(1), 4-14.

Fox, R. (1984). Evaluating management of large complex projects. *Technology in Society, 6*, 129-139.

Galbraith, J. R. (1982). Designing the innovating organization. *Organizational Dynamics, 11*(2), 3-24.

Gherardi, S., & Nicolini, D. (2000). The organizational learning of safety in communities of practice. *Journal of Management Inquiry, 9*(1), 7-18.

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 78*, 1360-1380.

Grant, R. M. (1996). Prospering in dynamicallycompetitive environment: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Gregory, K. L. (1983). Native-view paradigms: Multiple cultures and culture conflicts in organizations. *Administrative Science Quarterly, 28*(3), 359-376.

Hargadon, A., & Sutton, R. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly, 42*(4), 716-749.

Hayes, R. H., Wheelwright, S. C. and Clark, K. B. (1988). *Dynamic manufacturing.* New York: Free Press.

Henke, J., Krachenberg, R., & Lyons, T. (1993). Perspective: Cross-functional teams: Good concept, poor implementation! *Journal of Product Innovation Management, 10*(3), 216-229.

Horvath, L., Callahan, J. L., Croswell, C., & Mukri, G. (1996). Team sensemaking: An imperative for individual and organizational learning. *Proceedings of the Academy of Human Resource Development Conference*.

Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Janis, I. L. (1982). *Groupthink: Psychological studies of policy decisions and fiascoes*. Boston: Houghton Mifflin.

Kanter, R. M. (1988). When a thousand flowers bloom: Structural, collective, and conditions for innovation in organizations. In B. Staw & L. L. Cummings (Eds.), *Research in organizational behaviour* (pp. 169-212). Greenwich, CT: JAI Press.

Kirton, M. J. (1988). Adaptors and innovators: Problem solvers in organizations. In K. Grønhaug & G. Kaufmann (Eds.), *Innovation: A cross-disciplinary perspective* (pp. 65-85). Oslo: Norwegian University Press.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs, NJ: Prentice Hall.

Kuhn, T. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Lundin, R. A. & Söderholm, A. (1995). A theory of the temporary organization. *Scandinavian Journal of Management, 11*(4), 437-455.

March, J. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*(1), 71-86.

March, J., Sproull, L., & Tamuz, M. (1991). Learning from samples of one or fewer. *Organization Science, 2*(1), 1-13.

Mohrman, S. A., Mohrman, A. M., Jr., & Cohen, S. G. (1995). Organizing knowledge work system. In M. M. Beyerlein, D. A. Johnson, & S. T. Beyerlein (Eds.), *Advances in interdisciplinary studies of work teams* (pp. 61-91). Greenwich, CT: JAI Press.

Morris, P. (1994). *The management of projects*. London: Thomas Telford.

Neufeldt, V., & Guralnik, D. B. (Eds.). (1988). *Webster's new world dictionary of American English*. New York: Webster's New World.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., & Takeuchi, H. (1995). *The knowledgecreating company: How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.

Orr, J. E. (1996). *Talking about machines. An ethnography of a modern job*. Ithaca, NY: ILR Press.

Packendorff, J. (1995). Inquiring into the temporary organization: New directions for project management research. *Scandinavian Journal of Management, 11*(4), 319-333.

Penrose, E. T. (1959). *The theory of the growth of the firm*. New York: John Wiley & Sons.

Sahlin-Andersson, K. (1998). The social construction of projects. A case study of organizing of an extraordinary building project: The Stockholm Globe Arena. In N. Brunsson & J. P. Olsen (Eds.), *Organizing organizations* (pp. 89-106). Bergen-Sandviken: Fagbokforlaget.

Saint-Onge, H. (1996). Tacit knowledge: The key to the strategic alignment of intellectual capital. *Planning Review, 24*(2), 10-14.

Schön, D. A. (1987). *Educating the reflective practitioner: Towards a new design for teaching and learning in the professions*. San Francisco: Jossey-Bass.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Currency Doubleday.

Skyrme, D., & Amidon, D. M. (1997). *Creating the knowledge-based business*. London: Business Intelligence.

Souder, W. E. (1981). Disharmony between R&D and marketing. *Industrial Marketing Management, 10*, 67-73.

Takeuchi, H., & Nonaka, I. (1989). The new new product development game. *Managing Projects and Programs* (pp. 85-103). Boston: Harvard Business School Press.

Van de Ven, A. H. (1986). Central problems in the management of innovation. *Management Science, 32*(5), 590-607.

von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.

von Krogh, G., & Roos, J. (1996). Imitation of knowledge: A sociology of knowledge perspective. In G. von Krogh & J. Roos (Eds.), *Managing knowledge: Perspectives on cooperation and competition* (pp. 32-54). London: Sage.

Weick, K. E. (1995). *Sensemaking in organizations*. Thousand Oaks, CA: Sage.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge, UK: Cambridge University Press.

Wenger, E., & Snyder, W. (2000). Communities of practice: The organizational frontier. *Harvard Business Review, 78*(1), 139-145.

Wheelwright, S. C., & Clark, K. B. (1992). *Revolutionizing product development: Quantum leaps in speed, efficiency, and quality*. New York: Free Press.

Wiebecke, G., Tschirky, H., & Ulich, E. (1987). *Cultural differences at the R&D/marketing interface: Explaining inter-divisional communication barriers. Proceedings of the IEEE Conference on Management and Technology*, Atlanta, Georgia.

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Chapter 4.21
Knowledge Integration

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INTRODUCTION

In most organizations, specialized knowledge is dispersed over organization members (Tsoukas, 1996). Organization members have different educational backgrounds and working experiences and develop different perspectives. Yet, the development and production of complex goods and services normally requires the application of multiple disciplines and perspectives. Therefore, the integration of knowledge is an important task for managers and other organization members (Carlile, 2002; De Boer, Van den Bosch, & Volberda, 1999; Galunic & Rodan, 1998; Grant, 1996a, 1996b; Kogut & Zander, 1992; Okhuysen & Eisenhardt, 2002; Ravasi & Verona, 2000).

Knowledge integration has to be realized through the actions of the specialists involved, but knowledge management professionals can facilitate this task. Several mechanisms can be deployed to realize knowledge integration. An important question is what instrument is suited for what circumstances, for example, which knowledge integration mechanisms fit an exploration strategy and which mechanisms fit an exploitation strategy (March, 1991). If organizations do not explore, they can get stuck in a suboptimal or deteriorating situation. In contrast, if organizations do not exploit, they will have high costs and low incomes. Yet, exploitation and exploration require contrasting approaches to knowledge integration.

The next section presents the theoretical background on the topic of knowledge integration. Subsequently, we describe the knowledge integration mechanisms that can be found in the literature and basic conditions for the successful utilization of these mechanisms. We introduce a framework that distinguishes knowledge integration mechanisms, which can be used to assess the value of particular mechanisms for different situations. This framework is applied in a discussion of the knowledge integration approaches that are required for exploration and exploitation. The concluding section suggests directions for future research.

BACKGROUND

Several disciplines have contributed to the study of knowledge integration. Economists and strategy theorists formulated the outlines of a knowledge-based view of the firm (Demsetz, 1991; Grant, 1996b; Galunic & Rodan, 1998; Kogut & Zander, 1992; Nelson & Winter, 1982; Teece, Pisano, & Shuen, 1997). They have built upon work in organization science, including the information processing perspective (Galbraith, 1973; Tushman & Nadler, 1978) and earlier work on the differentiation and integration of tasks (Lawrence & Lorsch, 1967; Thompson, 1967). Disconnected from those studies, social psychologists studied the effectiveness of knowledge integration under different conditions in experimental studies (e.g., Hollingshead, 1998; Stasser, Stewart, & Wittenbaum, 1995; Wegner, 1987). Combining insights from these disciplines, the problem of knowledge integration can be sketched as follows.

The development and production of complex goods and services requires a wide and expanding range of technological, marketing, and organizational knowledge (Demsetz, 1991; Grant, 1996a, 1996b; Tsoukas, 1996). For example, Ford not only needs a competency in road vehicles and engines, but in 15 other major technological fields as well, including chemical processing, metallurgy, semiconductors, and instruments and controls (Granstrand, Patel, & Pavitt, 1997). In addition to the breadth of knowledge involved, the depth of technologies—their analytical sophistication—also is increasing (Wang & Von Tunzelmann, 2000).

A single individual cannot have the breadth and depth of knowledge required for the development and production of most goods and services. Individuals have restricted learning capacities (Simon, 1991). Furthermore, due to the situatedness of learning processes (Lave & Wenger, 1991), individuals are only able to become experts in fields in which they are actively involved. Finally, learning processes are characterized by an increasing rate of return (Levinthal & March, 1993). That is, the more knowledge one has in a particular field, the easier it is to learn something new within that field. For these reasons, individuals have to specialize in a certain field in order to develop the level of expertise required. It is through the specialization of individuals in different fields, and hence the differentiation of knowledge, that an organization is able to acquire both the required breadth and depth of knowledge (Carlile, 2002; Marengo, 1993; Wegner, 1987).

When the knowledge required for innovation or production lies dispersed across individuals, departments, and organizations, a fundamental task for organization members and management is to integrate that knowledge. The differentiation of knowledge creates a need for knowledge integration. We define knowledge integration as "the process in which different pockets of knowledge, which are valuable for a particular organizational process and held by different organization members, are applied to that organizational process." As we will discuss next, this process can be realized through several mechanisms.

KNOWLEDGE INTEGRATION MECHANISMS

Six different knowledge integration mechanisms can be found in the current literature: (1) sequencing, (2) decision support systems, (3) direction, (4) thinking along, (5) group problem-solving, and (6) knowledge transfer. These mechanisms can be used separately and in combination with each other. This section describes each of them and discusses two basic conditions for the successful utilization of these mechanisms.

Sequencing

The first mechanism for knowledge integration is the sequencing of tasks (Demsetz, 1991; Grant, 1996b; Nelson & Winter, 1982). This mechanism exploits the specialization of organization members. As a knowledge integration mechanism, sequencing refers to the assignment of tasks to those organization members who have the relevant knowledge for it. When routines of sequenced tasks are created, individuals only need to know their part of the routine in order to realize that specialized knowledge is applied in a coordinated way (Nelson & Winter, 1982, p. 101).

Decision Support Systems

Decision support systems are a second way to integrate knowledge. When specialists codify their knowledge and embed it in a decision support system, their original specialist knowledge can be integrated in the practices of a wide range of other organization members (e.g., Davenport & Glaser, 2002). Advances in information technology and knowledge engineering have greatly enhanced the feasibility of this approach to knowledge integration, though there are also clear limits to its applicability (e.g., Dreyfus, 1992).

Direction

Specialists in one area of knowledge can issue rules, directives, and operating procedures to guide the behavior of non-specialists, less mature specialists, and specialists in other fields (Grant, 1997, p. 451). Demsetz (1991) called this mechanism "direction." Rules and directives can be interpreted as translations of a wider body of explicit and tacit knowledge into a limited instruction. The organization members applying these rules and directives do not need to fully understand the wider body of knowledge underlying them.

Thinking Along

Berends, Debackere, Garud, and Weggeman (2004) introduced thinking along as another knowledge integration mechanism. Thinking along takes place in interactions between organization members, but it differs from knowledge transfer. Thinking along consists in the temporary application of one's knowledge to somebody else's problem. The application of this knowledge—including tacit knowledge—may yield ideas, hypotheses, suggestions, comments, and questions that contribute to the process of knowledge creation. These contributions are much easier to communicate than the background knowledge used to produce them. Yet, through thinking along, that background knowledge gets applied to the organizational process involved. In the study of Berends et al. (2004) this mechanism was frequently found in the interactions between industrial researchers.

Group Problem-Solving

Okhuysen and Eisenhardt (2002) limit the concept of knowledge integration to group problem-solving. This mechanism consists of the direct combination of knowledge previously dispersed over individuals in order to solve a problem or make a decision. Okhuysen and Eisenhardt emphasize that this is not just a passive process of combining pieces of knowledge in a way comparable to building with LEGO blocks or making a jigsaw puzzle. The integration of knowledge involves the active use of knowledge and the generation of new ideas, aided by the combination of knowledge. In contrast with thinking along, group problem-solving concerns a shared problem and symmetrical contributions from those involved. Group problem-solving is widely researched in field studies, such as multi-disciplinary innovation projects (e.g., Carlile, 2002; Huang & Newell, 2003), and in experimental studies (e.g., Okhuysen & Eisenhardt, 2002; Stasser et al., 1995).

Knowledge Transfer

Knowledge transfer is presumably the most widely studied mechanism for knowledge integration (e.g., Hansen, 1999; Szulanski, 1996). Though knowledge integration can be realized through knowledge transfer, knowledge transfer alone does not constitute knowledge integration. Knowledge integration requires that the receivers of knowledge are able to absorb it, combine it with their existing knowledge, and apply it to an organizational process. Past research has discovered a wide range of factors that enable or constrain knowledge transfer (e.g., Cummings & Teng, 2003; Szulanski, 1996; Van der Bij, Song, & Weggeman, 2003). Among these factors are characteristics of knowledge such as its tacitness, characteristics of senders such as their motivation, characteristics of receivers such as their absorptive capacity, characteristics of relationships such as the level of trust, and characteristics of the organizational context such as the communication infrastructure. Furthermore, the literature distinguishes several types of knowledge transfer. For example, Dixon (2000) discerns five types of knowledge transfer: serial transfer, near transfer, far transfer, strategic transfer, and expert transfer. Dixon argues that these types of knowledge transfer are suited for different situations and conditions.

Past research has identified several conditions for successful knowledge integration. Two conditions are fundamental. First, organization members need to recognize opportunities for knowledge integration (Galunic & Rodan, 1998). Social psychologists have stressed the importance of a well-developed transactive memory system (Wegner, 1987). Transactive memory refers to the metaknowledge people have about the knowledge and skills of others (Wegner, 1987). Research has shown that such knowledge about others enhances sequencing (Moreland, 1999), thinking along (Berends et al., 2004), group problem-solving (Stasser et al., 1995; Okhuysen & Eisenhardt, 2002), and knowledge transfer (Hollingshead, 1998).

Second, many authors have mentioned the importance of shared understanding (e.g., Galunic & Rodan, 1998; Grant, 1996a; Tushman, 1978). The specialization of organization members not only enables an organization to acquire the range of required expertise, it also creates diverging thought worlds and frames of reference (Carlile, 2002; Dougherty, 1992). Boundaries between groups and practices may create serious barriers to knowledge integration. A basic level of common knowledge and a shared conceptual framework may help to overcome these barriers. Ethnographic field studies have emphasized the role of boundary objects for the success of knowledge integration. A boundary object is an object that is shared and shareable across different contexts and enables collaboration across boundaries (Carlile, 2002; Star & Griesemer, 1989). An example of such a boundary object is the drawing of a new machine, which can be used by different disciplines contributing to the machine.

CHARACTERIZING KNOWLEDGE INTEGRATION MECHANISMS

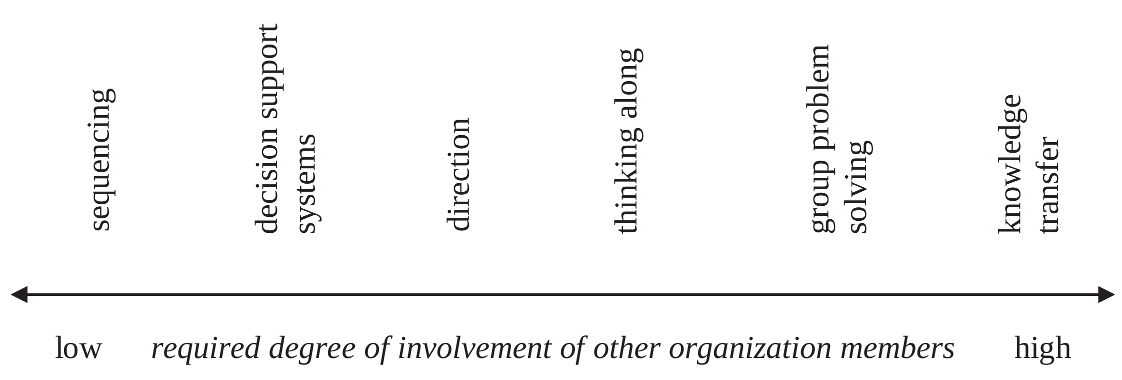
The existing literature describes a range of knowledge integration mechanisms. However, it does not offer a conceptual framework to distinguish and order these mechanisms. Grant (1996b), for example, does not offer an integrated perspective on the mechanisms he introduces. This deficiency in the literature limits our ability to assess the suitability of mechanisms for different organizational processes and conditions. As a first step toward filling this gap, we introduce a dimension that characterizes and distinguishes knowledge integration mechanisms.

Knowledge integration mechanisms differ in the degree to which the application of a piece of knowledge, which is valuable for realizing an organizational process, involves somebody else other than the person having that piece of knowledge. The knowledge of an organization member can be integrated into an organizational process by directly applying it, by incorporating it in a decision support system, by translating it into a rule, by using it when thinking along with someone, by using it in group problem-solving, and by transferring it to someone else. These options differ in the amount of effort required from other persons to realize that the knowledge is applied to a specific organizational process. Two extremes are knowledge transfer and sequencing. Knowledge transfer demands high involvement from the organization members receiving knowledge, since they should absorb the knowledge and apply it in their part of the organizational process. In contrast, sequencing only requires that everyone applies his or her knowledge to his or her own task:

"While each organization member must know his job, there is no need for anyone to know anyone else's job" (Nelson & Winter, 1982, p. 105).

Figure 1 locates each of the knowledge integration mechanisms discussed in the previous section on a continuum from a low to a high degree of involvement of other organization members. Integrating knowledge via rules and directives, for example, lies between the extreme cases of sequencing and knowledge transfer. To some degree it is like knowledge transfer. Organization members other than the ones issuing a rule are needed to apply rules in an organizational process. Yet, to the degree that rules and directives are translations of larger bodies of knowledge, direction does not require as much involvement of other organization members as the transfer of those complete bodies of knowledge would have taken. Similarly, decision support systems, thinking along, and group problem-solving occupy intermediate positions.

Figure 1. Characterization of knowledge integration mechanisms with regard to the required involvement of other organization members



EXPLOITATION AND EXPLORATION

Knowledge integration mechanisms characterized by a high or a low degree of involvement have different advantages and disadvantages. This has implications for their suitability for different organizational processes and conditions. In this section, we will focus on the distinction between exploitation and exploration (March, 1991). Whereas exploration is related to the creation of new knowledge and value, exploitation involves the extraction of value from existing intellectual capital (Sullivan, 1999). Several authors have argued that exploration and exploitation are facilitated by sharply different organizational characteristics (Benner & Tushman, 2003; Hill & Rothaermel, 2003; Levinthal & March, 1993; McNamara & Baden-Fuller, 1999). We will argue that exploration and exploitation also require different approaches to knowledge integration.

Exploitation is served by mechanisms that require a low degree of involvement of other organization members—except when those other organization members are able to reuse knowledge. Exploitation refers to "the use and development of things already known" (Levinthal & March, 1993, p. 105). Exploitation requires that available knowledge is applied where effectively possible, to low costs. In general, low degrees of involvement are less costly. Being deeper involved in the application of knowledge to a particular part of an organizational process takes more time and effort. Particularly, if knowledge has to be transferred to someone else to be applied, this requires time and effort of both sender and receiver. Efficient knowledge integration is realized when the division of tasks is in accordance with the division of knowledge. That is, it is most efficient when a task is assigned to the person who has the relevant knowledge for it. This minimizes the costs associated with knowledge transfer. Thus, Grant (1996b, p. 114) states: "If production requires the integration of many people's specialist knowledge, the key to efficiency is to achieve effective integration while minimizing knowledge transfer through cross-learning by organizational members."

Matching the division of tasks to the division of knowledge—and thus avoiding mutual involvement—can be done primarily by sequencing, but direction and decision support systems also exploit specialization. As Grant (1996b, p. 115) writes: "Thus it is highly inefficient for a quality engineer to teach every production worker all that he knows about quality control. A more efficient means of integrating his knowledge into the production process is for him to establish a set of procedures and rules for quality control." To a lesser degree, the matching of tasks to knowledge can be realized by thinking along. In thinking along, the person having relevant knowledge is not assigned a separate task, but applies his or her knowledge to a problem of somebody else and communicates resulting ideas for solving that problem.

Matching the division of tasks to the division of knowledge is more important when the knowledge involved is tacit and when boundaries exist between bodies of knowledge (Carlile, 2002). Those conditions make knowledge transfer more difficult, and therefore make it more important to avoid (Berends et al., 2004).

This reasoning points at limits to the usefulness of knowledge transfer. However, as stated, when other organization members are able to reuse knowledge in later activities, knowledge transfer may be valuable. When knowledge is in line with someone's specialization, economies of scale and scope make its transfer to that person more valuable (Grant & Baden-Fuller, 2004). For example, this is the case when best practices are transferred from one production facility to another one that uses the same kind of process (Szulanski, 1996).

Exploration requires a different approach to knowledge integration than exploitation. Exploration is "the pursuit of new knowledge, of things that might come to be known" (Levinthal &

March, 1993, p. 105). Schumpeter and many later authors have argued that innovation stems from the recombination of existing pieces of knowledge (e.g., Galunic & Rodan, 1998; Nelson & Winter, 1982). Accordingly, scholars working within the resource-based view argue that the innovative potential of a firm lies in its capability to recombine knowledge and other resources (Kogut & Zander, 1992; Teece et al., 1997). Furthermore, several authors have emphasized that exploration requires the generation of variety (Benner & Tushman, 2003; March, 1991). Given that "most new ideas are bad ones" (Levinthal & March, 1993), many ideas have to be suggested and tried before a successful innovation is created. Combining the ideas that innovation is realized through the recombination of knowledge and that exploration requires a variety of alternatives, we claim that exploration requires knowledge integration mechanisms that create variety in opportunities for knowledge recombination. We will argue that a higher degree of involvement facilitates such variation and that, therefore, group problem-solving, thinking along, and knowledge transfer are particularly suited for exploration.

That a higher degree of involvement enables variation in knowledge integration can be attributed to three factors. First, a higher degree of involvement gives more freedom to apply knowledge in diverse ways. For example, in an ethnographic study within a research organization, we observed the following interaction. In a biweekly cluster meeting, one researcher, Patrick, told about a lubricant he used to enhance the coating of optical discs. Jason, one of his colleagues, who worked on the coating of television screens, responded: "That's a nice solution. It might also work for the coating of screens. I will try that." When knowledge is transferred to others, those persons can decide in what ways to use that knowledge and, thus, how to integrate it with their existing knowledge.

Second, a higher degree of involvement enables one to detect more opportunities for the combination of knowledge. Galunic and Rodan (1998) introduced the notion of detection capability to refer to the capability to detect opportunities for fruitful recombinations of knowledge. In the previous example, Jason used his capability to detect a possible new application of the idea presented by Patrick. In group problem-solving or thinking along, each person involved can use his or her capability to detect ways to combine knowledge. Thus, especially when several people are jointly involved, the chances are higher that new combinations of knowledge are detected.

Third, the value of joint involvement for exploration also originates from the unexpected associations and reactions that interactions can trigger (Berends et al., 2004). For example, Okada and Simon (1997) found that specifically the questioning of each other's ideas is one of the strengths of group problem-solving. A question may trigger a new problem representation, which may trigger new ideas, which in turn may raise evaluative comments, and so on. Such a process prompts the knowledge bases of each of the persons involved in heterogeneous and unexpected ways.

CONCLUSION

Knowledge integration is of crucial importance when production or innovation requires knowledge from several organization members. The literature suggests several mechanisms for knowledge integration (though these mechanisms are not always interpreted in this particular way). In this article, we contributed to the study of knowledge integration by introducing a dimension that captures important differences between knowledge integration mechanisms. This dimension is the degree of involvement of other organization members that is required by a knowledge integration mechanism. Furthermore, we used this dimension in a discussion of the value of different mechanisms for exploitation and exploration.

Future research is required for the further development of theoretical and practical insight in knowledge integration. First, a number of conceptual issues require additional attention. What other dimensions can be used to differentiate knowledge integration processes and mechanisms? What is the relationship between task integration mechanisms and knowledge integration mechanisms? Second, theory building should extend beyond what has been presented in this article and include other characteristics of knowledge integration, contextual factors, and organizational outcomes. Furthermore, the arguments on the suitability of knowledge integration strategies for exploration and exploitation presented in this article should be rigorously tested. Third, we need more insight in the way in which each of the knowledge integration mechanisms can be realized and facilitated. Special attention is required for strategies to overcome boundaries between disciplines and strategies to deal with uncertainty and ambiguity within disciplines. We believe that the advancement of insight will be served by continuing the utilization of a multitude of methodological approaches, including qualitative field studies (e.g., Ravasi & Verona, 2000), quantitative survey research (e.g., Hansen, 1999), experimental studies (e.g., Stasser et al., 1995), and simulation studies (e.g., Marengo, 1993).

REFERENCES

Benner, M.J., & Tushman, M.L. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review, 28*(2), 238-256.

Berends, H., Debackere, K., Garud, R., & Weggeman, M. (2004). *Knowledge integration by thinking along.* ECIS Working Paper 04.05, Eindhoven: Eindhoven University of Technology, Eindhoven Centre for Innovation Studies.

Carlile, P.R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science, 13*(4), 442-455.

Cummings, J.L., & Teng, B.S. (2003). Transferring R&D knowledge: The key factors affecting knowledge transfer success. *Journal of Engineering and Technology Management, 20*(1-2), 39-68.

Davenport, T.H., & Glaser, J. (2002). Just-in-time delivery comes to knowledge management. *Harvard Business Review, 80*(7), 107-112.

De Boer, M., Van den Bosch, F.A.J., & Volberda, H.W. (1999). Managing organizational knowledge integration in the emerging multimedia complex. *Journal of Management Studies, 36*(3), 379-398.

Demsetz, H. (1991). The theory of the firm revisited. In O.E. Williamson, S.G. Winter, & R.H. Coase (Eds.), *The nature of the firm.* New York: Oxford University Press.

Dixon, N.M. (2000). *Common knowledge.* Boston: Harvard Business School Press.

Dougherty, D. (1992). Interpretative barriers to successful product innovation in large firms. *Organization Science, 3*(2), 179-202.

Dreyfus, H.L. (1992). *What computers still can't do.* Cambridge, MA: MIT Press.

Galbraith, J.R. (1973). *Designing complex organizations.* Reading, MA: Addison-Wesley.

Galunic, D.C., & Rodan, S. (1998). Resource combinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management Journal, 19*(12), 1193-1201.

Granstrand, O., Patel, P., & Pavitt, K. (1997). Multi-technology corporations: Why they have "distributed" rather than "distinctive core" competences. *California Management Review, 39*(4), 8-25.

Grant, R.M. (1996a). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Grant, R.M. (1996b). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(Winter Special Issue), 109-122.

Grant, R.M. (1997). The knowledge-based view of the firm: Implications for management practice. *Long Range Planning, 30*(3), 450-454.

Grant, R.M., & Baden-Fuller, C. (2004). A knowledge accessing theory of strategic alliances. *Journal of Management Studies, 41*(1), 61-84.

Hansen, M.T. (1999). The search-transfer problem. *Administrative Science Quarterly, 44*(1), 82-111.

Hill, C.W., & Rothaermel, F.T. (2003). The performance of incumbent firms in the face of radical technological innovation. *Academy of Management Review, 28*(2), 257-284.

Hollingshead, A.B. (1998). Retrieval processes in transactive memory systems. *Journal of Personality and Social Psychology, 74*(3), 659-671.

Huang, J.C., & Newell, S. (2003). Knowledge integration processes and dynamics within the context of cross-functional projects. *International Journal of Project Management, 21*(3), 167-176.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

Lave, J., & Wenger, E. (1991). *Situated learning.* Cambridge: Cambridge University Press.

Lawrence, P.R., & Lorsch, J.W. (1967). *Organization and environment: Managing differentiation and integration.* Boston: Harvard Business School Press.

Levinthal, D., & March, J. (1993). The myopia of learning. *Strategic Management Journal, 14*(Winter Special Issue), 95-112.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*(1), 71-87.

Marengo, L. (1993). Knowledge distribution and coordination in organizations. *Revue Internationale de Systémique, 7*(5), 553-571.

McNamara, P., & Baden-Fuller, C. (1999). Lessons from the CellTech case: Balancing knowledge exploration and exploitation in organizational renewal. *British Journal of Management, 10*(4), 291-308.

Moreland, R.L. (1999). Transactive memory: Learning who knows what in work groups and organizations. In L.L. Thompson, J.M. Levine, & D.M. Messick (Eds.), *Shared cognition in organizations.* Mahwah, NJ: Lawrence Erlbaum.

Nelson, R.R., & Winter, S.G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

Okada, T., & Simon, H.A. (1997). Collaborative discovery in a scientific domain. *Cognitive Science, 21*(2), 109-146.

Okhuysen, G.A., & Eisenhardt, K.M. (2002). Integrating knowledge in groups: How formal interventions enable flexibility. *Organization Science, 13*(4), 370-386.

Ravasi, D., & Verona, G. (2001). Organising the process of knowledge integration: The benefits of structural ambiguity. *Scandinavian Journal of Management, 17*(1), 41-66.

Simon, H.A. (1991). Bounded rationality and organizational learning. *Organization Science, 2*(1), 125-134.

Star, S.L., & Griesemer, J.R. (1989). Institutional ecology, "translations" and boundary objects. *Social Studies of Science, 19*(3), 387-420.

Stasser, G., Stewart, D.D., & Wittenbaum, G.M. (1995). Expert roles and information exchange during discussion. *Journal of Experimental Social Psychology, 31*(3), 244-265.

Sullivan, P.H. (1999). Profiting from intellectual capital. *Journal of Knowledge Management, 3*(2), 132-142.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within a firm. *Strategic Management Journal, 17*(Winter Special Issue), 27-44.

Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

Thompson, J.D. (1967). *Organizations in action.* New York: McGraw-Hill.

Tsoukas, H. (1996). The firm as a distributed knowledge system. *Strategic Management Journal, 17*(Winter Special Issue), 11-25.

Tushman, M.L. (1978). Technical communication in R&D laboratories: The impact of project work characteristics. *Academy of Management Journal, 21*(4), 624-645.

Tushman, M.L., & Nadler, D.A. (1978). Information processing as an integrating concept in organizational design. *Academy of Management Review, 3*(3), 613-624.

Van der Bij, H., Song, X.M., & Weggeman, M. (2003). An empirical investigation into the antecedents of knowledge dissemination at the strategic business unit level. *Journal of Product Innovation Management, 20*(2), 163-179.

Wang, Q., & Von Tunzelmann, G.N. (2000). Complexities and the functions of the firm: Breadth and depth. *Research Policy, 29*(7/8), 805-818.

Wegner, D.M. (1987). Transactive memory. In B. Mullen & G.R. Goethals (Eds.), *Theories of group behavior* (pp. 185-208). New York: Springer Verlag.

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Chapter 4.22
Mobile Technology for Knowledge Management

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INTRODUCTION

IT support for knowledge management (KM) is a widely discussed issue. Whereas an overemphasis on technology is often criticized, the general consensus is that a well-balanced combination of technical and social approaches can be a rewarding departure (Alavi & Leidner, 1999). The usage of knowledge management systems (KMSs) (i.e., information systems including for example data warehouse techniques and artificial intelligence tools) is seen as a factor that can beneficially support different KM processes (Frank, 2001; Wiig, 1995). Due to the fact that an increasingly large proportion of work is not conducted in the context of stationary workplaces anymore, it becomes necessary to make KMSs available to those mobile workers (Rao, 2002; Sherman, 1999). Considering the different technological infrastructure in the stationary, as well as the mobile context, a KMS that so far is only available at a stationary workplace cannot simply become mobile without any changes. Further, the aspect of mobility implies specific design requirements for KMS. Taking together the rapid developments in the field of technology, allowing more and more mobile processes to be potentially supported through mobile KMS, as well as the current social and occupational developments, resulting in more mobile workplaces and business processes (Gruhn & Book, 2003), the relevance of mobile KM can be expected to increase in the future.

Once the focus is shifted away from the superordinate process perspective and addresses the design and development of applications to support mobile knowledge workers, technology and its use by human actors turns out as a major factor that has to be considered. The multiplicity of devices as well as the variety of KM applications, combined with technological and human limitations, all affect the development of mobile KMS. This article aims at addressing important design requirements pointing to different directions that need further research. By doing so, the goal is to put not too much emphasis on technological issues, but rather to introduce the relevant mobile technology and provide a basis for the further discussion of mobile technology usage in the context of KM.

BACKGROUND

Taking into account the wide range of literature available in the field of KM, the aspect of mobility as such is comparably under-researched so far. The same is true for the use of mobile information and communication devices in the context of KM. Studies on workplaces usually focus on stationary characteristics (Churchill & Munro, 2001). To approach the issue of mobile technology in the context of KM, input has to be taken from several different disciplines, including the area of computer-supported cooperative work (CSCW), which has been dealing for some time with the potential of mobile devices to support human decision-making and interaction processes is a comprehensive source. Further, literature dealing with mobile commerce can deliver some input as well. Finally, organization and work studies can contribute insights, especially when it comes to the wider context of mobile KM. In the following, relevant trends concerning the aspects of knowledge work and mobility are presented, and by doing so the basis for the further discussion is laid.

Knowledge Work

Knowledge work is, like many other types of work, influenced by development of an increasingly mobile workforce. Due to changes in work processes and structures as well as the adoption of information and communication technology (ICT), workplaces become increasingly mobile. In this context, not only dependent workers but also independent knowledge workers—freelancers—have to be considered, as their number is dramatically increasing (Kakihara & Soerensen, 2002b). This new form of worker is backed by ICT, allowing mobile workers to coordinate their interactions and communicate with other parties involved. This group of knowledge workers is also referred to as (digital) "nomads" (Soerensen, 2002; Hardless, Lundin, & Nuldén, 2001) or "post-modern professionals" (Kakihara & Soerensen, 2002b). The first term conveys the two characteristic properties of those workers. Firstly, they use ICT to connect and coordinate; secondly, they are on the move for a considerable amount of their working time.

Mobility

The concept of mobility can be seen from different points of view, which have to be addressed in order to develop a common understanding of mobile knowledge work. Literature is providing several different perspectives of mobility. Traditionally, mobility is considered as being geographically without constraints. Kakihara and Soerensen (2002a) however extend that view by focusing on the aspect of human interaction and provide a differentiation between three aspects of mobility. Spatial mobility refers not only to the geographical mobility of humans, but also to the mobility of objects and symbols. With the Internet they are no longer bound to a certain space, but are available regardless of their location. Temporal mobility pertains to the opportunities of ICT to enable asynchronous communication and thus frees the user from the restrictions of time. Contextual mobility serves next to spatial and temporal mobility as a major factor influencing human action. For the purpose of this article, we are focusing on that aspect of mobility that can be considered as spatial mobility, as this factor is most relevant for the perspective we are pursuing. Depending on the mode of spatial mobility, different requirements for the evaluation of mobile technology in the context of KM have to be considered.

Taking a closer look at the idea of spatial mobility can provide insights regarding the particular requirements during the period of being mobile. Kristoffersen and Ljungberg (2000) classify the following types of spatial mobility. Traveling refers to the process of changing from one location to another location usually using some kind of vehicle. Visiting describes the process of spending time in one particular location before traveling to another location. Visitors can either bring their ICT equipment with them or use the ICT that is already there. However, if visiting involves a certain degree of wandering (see below) between different offices and meeting rooms, the possibility to use existing ICT equipment is usually not a realistic option. Wandering refers to restricted spatial mobility in a building or a restricted area. This form of mobility is usually conducted by support workers or knowledge workers interacting with several other mobile workers. Due to the high degree of physical movement, the use of easily portable devices is feasible. Taking into account the fact that some forms of spatial mobility allow certain devices to be used and others not, stresses the importance of a detailed analysis for determining design requirements for mobile KM. While traveling in an airplane, it might for example be possible to use an laptop PC, although that is not always realistic, considering the fact that power supply is usually restricted to business class passengers. Thus, in that context it might for example be feasible to use a mobile device with less power demand, enabling longer running time.

MAIN FOCUS OF THE ARTICLE

After having addressed the issues of mobility and knowledge work, this section provides an overview of relevant mobile technologies and introduces certain mobility-specific requirements.

Mobile Devices

We use the term mobile devices for information and communication devices that have been developed for mobile use. Thus the category of mobile devices encompasses a wide spectrum of appliances. Although the laptop is often included in the definition of mobile devices, we have reservations to include it here without precincts due to its special characteristics: It can be moved easily, but it is usually not used during that process. For that reason we argue that the laptop can only be seen to some extent as a mobile device. In the following the devices are differentiated according to their relevant interfaces, functionality, as well as their possibilities for user interaction. In particular, the following four characteristics can be introduced enabling the realization of certain KMSs (Turowski & Pousttchi, 2003):

- Voice functionality, usage of IVR (Interactive Voice Response)
- Capability to send and receive short messages (Short Message Service, or SMS)
- Internet-enabled
- Capability of executing applications

Mobile phones are mobile devices that are primarily geared at the use of the telephone functionality. 2G mobile phones are usually Internet enabled and support Short Message Service. With Java support, even complex applications can be implemented. Smartphone is a device that can only be roughly defined as there is no clear delineation. Typical characteristics of a Smartphone include mobile phone functionality and an operating system that is similar to that of a personal digital assistant (PDA). A PDA is a handheld computer with core functionality similar to a personal information manager. Current models include the possibility to establish an Internet connection using modem-supported mobile phone, GSM cards, or integrated mobile phone technology. Operating systems are similar to that of conventional PCs. Tablet PC describes a modification of the laptop PC which can be used in stationary as well as mobile settings. Wearable computing is the term for miniature devices that can be integrated for example into clothing and thus have the characteristic to be immediately available. Additionally, proprietary devices that have been designed according to the specific needs of an organization have to be considered as well. However, as those devices are usually derived from the types introduced above, we are not going to specify them further.

Communication Standards

Where the communication standards are concerned, there are currently with 2G (e.g., GSM, IS-136, IS-95) and 3G (Universal Mobile Telecommunications System, or UMTS) two main standards available for the transmission of data. Whereas the 2G networks are generally capable for transmitting data, they are optimized for voice transmission. With 2.5 technologies like General Packet Radio Service (GPRS) and Enhanced Data Rate for Global Evolution (EDGE), however, packet transmission is possible, enabling always-on operation. Using up to 8 time slots, data speeds of a maximum of 171.2 kbps are theoretically possible.

Due to the restricted capacity of current mobiles devices and networks, a realistic downlink speed of approximately of 40.2 kbps to 62.4 kbps can be expected. The advent of UMTS will make bandwidth concerns increasingly negligible, enabling transfer rates up to 384 kbps (using UMTS FDD) respectively 2 mbps (using UMTS TDD), although the realistic speed—depending on network capacity—will be in the area of 128 kbps. For some KM applications, UMTS will act as an enabler; for example, videoconferencing will become possible.

Figure 1. Functionality of mobile devices

	Availabe Functionality			
Type of Mobile Device	IVR	SMS	Internet	Programm Code executable
Mobile Phone (speech functionality only)	x			
Mobile Phone (SMS-enabled)	x	x		
Mobile Phone (Internet-enabled)	x	x	x	
Mobile Phone (Java-enabled)	x	x	x	x
Smart Phone	x	x	x	x
PDA	(x)	(x)	(x)	x
Tablet PC	x	x	x	x
Wearable Computing	Depending on the combination with other mobile devices			x

For mobile devices used within the premises, the bandwidth problem can be neglected, considering the application of wireless LAN technologies. Handheld devices with WLAN connectivity are already in rapid advance in industrial production management, which provides a promising base for in-premises mobile KM. As the restricted range of wireless LAN cannot fulfill the requirement of ubiquitous access, this technology has to be treated with some reservations in this context.

Concept and Design Requirements

In contrast to mobile commerce, mobile KM aims almost exclusively at the intraorganizational or interorganizational use. That enables the particular organization to choose the most appropriate technology for the desired KM solution and regulate its use. The same is true at an intraorganizational level, where the employed technology can be determined by an agreement with the respective business partners. Compared with mobile commerce, that results in a considerable advantage, because that way an optimal fit between the type of mobile devices and the employed KM solution is ensured. Thus certain problems arising due to the heterogeneity of devices can be avoided. Further, the employment of devices can be intentionally managed in order to ensure the fit of individual users' KM needs and the particular features of the different mobile devices. But as stated above, the different modes of spatial mobility require the use of different mobile devices. That results in the fact that although in the organizational context the use of mobile devices can be regulated to some extent, there still exists a considerable amount of heterogeneity. Heterogeneity implies special requirements for the design process of mobile KMS solutions. As the different mobile devices possess diverse technological characteristics, there is no one-size-fits-it-all solution. For that reason it is recommended to choose a platform-independent approach for the implementation (Grimm, Tazari, & Balfanz, 2002).

Taking KM mobile has to account for further special requirements that are associated with mobile technology. Limitations for the use in the mobile KM context arise above all due to displays and input possibilities, as well as bandwidth and transfer modes. With the exception of tablet PCs, the display sizes range from a few lines only (mobile phone) to 240x320 or larger (PDA). Regarding the input methods, the possibilities vary from a restricted number of pushbuttons that enable operating simple menus to more sophisticated solutions like handwriting recognition or virtual keyboards. Further, design requirements for common user interfaces need to be adjusted, as they are developed for stationary use, assuming that all concentration is focused on the display. That is naturally not the case if the device is used on the move.

Where the employment of mobile devices is concerned, every type of device introduced earlier can be used in the KM process. Categorizing mobile KM into the following different groups enables delineation of the effectual technological requirements (Derballa & Pousttchi, 2004):

1. Mobile Information Exchange includes the transfer of data and information using e-mail, as well as the access to operational systems used in an organization to retrieve sales figures or market data.
2. Mobile Business Intelligence refers to the access of processed enterprise data using mobile devices. It involves the technologies introduced earlier (e.g., data mining and data warehouses).
3. Mobile KM describes that management process in the course of which mobile communication techniques in conjunction with mobile devices are employed for the creation, validation, presentation, distribution, or application of knowledge.

Mobile Information Access

For the retrieval of data and information, all mobiles devices can be used that feature the basic capability of displaying text. It has to be taken into account though that in reading longer textual information like e-mails, the use of small display devices is not very feasible. Mobile phones thus are suited best for the display of a small amount of data and information.

Mobile Business Intelligence

The display of processed enterprise data requires the mobile devices used to be able to display complex tables and maybe graphical visualization of the processed data. Thus more processing power is needed, which disqualifies simple mobile phones from being used in that context. Consequently, Smartphones as well as PDAs meet the minimum requirements for that mobile KM stage.

Mobile KM

In this context we are referring to the definition of KM in the narrower sense introduced above. The specific requirements for mobile devices used results from the type of KM technique that is taken mobile. For low-technology KM solutions like expert finder—as long as there is no graphical visualization—even mobile phones can be considered. However, with the richness of the KM solution, the requirements regarding display, processing power and entering methods, and required bandwidth increase dramatically. That is for example the case when a lessons learned database includes complex graphics for visualization purposes.

FUTURE TRENDS

Considering the fact that research for IT support for mobile business processes in general and mobile KM in particular is still in its early days, a considerable amount of work has to be done to catch up with the state of research in other areas of KM. The questions to be answered are manifold, but the following issues, without claiming to be exhaustive, are introduced as possible research topics.

We consider a KMS as a socio-technical system, according to Ropohl (1979), comprising the elements human actors, tasks, and technology. Based on that perspective, possible research questions are grouped into the following categories.

Human Actor-Related Questions

Apart from the potential to greatly improve mobile business and knowledge processes, the wide use of mobile devices might lead to some undesirable effects. A current example for this problem can be observed in the United States with the increasing popularity of the Blackberry. Its owner is always connected, always on, has the possibility to interact, and is never cut off from the information flow. According to recent reports, that results in an excessive overuse of the device, including derogatory effects on the mental condition of its user, which resulted in the fact that the Blackberry is ironically called "Crackberry" (e.g., Pilcher, 2004). Two main problems can be addressed in this area and need further empirical research: information overload and interaction overload. Certain types of (knowledge)work require outmost concentration. Considering the possibility to provide the user with information on a push basis, these moments of concentration might be interrupted, leading to unwanted performance loss of the individual user (Davis, 2002). It might however be possible to fight information overload with the possibility to deliver context-relevant information only, which is enabled through the aspect of context-specifity. Until today, it has however not been fully evaluated whether the delivery of context-specific information can be conducted with enough feasible practicability.

With an accretive amount of interaction shifting towards the space of mobility, there is further the problem of too much interaction, of interaction overload. Similar to information overload, the possibility to interact continuously might reach dimensions in which the amount of interaction is detrimental to the productivity of individual workers.

Task-Related Questions

Mobile knowledge work can be considered as work that includes a considerable amount of self-management. The introduction of mobile KM might reduce this amount of freedom in exchange for more structured processes and greater control. It needs to be tested how this development might influence worker's productivity. A basic precondition for the adoption of new technology, in this case mobile technology, assumes that the prospective users are willing to use new technology. That however might not always be the case. Further, organizational effects can be expected due to the extensive effect mobile technology can have on business processes. Adaptive Structuration Theory can provide a framework for the evaluation of the possible effects on work processes and organizational changes (DeSanctis & Poole, 1994).

Technology-Related Questions

With the focus on technology, it needs to be empirically tested which type of mobile device can be feasibly used during different types of spatial mobility. Krogstie (2003) cites a case study dealing with an electronic newspaper delivery guide, demonstrating that the usage of mobile devices to support workers with the task of route planning and scheduling of activities, is potentially remunerative compared to the earlier paper-based solution. As potential benefits he identified for example the optimized scheduling and planning process. Practice however showed that the mobile devices used were not robust enough to withstand snow, rain, and other environmental influences.

CONCLUSION

According to the general technological and social trends introduced above, mobile technology in the context of KM will become an increasingly relevant topic. Technology will act as an enabler in this field, with increasingly powerful mobile devices as well as higher data transmission speeds allowing significant KMSs to be taken mobile. Designing mobile KM solutions, however, has to cater for several different requirements that are still subject to further research. This article addresses important design issues in order to provide some leads for the further discussion of mobile KM, and presents an introduction to the relevant mobile technologies.

REFERENCES

Alavi, M., & Leidner, D.E. (1999). *Knowledge management systems: Issues, challenges, and benefits.*

Churchill, E.F., & Munro, A.J. (2001). WORK/PLACE: Mobile technologies and arenas of activity. *SIGGROUP Bulletin, 22*, 3-9.

Davis, G.B. (2002). Anytime/anyplace computing and the future of knowledge work. *Communications of the ACM, 45*(12), 67-73.

Derballa, V., & Pousttchi, K. (2004). Extending knowledge management to mobile workplaces. *Proceedings of the 6th International Conference of Electronic Commerce*, Delft, The Netherlands.

DeSanctis, G., & Poole, M.S. (1994). Capturing the complexity in advanced technology use: Adaptive Structuration Theory. *Organization Science, 5*(2), 121-145.

Frank, U. (2001). Knowledge management systems: Essential requirements and generic design patterns. *Proceedings of the International Symposium on Information Systems and Engineering (ISE),* Las Vegas, NV.

Grimm, M., Tazari, M.-R., & Balfanz, D. (2002). Towards a framework for mobile knowledge management. *Proceedings of the PAKM,* Vienna.

Gruhn, V., & Book, M. (2003). Mobile business processes. *Proceedings of the Innovative Internet Community Systems 3rd International Workshop (IICS 2003),* Leipzig.

Hardless, C., Lundin, J., & Nuldén, U. (2001). Mobile competence development for nomads. *Proceedings of the International Conference on System Sciences (HICSS)*, Hawaii.

Kakihara, M., & Soerensen, C. (2002a). Mobility: An extended perspective. *Proceedings of the International Conference on System Sciences (HICSS),* Hawaii.

Kakihara, M., & Soerensen, C. (2002b). 'Post-modern' professionals' work and mobile technology. *Proceedings of the New Ways of Working in IS: The 25th Information Systems Research Seminar in Scandinavia (IRIS25),* Copenhagen.

Kristoffersen, S., & Ljungberg, F. (2000). Mobility: From stationary to mobile work. In K. Braa (Ed.), *Planet Internet* (pp. 137-156). Lund.

Krogstie, J. (2003). Mobile process support systems—myths and misconceptions. *Proceedings of the Workshop on Ubiquitous Computing Environment,* Cleveland, OH.

Pilcher, J. (2004). Blackberry or Crackberry? *The Detroit News,* (October 8).

Rao, M. (2002). *Mobilizing knowledge workers with wireless solutions.* Retrieved October 5, 2004, from http://www.destinationkm.com/articles/default.asp? ArticleID=973

Ropohl, G. (1979). *Eine Systemtheorie der Technik: Zur Grundlegung der Allgemeinen Technologie*. Munich.

Sherman, L. (1999). *The knowledge worker unplugged.* Retrieved February 5, 2004, from www.destinationkm.com/ articles/default.asp?ArticleID=973

Soerensen, C. (2002). *Digital nomads and mobile services.* Retrieved June 9, 2004, from http://www.receiver. vodafone.com /archive/inner.html

Turowski, K., & Pousttchi, K. (2003). *Mobile commerce*. Heidelberg.

Wiig, K.M. (1995). *Knowledge management methods: Practical approaches to managing knowledge.* Arlington.

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Chapter 4.23
Knowledge Sharing Between Individuals

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INTRODUCTION

As Peter Drucker (2000) has pointed out, the foundation of the 21st century organization is no longer money or capital or even technology; it is knowledge. In order for that knowledge to create value, it must be shared. Some discussions of knowledge sharing in organizations and, indeed, some knowledge management initiatives seem to assume that given the right technology and/or the proper culture, knowledge will flow readily throughout the firm. Technologies that facilitate knowledge sharing (e.g., databases, intranets, and groupware) currently exist and are constantly improving. But technologies are only part of the knowledge management equation.

In 1997, the Ernst and Young Center for Business Innovation conducted a study of 431 U.S. and European organizations (Ruggles, 1998). Of those responding, only 13% rated their organizations as good or excellent at sharing knowledge internally. Even when knowledge was accessible, only 30% reported that their organizations were good or excellent at using that knowledge in making decisions. When asked what was the biggest obstacle to knowledge sharing within their organizations, 54% cited culture. To understand knowledge sharing within an organization, we must look beyond culture and start with the individual.

BACKGROUND

There has been much written about defining, creating, assessing, and changing organizational culture. In most of these writings, the focus has been the organization as a whole (e.g., Deal & Kennedy, 1982; Kotter & Heskett, 1992; Schein, 1999) or its subdivisions (e.g., Sackmann, 1992). The focus has not been on the individual or on knowledge sharing.

What exactly do we mean by knowledge sharing? There are numerous definitions of knowledge ranging from the pragmatic to the philosophical.

We shall adopt a definition based on Turban (1992) that knowledge is information that has been organized and analyzed to convey understanding, experience, learning, and expertise so that it is understandable and applicable to problem solving or decision making. Although knowledge sharing and knowledge transfer are often used interchangeably, we shall make a distinction between them. Knowledge sharing as used here refers to an exchange of knowledge between two individuals: one who communicates knowledge and one who assimilates it. Knowledge sharing focuses on human capital and the interaction of individuals. Knowledge transfer focuses on structural capital and the transformation of individual knowledge to group or organizational knowledge, which becomes built into processes, products, and services. Strictly speaking, knowledge can never be shared. Because knowledge exists in a context, the receiver interprets it in light of his or her own background.

Several authors have looked at the organizational factors that inhibit the sharing of knowledge. Believing that most people "have a natural desire…to share what they know," O'Dell and Grayson (1998, p. 16) attribute the lack of internal knowledge sharing in organizations to "a set of organizational structures, management practices, and measurement systems that discourage-rather than encourage-sharing" (p. 17). Szulanski (1996, 2003) identifies four sets of factors that determine how readily knowledge will be shared within the firm: the characteristics of knowledge, the characteristics of the source, the characteristics of the recipient, and the organizational context. Hubert Saint-Onge, chief executive officer (CEO) of Konverge Digital Solutions Corp, offers a different explanation for the lack of knowledge sharing: "Sharing knowledge is an unnatural act. You can't just stand up and say 'Thou shalt share knowledge'-it won't work" (as cited in Paul, 2003).

E. von Hippel (1994) coined the phrase "sticky information" to describe "the incremental expenditure required to transfer that unit of information to a specified locus in a form usable by a given information seeker" (p. 430). The higher the incremental expenditure, the stickier the information is. Stickiness may be an attribute of the information itself, or it may refer to attributes and choices made by someone seeking information or by someone providing it.

If we are to understand knowledge sharing, we must examine what happens at the level of the individuals who are at the core of the knowledge sharing process. Maslow's (1987) hierarchy of needs provides one widely accepted explanation of the behavior and attitudes of individuals in organizations. Maslow identified five levels of human needs: physiological (e.g., food, water), safety (e.g., security, protection), social (e.g., love, affection, sense of belonging), esteem (e.g., respect and recognition from others, personal sense of competence), and self-actualization (e.g., fulfillment of one's potential). According to Maslow, an unsatisfied need motivates behavior. Because these five needs exist in a hierarchy, a lower level need must be satisfied before the next higher level need is activated until the highest level, self-actualization, is reached. The more the self-actualization need is satisfied, the stronger it grows. Although there may be a variety of ways to satisfy a need, individuals can be expected to engage in knowledge sharing behaviors to the extent that they perceive that knowledge sharing leads to the satisfaction of a need.

Shannon and Weaver (1949) provide us with a transmission model of communication. Their model consists of six basic elements: the source, encoder, message, channel, decoder, and receiver. Although this model is often referred to in explaining human communication, it was actually designed for information theory and cybernetics, and is therefore technologically oriented. As a result, it does not address factors that can affect human communication, such as the context of the communication or the content of the message itself. Nevertheless, it provides insight into the communication process by dividing that process into discrete units.

Berlo's (1960) model of communication also refers to the source, message, channel, and receiver, but his focus is on interpersonal dyadic communication. The source and receiver are defined in terms of communication skills, knowledge, social systems, culture, and attitudes. Communication skills include speaking, writing, listening, reading, and thinking or reasoning. Knowledge refers to the source's knowledge of his or her own attitudes, options for producing a message, choices of communication channels, and subject matter. Social systems are produced through communication and refer to the collective behaviors and structures associated with a group of individuals who have interdependent goals. Culture, which consists of our shared beliefs, values, and behaviors, will influence our communication patterns as well. Finally, attitudes toward self, the subject matter, and the receiver also affect communication.

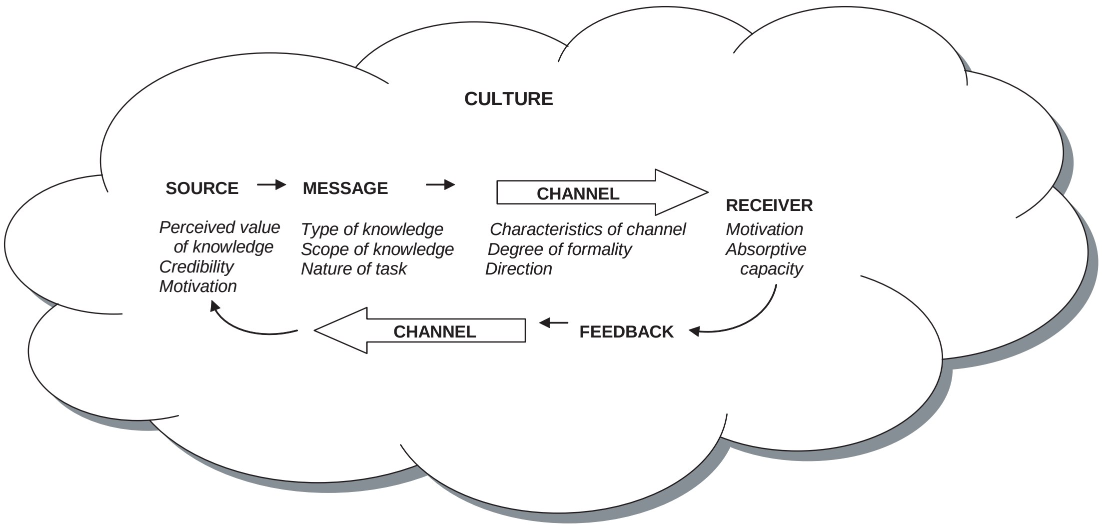
Models of the communication process, such as Berlo's (1960) model, apply to communication in general and not specifically to knowledge sharing, although knowledge sharing requires communication in some form (verbal or nonverbal, written or spoken, etc.). From an organizational semiotics perspective, knowledge sharing can therefore be analyzed in terms of communication functions.

Previous work on knowledge sharing has often focused on teams or groups and has overlooked important factors that affect the exchange of knowledge between two individuals. As Nonaka and Takeuchi (1995, p. 59) have pointed out, "An organization cannot create knowledge without individuals." The purpose of this article is to describe a model of knowledge sharing between individuals in organizations.

A MODEL OF KNOWLEDGE SHARING

Borrowing from the work of Shannon and Weaver (1949) and from Berlo (1960), we focus on six factors involved in knowledge sharing: the knowledge

Figure 1. A model of knowledge sharing between individuals in an organizational context (based on Shannon & Weaver, 1949)



source, the message, the knowledge receiver, the communication channel, feedback, and the environment or culture in which the knowledge sharing occurs (see Figure 1).

Knowledge Source

The knowledge source is an individual who possesses knowledge and transmits it. The transmission of knowledge may or may not be intentional (Hendriks, 1999). An example of unintentional transmission would be someone acquiring knowledge by watching you perform a task. Three characteristics relate to the knowledge source. The first characteristic suggests that, because the flow of knowledge between individuals has a cost associated with it, knowledge that is perceived by the source as being more valuable is more likely to be shared than knowledge that is perceived to be of lesser value or duplicative (Gupta & Govindarajan, 2000). Of course, it is always possible that the possessor of the knowledge does not realize the value of that knowledge. The second characteristic is the credibility of the source. Knowledge is more likely to be shared if the source is seen as credible. Factors associated with credibility include trustworthiness, status, education, and position (Szulanski, 2003).

The third characteristic relates to the motivation of the source to share knowledge. Individuals or groups who perceive that their unique, valuable knowledge provides them with power or status in the organization will be less likely to share that knowledge (Gupta & Govindarajan, 2000; Szulanski, 2003). Conversely, those individuals who are motivated to share their knowledge will have a positive effect on knowledge sharing (Gupta & Govindarajan). This motivation may arise from altruism (a desire to help others or to help the organization), from a passion for the subject, or from a desire to be recognized as an expert, what Maslow (1987) referred to as the esteem need). It may also arise from the expectation that, at some point in the future, the receiver will be willing to return the favor, either as knowledge shared or in some other form (Davenport & Prusak, 1998).

What kinds of rewards should an organization provide to motivate employees to share knowledge? In three large scale studies on knowledge management, the American Productivity and Quality Center concluded, "…if the process of sharing and transfer is not inherently rewarding, celebrated and supported by the culture, then artificial rewards won't have much effect" (O'Dell & Grayson, 1998, p. 82). If knowledge sharing helps people do their work better or more efficiently, or if it provides them with recognition as experts, they will be motivated to do it (Maslow, 1987). This is not to say that explicit rewards should never be used. In 1993, the most active participants in Buckman Laboratories' online knowledge sharing network received a surprise trip to a conference in Arizona, a $150 leather bag, and an IBM Thinkpad 720. The bag and computer quickly became status symbols around the company (O'Dell & Grayson).

The Message

The second factor in the knowledge sharing process involves the message itself. What is the type of knowledge that is being shared, and what is the scope of that knowledge (Dixon, 2000)? Although there are various typologies of knowledge (e.g., Blackler, 1995; Collins, 1993; Machlup, 1980; Quinn, Anderson, & Finkelstein, 1996; Wiig, 1994), we shall adopt Nonaka and Takeuchi's (1995) widely accepted framework because it focuses on the individual as central to the knowledge-creation process: "An organization cannot create knowledge without individuals" (p. 59). Based on the distinction first made by Michael Polanyi (1967), Nonaka and Takeuchi describe knowledge as existing on a continuum ranging from explicit to tacit. Explicit knowledge, sometimes referred to as codified knowledge, is objective knowledge that can be transmitted in formal, systematic language. It deals with past events or objects and can be transmitted electronically in documents and databases. Tacit knowledge is personal and context specific. It is more difficult to capture and express, existing primarily in people's heads (Nonaka & Takeuchi). Most knowledge found in organizations is a combination of the two, falling somewhere between the two ends of the continuum. Although explicit knowledge is generally considered easier to share than tacit knowledge, it may be that tacit knowledge simply requires different channels or different transmission processes. In a study of attitudes about information sharing in a technical context (Constant, Kiesler, & Sproull, 1994), it was found that participants were willing to share explicit knowledge in the form of documents that belonged to the organization. Although the participants were also willing to share personal expertise (tacit knowledge) such as providing assistance with a software package, when sharing tacit knowledge they expected something in return (e.g., acknowledgement of their expertise).

The scope of the knowledge, the second characteristic of the message, refers to the number of functional areas in the organization that will be affected by the knowledge being shared. Knowledge that is narrower in scope is generally less complex and more explicit, making it easier to share. Knowledge that involves multiple functional areas tends to be more complex and therefore more difficult to share (Dixon, 2000).

A third characteristic of the message concerns the nature of the task. Tasks may be routine or nonroutine, and may occur regularly or infrequently. Routine tasks that occur regularly involve knowledge that can be readily shared. Nonroutine tasks that occur less frequently or only under unusual circumstances make knowledge sharing more challenging. If the knowledge source and the intended receiver are doing similar tasks in similar contexts, knowledge can be shared more easily (Dixon, 2000).

Knowledge Receiver

The knowledge receiver, the target of the communication, is the third factor in the knowledge sharing process. The effectiveness of the knowledge sharing process will depend on the receiver's motivation and absorptive capacity. Motivation may be influenced by the "not-invented-here" syndrome, which suggests that we tend to regard knowledge from another source as less valuable than what we already know. This may derive from our reluctance to admit that someone else is more competent than we are. It might also derive from power struggles in the organization, which cause us to denigrate or disregard any knowledge contributions from an individual or a unit that we perceive to be a competitor. Or we may simply not see the value or relevance of that knowledge (Gupta & Govindarajan, 2000).

Several companies have created awards to encourage employees to use knowledge from other sources. Understanding the reluctance to use knowledge from another source and the motivation associated with recognition, Texas Instruments created the NIHBIDIA Award (Not Invented Here But I Did It Anyway) for ideas borrowed either from inside or outside of the company. British Petroleum bestows a Thief of the Year award to the person who has "stolen" the best idea (Davenport & Prusak, 1998).

The second characteristic related to the receiver is his or her capacity to absorb new knowledge, which is influenced by the ability to recognize the value of new knowledge that is encountered, to assimilate that knowledge, and to apply it (Cohen & Levinthal, 1990). Prior related knowledge will increase our ability to absorb new knowledge. Similarly, if the source of that knowledge is an individual like ourselves in terms of education, background, and so forth, we are more likely to absorb new knowledge or change our attitudes and behavior (Dixon, 2000; Gupta & Govindarajan, 2000; Szulanski, 2003).

Davenport and Prusak (1998) recount the story of a group of 23 surgeons who specialize in coronary artery bypass surgery. They wanted to find out if skill sharing and observing one another in surgery would improve their success rate. They started by sharing their success rates and comparing them with statistics of other surgeons in the medical center and in the region. They also received training in continuous improvement techniques. The overall result was that these surgeons achieved a 24% drop in the mortality rate associated with the surgery. A major factor in the success of this project was that these surgeons all worked in the same area of specialization and all shared almost identical training and experience. The similarity in background and experience allowed them to easily understand and absorb each other's words and actions.

Communication Channel

The fourth factor in the knowledge sharing process is the communication channel, or the means by which a message is communicated. A communication channel may involve seeing, hearing, touching, smelling, or tasting (Berlo, 1960). Telephone, the Internet, braille, airwaves, and roadside billboards are all examples of communication channels. Knowledge sharing will be enhanced by the richness, bandwidth, and reliability of the communication channel. For example, knowledge sharing may be facilitated by face-to-face meetings that involve seeing and hearing as opposed to electronic communication (e.g., e-mail, databases, or direct mail) that only involves seeing. Channels can be either formal or informal. Formal mechanisms for linking organizational units might include task forces, permanent committees, or formally appointed liaison personnel. Informal mechanisms would involve ad hoc, interpersonal interactions among employees. The better your relationships with your coworkers and the more opportunities you have to interact, the greater the possibility of knowledge sharing. These interactions are typically horizontal (peer to peer) or vertical (e.g., corporate mentoring programs or internships; Gupta & Govindarajan, 2000; Szulanski, 2003).

Some organizations have created open office spaces to encourage face-to-face interaction among employees. Newspaper offices have used this model for some time because editors understand that it facilitates rapid knowledge sharing so that deadlines can be met. Sun Microsystems' offices in Menlo Park, California, use architectural design to encourage interaction and knowledge sharing. Only about one third of their floor space is devoted to offices; the rest is designed to encourage informal project discussions with lots of light, comfortable couches, and white boards (Fisher & Fisher, 1999). Hewlett-Packard has also made open space offices compulsory for its subsidiaries (Sveiby, 1997).

Feedback

It can be argued that knowledge sharing has not occurred unless the knowledge receiver has assimilated what has been communicated. This can be determined by the response (either verbal or nonverbal) of the receiver. Feedback may consist of a verbal reply, a nod, or the successful completion of a task, indicating that the receiver understood the message. Conversely, a puzzled look may signal a lack of understanding. The receiver's response may thus influence future messages from the knowledge source. If the receiver has assimilated the knowledge, it should lead to increased value for the organization, either through a change in behavior or through the development of a new idea that leads to a change of behavior.

Culture

Finally, the knowledge sharing process takes place within an organizational culture, which Schein

(1985) has defined as a "shared view." Culture is reflected in an organization's values, norms, and practices such that values are manifested in norms, which determine specific practices (De Long & Fahey, 2000). Excellent companies have shared values that are clear to all employees throughout the organization (Peters & Waterman, 1982) and that determine how employees think and act. De Long and Fahey describe four aspects of organizational culture that influence knowledge-related behaviors: culture shapes assumptions about which knowledge is important; it mediates the relationships among individual, group, and organizational knowledge; it creates the organizational context for social interactions; and it impacts the creation and adoption of new knowledge.

One of the values that must be part of a knowledge sharing culture is trust, which is defined in terms of respecting the ownership of ideas (Andrews & Delahaye, 2000; Zand, 1972). Knowledge sharers must know that they will get credit and that others will reciprocate. Trust must be visible, it must be ubiquitous, and it must start at the top (Davenport & Prusak, 1998). Top management in particular must emulate trustworthiness because their actions define the values of the organization.

When asked to name the three critical factors in knowledge management, Robert Buckman, president, chairman, and CEO of Bulab Holding, Inc., replied, "Culture, culture, culture" (as cited in O'Dell & Grayson, 1998, p. 71). If top management believes that power comes from accumulating and hoarding knowledge, then knowledge sharing will not occur. In Buckman's view, "The most powerful individuals will be those who do the best job of transferring knowledge to others" (p. 77).

FUTURE TRENDS

Knowledge has arguably become the most important resource for organizations today. Because organizations cannot create knowledge without people, the knowledge worker has become an organization's single greatest asset. If knowledge is to create a competitive advantage for the organization, it must be shared. Any effort to effect knowledge sharing must begin with an understanding of the factors that influence knowledge sharing between individuals.

As the examples above clearly illustrate, organizations are beginning to address some of the issues involved in knowledge sharing. What is needed now is a model that brings all the relevant factors together in an organized fashion, and that model is provided here. Wiig and Jooste (2003) point out that the first generation of knowledge management in the 1990s focused on "visible aspects of work…The new second generation approaches seek greater impacts and better business results and therefore require more effective methods" (pp. 300-301). This model of knowledge sharing between individuals provides a shift from the isolated projects of the first generation to integrated practices, and from the more narrow applications of the 1990s to a broader approach and deeper understanding of knowledge sharing.

Understanding the factors involved in knowledge sharing is a first step in understanding how to manage the knowledge sharing process. Although a detailed framework for managing knowledge sharing is beyond the scope of this article, three general suggestions are offered.

First, an organization that values knowledge sharing must ensure that its culture (e.g., norms, values, and practices) consistently supports it. Individuals must receive appropriate rewards for knowledge sharing, and they must receive credit for their ideas. Knowledge sharing is facilitated when people share the same work culture (Davenport & Prusak, 1998), but it must be recognized that cultures are not always homogeneous throughout an organization (McDermott & O'Dell, 2001). An essential element of culture is trust, which must be ubiquitous, must be visible, and must be modeled from the top of the organization on down (Davenport & Prusak).

Second, motivation is a key factor for both the source and the receiver. With reference to Maslow's (1987) hierarchy of needs, knowledge workers are motivated by esteem and self-actualization needs. Individuals can be expected to engage in knowledge sharing behaviors to the extent that doing so satisfies these needs. Managers who want to promote knowledge sharing should therefore provide employees with opportunities for satisfying these needs through creative and challenging work, recognition, and promotion. Managers should also try to minimize or remove any obstacles that block need satisfaction and therefore inhibit knowledge sharing.

Herzberg's (1968) two factor theory provides us with another perspective on motivation. According to Herzberg, factors that produce job satisfaction (motivators) are separate and distinct from those that lead to job dissatisfaction (hygiene factors). Motivators relate to job content and include achievement, recognition for achievement, advancement, growth, and responsibility. These factors can increase job satisfaction, but they will not prevent job dissatisfaction. Hygiene factors relate to job context and include company policy, supervision, working conditions, salary, and security. These factors do not motivate behavior, but they may lead to dissatisfaction and therefore decreased motivation if they are absent. A manager's goal should be to keep job dissatisfaction low and job satisfaction high. High satisfaction can be expected to result in increased effort (i.e., increased motivation of the knowledge source and receiver) and receptivity to ideas and suggestions (i.e., the absorptive capacity of the receiver; Locke, 1970).

Third, managers need to provide and promote opportunities for knowledge sharing. While such opportunities are necessary for knowledge sharing, they are not sufficient and must be in conjunction with the proper culture and motivation. These opportunities may range from informal face-to-face meetings to formal electronic communication systems (e.g., e-mail, discussion boards). Mentoring programs may be used to encourage more seasoned employees to share knowledge with new hires. A physical environment that includes open office space and areas for informal interaction may also encourage knowledge sharing.

This model of knowledge sharing between individuals in an organizational context provides a framework for future research to explore these factors in greater depth. For example, how do the characteristics of the communication channel interact with the characteristics of the source or the receiver? Are some communication channels more appropriate for some kinds of messages? Is this model valid for all kinds of knowledge? How can trust be built in a colocated community? Are the same methods for building trust in a colocated community also effective in a virtual community? How can trust be built in a cross-cultural community? What is the relationship between this model and various organizational, or even national, cultures?

CONCLUSION

There have been several systematic research studies of knowledge sharing in organizations (e.g., Constant et al., 1994; O'Dell & Grayson, 1998; Ruggles, 1998), but much of what we think we know is based on anecdotal evidence. This model offers us a starting point for a more systematic and scientific approach. A better understanding of organizational knowledge sharing at the dyadic level will provide a foundation for understanding knowledge sharing within and among groups, and ultimately, within and among organizations.

REFERENCES

Andrews, K. M., & Delahaye, B. L. (2000). Influences on knowledge processes in organizational learning: The psychosocial filter. *The Journal of Management Studies, 37*(6), 797-810.

Berlo, D. K. (1960). *The process of communication: An introduction to theory and practice.* New York: Holt, Rinehart & Winston, Inc.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organizational Studies, 16*(6), 1021-1046.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35,* 128-152.

Collins, H. (1993). The structure of knowledge. *Social Research, 60,* 95-116.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-422.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

De Long, D. W., & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *The Academy of Management Executive, 14*(4), 113-127.

Deal, T. E., & Kennedy, A. A. (1982). *Corporate cultures: The rites and rituals of corporate life.* Reading, MA: Addison-Wesley Publishing Co.

Dixon, N. M. (2000). *Common knowledge: How companies thrive by sharing what they know.* Boston: Harvard Business School Press.

Drucker, P. F. (2000). Knowledge work. *Executive Excellence, 17*(4), 11-12.

Fisher, K., & Fisher, M. D. (1999). Shedding light on knowledge work. In J. W. Cortada & J. A. Woods (Eds.)*, The knowledge management yearbook, 1999-2000* (pp. 157-167). Boston: Butterworth-Heinemann.

Gupta, A., & Govindarajan, V. (2000). Knowledge flows within multinational corporations. *Strategic Management Journal, 21*, 473-496.

Hendriks, P. (1999). Why share knowledge? The influence of ICT on the motivation for knowledge sharing. *Knowledge and Process Management, 6*(2), 91-100.

Herzberg, F. (1968). One more time: How do you motivate employees? *Harvard Business Review, 46*(1), 53-62.

Kotter, J. P., & Heskett, J. L. (1992). *Corporate culture and performance.* New York: Free Press.

Locke, E. A. (1970). Job satisfaction and job performance: A theoretical analysis. *Organizational Behavior and Human Performance, 5*, 484-500.

Machlup, F. (1980). *Knowledge: Its creation, distribution, and economic significance: Vol. 1. Knowledge and knowledge production.* Princeton, NJ: Princeton University Press.

Maslow, A. (1987). *Motivation and personality* (3rd ed.). New York: Harper and Row.

McDermott, R., & O'Dell, C. (2001). Overcoming cultural barriers to sharing knowledge. *Journal of Knowledge Management, 5*(1), 76-85.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

O'Dell, C., & Grayson, C. J., Jr. (1998). *If only we knew what we know.* New York: Free Press.

Paul, L. G. (2003). Why three heads are better than one: How to create a know-it-all company.

CIO. Retrieved from http://www.cio.com/archive/120103/km.html

Peters, T. J., & Waterman, R. H., Jr. (1982). *In search of excellence: Lessons from America's best-run companies.* New York: Harper & Row.

Polanyi, M. (1967). *The tacit dimension.* Garden City, NY: Anchor Books.

Quinn, J. B., Anderson, P., & Finkelstein, S. (1996). Managing professional intellect: Making the most of the best. *Harvard Business Review, 74*(2), 71-80.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Sackmann, S. A. (1992). Culture and subcultures: An analysis of organizational knowledge. *Administrative Science Quarterly, 37*(1), 140-161.

Schein, E. H. (1985). *Organizational culture and leadership.* San Francisco: Jossey-Bass.

Schein, E. H. (1999). *The corporate culture survival guide: Sense and nonsense about culture change*. San Francisco: Jossey-Bass.

Shannon, C. E., & Weaver, W. (1949). *The mathematical theory of communication.* Chicago, IL: University of Illinois Press.

Sveiby, K. E. (1997). *The new organizational wealth.* San Francisco: Berrett-Koehler Publishers, Inc.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*, 27-43.

Szulanski, G. (2003). *Sticky knowledge: Barriers to knowing in the firm.* London: SAGE Publications.

Turban, E. (1992). *Expert systems and applied artificial intelligence.* New York: Macmillan.

von Hippel, E. (1994). "Sticky information" and the locus of problem solving: Implications for innovation. *Management Science, 40*(4), 429-439.

Wiig, K.M. (1994). *Knowledge management: The central management focus for intelligent-acting organizations.* Arlington, TX: Schema Press.

Wiig, K. M., & Jooste, A. (2003). Exploiting knowledge for productivity gains. In C. W. Holsapple (Ed.), *Handbook on knowledge management* (pp. 289-308). Berlin, Germany: Springer.

Zand, D. (1972). Trust and managerial problem solving. *Administrative Science Quarterly, 17,* 229-239.

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Chapter 4.24
Client/Server and the Knowledge Directory

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INTRODUCTION

Data, information, and knowledge are three related but not interchangeable concepts. Data are a set of discrete, objective facts about events. Information is organized data presented in context. Data become information when their creator adds meaning or value. Similarly, knowledge derives from information as information derives from data. Knowledge can be viewed as information in context, together with an understanding of how to use it. Knowledge can be either explicit (knowledge for which a person is able to make available for inspection) or tacit (knowledge for which a person is unable to make available for inspection) (Brooking, 1999; Davenpot & Prusak, 1998). In Table 1, a list of knowledge that is particularly critical for business organizations is given.

Knowledge is an intellectual property that although paid for in part by the employer is a difficult asset to control, as it is fragmented in documents, policies, procedures, and other data storage mediums. Another challenge for management is to retain this knowledge in a form that is easily retrievable. This is not an easy task, since the enterprise must first identify the location of all needed knowledge, and second, determine the easiest way to retrieve it.

There are many definitions of knowledge management, but the Gartner Group (1999) description seems most appropriate for the perspective expressed in our article: “Knowledge management

Table 1. Knowledge that is particularly critical (Brooking, 1999)

- Knowledge of a particular job
- Knowledge of who knows what in a company
- Knowledge of how to get things done in a company using the corporate culture
- Knowledge of who is best to perform a particular job or task
- Knowledge of corporate history (how and why)
- Knowledge of business customs
- Knowledge of a particular customer account
- Knowledge of how to put together a team that can achieve a particular task
- Knowledge of how to approach a particular problem that is difficult to solve

promotes an integrated approach to identifying, capturing, retrieving, sharing, and evaluating an enterprise's information assets. These information assets may include databases, documents, policies and procedures, as well as the un-captured tacit expertise and experience stored in individual workers' heads."

This definition implies that information assets are plentiful and are stored in numerous locations throughout the organization. Storage options include documents, documents in document management systems, groupware such as Lotus Notes, and expert or knowledge-based systems (Brooking, 1999). Physically these information assets can be electronically stored on compact disk, laser disk, mechanical hard drives, microfilm, microfiche, and embedded in computer programs. Further, information assets are also stored in books, documents, and other paper-based medium.

BACKGROUND

In a world of multiple computer languages, database management systems, assorted collaborative and group support software, network technologies, and data storage methods, it can be a difficult and complex problem to locate and retrieve enterprise knowledge. If KM promotes an integrated approach to identifying, capturing, retrieving, sharing, and evaluating an enterprise's information assets, then the challenge is to create a knowledge management system in order to get the right information to the right person at the right time.

"An integrated and integrative technology architecture is a key driver for Knowledge Management Systems (KMS) … KMS seem to require a variety of technologies: database and database management, communication and messaging, and browsing and retrieval. The need for seamless integration of the various technologies may lead to the dominance of the Internet and Internet-based KMS architectures" (Alavi & Leidner, 1999). Alavi and Leidner (1999) also note that "organizational intranets will also play a dominant role in support of internal knowledge management activities due to cost-effective technical capabilities including: access to the legacy systems, platform independence, access to multimedia data formats, a uniform and easy-to-use point-and-click interface, and capability for easy multi-media publication for knowledge sharing."

A CLIENT/SERVER ARCHITECTURE FOR KMS

Computing sources for the first 30 years of the information technology revolution were dominated by isolated hardware and network environments. Mainframes, mini-computers and local area networks were initially set up to support specific business functions. Each computing complex was installed with a separate physical data network. IBM mainframes used coaxial cable and 3270 terminal emulation and the IBM System 38 mini-computer used twin-axial cable and 5250 terminal emulation. Local area networks used their own respective cabling medium and data network architecture. As a result, these environments were isolated and data sharing was almost impossible (Kern et al., 1998).

Information systems written for these monolithic computer complexes contain three basic components: a presentation layer, a processing layer, and a data storage layer (Boar, 1996; Borthick & Roth, 1994). All three layers execute on one hardware platform. During the 1980s and 1990s, multiple protocol support between different platforms across inexpensive connections became more common. This connectivity enhancement helped the development of client/server technologies, which distributed these layers across hardware and operating systems platforms (Boar, 1996; Duchessi & Chengalur-Smith, 1998; Schulte, 1995). A client/server architecture consists of three layers: the presentation layer, the business logic layer, and the data layer. A two-tier client/server architecture places the presentation layer on the client and data layer on the server. The business layer may reside on either the client or server, or both. A three-tier client/server architecture places the presentation layer on the client, the business logic layer on a middle tier, and the data layer on a server. Although there are many variation of the client/server model, two-tier and three-tier are the two basic deployments (Edwards, 1999; Weston, 1998).

The three-tier client/server architecture has many advantages over the two-tier client/server architecture, including less complexity, higher security, higher encapsulation of data, better performance efficiency, excellent scalability, excellent application reuse, a good server-to-server infrastructure (via server-side middleware), legacy application integration (via gateways), excellent internal support, support for heterogeneous databases, rich communication choices, excellent hardware architecture flexibility, and excellent availability. The main disadvantage is the difficulties in development, but these difficulties are getting less and less over time (Orfali et al., 1999). One way around this development problem is to adopt a component-based architecture design.

Employing a three-tier client/server architecture would provide a good flexible architecture for KMS. The structure would be very similar to the three-tier client/server architecture detailed by Orfali et al. (1999), except it would also have a knowledge directory (covered in the next section). The client layer would have at least the following: a nice GUI, a Web browser, the client operating system, and any required client-side applications for KM (such as Lotus Notes). The middle layer would contain a network operating system, and transport stack (such as TCP/IP) and service specific middleware for: databases (such as ODBC, JDBC, and SQLJ), internet/intranets (such as HTTP and CGI), e-mail (such as SMTP and POP3), storing and accessing multimedia documents, coordinating group conferencing, linking individuals in group scheduling, and workflow processes. The server layer would contain the server operating system and specific server-based applications such as database management systems, document management systems, server side groupware, and so forth.

Knowledge Management Directory

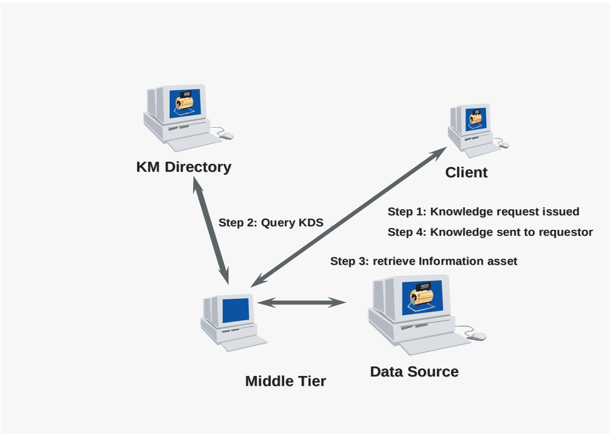
Achieving the connection to numerous data and information sources is a serious challenge for the development of KMS. Organizational knowledge management strives to cultivate, nurture and exploit knowledge at different levels and in different contexts throughout the organization (Handzic & Bewsell, 2001). The demands placed on the information technology infrastructure to support an integrated approach to identifying, capturing, retrieving, sharing, and evaluating an enterprise's information assets is a major undertaking; especially since these information assets may include databases, documents, policies and procedures stored in electronic forms.

One of the major requirements of KM is the ability to locate the knowledge and present it to the knowledge requester. The need for a directory of information assets is imperative. A facility, such as the Knowledge Management Directory (KMD), supports the central task of organizational knowledge management and knowledge mapping (Galup, Dattero, & Hicks, 2003). Knowledge mapping provides a continuously evolving organization memory by capturing and integrating knowledge sources and communicating knowledge in an understandable way (Wexler, 2001).

A knowledge directory (some sort of list or picture) points to knowledge (in people, documents, or databases) but does not contain it. The KMD resolves the client request to connect to an information asset by translating the keyword into a data source location, thereby permitting the

Figure 1.Knowledge management directory process (Galup & Dattero, 2000, 2002)

Step 1: The knowledge requester issues an inquiry for knowledge.
Step 2: An inquiry is sent to the Knowledge Management Directory and a summary listing similar to an Internet search is presented.
Step 3: A second request is sent to retrieve the information asset from the respective server.
Step 4: The knowledge is sent to the requester.



customer to navigate the numerous information asset resources and locate the best match.

The KMD categorizes the context of the knowledge and provides the computational tools to provide the user with access to the requested knowledge. To use the KMD, a user selects a topic from the user interface screen. When the topic is selected, a list of all resources of each type (expert/practice, decision support systems/warehouse, database, expert, and document) is displayed. The user then selects and evaluates sources until the knowledge is acquired. When multiple knowledge sources exist for a topic, the user will have to choose which knowledge source is most accurate and best suited to his or her needs. The knowledge seeker should be influenced to select the most complete and accurate knowledge available. In the KMD design, this is accomplished by ordering the knowledge sources by their inherent verification characteristics. The most accurate sources are placed at the top of the display, implying their desirability to the user. Expert systems and best practices represent complete, accurate solutions to specific problems, so they are the most desirable knowledge source and are ordered first. Data warehouses and decision support systems applications are the next highest in accuracy, followed by experts and documents (Hicks, Dattero & Galup, 2002, 2003).

CONCLUSION

Our three-tier client/server architecture for KMS has traits of the network model for KMS (Alavi & Leidner, 1999; Bowman, 2002). A network KMS "… focuses on building knowledge directories. This involves defining the knowledge categories that are relevant to the organization, identifying knowledge owners for each category, and creating a searchable directory to help others in the organization identify and locate knowledge owners" (Bowman, 2002). Our three-tier client/server architecture for KMS also has traits of the repository model for KMS (Alavi & Leidner, 1999; Bowman, 2002), because our KMS architecture retrieves explicit organizational knowledge. Therefore, our three-tier client/server architecture for KMS has the traits of the two major models for KMS. Further, it provides a seamless integration of the variety of technologies required for a KMS such as database management, document management, groupware, and e-mail.

REFERENCES

Alavi, M., & Leidner, D. (1999). Knowledge management systems: Issues, challenges, and benefits. *Communications of the Association for Information Systems, 1*(7).

Boar, B. (1996). *Cost-effective strategies for client/server systems.* John Wiley & Sons, Inc.

Borthick, A.F., & Roth, H.P. (1994). Understanding client/server computing. *Management Accounting, 76*(2), 36-41.

Bowman, B.J. (2002). Building knowledge management systems. *Information Systems Management, 19*(3), 32-40.

Brooking, A. (1999). *Corporate memory.* International Thomson Business Press.

Davenport, T., & Prusak, L. (1998). *Working knowledge.* Harvard Business School Press.

Duchessi, P., & Chengalur-Smith, I. (1998). Client/server benefits, problems, best practices. *Communications of the ACM, 41*(5), 87-94.

Edwards, I. (1999). *3-tier client/server at work* (rev. ed.). Wiley.

Galup, S., & Dattero, R. (2000). Client/server and the knowledge directory: A natural relationship. *Proceedings of the Information Resource Management Association,* Anchorage, Alaska.

Galup, S., & Dattero, R. (2002). Client/server and the knowledge directory: A natural relationship. In D. White (Ed.), *Knowledge mapping and management* (pp. 187-194). Hershey, PA: IRM Press.

Galup, S., Dattero, R., & Hicks, R. (2003). Enterprise knowledge dictionary. *Knowledge Management Research & Practice, 1*(2), 95-101.

Gartner Group. (1999). *White papers on knowledge management.*

Handzic, M., & Bewsell, G. (2003, May 18-21). Corporate memories: Tombs or wellsprings of knowledge. *Proceedings of the Information Resources Management Association International Conference (IRMA 2003),* Philadelphia (pp. 171-173).

Hicks, R., Dattero, R., & Galup, S. (2002/2003). A verification-based conflict resolution strategy for knowledge management systems. *Journal of Computer Information Systems, 43*(2), 36-41.

Kern, H., Johnson, R., Galup, S., & Horgan, D. (1998). *Building the new enterprise: People, processes, and technology.* CA: Sun Microsystems Press – Prentice Hall.

Orfali, R., Harkey, D., & Edwards, J. (1999). *Client/server survival guide* (3rd ed.). Wiley.

Schulte, R. (1995). *Middleware and three-tier architectures.* GartnerGroup Symposium/Itxpo 95: Managing the revolution.

Weston, R. (1998). Client/server evolution: Thin clients, fat servers. *Computerworld, 32*(6), 20.

Wexler, M. (2001). The who, what and why of knowledge mapping. *Journal of Knowledge Management, 5,* 249-263.

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Chapter 4.25
Assessing Knowledge Management System User Acceptance with the Technology Acceptance Model

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ABSTRACT

This article presents the results of a study investigating the applicability of Davis' Technology Acceptance Model (TAM) to user acceptance of a knowledge management system (KMS) in a modern organizational environment. The study endeavors to expand empirical research of two important and complex research questions: (1) What are the important factors, conditions, and mechanisms that affect people's acceptance and usage of collaborative and interdependent KMS in the modern organizational environment?, and (2) How applicable is the TAM, and the substantial body of information technology (IT) research around this model, to user acceptance and usage of a KMS in a modern organizational environment where collaboration, knowledge sharing, and role based system usage is necessary for the organization to function competitively? The study provides preliminary evidence suggesting previous TAM research may serve as a foundation for research of KMS user acceptance. Relationships among primary TAM constructs found in this study are in substantive agreement with those of previous research. These findings are significant because they suggest that the considerable body of previous TAM related IT research may be usefully applied to the knowledge management (KM) domain where interdependent social processes that

require knowledge creation, storage and retrieval, transfer, and application are required for effective organizational functioning.

INTRODUCTION

Although business investment in IT has declined somewhat in recent years, firms around the world still spend more than $2 trillion dollars a year on IT (Carr, 2003). It is also estimated that IT investment comprises approximately 50% of U.S. business capital investment, making it the top capital investment area for American businesses (Carr, 2003). With these continuing enormous business resource investments, understanding and creating conditions under which IT will be accepted and used in the organization remains a high priority within the IT research community (Venkatesh & Davis, 2000). Understanding why individuals accept or reject IT systems has proven to be one of the most challenging issues in information systems research (Doll et al., 1998). User acceptance of IT — a phenomenon that is not yet well understood — and usage are widely considered to be crucial factors in the ultimate determination of information system success, since information systems that are not used are of little value (Mathieson et al., 2001). Nevertheless, as will be discussed later, system usage alone may not be entirely representative of KMS organizational benefits.

A preponderance of research and accumulated knowledge of the factors affecting IT acceptance has as its foundation the technology acceptance model (TAM). TAM, originally conceived by Fred Davis in 1986, is an intentions based model derived from the theory of reasoned action (TRA) tailored to meet the needs of information technology research (Davis et al., 1989). Since its inception TAM has enjoyed growing acceptance and has proven to be a reasonably accurate predictor of both users' intentions to use an IT, and of IT usage. Evidence of the research community's growing acceptance of TAM is reflected in the fact that the Institute for Scientific Information Social Science Citation Index recently listed 335 journal citations since 1999 of the initial TAM research paper published by Davis et al. (1989). This represents a significant recent research citation increase when compared to February 2000 citation reference information cited by Venkatesh and Davis (2000).

A second related topic of considerable interest in the business world is the multi-faceted concept widely referred to as knowledge management (KM). KM can be defined broadly as the set of systematic and disciplined actions an organization can take to obtain the greatest value from the knowledge available to it (Marwick, 2001), and/or to efforts aimed at "identifying and leveraging the collective knowledge in an organization to help the organization compete" (Alavi & Leidner, 2001, p. 113). KM is rapidly becoming a critical integral business function as organizations increasingly realize their competitiveness in the intensely competitive global marketplace hinges on effective management of intellectual resources (Davenport & Grover, 2001). Increased interest and investment in KM can be attributed to the growing recognition that one of a firm's most unique and inimitable resources is the intellectual capabilities of its workers.

Reflecting this interest, recent literature is replete with research of a wide range of important issues related to the question of how organizations can best capitalize on their knowledge resources, develop processes to support KM, and broadly integrate KMS into organizational functioning. A cursory sampling of key KM issues reported recently include KM and new organizational structures (Malhotra, 2000), assessments of KM organizational capability prerequisites (Gold, Segar & Malhotra, 2001), KM strategies and taxonomies (Earl, 2001; Zack, 1999), the relative importance of various knowledge types (Lam, 2000), general discussions of KM benefits and challenges (Alavi & Leidner, 1999), the mapping of organizational knowledge (Vaill, 1999), the integration of information technology to enhance organizational KM (Bourdreau & Couillard, 1999), and the development of a KM research agenda (Grover & Davenport, 2001). Grant (1996) and Spender (1996) elevate the KM agenda further through their discussions of a knowledge-based theory of the firm.

An important topic in the evolving scholarly KM discourse is empirical research of factors, conditions, and mechanisms affecting individual acceptance and usage of IT implemented as a KMS. In their survey of KMS conceptual foundations and research issues, Alavi and Leidner (2001, p. 115) observed that while "the majority of knowledge management initiatives involve at least in part, if not to a significant degree, information technology….little research exists in the design, use, or success of systems to support knowledge management". Since then, measurable progress has been made. Ericsson and Avdic (2003) provided insightful ideas and directions relative to KM enablers and facilitating conditions. Jennex and Olfman (2002, 2003) have performed empirical KMS research based on the information system success model of Delone and McLean (1992). Their research incorporates the intention to use construct to help predict voluntary KMS usage and revealed that the perceived benefit model was useful for predicting continued use of a KMS in an engineering organization. Jennex and Olfman (2004) assessed KMS success factors and proposed a theory-based KMS success model that was shown to be a useful framework for assessing KMS success models.

Nevertheless, there remains a need for empirical field research into factors affecting KMS acceptance and usage. Evidence of this need can be found in Legris, Ingraham, and Collerette (2002), who synthesized findings of 22 scholarly IT acceptance studies. None of the studies considered in this meta-analysis addressed KMS acceptance. Furthermore, the majority was situated in educational settings that bear little resemblance to the modern organizational environment. Indeed, a survey of IT acceptance literature indicates most findings are drawn from analysis of individual usage IT, and are for the most part situated in settings not representative of the modern organizational environment. The importance of the distinction between the IT acceptance research that has been done to date, and that which is asserted to be needed around KMSs is reflected by Alavi and Leidner (2001, p. 123), who observe:

"… knowledge management consists of a dynamic and continuous set of processes and practices embedded in individuals, as well as in groups and physical structures. At any point in time and in any part of a given organization, individuals and groups may be engaged in several different aspects and processes of knowledge management. Thus, knowledge management is not a discrete, independent, and monolithic organizational phenomenon."

There is a consensus among organizational scholars and practitioners regarding the importance to organizations of leveraging their unique human intellectual resources. Additionally, in spite of a substantial research effort focused on IT acceptance and usage, numerous questions remain. As noted by Lesrig et al. (2002) and Kankanhalli et al. (2001), IT implementation in general, and KMS implementation in particular, continue to experience difficult challenges in the organizational environment. Due to the widely acknowledged social nature of successful organizational KM, KMS acceptance and usage represents a more complex phenomenon than individual acceptance and use of IT. It may involve a mix of voluntary and mandatory behaviors, integrated organization processes, and complex social forces and relationships. KMS acceptance research can be seen as the intersection of these two important areas and warrants increased attention.

KM SYSTEMS

KM is widely acknowledged to encompass a diverse mix of complex and dynamic factors. Furthermore, scholar and practitioner admonitions to resist the temptation to research exclusively technology matters at the expense of complex KM social and behavioral issues seem ubiquitous (Alavi & Leidner, 2001). Nevertheless, modern IT is unquestionably critical to current organizational KM. The ability of modern IT to synchronously or asynchronously span previously insurmountable organizational, time, and geographic barriers is a critical enabler that must be viewed as a catalyst for increased KM interest. Thus, it is not surprising that modern information technology has been the center of gravity for most enterprise knowledge management initiatives (Alavi & Leidner, 1999; Grover & Davenport, 2001). As Taylor (2003) and Kankanhalli et al. (2001) observe collectively, modern IT can be viewed as a virtually necessary, albeit not sufficient component of successful organizational KM.

Information-related technologies that support knowledge management include collaboration and community of interest/practice support technologies, structured and unstructured data indexing, categorization, and taxonomy producing tools, common databases, data warehousing technology, search and retrieval, and document management tools, to name just a few.

As with any IT implementation, the success of a KMS begins inevitably with individual acceptance. This research attempts to expand our understanding of the linkages between two important IT research topics: user IT acceptance and organizational KM. Davis' TAM is used as a framework to investigate the implementation of a KMS within an organizational unit of a large private consulting and technical services firm. TAM was selected for this research due to its broad — and seemingly growing — adoption among IT researchers, the well-established reliability and validity of its constructs, and the realization that the model had not been applied to KMS acceptance.

The firm studied has a global presence and is involved in a broad range of high technology product and service business areas. The specific organizational unit studied provides highly technical command and control, communications, computer, intelligence, surveillance, and reconnaissance project management and related consulting services to predominantly Department of Defense clients. The vast majority of the members of the organizational unit studied are well-educated professionals. They work in a highly competitive business environment and the work they perform can be accurately described as knowledge work. The KMS studied is a Web-based document repository and management tool intended primarily to support three organizational objectives: (1) improvement of internal software development processes to achieve Software Engineering Institute Level 2 accreditation, (2) enhanced diffusion of internal research and development (IR & D) products throughout the organization by providing employees better access to IR & D products, (3) enhance business process and employee professional development by providing convenient electronic access to current and past project information and documentation.

RESEARCH QUESTIONS

Given the broad reach of TAM IT acceptance research and the potential benefit of improved understanding of KMS acceptance, this research is focused on questions critical to KM acceptance using TAM. It is intended to develop preliminary answers to the following two basic questions:

1. What are the important factors, conditions, and mechanisms that affect people's acceptance and usage of a KMS in an organizational environment where collaboration, knowledge sharing, and role based system

usage are necessary for the organization to compete?

2. How well does TAM substantiate the predicted relationships and mechanisms relative to user acceptance and usage of a KMS in a modern organizational environment where collaboration, knowledge sharing, and role based system usage are necessary for the organization to compete?

THEORETICAL BACKGROUND AND DISCUSSION OF THE TECHNOLOGY ACCEPTANCE MODEL

Davis developed the TAM to provide an explanation of the determinants of computer acceptance that is general and capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while also being both parsimonious and theoretically justified (Davis, 1989). TAM cuts a wide theoretical swath that includes the adoption of innovations, the cost-benefit paradigm, expectancy theory, and self-efficacy theory (Davis, 1989). Davis's original technology acceptance model is shown in Figure 1.

TAM is a derivative of the theory of reasoned action (TRA) model developed by Fishbein and Ajzen (1975). TRA focuses on situation-specific combinations of personal beliefs and attitudes, and the effects of the beliefs of others close to the individual (Szajna, 1996). The fundamental premise of TRA is that individuals will adopt a specific behavior if they perceive it will lead to positive outcomes (Compeau & Higgins, 1995). TAM is a TRA derivative tailored to the study of a broader range of user behavior in the context of IT acceptance (Davis, 1989). TAM includes two primary belief constructs hypothesized by Davis to affect a potential user's attitude and intention to

Figure 1. Technology acceptance model (Davis, 1989)

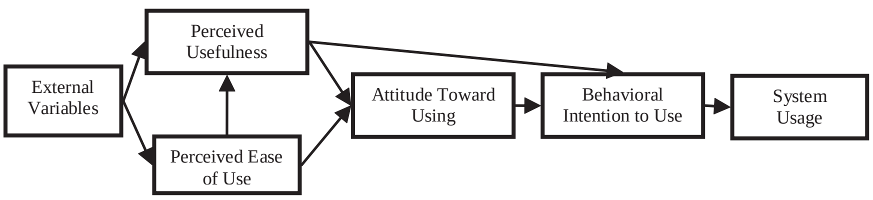
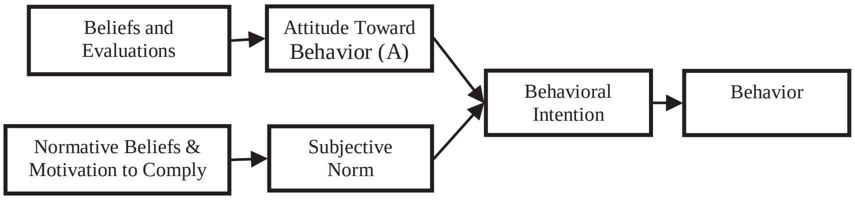


Figure 2. Theory of reasoned action (Fishbein & Ajzen, 1975)



use an information technology: perceived usefulness ("the degree to which a person believes that using a particular system would enhance his or her job performance"), and perceived ease of use ("the degree to which a person believes that using a particular system would be free of effort") (Davis et al., 1989). Perceived usefulness and perceived ease of use and other TAM constructs relevant to this research will be discussed briefly next.

Perceived Usefulness

In developing TAM, Davis theorized that an individual's perception of usefulness would influence intention to use the technology primarily through the creation of a positive attitude. This was consistent with TAM's theoretical precursor, the TRA, which held that attitude (an individual's positive or negative feelings (evaluative affect) about performing a target behavior mediated the effects of beliefs (and subjective norm) on behavioral intention.

In a departure from the TRA, a direct effect of perceived usefulness on intention to use was also included in Davis' original TAM. Davis rationalized this effect by theorizing users may decide to accept and use a technology, regardless of their affective attitude towards it, if they have a sufficiently strong perception that it will contribute positively to their job performance (Davis et al., 1989).

Given the importance of perceived usefulness to the formation of a positive intention to use an IT, subsequent research has been directed to developing an understanding of the antecedents of usefulness. Venkatesh and Davis (February 2000) examined job relevance, output quality, and result demonstrability as antecedents to perceived usefulness. All three constructs were positively related to perceptions of information system usefulness.

Perceived Ease of Use

TAM's second principal belief construct, perceived ease of use, reflects an individual's assessment of the ease of use and ease of learning of a given system (Gefen & Straub, 2000). Davis (1989) and Davis et al. (1989) argued for the inclusion of ease of use as a separate belief construct based largely on the concept of self-efficacy (an individual's judgment of his/her ability to organize and execute tasks necessary to perform a behavior). They also cited factor analyses showing that usefulness and ease of use are statistically distinct constructs.

Venkatesh (2000, p. 344) noted that a "vast body of research in behavioral decision making and IS demonstrate that individuals attempt to minimize efforts in their behaviors, thus supporting a relationship between perceived ease of use and usage behavior, albeit through intention as suggested by TAM," and that "other theoretical perspectives studying user acceptance have also employed similar constructs".

The relationship between perceived ease of use and perceived usefulness has proven to be complex. There is a lack of consensus in the literature regarding how perceived ease of use affects attitudes and/or intentions to use IT. In the original TAM, Davis hypothesized perceived ease of use to affect both attitude and usefulness directly. As noted earlier, Davis et al. (1989) suggested elimination of the attitude construct, postulating a direct relationship between perceived ease of use and intention to use, rather than an indirect one through attitude. Finding that when the effects of usefulness are controlled for, the effect of ease of use "all but vanishes," Davis (1989) suggested that ease of use might be an antecedent to usefulness rather than a direct determinant of intention and usage. Subsequent research postulated dual TAM constructs; one for scenarios in which potential users were briefly introduced to a system, and another for scenarios in which users had acquired hands-on experience with the system (Szajna, 1996). According to this line of thinking, perceived ease of use would have a different effect in the two scenarios.

In brief introduction scenarios, ease of use was thought to have a direct effect on user intention to use that was anchored by the individual's computer self-efficacy. In scenarios in which users accumulated considerable experience with the system, it was hypothesized that perceived ease of use affected user intentions and usage only indirectly through perceived usefulness. This suggested that after hands-on experience, users create their own perception of a system's ease of use and consciously or subconsciously consider it a dimension of system usefulness. This stream of research also suggested that only after direct hands-on experience did a system's objective ease of use (as measured by comparing expert/novice task achievement times) become a factor in an individual's perception of system ease of use (Venkatesh & Davis, 1996).

Szajna (1996) found perceived ease of use influenced intentions only through usefulness and suggested that a single version of the TAM with this causal path was sufficient. Echoing others, including Davis, Szajna interpreted these findings to imply that unless individuals perceive a technology to be useful, its perceived ease of use characteristics are not critical. However, once an individual perceives a technology to be useful, then increased perceived ease of use contributes to its usefulness.

Gefen and Straub (2000) contributed another interesting perspective to the perceived ease of use discourse: that the effect of perceived ease of use on user acceptance would be task dependent. They noted most research had failed to address the nature of the task to be performed, focusing only on use, or intent to use. Their research, performed in the context of e-commerce technology, investigated the hypothesis that when a task was "extrinsic" to the IT (e.g., buying from an e-commerce site), ease of use was not a determinant of adoption. In contrast, when the task performed was "intrinsic" to the IT (e.g., gathering information) the individual's ease of use perception would affect his or her decision to adopt. Their findings supported this hypothesis, providing a potentially new interpretation of the effect of ease of use on IT acceptance that merits further investigation.

Most TAM research has substantiated Davis et al. (1989), who concluded that perceived usefulness is a "major determinant" of individuals' intention to use computers and that perceived ease of use is a "significant secondary determinant" of usage intentions. This logic is rationalized with the argument that users will tolerate ease of use shortcomings if they perceive the system is useful in their job. Conversely, users will not accept and use a system that is not useful - regardless of how easy it is to use.

Davis (1993) found evidence that perceived usefulness, perceived ease of use, and attitude fully mediated the effects of system design features on intention to use and usage. This research also found that perceived usefulness influenced attitude more than four times as much as perceived ease of use and that perceived usefulness was 50% more influential than perceived ease of use in explaining an individual's intention to use an information technology.

Attitude

Davis' original TAM theorized that an individual's perceptions of usefulness and ease of use would influence intention to use the technology primarily through the creation of a positive attitude.

Subsequent research suggests the role of attitude as a mediator of the effects of perceived usefulness on intention to use is less clear. Davis et al. (1989) found attitude was at best a partial mediator of the effect of perceived usefulness on intention to use and that it added little causal explanatory power. Davis (1993) found that the direct effect of perceived usefulness on intention to use was more than twice the influence of attitude on usage. Together, these findings led to the suggestion that attitude be eliminated from TAM to create an even more parsimonious model reflecting a direct influence of usefulness and ease of use perceptions on intention to use.

Behavioral Intention

Behavioral intention (a measure of the strength of one's intention to perform a specified behavior (Davis et al., 1989)) is a construct borrowed from the discipline of social psychology. Behavioral intention has been an important construct in most previous TAM research. The significance of behavioral intention derives from the theoretical perspective that intentions — as determined by a combination of attitudes and subjective norm — are the best predictor of an individual's behavior (Jackson et al., 1997). Davis et al. (1989) validated the notion that behavioral intention to use IT is a reasonably reliable predictor of use. Venkatesh et al. (2003, p. 427) note: "The role of intention as a predictor of behavior (e.g., usage) is critical and has been well established in IS and the reference disciplines". Evidence substantiating the hypothesized positive relationship between intentions and behavior is found in a meta-analysis of 86 TRA studies conducted by Shephard, Hartwick, and Warshaw (1989) that found a mean correlation of .54 between intentions and actions.

As Straub et al. (1995) observe, the purpose in measuring intention is to predict future behavior. Thus, in research scenarios associated with the brief introduction of an IT to predict future acceptance and usage, the TAM intention to use construct is particularly critical.

External Variables

Davis defined this construct to include system design characteristics, user characteristics (e.g., cognitive style and other personality variables), and task characteristics (nature of the development or implementation process, political influences, and organizational structure) that might affect attitude, intentions to use, and/or usage. It is a central tenet of TAM that the effects of these external factors on attitude, intentions, or usage are mediated by the individual's perceived usefulness and perceived ease of use beliefs.

System Usage

System usage is a construct of some controversy in IT acceptance research. With relatively few exceptions (e.g., Straub, 1995; Szajna, 1995; Taylor & Todd, 1995; Venkatesh, 2002), most TAM related research has measured the effect of the perceived usefulness and perceived ease of use constructs on intention to use (e.g., Jackson et al., 1997) and/or self-reported usage (Davis et al., 1989), as opposed to objective (actual) usage data. This widespread practice notwithstanding, there remain significant questions regarding its effect on research findings and a number of researchers who value actual usage over self-reported usage.

The research of Taylor and Todd (1995), using actual usage data, supported previous TAM research based on self-reported usage, concluding that an assessment of the usefulness of TAM in predicting usage behavior requires exploration of the model using objective actual usage data. However, Straub et al. (1995) found self-reported usage and actual usage constructs were not strongly related. Their findings also suggested the fundamental TAM constructs, perceived usefulness and perceived ease of use, were more strongly related to self-report usage data than to actual usage data.

Straub et al. (1995) also posed thought-provoking questions concerning the relevance of IT usage measurement in general. If one accepts the widespread assumption that system usage is the primary variable through which IT affects performance (Straub et al., 1995), it seems legitimate to question which of several alternative usage dimensions best captures the desired effect; frequency of use, duration of use per time period, type of use, and diversity of use are just a few candidates. One might even question the legitimacy of usage as the real variable of interest when attempting to ultimately understand and/or measure IT benefits. It could be argued usage is but a surrogate for what researchers really need to capture; that is, a measure of the benefit or utility derived from IT.

Szajna (1996) found statistically significant differences in the effects of user intentions on self-reported and actual usage data (stronger relationship for self-report than actual) and low correlation (.26 at < .05 significance) between the two. These results led her to conclude that substitution of self-report usage for actual usage should be discouraged.

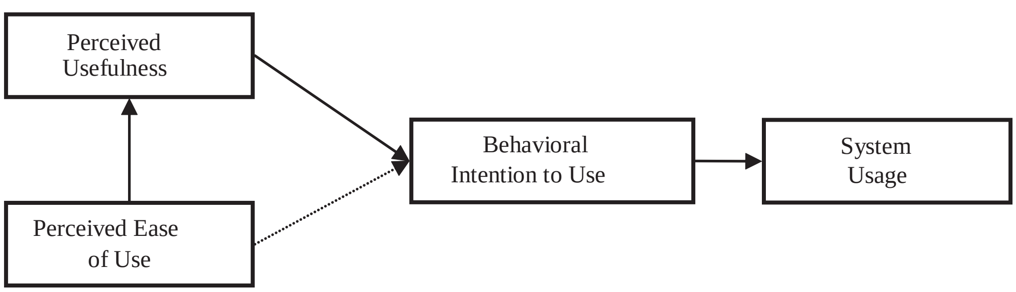
Igbaria et al. (1995) cited prior indications that users might over-report usage when self-reporting and called for additional research into the potential differences in the relationships between the TAM constructs and self-report usage data and actual usage data.

In summation, while there remain some inconsistent findings and beliefs surrounding the stream of TAM centered research, a significant and growing body of work has tended to confirm the model's usefulness as an IT acceptance research tool. As human knowledge has been recognized as an organization's most valuable resource and as a foundation of competitive advantage, there is widespread interest and investment in IT KMS systems (Kankanhalli, 2001). TAM research to date has focused on individual use IT and has been largely conducted in educational environments. Individual acceptance and usage of IT implemented to support KM objectives in an organizational scenario represents a more complex phenomenon. Empirical research is required to determine if past TAM research can help inform the understanding of factors affecting individual acceptance and use of IT implemented to support organizational KM objectives.

RESEARCH MODEL AND RESEARCH HYPOTHESES

The research model is presented in Figure 3. It supports the specific objective of this research to assess the relationships between TAM's two primary belief constructs: perceived usefulness and perceived ease of use, and users' intention to use, and their usage of the target knowledge management system. The research model is similar to Davis' original TAM (Figure 1). In accordance

Figure 3. Research model



with the findings of Davis et al. (1989), the attitude construct is not included. The "external variables" constructs are also not included in the research model since there is no intention here to investigate antecedents to perceived usefulness and ease of use.

The research hypotheses investigated in this study are:

H1: Perceived usefulness of the knowledge management system will exhibit a significant positive direct relationship with behavioral intention to use the system.

H2: Perceived ease of use will have both a direct and indirect effect on behavioral intention to use the system. The indirect effect (mediated by perceived usefulness) will be stronger than the direct effect.

H3: Behavioral intention to use the system will exhibit a significant positive relationship with system usage.

METHODOLOGY

A 14-item survey comprised of tailored measurement scales designed to measure each of the four constructs was used in this research. Measurement scales for each research model construct were drawn from previous IT acceptance research.

Perceived usefulness and perceived ease of use were measured using four-item measurement scales consistently demonstrating excellent psychometric qualities in previous research (Venkatesh & Davis, 1996).

A three-item scale measuring behavioral intention to use the target system was adapted from Venkatesh and Davis (2000). Subsequent research has shown it to have both high reliability and excellent psychometric qualities.

Three items were used to measure user self-reported system usage. The first self-report usage item was adapted from Davis et al. (1992). The third item was also drawn from the work of Davis et al. (1992) and has been used widely in information technology acceptance research.

Employees in two major Northeastern U.S. metropolitan areas with system access were identified by the organization as survey subjects. Each was provided password access to the survey that was hosted on a university server. Employee participation was optional but encouraged through correspondence from management that authorized employees to charge time spent completing the anonymous survey. Access to completed surveys was strictly limited to the researchers.

RESULTS

Fifty-one employees, approximately 20% of the identified survey subjects, responded. Sixteen responses had to be excluded: three due to significant incompleteness and 13 due to respondent comments indicating no system awareness and/or no experience using it. (This finding within the survey target group was an unhappy surprise to management, although, given the broad organizational scope of the KMS studied, this might have been a predictable finding.) Demographic information collected with the survey confirmed the 35 usable responses were submitted by a cross section of organization personnel that included division managers, project managers, technical specialists, configuration control technicians, and administrative personnel.

DATA ANALYSIS

Data analyses included reliability and validity analyses, correlation analysis, and simple and multiple regression. All statistical analyses were performed using Statistical Analysis System (SAS) Version 8.0.

Cronbach Alpha measurement scale reliability coefficients calculated for each construct are shown in Table 1.

The reliability of all measurement scales was comfortably above the recommended minimum level of .70 for social science research (Hatcher, 1994), and the accepted "desirable" level of .80 for social science research. The overall weighted reliability of the survey instrument was .938.

The perceived usefulness and perceived ease of use instruments used in this study have been validated extensively through prior research. Nevertheless, factor analysis was performed to assess their validity here. The eight questionnaire items comprising these two measures were subjected to exploratory factor analysis using squared multiple correlations as prior estimates of communality. Questionnaire items associated respectively with the two constructs loaded heavily (all but one well in excess of .80) on two different factors, thereby replicating the findings of Davis that the two beliefs comprise distinct constructs. Results of the factor analysis appear in Table 2.

The three behavioral intention to use construct items were also subjected to factor analysis. Results presented in Table 3 indicate they all loaded heavily on a single factor, providing evidence of construct validity.

Correlation analysis results appear in Table 4 and include the observed correlations and associated p-values (probability of observed correlation value under the null hypothesis of zero correlation) in the context of the research model in Figure 4. Data analysis results are discussed in the context of the research hypotheses.

H1 postulated a significant positive relationship between perceived usefulness and behavioral intention to use the KMS. Evidence supporting confirmation of this hypothesis can be found in

Table 1. Cronbach Alpha reliability coefficients

Construct (Items)	Cronbach Alpha
Perceived Usefulness (4)	.978
Perceive Ease of Use (4)	.938
Behavioral Intention To Use (3)	.925
Frequency of Use (3)	.896
Overall (14)	.938

Table 2. Perceived usefulness and perceived ease of use validity factor analysis results

Item	Factor 1 Loading	Factor 2 Loading
Using the KMS improves my job performance.	.82	.14
Using the KMS increases my productivity	.89	.05
Using the KMS enhances my effectiveness on the job.	.82	.16
I find the KMS to be useful in my job.	.85	.10
My interaction with KMS is clear.	.32	.59
Interaction with the KMS does not require a lot of mental effort.	.02	.87
I find the KMS easy to use.	.12	.86
I find it easy to get the KMS to do what I want it to do.	.14	.79

Table 3. Behavioral intention construct factor analysis results

Item	Factor Loading
Assuming I had access to the **KMS** and its use was voluntary, I would intend to use it to search for information while creating work products.	.96
Assuming I had access to the **KMS** and its use was voluntary, I would intend to use it to obtain, retrieve, and output stored products.	.81
Assuming I had access to the **KMS** and its use was voluntary, I would intend to use it to research topics relevant to my current work product.	.92

Table 4. Correlation matrix

	Perceived Usefulness	Perceived Ease of Use	Behavioral Intention To Use	System Usage
Perceived Usefulness	1	.795 <.0001	.704 <.0001	.573 .0003
Perceived Ease of Use	.795 <.0001	1	.635 <.0001	.463 .005
Behavioral Intention To Use	.704 <.0001	.635 <.0001	1	.398 .018
System Usage	.573 .0003	.463 .005	.398 .018	1

Table 5. Regression results (H2)

Condition	β Ease of Use (p-value)	β Usefulness (p-value)	R^2
1. Bivariate: Usefulness = *f* (Ease of Use)	.783 (<.0001)	N/A	.632
2. Bivariate: Intention to Use = *f* (Ease of Use)	.615 (<.0001)	N/A	.403
3. Multivariate: Intention to Use = *f* (Ease of Use & Usefulness)	.1,7 (..327)	.534 (.012)	.511

the positive correlation (.704, p value <.0001) and regression analysis showing that perceived usefulness explained 49.6% of the variation in behavioral intention to use in the sample.

H2 hypothesized positive direct and indirect relationships between perceived ease of use and behavioral intention to use the system. It was further hypothesized that the indirect effect (mediated by perceived usefulness) would be greater. This hypothesis was examined using multiple regression techniques. The Ordinary Least Squares regression methodology was deemed most appropriate for this study due to the research model's simple factor structure and the fact that the TAM model structure has been extensively researched.

To establish perceived usefulness as a mediator of the relationship between perceived ease of use and behavioral intention to use, it is necessary to demonstrate the existence of four conditions: (1) a significant bivariate relationship between perceived ease of use and perceived usefulness, (2) a significant bivariate relationship between perceived ease of use and behavioral intention to use, (3) a significant relationship between perceived usefulness and intention to use when perceived ease of use is controlled for, and (4) a reduced or weakened relationship between perceived ease of use and perceived usage when usefulness is controlled for (Baron & Kenney, 1986).

Regression analysis results relevant to hypothesis two are presented in Table 5. The first two data rows of the table illustrate necessary statistically significant bivariate relationships between perceived ease of use and usefulness and ease of use and intention to use. Results of the multiple linear regression of behavioral intention to use on perceived usefulness and perceived ease of use appear in the third row. These results reveal the hypothesized multivariate relationship in the survey data. Consistent with required mediation conditions three and four, the relationship between perceived usefulness and behavioral intention to use is statistically significant when the effects of ease of use are controlled for (p value of .012). Additionally, as required, the relationship between perceived ease of use and behavioral intention is diminished (smaller β estimate) when the effects of usefulness are controlled for in the multiple regression.

These results are consistent with the mediation criteria of Baron and Kenny (1986) and support confirmation of hypothesis two that the effects of perceived ease of use on behavioral intention to use are mediated by perceived usefulness. They also show that when the effects of perceived usefulness are controlled for in multiple regression, perceived ease of use has very little unique explanatory value with regard to intention to use. Perceived usefulness uniquely accounted for more than seven times as much variation in intention to use (10.8%) as did perceived ease of use (1.49%). However, these two beliefs combined to uniquely account for only 12.3% of the variation in intention to use. Thus, almost 39% of the variation in intention to use was explained by the two constructs jointly (this is consistent with the high correlation (.795) between these two constructs shown in Table 4).

H3 hypothesized a positive and significant relationship between behavioral intention to use the system and system usage. Table 4 presents evidence of confirmation of this hypothesis in the positive correlation (.398, p-value .018) between these constructs. Regression analysis indicates behavioral intention explains only 15.9% of the variation in usage in the sample. This intention-behavior relationship is not as strong as expected. While some TAM research has yielded weaker intention-behavior correlations (e.g., Szajna, 1995), many have found evidence of a stronger tie between these constructs.

DISCUSSION

The only finding in this research not fully consistent with previous TAM research is that concerning the relationship between behavioral intention to use and system usage constructs.

Perceived usefulness and perceived ease of use combine to explain 51.1% of the variation in behavioral intention to use the KMS. This is consistent with previous TAM research. The individual relative effects of the two belief constructs are also consistent with previous findings. Both beliefs exhibit significant bivariate relationships with intention to use. However, when the effects of perceived usefulness and perceived ease of use are isolated in multiple regression, it can be seen that the effect of perceived ease of use on behavioral intention to use the KMS actually derives from potential users' perception of its usefulness (i.e., perceived usefulness mediates the relationship between perceived ease of use and intention to use the system). This is generally consistent with most previous TAM research addressing individual IT use, although a reduced direct effect was anticipated.

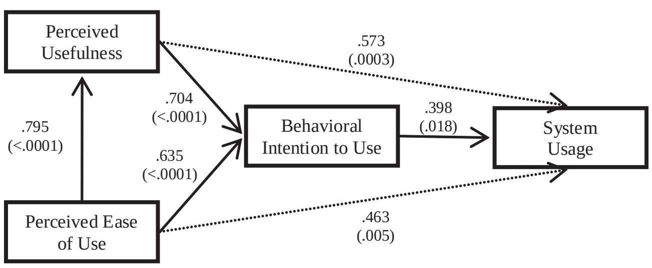
The correlation between intention to use the KMS and self-reported system usage found in this study is lower than what has been typically observed in previous TAM research.

This potentially inconsistent finding may be attributable to the nature of the study scenario. The research data were collected long after the introduction of the target KMS. As Straub et al. (1995) observed, the value of measuring inten-

Table 6. Summary of research hypothesis findings

Hypothesis	Comments
1. Perceived usefulness will exhibit a significant positive relationship behavioral intention	• Confirmed, consistent with previous research
2. Perceived ease of use will have both a direct and indirect (mediated by perceived usefulness) relationship with behavioral intention	• Strong mediation effect of perceived usefulness confirmed, consistent with most prior research • No unique perceived ease of use effect when perceived usefulness controlled for
3. Behavioral intention will have a significant positive relationship with system usage	• Confirmed • Intention-behavior relationship not as strong as many earlier studies

Figure 4. Research model and observed correlations (p-values)



tion is to predict future behavior. Therefore, in research scenarios characterized by a brief introduction of an IT intended to help predict future acceptance and usage, the behavioral intention construct is critical. In this research, the intent was not to predict usage, but to interpret experience with the target KMS through the lens of the TAM. Research by Davis et al. (1989) indicated that the strength of the link between intentions and behavior is positively correlated with user experience and negatively correlated with the elapsed time between the measurement of intentions and behavior (Venkatesh & Davis, 1996). In this case, respondents had an extended period in which to form their beliefs regarding the usefulness and ease of use of the target KMS. We believe measurement of intentions significantly post facto may have contributed to ambiguous results surrounding the relationship between the intention and usage constructs.

Other explanations of the intentions-usage relationship centering on whether or not frequency or accumulated time of system usage is really an important metric with regard to KMS usage and/or whether or not potential users' intention to use was adversely affected by the quality of the materials accessible in the KMS or its "output quality" are also plausible (e.g., see Kankanhalli et al., 2001).

CONCLUSION

The results of this research provide preliminary evidence that previous IT acceptance research based on TAM can serve as a basis for critically needed empirical research of KMS user acceptance. Relationships among primary TAM constructs found in this research are largely consistent with those typical of previous TAM research, with the exception of the correlation between intention to use the KMS and self-reported system usage. This correlation was found to be lower than what has been typically observed in previous TAM research. This potentially inconsistent finding may be attributable to the data collection long after the introduction of the target KMS; questions regarding the metrics with regard to KMS usage; and whether or not potential users' intention to use was adversely affected by the quality of the materials accessible in the KMS.

Perceived usefulness and perceived ease of use combined to explain 51% of behavioral intention to use the system. This result is consistent with a significant body of previous TAM research in which these two constructs have been typically found to explain 40% to 60% of the intention to use/usage variance. Significant positive relationships between perceived usefulness, perceived ease of use, intention to use, and the strong mediating effect of perceived usefulness on the effect of perceived ease of use on intention to use were consistent with previous TAM research.

LIMITATIONS

This research bears inevitable generalizability limitations of any study of one information system in one organizational environment. Additional investigation of knowledge KMS implemented in a representative range of modern organizational settings is essential to increased understanding of those factors, conditions, and mechanisms critical to their success. A second key shortcoming of this research is its limited sample size, both in absolute terms, and relative to the population of potential organizational users of the KMS. With approximately 12% of the population providing a usable response to the voluntary survey, one cannot summarily ignore the possibility of sample bias. However, the broad range of responses received across all measured constructs mitigates this concern somewhat. Another potential shortcoming of this research is its reliance upon self-reported usage. As noted earlier, previous researchers have raised credible and largely unanswered questions regarding the fidelity of self-report usage data and its relationship to key TAM constructs when compared with actual usage data. Finally, it must be recognized this study covers only a single point in time, whereas KMS adoption and usage issues are likely to evolve over longer time cycles. Given the complexity of KMS usage and adoption, longitudinal studies could provide valuable research insights not otherwise available.

FUTURE RESEARCH

Additional study of diverse KMS in a range of modern organizational settings is necessary to support the accumulation of knowledge and development of sound theory regarding the factors, conditions, and mechanisms critical to KM success. Given the complex and diverse nature of KMS and the approaches used to implement them (i.e., task/process oriented versus infrastructure/generic), a spectrum of situation- specific models/constructs may be required.

When possible, future researchers should attempt to collect and analyze both self-report and objective actual usage data. This will contribute to resolution of lingering questions regarding this important construct and its effect on previous TAM research. In addition and as suggested previously, further investigation of the relationship between intention to use and KMS usage is warranted.

Furthermore, although this research suggests previous TAM-based IT user acceptance research can serve as a basis for future investigation of KMS user acceptance, it seems inevitable that other factors associated with the complex socio-cultural organizational implications of KM must be explored.

To increase the explanatory power of the model relative to KMS, it will be necessary to incorporate additional theory-based constructs to the TAM. Given the social nature of KM, interesting candidates include items that measure important organizational culture and/or subjective norm influences.

Antecedents to the current TAM beliefs need to be researched to understand the components of perceived usefulness and perceived ease of use relative to KMS. This would be consistent with current trends in general IT user acceptance research such as those reported by Venkatesh et al. (2003).

Finally, more complete longitudinal and qualitative studies of organizational and user patterns that comprise the totality of a KMS over its development, implementation, and adoption should be pursued.

Given the critical importance of knowledge to the modern organization and the pivotal role of IT in organizational knowledge leveraging initiatives, further investigation of user KMS acceptance factors would seem a critical research priority.

REFERENCES

Alavi, M., & Leidner, D. (1999, February). Knowledge management systems, issues, challenges, and benefits. *Communications of the Associations of Information Management Systems, 1*(7), 1-37.

Alavi, M., & Leidner, D. (2001, March). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Baron, R., & Kenney, D. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Psychology, 51*(6), 1173-1182.

Bourdreau, A., & Couillard, G. (1999, Fall). Systems integration and knowledge management. *Information Systems Management,* 24-32.

Carr, N. (2003, May). IT doesn't matter. *Harvard Business Review, 81*(5), 41.

Compeau, D., & Higgins, C. (1995, June). Computer self-efficacy: Development of a measure and initial test, *MIS Quarterly, 19*(2), 189-211.

Davenport, T., & Grover, V. (2001, Summer). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-22.

Davis, F. (1989, September). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*, 319-339.

Davis, F. (1993, September). User acceptance of information technology: System characteristics, user perceptions and behavioral impacts. *International Journal of Man-Machine Studies, 38,* 475-487.

Davis, F., Bagozzi, R., & Warshaw, P. (1989, August). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Davis, F., Bagozzi, R., & Warshaw, P. (1992). Extrinsic and intrinsic motivation to use computers in the workplace. *Journal of Applied Psychology, 22*(14), 1111-1132.

DeLone, W., & McLean, E. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3,* 60-95.

Doll, W., Hendrickson, A., & Xiandong, D. (1998, Fall). Using Davis's perceived usefulness and ease-of-use instruments for decision-making: A confirmatory and multi-group invariance analysis. *Decision Sciences, 29*(4), 839-869.

Earl, M. (2001, Summer). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 214-233.

Ericsson, F., & Avdic, A. (2003). Knowledge management system acceptance. In E. Coakes (Ed.), *Knowledge and Management: Current Issues and Challenges* (pp. 39-51). Hershey: IRM Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.

Gefen, D., & Straub, D. (2000, October). The relative importance of perceived ease of use in IS adoption: A study of e-commerce adoption. *Journal of the Association of Information Systems, 1*(8), 1-28.

Gold, A., Malhotra, A., & Segars, A. (2001, Summer). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Grant, R. (1996, Winter). Toward a knowledge based theory of the firm. *Strategic Management Journal, Special Edition, 17*(Special Issue), 109-122.

Hatcher, L. (1994). *A Step-by-Step Approach to Using the SAS® System for Factor Analysis and Structural Equation Modeling.* Cary, NC: SAS Institute.

Igbaria, M., Guimaraes, T., & Davis, G. (1995, Spring). Testing the determinants of microcomputer usage via a structural equation model. *Journal of Management Information Systems, 11*(4), 87-114.

Jackson, C., Chow, S., & Leitch, R. (1997, Spring). Toward an understanding of the behavioral intention to use an information system. *Decision Sciences, 28*(2), 357-389.

Jennex, M., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity, a longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on Systems Sciences*. IEEE Computer Society.

Jennex, M., & Olfman, L. (2003). *A knowledge management success model: An extension of Delone and Mc Lean's IS success model.* Ninth

Americas Conference on Information Systems (pp. 2529-2539).

Kankanhalli, A., Tan, B., & Wei, K. (2001). *Seeking knowledge in electronic knowledge repositories: An exploratory study.* The 22nd International Conference on Information Systems (pp. 123-133).

Lam, A. (2000). Tacit knowledge: Organizational learning and societal institutions: An integrated framework. *Organization Studies, 21*(3), 187-209.

Legris, P., Ingham, J., & Collerette, P. (2002). Why do people use information technology? A critical review of the technology acceptance model. *Information & Management, 40,* 191-204.

Ma, Q., & Liu, L. (2004, January-March). The technology acceptance model: A meta-analysis of empirical findings. *Journal of Organizational and End User Computing, 16*(1), 59.

Malhotra, Y. (2000, January-March). Knowledge management and new organization forms. *Information Resources Management Journal, 13*(1), 5-14.

Marwick, A. (2001). Knowledge management technology. *IBM Systems Journal, 40*(4), 814-830.

Mathieson, K., Peacock, E., & Chin, W. (2001, Summer). Extending the technology acceptance model: The influence of perceived user resources. *The DATABASE for Advances in Information Systems, 32*(3), 86-112.

Sheppard, B.H., Hartwick, J., & Warshaw, P.R. (1988, December). The theory of reasoned action: A meta-analysis of past research with recommendations for modifications and future research. *Journal of Consumer Behavior, 15*(3), 325-343.

Spender, J.C. (1996, Winter). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, Special Edition, 17,* 45-72.

Straub, D., Limayem, M., & Karahanna-Evaristo, E. (1995, August). Measuring system usage: Implications for IS theory testing. *Management Science, 41*(8), 1328-1342.

Szajna, B. (1996, January). Empirical evaluation of the revised technology acceptance model. *Management Science, 42*(1), 85-92.

Szajna, B., & Mackay, M. (1995). Predictors of learning performance in a computer-user training environment: A path-analytic study. *International Journal of Human-Computer Interaction, 7*(2), 167-186.

Taylor, S., & Todd, P. (1995). Understanding information technology usage: A test of competing models. *Information Systems Research, 6*(2), 144-176.

Taylor, W. (2003, July). *Computer mediated knowledge sharing and individual user differences: An exploratory study.* Working Paper 03/06.

Vaill, E. (1999, Fall). Knowledge mapping: Getting started with knowledge management. *Infor. Systems Research,* 16-23.

Venkatesh, V. (2000, December). Determinants of perceived ease of use: Integrating control, and emotion into the technology acceptance model. *Information Systems Research, 11*(4), 342-365.

Venkatesh, V., & Davis, F. (1996, Summer). A model of the antecedents of perceived ease of use: Development and test. *Decision Science, 27*(3), 451-481.

Venkatesh, V., & Davis, F. (2000, February). A theoretical extension of the technology acceptance model: Four longitudinal studies. *Management Science, 46*(2), 186-204.

Venkatesh, V., Morris, M., Davis, G., & Davis. F. (2003, September). User acceptance of information technology: Toward a unified view. *MIS Quarterly, 27*(3), 425-478.

Zack, M. (1999, Spring). Developing a knowledge strategy. *California Management Review, 41*(3), 125-146.

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Chapter 4.26
Open Collectivism and Knowledge Communities in Japan

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INTRODUCTION

The aim of this article is to introduce an Eastern CoPs' specific approach that is quite different from that of Western communities. In a collectivist prevalent societal type, the "sharing of feelings should come first, naturally followed by knowledge sharing" type of approach works very well even in a business environment.

One of Japan's traditional manufacturers has launched several interesting knowledge communities that are different from the accepted Western KM approach that emphasizes cost and effect straightforwardly. Their approach emphasized the generation of social networking on intranet first, and at a later stage, they proceeded to knowledge sharing through communities of practice.

This "go slow to go fast" approach may look like one of the typical and traditional Japanese management styles. However, in this approach, the culture of this company group steadily changes from introverted and closed to extroverted and open.

Their approach to build open and extroverted collectivism that is generated by knowledge communities could be one of the new management style prototypes of Japanese companies in the future.

BACKGROUND

QP Corporation is a top-class Japanese company, manufacturing and marketing mayonnaise and salad dressings in Japan. One of the group companies manufactures jam. QP is one of the top brands in the food industry. They have been in the food manufacturing business more than 80 years with 2,200 employees. The total number of employees including group companies is 6,000.

This means that QP are typical of the traditional business group in Japan.

Their operation of knowledge communities has a 3.5-year history. In the past, their original KM approach failed when they built knowledge databases for knowledge sharing. This approach did not work well, let alone match the expectations of management. Therefore, this time, they decided against the mechanical approach such as building a knowledge database instead of building knowledge communities on their intranet was tried.

As far as the communities' approaches toward face-to-face activity, traditional socializing approaches such as company outings, pub drinking, and factory participation in local festivals where employees socialize with local people work very well in this company. And small-group employee activities for incremental improvement also work well. Therefore, the main activities of the revised QP KM plan focused on building knowledge communities on their intranet. The purposes was to change the company culture from a closed and introverted one to an open and extroverted one; promote employees to knowledge workers who are individually treasured; and promote workers into those who produce and share business ideas.

In the past, one of the features of Japanese companies was an introverted collectivism that supports the production of a quality product. However, in the 21st century of rapidly changing market environments, companies need fresh idea generation for new products and for new marketing, and it is clear that fresh ideas cannot emerge only between intimate colleagues. New ideas can come from anybody else inside and outside of organizations. Knowledge communities supply companies with "the strength of weak ties", backed by social networking that bridges silo type organizations.

SOCIAL NETWORKING BY KNOWLEDGE COMMUNITIES

KM Team Blogging

QP Corporation started building knowledge communities by using Lotus Notes software on their intranet. A centrally organized knowledge management team consisted of five employees. One of their roles is to behave as if they are company news reporters, and they compile different articles about the business and put them on the knowledge repository in Lotus Notes. They also provide company newsletters that brief all the employees of QP group by e-mail about these newly posted articles. After that, employees can voluntarily read some articles and post their comments. As far as posting comments are concerned, two different ways of posting were arranged by the KM team. One was posting for discussion on common forum, called the tea lounge, where a link from each article is prepared. Another way to comment is through the employee posting anonymously onto a bulletin board that is also linked to each article.

The category of these articles by the KM team varies from reports of shareholder meetings, introduction of new products, competitors' information to reports of management and employees' lives. As far as well visited articles are concerned, the articles relating to customers' voices are the most popular ones, and they convey customers' messages directly to all the employees. They sometimes include claims or request for product and services improvement.

The articles of customers' voices are compiled by the KM team, and the production process is the following: First, KM team contacts the call center to pick up customers' claims and needs. After that, the KM team contacts R&D or relevant manufacturing department for further information. Finally, compiled articles are posted on the bulletin board for employees' comments.

The same processes are repeated for the other categories of articles. They are regarded as KM team blogging, covering all the activities of companies. Interestingly, KM team blogging itself is declared as an informal message supply. It seems that currently, some articles are also voluntarily posted by local offices.

Employees' Regular Column Posting

In addition to the KM team article posting, individual employees' regular posting activities, called my opinion, are popular. My opinion is a weekly posted blogging by several employees. In my opinion, several volunteers such as young employees, experienced employees, men and women from varying divisions freely talk about their business and private life as either a diary or column, and the rest of the employees freely give their comments on them. In doing so, employees can get to know each other well, and they can share other employees' experiences and their way of thinking. For young employees, reading a senior's my opinion works as net-mentoring. Recently, female managers were employed in this company for the first time in its history. For these female employees, reading the female managers' my opinion is quite encouraging, and lots of them try to understand the way female managers think. It is a new form of tacit knowledge sharing in Japan. My opinion usually lasts for two to three months per employee. After that, they are replaced by different volunteers in rotation.

Business Volunteers' Recruiting

QP Corporation is a food manufacturer for consumers and businesses. Therefore, they sometimes recruit volunteers from employees to taste new products. For this purpose, knowledge communities are very useful and rewarding. When 10 to 20 employees are chosen for tasting volunteers, they sometimes voluntarily organize a community of practice on the intranet, and they regularly post their interesting reports for discussion about possible product improvements. They also sometimes recruit volunteer employees to distribute sample products in the employees' home neighborhood to pick up comments from their neighbors.

The recruiting and reporting by volunteers are all made known on knowledge communities. In particular, this reporting by volunteers is full of the voices of potential customers as well as their own feelings.

Usually, this type of business volunteers recruiting is requested from the KM team by official organizations such as marketing, and then the KM team coordinates between the knowledge communities and these divisions.

Business Q&A Exchange

The company recently started a business Q&A exchange. On the knowledge communities, knowledge seekers raise queries and knowledge givers post an answer. In this case, the KM team works as a facilitator.

COMMUNITIES OF PRACTICE AND FUTURE TRENDS

QP Corporation's Knowledge Community is a big community, called I-QP, covering all the group companies. As far as communities of practice are concerned, currently around 10 to 15 communities are operational. Among them, the working mother's community is the most fascinating. When it comes to the subject of raising knowledge workers, their current concern is how to raise the status of female workers. So far, the working mother's community is at an early stage, and the current central theme of discussion is baby food. However, this community has the potential to promote the improvement of female worker status in Japan.

As for business CoPs, the sales division has a community of practice, called find. In this CoP, all the sales staff are participants. All the noticed and found information in sales fields such as competitor's movement, distributor's movement, and popularity of new products is posted in this community of practice for knowledge sharing.

CONCLUSION

Throughout building knowledge communities, the QP organization has found that the employees have been gradually transforming themselves from "organization man" to self-supporting knowledge workers. Especially, the female workers have become more active and lively. However, from the building communities point of view, their approach to raise "open collectivism by knowledge workers" is still at an early stage and has a long journey ahead.

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Chapter 4.27
Tacit–Explicit and Specific–General Knowledge Interactions in CoPs

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INTRODUCTION

Over the last decade the fields of knowledge management and organizational learning have developed rapidly, showing increasing diversity and specialization in the academic literature. Ikujiro Nonaka has played a leading role in setting standards and earning academic legitimacy for the emergent field of "organizational knowledge management" (Easterby-Smith & Lyles, 2003). In the period 1995-2001, the book The Knowledge-Creating Company (Nonaka & Takeuchi 1995) was the most-cited knowledge management work from academic literature (Koenig & Srikantaiah, 2004). Interestingly, in this book and in following works, the authors themselves prefer to use the term "knowledge creation" rather than "knowledge management," later also dropping the term "organizational" from the initial proposition. Easterby-Smith and Lyles also state (2003, pp. 642-643) that in the field of organizational learning and knowledge management, among the topics of articles published in the last two years, "learning capabilities, experience, and absorptive capacity" is the largest category, including several articles that assess the impact of learning on performance. Seeming to be frequently interrelated, "organizational learning and knowledge management across boundaries," "knowledge creation and transfer," and "human resource management and human capital" are the next largest categories for articles. Communities of practice, socio-political processes, and the development of tacit knowledge or social identity are among the other topics frequently addressed in the literature, categorized in terms of "cognition, socio-political aspects, and tacitness."

Using the extant and emerging perspectives in knowledge management, organizational learning, and communities of practice literature, in the following sections of this short article, we will first discuss the importance of specific-general knowledge, and context for knowledge creation and management. Then we will introduce the conceptualization of "specific" and "general" knowledge interactions, and discuss a framework that proposes these interactions as contextual knowledge conversions for learning and practice. The following section will aim to contribute to the representation of our knowledge on these contextual knowledge interactions, using visualization tools like geometric figures. We will conclude our discussion by highlighting future research possibilities in the relevant research fields.

BACKGROUND

Specific-General Knowledge and Context for Knowledge Creation and Management

According to the organizational knowledge creation model of Nonaka and Takeuchi (1995), the continuous and dynamic interaction between tacit and explicit knowledge that happens at the individual, group, organizational, and inter-organizational levels can be significant for the sustainable development of any social setting. Nonaka and Takeuchi follow the distinction of Polanyi (1966) between tacit and explicit knowledge: Tacit knowledge is personal, context-specific, and therefore hard to formalize and communicate. Tacit-explicit knowledge interaction is identified as the epistemological aspect, while the interactions among the different levels (individual, group and organization, inter-organizational) correspond to the ontological aspect of the model. When the authors first introduced their model, at the epistemology level they identified four distinctive interactions between tacit and explicit knowledge: socialization, externalization, combination, and internalization. Socialization is the process of creating tacit knowledge from tacit knowledge, whereas externalization is that of articulating tacit knowledge into explicit concepts. Combination involves the process of systemizing concepts into an explicit knowledge system. Internalization is a process of embodying explicit knowledge into tacit knowledge.

Nonaka, Toyama, and Byosiere (2003) also suggest that at the foundation of their modeling lies ba: the context that knowledge needs in order to exist, in which it is shared, created, and utilized. Although the concept of ba shows similarities with that of communities of practice, especially highlighting the importance of context for learning and knowing, Nonaka et al. (2003) differentiate them according to the nature of the learning and participation that takes place within them. For instance, a community of practice is a place where members learn knowledge embedded in the community; ba is a place where new knowledge is created.

Real or virtual interactions among individuals or between individuals and their environments are key for the understanding of ba and knowledge creation. Especially, within the tacit knowledge conversions of socialization and externalization, a real ba where participants can interact face-to-face in the same time and space is essential (Umemoto, 2002). In general, with regard to the type of interaction (individual or collective) and the interaction medium (face-to-face contact or through "virtual" media) (von Krogh, Ichijo & Nonaka, 2000), four types of ba can be defined, corresponding roughly to socialization, externalization, combination, and internalization: originating ba, dialoguing ba, systemizing ba, and exercising ba (Umemoto, 2002).

Although initially knowledge creation and management was widely understood as simply the interaction between tacit and explicit knowledge, the type of interaction—individual (personal) or collective (group, social, societal)—is also increasingly being recognized as another dimension of knowledge interaction and conversion that parallels the tacit-explicit dimension of knowledge and knowledge interactions. For instance Wierzbicki (2004) sees socialization as the transition from personal tacit knowledge to group tacit knowledge; externalization, group tacit to group explicit knowledge; combination, group explicit to personal explicit knowledge; and internalization, personal explicit to personal tacit knowledge. In fact, tacitness relates to the transferability of knowledge, which also makes the location of knowledge an important issue (OECD, 2000).

According to von Krogh, Ichijo, and Nonaka (2001), knowledge can be observed and distinguished on two levels, individual and social. In addition, as recognized by various authors, there is "general knowledge," which is widely possessed by a large number of individuals and can be transferred easily among individuals, and "specific knowledge," which is idiosyncratic and narrowly possessed by a very limited number of individuals (Becerra-Fernandez, 2004). Whereas general knowledge is inexpensive to transfer, specific knowledge is expensive and costly (Jensen, 1998). Starting with global public knowledge, which is general and explicit, Stiglitz (2001) also analyzes the development of knowledge along two dimensions, general-local and implicit-codified. The description or classification of knowledge as a public or private good or asset retains an important place in the socio-economic modeling of knowledge (OECD, 2000). In order to redesign cross-cultural management, Holden (2002) discusses three domains of cultural knowledge as follows: general cultural knowledge, culture-specific knowledge, and cross-cultural know-how. While general cultural knowledge can be associated with explicit knowledge and cross-cultural know-how with tacit knowledge, culture-specific knowledge can be both tacit and explicit according to the convention. Gasson (2004) highlights the problems of managing and transferring local knowledge beyond its workgroup and specific context, and discusses the ways in which this distributed knowledge is managed, communicated, and translated across organizational boundaries. The shared explicit knowledge is transited into shared tacit knowledge, then to tacit distributed knowledge, and finally to explicit distributed knowledge.

Whether it is general, global, public, shared, common, collective, social, societal…or specific, idiosyncratic, local, private, distributed, individual, personal, and so forth, and although their units and levels of analysis differ, these various discussions all try to capture the same conceptual understanding about knowledge or knowing. However most of them remain as classifications of knowledge, rather than capturing the meaning of these knowledge types as knowledge interactions, and making use of these interactions for a better comprehension of knowledge creation.

"Specific" and "General" Knowledge Interactions

Nonaka and Takeuchi's (1995) generic knowledge conversion framework of socialization, externalization, combination, and internalization has become widely recognized in the academic and business worlds, and the organizational knowledge creation model has become known as the "SECI model." From this perspective, the main focus was on the tacit and explicit knowledge interactions as the epistemological aspect of the (organizational) knowledge creation model. There was no distinctive classification of knowledge interactions or conversions at what the authors called the ontology level, nor did the knowledge conversions of the SECI clearly identify the knowledge interactions at the individual, group, organizational, or social levels, and across these levels and entities. However, horizontal and vertical interactions among these levels and entities are just as important for organizational knowledge creation as the tacit-explicit knowledge interaction.

Nonaka and Takeuchi's classification of tacit and explicit knowledge interactions follows the logic that identifies from which knowledge to which knowledge the knowledge interaction occurs. The same distinction can be applied to

Table 1. Tacit-explicit and general-specific knowledge conversions in SECI interactions

Knowledge Interaction	**Tacit-Explicit Knowledge Conversion**	**Specific-General Knowledge Conversions such as**
Socialization	Tacit to Tacit	General to Specific
Externalization	Tacit to Explicit	Specific to Specific
Combination	Explicit to Explicit	Specific to General
Internalization	Explicit to Tacit	General to General

the various individual, group, organization, and society levels. One way of doing this can be the realization of the knowledge dimension of general versus specific (or global versus local) knowledge besides that of tacit versus explicit (or implicit versus codified) knowledge. Specific knowledge can mean the knowledge of one specific individual, group, society, time, or location. General knowledge, on the other hand, can be understood as the knowledge that goes across or is shared by particular individuals, groups, societies, times, and locations.

These definitions can then be incorporated into the conceptualization of the knowledge creation model. Knowledge is now seen not only as tacit or explicit, but also specific or general. Like tacit-explicit knowledge, specific-general (local-global) knowledge is not a discrete dichotomy, for actually all knowledge is both specific and general to some degree. At the ontological level, the recognition of knowledge as both specific and general comprehensively takes into account individual, group, organization, society, collective, and locative perspectives. This is also a relative understanding: knowledge that is general for one level or entity can be specific for another. For a generic knowledge creation model, this relative understanding is important in order not to become limited to specific levels of analysis. For the application of the model then, these levels and entities can be made clear such as individual or group, social versus personal, inter-organizational or universal.

According to this model then, we can find four distinct, different knowledge interactions like those within tacit and explicit knowledge: local to local, local to global, global to global, and global to local. Together, the tacit-explicit and local-global (specific-general) knowledge interactions can nurture efficacious knowledge management and creation in institutions and socio-economic systems. We can reinterpret the SECI interactions in light of the knowledge conversions between specific and general knowledge, in addition to those of tacit and explicit knowledge. For an example interpretation, please see Table 1.

Specific-General Knowledge Conversions as Contextual Interactions (for Learning and Practice)

All these specific-general interactions highlight the importance of the context within which knowledge creation takes place. Moreover, they are able to direct our attention to the interactions across boundaries, which are very crucial to understand if we want to improve our knowledge about knowledge, and its management and creation. This is the same as when we discuss learning through communities of practice. Wenger (1998) points out that knowing in practice involves an interaction between the local and global. Explaining organizational knowledge creation as simplified tacit-explicit knowledge conversions does not highlight the significance of this cross-boundary interaction, often placing too much emphasis on solutions to problems that cannot take advantage of the "landscape of practices" (p. 140). Since the processes of knowledge and learning are based and situated on the context, knowledge interactions on and across boundaries becomes essential.

In recognition of these cross-context transactions in knowledge transfer, in the academic and business literature, the "tacit-explicit"-ness and "specific-general"-ness of knowledge have noticeably been used together. For instance, Sudarshan (2000) concludes his discussion of the governance of economic and social development by claiming that a revival of concern for the role of local and tacit knowledge in development transformation should emerge as a global issue. He gives the example of India, which strongly rejected such local knowledge in favor of a world view derived from within the boundaries of codified and general knowledge, based on "colonial rule, with its accompanying territorial annexation and the need to create an elite with a shared world view and language…To revive the missing dimensions is a challenging, though not impossible, task" (p. 101).

Burton-Jones also contends (1999) that the commercial application of IT has had a 'leveling' effect, "reducing the specific to the general, the idiosyncratic to the standard, tacit knowledge to explicit knowledge, scarce goods and services to commodities." One reason for this is that businesses have historically "opted to use IT to control and standardize their operations." Another major reason is the tendency by firms to adopt standard software packages. For instance, SAP can provide "in detailed, explicit terms, a set of best practices for operating many routine functions of a business." Thus the companies can choose "to rely on externally provided knowledge of best practices, rather than have to develop and maintain that knowledge themselves…in doing so they may lose the benefits of firm-specific or tacit knowledge embedded in internal processes and procedures which are replaced by the standard system" (pp. 9-10). The same argument can also hold for other types of systemic interventions into institutions, including consultancy, management learning, and training and development activities.

To an important extent the literature has come to recognize the specific-general dimension of knowledge together with that of tacit-explicit. When it comes to the recognition of specific-general knowledge interactions alongside tacit-explicit ones, the existing knowledge base does not provide much beyond the works that we have discussed above or similar articles. However, the intermingling of these two types of interaction is very important for knowledge creation—identifying these interactive processes of knowing beside the classification of different knowledge types deserves special attention. This is especially true when we approach the concepts of knowledge, learning, action, and participation as contextual interactions within ba or communities of practice. For instance, originating ba through face-to-face interactions offers a context for socialization that yields "sympathized knowledge" (Nonaka & Takeuchi, 1995, p. 72), as important tacit knowledge can be shared among individuals. Empathizing with others, an individual transcends the boundary between self and others (Umemoto, 2002).

In Nonaka and Takeuchi's original model of organizational knowledge creation (1995), the starting point of knowledge creation, socialization, corresponds in practice to not only the sharing of tacit knowledge among the team members, but also to learning through apprenticeship. What is called "learning by doing" matches with internalization, although this interaction and the resulting tacit knowledge has also the meaning of feedback that can initiate a new knowledge spiral. These three concepts—sharing of tacit knowledge, learning by doing, and apprenticeship—have been incorporated into the conceptualizations of situated learning, legitimate peripheral participation, and communities of practice, while the term 'socialization' is understood with regard to its meaning in sociology literature (Lave & Wenger, 1991; Wenger, 1998).

On the other side, what is implicitly evident in the conceptualization of socialization as field-building tacit knowledge interaction in Nonaka and Takeuchi's original model (1995), is that a shared context exists among the participants of the knowledge interaction process. The participants share a background of common knowledge, which enables them to communicate without using explicit terms. As in the case of apprenticeship, newcomers can learn first by watching their seniors and then by practicing themselves. In the case of knowledge sharing among group members, ways of tacit interaction can be enough. Even conversation, which can be seen as a means of explicit knowledge interaction, actually incorporates important tacit and explicit elements together (Baker, Jensen & Kolb, 2002). For all these cases, in order to exchange and share tacit knowledge, participants should also share a common base of mutually understandable and usable knowledge, which enables them to transfer knowledge with tacit terms. Penrose (1989), for instance, exploits this tacit common base to explain the implicit understanding and communication between two mathematicians, even if they cannot express or do not understand each other explicitly. This common ground can start to develop with the start of the participant's acceptance in a community of practice. Then the members gradually learn and develop their knowledge with their practice and participation in the community.

In fact, the dynamic interaction between tacit-explicit and specific-general knowledge can be matched well with this mutual existence of learning and practice, or the duality of participation and reification in communities of practice (Wenger, 1998). Nonaka et al. (2003) try to differentiate ba from communities of practice according to the nature of the learning and participation that takes place. Nevertheless, both communities of practice (CoPs) and ba highlight the importance of context for learning and knowing, and the conceptualizations of SECI and ba can be integrated and contribute to our understanding of communities of practice. The conversions of knowledge can be enabled in the communities of practice, which can lead to the learning of existing knowledge or the generation of new knowledge, together with the development of community and its members. Nermian Al-Ali suggests (2003), for instance, that CoP strategies can be applied for creating new knowledge as innovations through the transfer of mainly tacit general knowledge.

Representation of our Knowledge on Contextual Knowledge Interactions

To represent our knowledge about communities of practices metaphorically, we can also use the geometric characteristics of an ellipse. Forming around the interplay and the duality of concepts like practice and learning, communities of practice can be visualized as an ellipse that is drawn over two center points of practice (or action) and learning (or knowing) (see Figure 1).

In this model we use the geometric characteristics of an ellipse to develop the existing models about learning, learning by doing (or doing by learning), and communities of practice. The ellipse has two fixed points, which are labeled practice (or action) and learning (or knowing) in our model. Thus we can suggest that our community of practice forms around the concepts of both practice and learning. In the ellipse, the sum of the distances between any point on the plane curve and the fixed points is constant. In our CoP ellipse, this also means that whatever is done in the community of practice always consists of some action and some learning, although their ratio could be different. Using other characteristics of ellipse, such as eccentricity, we can use this kind of approach to help us solve some problems related

Figure 1. Community of practice ellipse

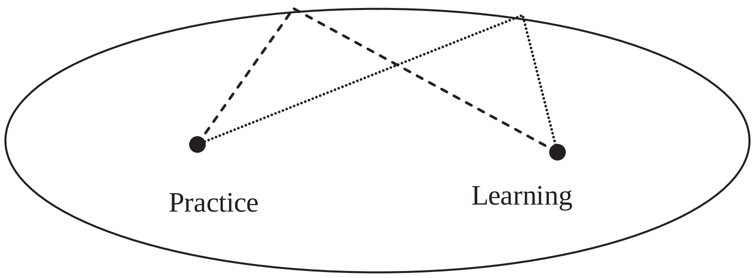
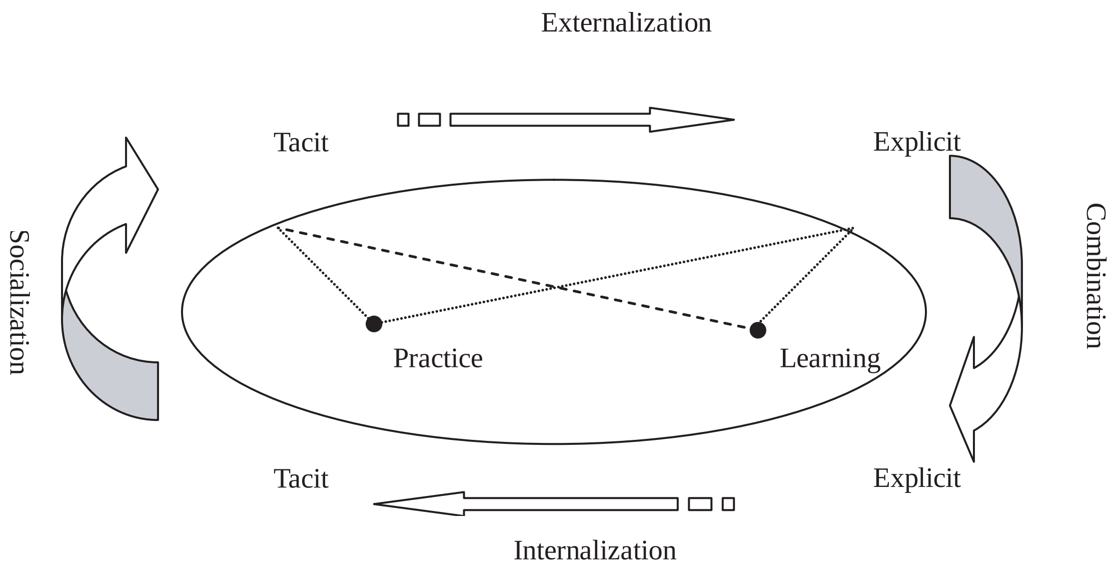


Figure 2. SECI interactions in the community of practice



to the different taxonomies of learning and action, which can also be a topic of another article.

Secondly, we can fit the SECI interactions onto this ellipse of community of practice, benefiting from the attachment of tacit knowledge with bodily experienced practice and explicit knowledge with learnt theory in mind (Nonaka & Takeuchi, 1995). However, by no means do we aim to propose a taxonomy, which could end up with another dichotomy. On the contrary, this modeling suggests that both tacit and explicit knowledge are bound to be together. Then, in the ellipse of the communities of practice, the conversion of knowledge can be enabled, which can lead to the generation of knowledge and development of the CoP (see Figure 2).

Table 2. Local-global (specific-general) interactions

To \ From	Local	Global
Local	LOCAL	GLOCAL
Global	LOBAL	GLOBAL

Then the specific and general knowledge conversions identify the interactions that go beyond individual entities, passing across boundaries. We distinguish these interactions in Table 2.

As suggested earlier, these interactions have relative meaning depending on the positioning of the entity besides other entities and levels (see Figure 3).

It is also possible to reinterpret and visualize SECI conversions as contextual, transboundary interactions as in Figure 4.

The conceptualization of tacit-explicit and specific-general knowledge interactions in a

Figure 3. Specific-general knowledge interactions within and across contextual entities and levels

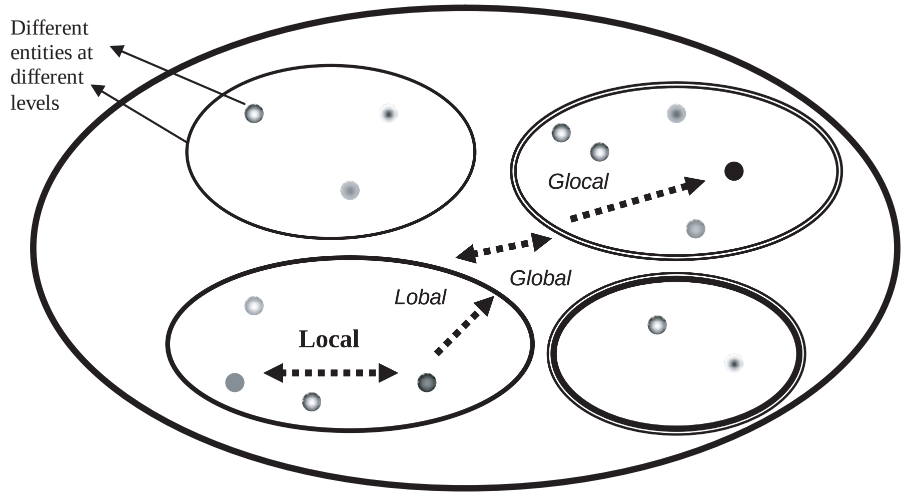
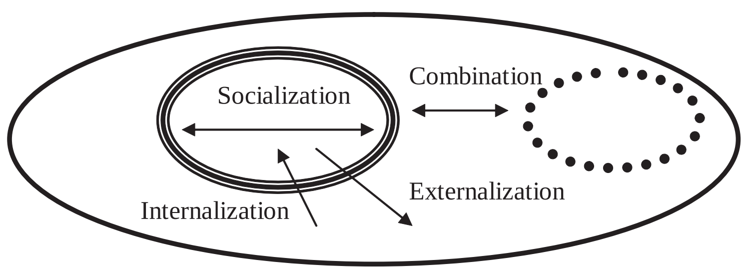


Figure 4. SECI conversions as contextual trans-boundary interactions



context for learning, participation, and knowledge creation highlights the existence of various processes as knowledge conversions or transactions. These processes of tacit-explicit and specific-general knowledge interactions, rather than the so-called "SECI" labels, can then be used to explain important mechanisms and dynamics in organizational knowledge creation and the communities of practice. For instance, a discourse can be seen as making any tacit knowledge explicit, which can only be truly understood with the specific knowledge of the context of that discourse. Relevant explanations can be made for other processes like reflection, justification, empathy, and different ways of learning. Even the tacit-explicit knowledge interaction within the knowledge conversion process itself can be better understood with the recognition of specific and general knowledge interactions. What makes these delicate knowledge interactions possible is the awareness of all participants of the similarities and differences among each other. Candid conversations in informal settings make community members aware of each other's background and personality characteristics, and then they can properly position themselves, adjusting their own attitudes and behaviors for the benefit of all individuals and the community.

FUTURE RESEARCH TRENDS

Distinguishing specific-general knowledge beside tacit and explicit underlines the necessity of a better articulated generic model of knowledge creation, which should aim to incorporate conceptualizations like context (ba or CoP), learning and action–knowledge and knowing (Cook & Brown, 1999); integrate different levels of analysis at individual, group, organization, and society level; and look more carefully to the interactions among various entities at these different levels. According to this, the knowledge interactions in a group can also be understood as knowledge interactions among individuals within the context of the group environment, and the knowledge interactions in an organization as knowledge interactions among individuals and groups within the context of the organizational environment. Moreover they are all under the influence of local, global, 'glocal', and 'lobal' dynamics coming from different levels and entities within and out of their own boundaries. The same applies to communities of practice and the community members, as well.

According to the findings of Easterby-Smith and Lyles (2003) about recent and future research trends, the following are likely to have the greatest impact on knowledge management and organizational learning in the next five years:

- research methods and measures of organizational learning/knowledge management;
- learning across boundaries;
- cognitive, socio-political aspects and tacitness, which also includes CoPs; and
- strategy, technology, and competitive advantage.

Among these, "learning across boundaries" has already become popular and is likely to continue its influence, in sharp contrast to the research on "learning capabilities, experience, and absorptive capacity." Less work has been done on the latter two areas; this is likely to change in the near future (pp. 645-646).

CONCLUSION

These findings point out that research on learning across boundaries and CoPs has a profound place in the literature of organizational development, and of knowledge creation and management. Studies on contextual specific-general knowledge interactions and CoPs, which can theoretically and practically identify and analyze the existing numerous interactions, knowledge transfer, and transitions, can contribute significantly to the knowledge-base of this emerging literature. The obverse is also true, that studies on organizational knowledge management can be used to further our understanding about CoPs and learning interactions across boundaries with regard to these communities and practices.

REFERENCES

Baker, A.C., Jensen, P.J., & Kolb, D.A. (2002). Learning and conversation. In A.C. Baker et al. (Eds.), *Conversational learning: An experiential approach to knowledge creation* (pp. 1-14). Westport, CT: Quorum Books.

Becerra-Fernandez, I., et al. (2004). *Knowledge management: Challenges, solutions, and technologies*. Singapore: Pearson Prentice-Hall.

Burton-Jones, A. (1999). *Knowledge capitalism: Business, work, and learning in the new economy*. Oxford, UK: Oxford University Press.

Cook, S.D.N., & Brown, J.S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organizational Science, 10*(4), 381-400.

Easterby-Smith, M., & Lyles, M.A. (2003). Introduction: Watersheds of organizational learning and knowledge management. In M. Easterby-Smith & M.A. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (pp. 1-16). Oxford, UK: Blackwell.

Easterby-Smith, M., & Lyles, M.A. (2003). Organizational learning and knowledge management: Agendas for future research. In M. Easterby-Smith & M.A. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (pp. 1-16). Oxford, UK: Blackwell.

Gasson, S. (2004). The management of distributed organizational knowledge. *Proceedings of the 37th Hawaii International Conference on Systems Science*, University of Hawaii at Manoa, USA.

Holden, N. (2002). *Cross-cultural management: A knowledge management perspective.* Singapore: Pearson Education.

Jensen, M.C. (1998). *Foundations of organizational strategy.* London: Harvard University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Nermien, A.-A. (2003). *Comprehensive intellectual capital management.* Hoboken, NJ: John Wiley & Sons.

Nonaka, I., Toyama, R., & Byosiere, P. (2003). A theory of organizational knowledge creation: Understanding the dynamic process of creating knowledge. In M. Dierkes et al. (Eds.), *Handbook of organizational learning and knowledge* (pp. 491-517). Oxford, UK: Oxford University Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* Oxford, UK: Oxford University Press.

OECD. (2000). *Knowledge management in the learning society.* Center for Educational Research and Innovation. Paris: OECD.

Penrose, R. (1989). *The emperor's new mind: Concerning computers, minds, and laws of physics.* Oxford, UK: Oxford University Press.

Polanyi, M. (1966). *The tacit dimension.* London: Routledge and Kegan Paul.

Ponzi, L.J. (2004). Knowledge management: Birth of a discipline. In M.E.D. Koening & T.K. Srikantaiah (Eds.), *Knowledge management lessons learned: What works and what doesn't* (pp. 9-28). Medford, NJ: American Society for Information Science and Technology.

Stiglitz, J. (2001). *Joseph Stiglitz and the World Bank: The rebel within.* London: Anthem Press.

Sudarchan, R.M. (2000). New partnership in research: Activist and think tanks. An illustration from the NCAER in New Delhi. In D. Stone (Ed.), *Banking on knowledge: The genesis of the global development network* (pp. 87-103). London: Routledge.

Umemoto, K. (2002). Managing existing knowledge is not enough: Knowledge management theory and practice in Japan. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge* (pp. 463-476). Oxford, UK: Oxford University Press.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation.* New York: Oxford University Press.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2001). Emergence of "ba": A conceptual framework for the continuous and self-transcending process of knowledge creation. In I. Nonaka & T. Nishiguchi (Eds.), *Knowledge emergence: Social, technical, and evolutionary dimensions of knowledge creation* (pp. 13-30). Oxford, UK: Oxford University Press.

Wenger, E. (1998). *Communities of practices: Learning, meaning, and identity.* Cambridge, UK: Cambridge University Press.

Wierzbicki, A. (2004). Knowledge theory at the beginning of the civilization era of informational and knowledge economy. *Proceedings of the 1st International Symposium on Knowledge Management for Strategic Creation of Technology, Ishikawa High-Tech Exchange Center, JAIST.*

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Chapter 4.28
Communities of Practice as Facilitators of Knowledge Exchange

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INTRODUCTION

For knowledge to create value in an organization, whether tacit or explicit, it must have the ability to be shared among employees. This intentional (or in some instances unintentional) flow of knowledge can become the driver for organizational learning. When examining knowledge sharing, it is important to consider the context in which the knowledge is developed, as the community in which the individual is learning can affect any knowledge that is created. Organizational learning is impacted by individuals, groups, and the organization as a whole, and how these three levels are linked by social processes (Crossan, Lane & White, 1999). However, it is very difficult to create the right social environment to produce optimum knowledge sharing and learning. Sharing knowledge is an 'unnatural act', and therefore firms must strive to create the right environment and means to assist employees in overcoming knowledge flow barriers (Ruppel & Harrington, 2001).

Previous research has identified communities of practice as a hub for sharing knowledge within an organization (Brown & Duguid, 1991; Ellis, 1998; Hildreth & Kimble, 1999). The ability of a community of practice to create a friendly environment for individuals with similar interests and problems to discuss a common subject matter encourages the transfer and creation of new knowledge. Practitioners with similar work experiences tend to be drawn to communities, and from this a common purpose to share knowledge and experience arises (Wenger, 1998). Blackler (1995) argues that the creation and deployment of knowledge is inseparable from activity, and different contexts manifest in the form of knowledge boundaries. A community of practice can help individuals remove this boundary through the creation of a common context that links different experiential knowledge in an environment suited for knowledge exchange.

BACKGROUND

Communities of practice bring value to individuals and organizations by allowing for the acquisition of knowledge that supports practice within a role or responsibility. Brown and Duguid (1998) distinguish between two types of knowledge: (1) "know-what" or topical knowledge, and (2) "know-how" or knowledge derived from experience and action. They define "know-how" as the ability for an individual to take his or her "know-what" knowledge and put it into practice.

Other perspectives focus on the knowledgeability of action (Orlikowski & Yates, 1994). Here the verb knowing is stressed, rather than the noun knowledge. The emphasis on the interactive requirement for individual learning rather than the passive receipt of knowledge is a perspective that fits well with communities of practice. The use of the verb participation, a requirement for membership within a community of practice, also suggests that knowledge is created and shared from participation in experience and active membership within a community. An individual's ability to know is inseparable from practice and context.

Communities of practice follow the logic that knowledge cannot be separated by practice, as what is learned is highly dependent on the context where the learning takes place (Hayes & Walsham, 2001). The concept of legitimate peripheral participation (LPP) is derived from this notion, as it postulates that members who are allowed the opportunity to fully participate in community activities begin to behave as community members, or as practitioners. It is through this membership that knowledge can be shared with the rest of the community. Learning within a community is situated, as it occurs through people interacting in context. The learner's situated perspective, including physical and social context, become an important aspect in their learning and interaction with the community (Lave & Wenger, 1991).

In some cases, a familiar context or environment becomes a crucial factor in a practitioner's ability to deal with unfamiliar, unstructured problems (Tyre & von Hippel, 1997). These members must have access to the periphery of the practice, which allows for either observation or participation in the practice that eventually contributes to their decision to join the community. The term periphery is not used in the geographical sense, but as the degree of involvement an individual may have with the community. Their participation must eventually become legitimized (though not in the formal sense), in order to empower the participants to participate in learning and personal development.

Knowledge is situated within these communities through the situated learning curriculum that is unique to each community of practice. Newcomers can access this curriculum to gain the common knowledge resident in the community as a first step towards full participation. However, learning is an improvised practice, and eventually the participant must go beyond this notion of structure and curriculum to acquire knowledge. Therefore, participation in any community where knowledge exists can be defined as the act of learning (Lave & Wenger, 1991).

Communities of practice are able to assist an individual with this knowledge conversion as long as the participants are situated within the same community. The transfer of knowledge across communities becomes more challenging due to the "sticky" nature of knowledge. As knowledge is situated within a particular context, the removal from this context may distort its value or meaning. Various means of overcoming this obstacle have been proposed. Boland and Tenaski (1995) propose the use of communication forums that span multiple communities, while both Star (1989) and Carlile (2002) support the use of boundary objects.

Facilitating Knowledge Sharing

Lesser and Storck (2001) examined communities of practice by identifying their influence on a firm's social capital. Social capital, or "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit " (p. 833), emphasizes the value of a cohesive group in organizational learning. This value can clearly be seen through examining the three dimensions of social capital: the structural dimension, the relational dimension, and the cognitive dimension. The following considers each dimension and the related factors that encourage knowledge flow and learning.

The structural dimension refers to the ease of which individuals can make connections with other similar practitioners. It identifies the processes, resources, and tools the community creates in order to augment and encourage social interactions. These may be in the form of physical resources, such as systems, or intangible resources such as face-to-face meetings and communities of practice.

Communities of practice can bring many structural benefits to an organization's knowledge sharing initiatives. They promote the use of IT tools in knowledge sharing, which can stimulate the use of this infrastructure and create a well-networked organization by use of the provided resources. Distributed cognitive theory addresses how learning in such a collaborative environment takes place. It defines a person's horizon of observation as the portion of the workspace that a participant can observe or monitor. Technologies designed for communities and knowledge sharing expand a member's horizon of observation, allowing for the identification of different knowledge sources that can contribute to the learning within the community. These technologies typically incorporate tools such as recorder tools, forums, local memory storage, and other knowledge collection aids in order to increase the spread of knowledge (Eales, 2003).

The community can act as a boundary-spanning object for geographical barriers through its distributed social nature and its ability to successfully use global IT resources. By allowing communities to work or partner with other company functions, they can become the facilitator for knowledge transfer, and encourage these functions to develop new knowledge. This situates them in the role of the educator in organizational learning. When implementing a knowledge strategy, the leadership within an organization can employ communities of practice to communicate the vision of a knowledge organization, set knowledge-related priorities and funding levels, facilitate communication that crosses business unit boundaries, encourage employee participation, and ensure alignment of company-wide systems and policies (Wenger, McDermott & Snyder, 2002).

The second dimension of social capital is the relational dimension. Here, the interpersonal relationships and activities of interaction come together to create a community that is not only willing, but also trusting and caring to share information with others.

Useful or valuable knowledge in organizations is often developed not by specialists or the people known for their subject matter expertise who are detached from the problem, but those who can operationalize the problem based on their work and who stand to benefit directly from the solution. These people are usually members of the community of practice where the solution is discovered (Brown & Duguid, 2001). By possessing a common goal for community (such as problem solving), relational capital is formed.

One method of determining how communities of practice share knowledge is by examining why people participate in these communities. A participant's motivation and justification for involvement will shed light on how knowledge is transferred. Wasko and Faraj (2000) view knowledge with the perspective that it is embedded not only in individuals and organizations, but also communities. Therefore knowledge can be managed as a public good, which is defined as "a commodity that can be provided only if group members contribute something towards its provision: however, all persons may use it" (p. 156). Organizations can be conceptualized as a group of overlapping communities that treat knowledge as a public good. The role that these communities play in knowledge flow throughout the organization is crucial.

Employees' motivation to exchange knowledge is impacted by their view that the decision to participate in such communities is either primarily economic and motivated by self-interest, or non-economic and motivated by community interest and moral obligation. This perspective can determine what stimulates an employee to share knowledge in a community of practice. Some participants become involved to generate tangible returns, such as access to useful information and expertise, answers to specific operational questions, and personal gain. They find that information received is up to date, compared to other sources such as company manuals or other information sources. In some cases, an individual can receive personal gain, including enhanced standing in the profession, a better reputation, or even to generate personal business. On the other hand, a community of practice can be a source of intangible benefits to its members, in the form of intrinsic rewards. Certain people find participation challenging, refreshing, and a means to refine their thinking in order to develop new insights. These individuals enjoy learning and sharing with others, and become confident with their expertise. They can also enhance their own personal learning through exposure to a variety of viewpoints from around the world. These are people that believe helping people is "the right thing to do" (Wasko & Faraj, 2000).

The final dimension of social capital is the cognitive dimension. This dimension provides a common context that allows for the efficient transfer of knowledge between individuals. It provides not only a common language, but addresses acronyms, subtleties, and underlying assumptions that are common to the daily operations of members. It can provide taxonomies for the classification of knowledge, and means that allow for knowledge transfer.

Knowledge flows most efficiently when seekers and experts are considered members of the same community and thus share the same values, norms, processes, and narratives. Furthermore, this flow is supported through making knowledge available that is deemed useful, timely, and helpful to the community (Wasko & Faraj, 2000). However, Pan and Leidner (2003) argue that organizations need to provide multiple channels of communication to support diverse knowledge sharing needs and preferences. The boundary of a community of practice should be dynamic and include other functions, people, and external sources. This generates the requirement to consider issues such as the need for a shared context, language, and culture, which can be nourished through motivation to share knowledge with individuals from different communities or the expansion of existing groups.

Many people have argued that larger organizations do not have the structure or capability of producing continuous and valuable innovation. However, with an organization of communities as described in Brown and Duguid (2001), large organizations supported and recognized by the larger community can develop these smaller, specialized communities. This potentially develops the capability of producing new knowledge, whether individually or in conjunction with other overlapping communities. Thus, larger organizations that are 'reflectively structured' are well positioned to be both highly innovative and capable of dealing with high degrees of change.

Challenges for Communities Sharing Knowledge

In many cases, the simple establishment of a community of practice will not contribute towards knowledge sharing. Underlying factors in either its design or the individuals participating can block members from interacting and sharing their knowledge. Participants will not contribute to the knowledge sharing within a community of practice for many reasons. For example, if they are not comfortable with their level of expertise, they become the victim of attacks on their ideas and opinions, or become overwhelmed with too much information being circulated. As well, a community that provides knowledge that is not useful or not interesting to its members creates the concern that participation is too time consuming and not a valuable use of time or resources (Wasko & Faraj, 2000).

In some organizations, employees may not feel the organizational climate provides a safe or desirable forum to share their valuable knowledge. Communities of practice can provide safe enclaves from organizational social-political pressures and encourage further knowledge sharing. Safe enclaves are characterized by shared electronic and non-electronic social spaces that allow for underlying views to be expressed. When communities are used for political purposes, it has been found the participation from members is very limited. It is common for managers and those removed from the community to attempt to influence or govern these communities from a distance, which also negatively influences participation. Genuine participation only occurs when the use of technology does not mirror the career or financial reward structure, or the control activities of senior management (Hayes & Walsham, 2001).

FUTURE TRENDS

A recent trend in the knowledge management field is to look beyond a firm's external boundaries for new sources of knowledge. Knowledge management strategies are encompassing not only the focal organization, but its partners, suppliers, and customers. Organizations will receive further knowledge benefits from communities of practice as the communities encompass individuals and knowledge assets located outside the organization. This partnership in knowledge sharing, with the community as the base of the relationship, will infuse new knowledge into the community and expand its knowledge creation capabilities.

Communities of practice are increasing their functional contributions within organizations by closer aligning with corporate strategies. A community that has grown within an organization can be formalized to contribute to the operations of the business, while serving its members in the original intended fashion. For example, instead of forming a product development team, an organization can utilize an existing community of practice to identify and involve the most appropriate people who possess the relative knowledge and skills. These formalized communities of creation have advantages over non-formal communities as they receive management recognition and support, priority in resource allocation, and increased recognition for their members' contributions. Eventually, these formalized communities will be the product or system development team, rather than an ad hoc assembly of staff.

As communities of practice become more fully integrated into job functions and business processes, they will become visibly integrated within the organization. As an organization is a community consisting of smaller communities, the boundary between communities and the formal structure of the organization will become seamless, and each new department or working group will have traits similar to communities already found in organizations. The social benefits of these communities working for a common goal under a common community structure will impacts the organization's social capital, its employee productivity, and its success in the marketplace.

CONCLUSION

Communities of practice have the capability to grow an organization's social capital through the increase in knowledge sharing that naturally occurs within these communities. By connecting individuals with similar experiences and interests, creating relationships between individuals and groups who may have not had the opportunity to meet through the formal structure of the organization, and providing a common context that encourages people to share their knowledge, a formal or informal community of practice can create the foundation for successful knowledge sharing within an organization.

Communities of practice can result in the following benefits to an organization and its knowledge strategy (Wenger et al., 2002):

1. create new business opportunities by developing internal expertise and relationships with an organization's customer base, resulting in the conversion of insights into new products;
2. reconstitute expertise that can become lost in a dynamic organization, and create a method of locating such expertise;
3. enable companies to compete on talent, then for talent—by becoming known as a home for experts that encourages the development of skills and expertise by employees; and
4. capitalize on the participation in multi-organizational communities of practice—by extending the firm's knowledge resources beyond its traditional boundaries.

Also noted by Brown and Duguid (2001), communities can design, develop, and maintain significant repositories for the storage and dissemination of knowledge throughout the organization. Although these repositories may be technical in nature or located in the individuals who hold the knowledge, the community becomes an identified source for knowledge on a particular subject matter. As organizations recognize the importance of supporting and maintaining communities of practice, they will experience increased knowledge capabilities and business success.

REFERENCES

Blackler, F. (1995). Knowledge, knowledge work, and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Boland, R.J., & Tenkasi, R. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, J. E., & Duguid, P. (1998). Organizing knowledge. *California Management Review, 40*(3), 90-111.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-57.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Carlile, P.R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science, 13*(4), 442-455.

Crossan, M.M., Lane, H.W., & White, R.E. (1999). An organizational learning framework: From intuition to institution. *Academy of Management Review, 24*(3), 522-537.

Eales, R.T.J. (2003). Supporting information communities of practice within organizations. In M. Ackerman, V. Pipek & V. Wulf (Eds.), *Sharing expertise: Beyond knowledge management* (pp. 275-295). Cambridge, MA: The MIT Press.

Ellis, S. (1998). Buckman Laboratories Learning Centre. *Journal of Knowledge Management, 1*(3), 189-196.

Hayes, N., & Walsham, G. (2001). Participation in groupware-mediated communities of practice: A social-political analysis of knowledge working. *Information and Organization, 11*, 263-288.

Hildreth, P., & Kimble, C. (1999). Communities of practice in the international environment. *Proceedings of the 2nd Workshop on Understanding Work and Designing Artefacts: Design for Collaboration,* King's Manor, University of York, UK.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lesser, E.L., & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal, 40*(4), 831-841.

Orlikowski, W.J., & Yates, J. (1994). Genre repertoire: The structuring of communitive practices in organizations. *Administrative Science Quarterly, 39*(4), 541-574.

Pan, S.L., & Leidner, D.E. (2003). Bridging communities of practice with information technology in pursuit of global knowledge sharing. *Journal of Strategic Information Systems, 12*(1), 71-88.

Ruppel, C.P., & Harrington, S.J. (2001). Sharing knowledge through intranets: A study of organizational culture and intranet implementation. *IEEE Transactions on Professional Communication, 44*(1), 37-52.

Star, S.L. (1989). The structure of ill-structured solutions: Heterogeneous problem-solving, boundary objects and distributed artificial intelligence. In M. Huhns & L. Gasser (Eds.), *Distributed artificial intelligence* (vol. 2, pp. 37-54). Menlo Park, CA: Morgan Kauffman.

Tyre, M.J., & von Hippel, E. (1997). The situated nature of adaptive learning in organizations. *Organization Science, 8*(1), 71-83.

Wasko, M.M., & Faraj, S. (2000). "It is what one does": Why people participate and help others in electronic communities of practice. *Journal of Strategic Information Systems, 9,* 155-173.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W.M. (2002). *Cultivating communities of practice.* Boston: Harvard Business School Press.

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Chapter 4.29
A Qualitative Study of the Characteristics of a Community of Practice for Knowledge Management and Its Success Factors

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ABSTRACT

A Community of Practice (CoP) is an organizational form receiving increasing attention as a structure for sense making, knowledge management and learning. The central question addressed in this article is how and why these communities form and grow over time. These questions are explored through a qualitative analysis of a CoP formed to help knowledge management practitioners. In this case study, a description of how the organization formed, survived, grew and matured over a five-year period (1999-2004) is given. Several practices and structures related to CoP development are identified; for example, operations, roles and responsibilities, communications, sub-group structures, use of information technologies and other aspects of organizing. Using data from several sources (e.g., membership surveys, interviews with key informants, document analysis), four sets of factors that have helped this organization succeed are identified: Individual, Content, Meeting and Organizational. These factors are arranged into a preliminary descriptive model of the function and structure of CoPs over the life cycle. To practitioners, the work sheds light on how to set up and successfully grow a community of practice.

OVERVIEW AND OBJECTIVES

A CoP should have the ability to sustain and renew itself over time (Barab & Duffy, 2000).

This observation raises several questions. How are CoPs formed? Why do some survive? What is inherent in the structures and operations of successful CoPs that allow them to stay in existence? What other critical success factors are required, such as intrinsic or extrinsic rewards for members? The purpose of this study is to better understand CoPs, how and why they form, and what sustains them over time.

The answers are important to theory and practice. To theory, it can shed light on loosely structured extra- and intra-organizational forms and the factors that lead to their success over the life cycle. We define CoP success here as effectively forming, being in existence for a significant period of time and showing continued signs of growth and development. To practice, the answers provide insight for individuals who wish to set up a successful, long-term CoP within their organizations as part of a broad knowledge management (KM) strategy. For those specifically interested in developing KM-centered CoPs, this study provides insights into the formation, survival and growth of such structures.

LITERATURE REVIEW: CHARACTERISTICS OF COPS

This article is grounded in the literature on CoPs, organizational memory (OM) and KM. The concept of a CoP has emerged as a useful construct to describe a social form that has been in existence for centuries (e.g., guilds), but has been recently been "rediscovered" in the context of corporations and applications in KM. The concept owes its early modern formulation to the works of Lave (1988, 1991), Wenger (1998), Lave and Wenger (1991) and Brown and Duguid (1991, 2001). Initial works focused on the shared meaning and knowledge that developed in occupational groups such as midwives and butchers (Buysse, Sparkman & Wesley, 2003) or repair specialists (Iverson & McPhee, 2002). It now is applied to any knowledge-sharing group within and between organizations (Brown & Duguid, 2001; Swan, Scarbrough & Robertson, 2002) and is viewed as a non-technical component of many KM strategies.

Definition

The definition of a CoP has evolved over time. Wenger, McDermott and Snyder (2002) see a CoP as a set of people who "… share a concern, a set of problems or a passion about a topic, who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (p. 4). Buysse, Sparkman and Wesley (2003) observe that "… a community of practice generally can be defined as a group of professionals and other stakeholders in pursuit of a shared learning enterprise, commonly focused on a particular topic…" (p. 4). Swan, Scarbrough and Robertson (2002) define a CoP as "an activity system about which participants share understandings concerning what they are doing and what that means in their lives and for their community. Thus, they are united in both action and in the meaning that that action has, both for themselves and for the larger collective" (p. 2). Brown and Duguid (1998) observe that "… collective practice leads to forms of collective knowledge, shared sense-making and distributed understanding that doesn't reduce to the content of individual heads. A group [in which] such know-how and sense-making are shared … has been called a 'community of practice'" (p. 5).

Characteristics

Wenger's (1998) work specifies three characteristics of CoPs: mutual engagement (i.e., interaction among the members), negotiation of joint enterprise (i.e., enacting meaning and significance; defining goals and priorities) and shared repertoire (i.e., the stories, methods, tools and theories used by members). The works of Buysse, Sparkman and Wesley (2003) and Barab and Duffy (2000) define three essential characteristics of CoPs: (a) shared cultural and historical heritage, as well as shared goals and meanings; (b) interdependent participants who are part of a larger social system; and (c) a reproductive cycle whereby older members leave and new members enter the community. Wenger's most recent work (2004) identifies three characteristics of a CoP that differ from his earlier works: (a) Domain (i.e., the area of knowledge that brings the community together); (b) Community (i.e., the group of people for whom the domain is relevant); and (c) Practice (i.e., "the body of knowledge, methods, tools, stories, cases, documents which members share and develop together" (p. 3)).

A careful reading of the prior works suggests that five distinct aspects of CoPs identify them as such:

1. A knowledge domain of interest;
2. A set of interested and interconnected participants;
3. Opportunities for ongoing processes of sense-making, knowledge sharing and discovery within the domain of interest;
4. A set of resources related to the domain of interest, including methods, tools, theories, practices and so forth, that are acquired, retained and accessible by the community; and
5. Processes by which the community maintains and refreshes its membership.

These five criteria are useful in distinguishing between CoPs and other similar but more narrow forms of organization such as communities of interest (CoI), communities of learners and learning communities (Barab & Duffy, 2000; Buysse, Sparkman & Wesley, 2003). For instance, communities of interest share only some, but not all of the characteristics of CoPs. According to Walters and Clark (1996, p. 1): "Communities of interest or electronic communities … offer people who live in the same locale and share common interests and concerns a virtual place to exchange information." The distinct focus of a CoI is on electronic information exchange, as opposed to the far-richer concept of sense making and enacted meaning found in CoPs; that is, sense making is seen as a key distinguishing feature of CoPs. The importance of sense making to organizing is found in management literature in several works. Sense making in organizations has been seen as a critical factor related to crisis management (e.g., Weick, 1979, 1995), strategic management (Gioia & Chittipeddi, 1991), organizational learning, knowledge management and performance (e.g., Thomas, Clark & Gioia, 1993; Thomas, Sussman & Henderson, 2001), creativity in organizations (e.g., Drazin, Glynn & Kazanjian, 1999), product innovation (e.g., Dougherty, Borrelli, Munir & O'Sullivan, 2000), managing organizational complexity (e.g., Moss, 2001) and information technology use (e.g., Griffith, 1999).

Another defining characteristic of CoPs is their ability to process knowledge through knowledge discovery, retention and use. This function finds support in the literature on organizational memory (e.g., Ackerman & Halverson, 2000; Anand, Manz & Glick, 1998; Cross & Baird, 2000; Croasdell, 2001; Moorman & Minor, 1997, 1998; Nissley & Casey, 2002; Rulke & Rau, 2000; Stein, 1995; Stein & Zwass, 1995; Walsh & Ungson, 1991; Wijnhoven, 1999; Wishart, Elam & Robey, 1996) and KM. According to OM research, organizations intentionally construct, acquire, retain and retrieve organizational memories to support organizational activities (e.g., positive memories) and adapt to cope with the effects of outdated knowledge and information (e.g., negative memories).

Knowledge management has been defined in the works of Nonaka (1994, 1995, 2001) and others as inclusive of the processes of knowledge creation, transfer and use. Earl (2001) segments KM interests and application into three areas. The first area (Technocratic) focuses on the use of information technologies to achieve such KM goals as knowledge retention and retrieval. The second area (Economic) pertains to how organizations use knowledge for competitive advantage and to formulate business strategies (e.g., Davenport, 1998). The third area (Behavioral) is most closely aligned with this work, which "… describes the use of organizational structures, or networks, to share or pool knowledge. Often described as 'knowledge communities,' the archetypal organizational arrangement is a group of people with a common interest, problem or experience" (Earl, 2001, p. 6). In a similar vein, Demarest (1997) divides the KM world into two parts: one that makes knowledge explicit and stores it using information technologies, or one that facilitates the growth and enrichment of knowledge through the formation of social networks bound by communication and learning processes. CoPs, it can be argued (Iverson & McPhee, 2002) offer "… a theoretical construct for understanding the interactive roles of information systems and people and also as a model for understanding how KM is negotiated communicatively between people" (p. 1). Brown and Duguid (1998) also recognize the importance of CoPs to KM, but caution that they "can easily be blinkered by limitations of their own world view" (p. 5). Less circumspect, Wenger (2004) argues that "communities of practice are the cornerstones of knowledge management" (p. 1). At the least, CoPs can be viewed as a means of implementing KM in organizations. For example, organizations reluctant to commit resources to KM information technologies often start with CoPs because they are perceived as a low-cost alternative. Others simply want to test the KM waters and view CoPs as a means of doing so. To those that embrace the human side of organization, CoPs are considered the primary way to implement KM.

In summary, CoPs are a useful social form that has been in existence for many years. Studies of these systems have illuminated much about their functional aspects; that is, ability to process knowledge and information, and usefulness to its members or to the organizations that support them. On the other hand, less is known about their actual structures, how they come into existence, how they grow and how they are self-sustaining over time. The goal of this article is to explore the evolution of CoPs and the organizing activities that contribute to longevity and success.

RESEARCH QUESTIONS AND PROPOSITIONS

The following research questions and propositions (see Table 1) were framed based on the author's field experience and the literature review. The central questions are: Why (and how) are some CoPs able to smoothly move from one life cycle phase to another? Why are some CoPs in existence for several years without a formal budget or commitment of resources? In short, this research hopes to identify the organizational factors that have led to success. These include motivational factors (e.g., what motivates organizational leaders and members to contribute) and factors related to context, knowledge content, organization and structure. The study also addresses several how-to questions related to CoP formation and development; for example, operations, roles and responsibilities, meeting management and so forth, which are of particular relevance to practitioners.

The propositions are grouped according to the life-cycle phases of organizations; that is, from formation to maturity. The concept of the organizational life cycle is not new, appearing first in the works of Haire (1959) and Chandler (1962), and later in several works in organization theory. Gupta and Chin's (1994) extensive review identifies five areas of impact on management literature: organizational effectiveness (e.g., Quinn & Cameron, 1983); entrepreneurship (e.g., Smith & Minor, 1983); strategy making (e.g., Gupta & Chin, 1992); organizational power (e.g., Mintzberg, 1984); and organizational politics (e.g., Gray & Ariss, 1985). The concept (which is applied typically to formal organizations, such

Table 1. Research questions and propositions

Research Questions	• Why are CoP's formed? How? • Why do some CoP's endure for years after they are formed? • Why do people join and contribute to a knowledge-based CoP? • How is a CoP structured? How is a CoP operated? • What benefits does a CoP deliver to its members?
Research Propositions	*Formation Propositions* • CoP's can form from a single meeting or presentation • The cost to form a CoP is low and only requires a small investment in a meeting place and refreshments • To ensure its survival, a core set of participants must commit to future meetings and establish means of communication and coordination
	Survival and Early Growth Propositions • Having a clearly defined and executed mission is important to survival and growth • Social networks of the members are important to survival and growth • Knowledge assets of the members are important to survival • Organizational champions are a key to survival • Pooled resources are a key to survival and growth
	Late Growth and Maturity Propositions • CoP's provide explicit benefits to members at meetings; e.g., topic, knowledge exchange, as well as implicit benefits such as recognition, affinity, expanding social networks, and emotional support • CoP's create organizational structures, establish roles and responsibilities, and create procedures to ensure operational efficiency and to move from survival to growth • CoP's can choose that its structures and processes remain informal and low-cost • Information technologies and communication processes play a key role in ensuring a CoP's continuation
	Decline or Renewal Propositions • CoP's that adapt to changing conditions will experience renewal • CoP's that fail to adapt to changing conditions, modify its mission, or recruit new members will experience decline and cease to exist.

as corporations) contends that organizations go through various stages throughout their development, pursuing different ends and exhibiting different characteristics over time. Most works specify a four-stage model: Formation, Survival and Early Growth, Late Growth and Maturity, Decline or Renewal.

The formation phase is characterized by the development and implementation of a plan or vision, acquisition of resources and fulfillment of customer needs (Jawahar & McLaughlin, 2001). In the survival and early growth phases, the organization stabilizes its position and pursues opportunities for expansion. Most organizations focus on product or service reliability and work to formalize organizational structures (Dodge & Robbins, 1992, Jawahar & McLaughlin, 2001). In the mature phase, the organization becomes more confident in its abilities but also more risk adverse. The rate of growth has slowed by this time and there is some uncertainty regarding new opportunities (Jawahar & McLaughlin, 2001). Finally, the organization faces a crisis: It reinvents itself and transitions to a new cycle or it goes into a decline phase that leads to its eventual termination.

These stage distinctions are useful in grouping the research propositions with the understanding that CoPs differ from formal organizations in important ways, yet they share some of the same evolutionary life-cycle characteristics.

RESEARCH DESIGN AND METHODS

A single case study design was chosen for this research. Case studies offer an opportunity to examine an organization in depth through the development of rich description.

Case Selection

A CoP devoted to knowledge management that has been viable for more than five years was selected for this study. This organization met the five criteria identified for CoPs as noted above: a domain of interest, set of interconnected participants1, opportunities for sense-making, tools and supporting resources and mechanisms for renewal (see Table 2).

Types of Data Collected

Data for the case came from multiple sources to provide cross checks of validity and to triangulate the results as suggested by Yin (1989) and Eisenstadt (1989). In general, the overall rigor of case studies can be increased by using multiple sources, establishing a chain of evidence and having key informants review drafts of the work (Yin, 1989). These methods were employed to the greatest extent possible in this study. The work is considered exploratory in nature and accompanied by the caveats that apply to such research.

Data sources included documents, interviews, surveys and participant observation by the author (the latter has been an executive member of the organization for more than five years). Documents were collected from the organization, including schedules, Web materials, lists, membership databases, minutes of meetings, postings of threaded discussions and e-mails. Interviews and surveys were conducted with present executive committee

Table 2. Characteristics of study case as CoP

Characteristic	Value
A knowledge domain of interest?	Yes. Knowledge management theory and practice
A set of interested and interconnected participants?	Yes. Drawn from area businesses and universities. Bound by strong to weak ties.
Opportunities for on-going processes of sense-making, knowledge sharing, and discovery within the domain of interest?	Yes. Monthly meetings and Executive Committee meetings. Threaded discussions on-line.
A set of resources related to the domain of interest including methods, tools, theories, etc.?	Yes. Knowledge is retained in people's heads and the documents produced by the community (e.g., presentations from the monthly meetings made available through the organization's web site).
Processes by which the community maintains and refreshes its membership?	Yes. The organization has grown from ten members to over two hundred over a five year period. New members attend and are added each month.

members to test assumptions and propositions regarding the organization. Surveys were also conducted with the entire membership. In addition to these sources of data, data regarding the organization were collected by the author as a participant-observer within the organizational setting. All data were collected using instruments and methods approved by the University's Office for Research Protections, which ensures the protection of human subjects according to federal guidelines.

Form of the Report

The data were compiled into three sets of findings and a case discussion section. The case discussion ties the findings back to the research questions and propositions noted in Table 1. Preliminary models are provided of the factors that contributed to the success of the organization. The insights of the discussion section are grouped according to the life cycle stages noted earlier.

FINDINGS 1: CHARACTERISTICS OF THE CASE ORGANIZATION

These findings are based on the collection, compilation and analysis of existing documents, informal discussions with members and participant observation.

Formation and History

The organization chosen for study was the Knowledge Management Group of Philadelphia, from its inception in April 1999 to April 2004. This is the third-longest continuously running KM group of this kind in the United States (U.S.) as of this writing. The organization has been through the formation, survival and growth phases and is in, or moving toward, a state of maturity2. The group evolved from a meeting held in March 1999. The original meeting described KM strategies and practices at Hewlett-Packard, with particular emphasis on its consulting division. Based on the interest generated by this meeting, a meeting sponsored by the local-area Chamber of Commerce was held in April 1999 to explore the possibility of starting a KM learning community. About 50 people attended this meeting, representing industry and academia. At the meeting, a handful of people willing to lead future meetings were identified. These eight people represented several industries, including education, engineering, energy, government and consulting. Of the eight, five became active members of an Executive (Steering) Committee (EC). The role of the EC was to coordinate and host meetings and set the organization's direction. The group met once a month in the morning throughout the calendar year (after the first year, meetings in July and August were not scheduled due to vacations and work slow-downs). As of April 2004, the group successfully concluded its fifth year of activity, having held more than 52 meetings. The group has more than 240 registered members.

Goals and Objectives

The stated aims of the KM Group are:

The Knowledge Management Group (KMG) was formed to address the needs of area organizations in managing knowledge assets. Knowledge assets include intellectual capital (e.g., what employees know, patents), procedural knowledge contained in documents and administrative structures and knowledge embedded in information systems.

Knowledge management includes activities related to the creation, capture, organization, maintenance, retrieval and use of organizational knowledge to promote improved decision-making and performance. KMG's goal is to promote the sharing of KM best practices, to provide a forum for group problem solving on KM problems, and to encourage networking and professional col-

laboration in the area of KM. (Reference: www.kmgphila.org)

Thus, the explicit goals of the group are to (a) to promote networking, and (b) to promote learning and shared understanding about KM. The group promotes networking between professionals in the area who work for knowledge-intensive organizations. These include pharmaceutical firms, consulting firms, software developers, manufacturers and academic institutions. The main learning objective is to share the latest theoretical and practical knowledge among the members. Each meeting is structured around a theme or idea, and presentations are made by member companies or by outside experts. The meetings provide a forum to challenge assumptions, foster sense making, absorb new ideas and developed a shared understanding of the domain.

Meetings

Meetings are scheduled on the second Wednesday of the month from 7:45 to 9:45 a.m. to allow members to attend and then return to work. The first half hour is devoted to networking. At 8:15 announcements are read, an introduction is provided to KMG and, time permitting, members introduce themselves. The main part of the meeting lasts about one hour, followed by questions/answers. People leave around 9:45 a.m. or stay to discuss issues informally. About two-thirds of the meetings are located in the suburbs, and one-third take place in the city to encourage a broad cross-section of attendees. Topics range from presentations of theory and frameworks (e.g., "Teams and the Social Construction of Knowledge") to case studies (e.g., "KM at the DuPont Company") to experiential exercises (e.g., "Knowledge Acquisition and Retention") to sessions about KM tools and strategies (e.g., "Communities of Practice," "IT support for KM")3. The meetings range in size from 30 to 50 people.

Membership

The organization began with a core group of about 20 members. After five years, the database of members included more than 240 members from several industries and organizations. Statistics summarizing the industries and positions held by the membership are presented in Table 3. About 40% of the members in the database consistently attend meetings. The largest percentage of organizations comes from the information technologies sector (18%), followed by pharmaceuticals (12%) and consulting (9%). Managers and senior mangers from these companies make up almost one-third (33%) of the attendees, followed by information technology (15%) and KM professionals (10%). The majority of the firms (>65%) are located outside the city in its suburbs or neighboring states.

Administrative Structures

The primary administrative structure of the organization is the EC. The purpose of the EC is to select topics for future meetings, find host sites, set policy and procedures, and guide the group. Members of the EC serve on a voluntary basis. The committee is composed of members of large and small organizations, consultants and academics. The board strives for a balanced representation of these three groups. Two of the current members, including the author, have been in the organization since its start in 1999. The EC members have both breadth and depth of knowledge about its activities.

The EC meets the Friday following the monthly meetings and conducts an after-action review of the event. These members are responsible for the running of the organization and have the highest levels of participation among the membership. In 2003-2004, the EC was composed of eight members. Membership on the EC requires taking responsibility for the welfare of the group. These

Table 3. KMG-P membership by organization type, job title and geography

Organization Type	Count	%
Consulting	22	9%
Engineering	9	4%
Finance	5	2%
Government	9	4%
Insurance	8	3%
Information Technologies	43	18%
Manufacturing	16	7%
Other	39	16%
Pharmaceutical	29	12%
University	14	6%
na	47	20%
TOTAL	241	100%

Job Title/Type	Count	%
Consultant	13	5%
Professor	11	5%
Information Professional	35	15%
Knowledge Mgt Professional	24	10%
Library Professional	3	1%
Manager	32	13%
Senior Manager	48	20%
na	75	31%
TOTAL	241	100%

Location	Count	%
City	33	14%
Suburbs	157	65%
na	51	21%
TOTAL	241	100%

Notes:

1. Organization Type table does not include 47 unidentified cases (Total N=241).
2. Job Type table does not include 75 unidentified cases (Total N=241). Classes based on job title.
3. na = data not available or in database.

requirements are noted on the organization's Web site, which evolved over the five-year period and were not codified until the fifth year.

Several roles and responsibilities evolved over time within the EC group to meet the needs of running the organization. The most important logistical issue to deal with each month is to select a topic, get a speaker and find a venue to host the meeting. Ongoing activities include managing the membership list of names, the Web site and the

Table 4. Requirements for application and roles and responsibilities of EC members

Requirements for Application to the EC
• Attend and participate in KMG meetings for 6 months or more prior to application • Assist in the planning and management of one or more KMG meetings prior to application • Contribute to the intellectual capital of the KMG meetings for 6 months or more • Be nominated for participation on the board by two or more EC members • Commit to regularly attend and contribute intellectual assets and time to monthly main and EC meetings if elected to EC

Role*	Responsibility	Tasks
Meeting Coordinator	Take responsibility for coordinating the hosting of one or more meetings per year	• Find venue • Arrange for refreshments at meeting • Manage logistics at meeting
Speaker Coordinator	Take responsibility for obtaining a speaker for one or more meetings per year	• Find and manage speaker • Introduce speaker at meeting
Resources Coordinator	Solicit and identify resources on behalf of the organization	• Obtain in-kind services, host locations, etc.
Management Coordinator	Manage meeting and participate in the internal running of the organization	• Select topics for calendar year • Set agenda for EC meetings • Run meetings
Communications Coordinator	Manage communications of the organization	• Communicate announcements of meetings to members via email • Manage Web site • Manage Yahoo groups
Membership Coordinator	Maintain and grow membership	• Solicit new members • Manage member database

*Note: some roles are shared among one or more members

threaded discussion group on Yahoo. See Table 4 for a complete list of the requirement, roles and responsibilities of EC members.

IT and Communications

Information technology and related procedures have played a role in the development of the organization. The member database was one of the most important.4 A database (e.g., in MS Word or Excel) of members was set up early in the first year. The database was populated with information obtained at monthly meetings, through referrals and through the organization's Web site. At the monthly meetings, attendees sign in or verify contact information on a list. This information is used to augment or keep up to date the member database. The member database is central to the notification process of upcoming meetings. For instance, an e-mail is sent out about two weeks prior to a meeting announcing its whereabouts and the topic. The mailing list is not used for commercial purposes.

Notice of upcoming meetings is also posted on the organization's Web site. The Web site was started in the second year of the organization and includes a meeting calendar, links to other KM sites, a list of EC members and sponsors, contact information, document archives and member sign-up. The Web site was designed, maintained and hosted by one of the EC members5 for the first five years. More recently, it is hosted using an inexpensive ISP and is jointly maintained by two EC members.6 Calendars for each year are archived and presentations are made available through the site. Member communications are facilitated via e-mail and through Yahoo-Groups. At Yahoo-Groups, members can engage in threaded discussions and post documents of interest.7

FINDINGS 2: MEMBERSHIP SURVEY

Results of the Survey of the Membership

The following questions were posed to the general membership:

- How did you first learn of the existence of the Knowledge Management Group?
- Why did you join the Knowledge Management Group?
- What do you like most about the organization?
- Would you call this organization a success?
- Do think it is likely that the organization will continue to exist for another five years?

An anonymous online survey8 was conducted over a three-week period that concluded the first week of December 2003. E-mail invitations to participate in the study were sent to 241 members. Of these, 37 were returned due to incorrect e-mail addresses, leaving 204 invitations. Of these, 97 completed the five-question, Web-based survey, which yielded a response rate of 48%. The assumption was made that respondents were representative of the group, given the relatively high response rate.9

The results of the survey are provided in Table 5 and are as follows10. 74% of the respondents indicated that they learned of the group from a colleague, 9% through a Web search and 21% through other means. These data reinforce the networking and "word-of-mouth" aspects of communications regarding the group. The primary reasons that people joined the group were because they were interested in the topic (84%), to network (75%) and to learn practical methods regarding KM (62%). Of lesser importance were career advancement (13%) and to look for new business (19%). More than one out of every five joined the group to be in a supportive environment (21%).

The primary aspects of the organization that people liked the most included intellectual stimulation (66%), the quality of the topics (65%), the quality of the people at the meetings (59%), the quality of the speakers (57%) and networking opportunities (48%). The way the meetings were run and times of the meeting were also important (39% and 27%, respectively).

Overwhelmingly, the organization was considered a success by the respondents (99%), and 93% thought it would exist for another five years.

FINDINGS 3: EC INTERVIEW DATA

Data Collection and Methods

Data were collected from the current EC members via e-mail and informal interviews. The following questions were posed:

- Why was this organization started?
- Why do you think people join and participate in the organization?
- Why do you think someone volunteers to work on the EC?
- Why is the organization still functioning after five years?

Table 5. Results of the survey of the KMG membership, Dec. 2003

How did you first learn of the existence of the Knowledge Management Group? (check all that apply)	Number of Responses	Response Ratio
Colleague	72	74%
Web search	9	9%
other	20	21%
Why did you join the Knowledge Management Group? (check all that apply)	Number of Responses	Response Ratio
Required by job	0	0%
Career advancement	13	13%
Interested in topic	81	84%
To network with other professionals	73	75%
To learn practical methods and techniques of KM	60	62%
To be in a supportive environment	20	21%
To look for new business	18	19%
other	6	6%
What do you like most about the organization? (check all that apply)	Number of Responses	Response Ratio
Quality of speakers	55	57%
Choice of topics	63	65%
The way the meetings are run	38	39%
The people you interact with at meetings	57	59%
The times of the meetings	26	27%
Communications following the meeting	13	13%
Friendships	11	11%
Networking	47	48%
Intellectual stimulation	64	66%
Other	3	3%
Would you call this organization a success?	Number of Responses	Response Ratio
Yes	96	99%
No	1	1%
Do think it is likely that the organization will continue to exist for another five years?	Number of Responses	Response Ratio
Yes	90	93%
No	7	7%

- What are the factors that have led to the success of this organization?

All EC members (excluding the author) participated in the data collection (n=7), yielding a response rate of 100%. The written responses were compiled and analyzed using Atlas TI, a content analysis program. After all responses to each question were compiled for all respondents, codes were assigned to the material. The coding was done in an iterative fashion. First, the program provided frequency counts of words; these lists provided candidates for content codes. Next, the program searched for sentences that contained the codes identified in the previous step, and these were auto-coded. Several reviews of the material resulted in the addition of new codes and the refinement of existing codes. Finally, the remaining text was manually coded using the master list of codes that was created. The efficacy of the codes was tested with alternate raters (two university staff members11) who were asked to match the codes to a sample set of statements from the primary material. The first reviews found that inter-rater reliability was about 72%. Subsequent refinements improved rater reliability to better than 80% and the codes were considered to be reliable for the purposes of this article. Once the coding of the responses was complete, quotations from each member (e.g., P1, P2, P3,….Pn) were organized according to topic, and preliminary models (e.g., influence diagrams) were constructed.

Interview Results

Q1: Why was the organization started?

Three primary reasons were given: knowledge sharing, networking opportunities and a desire to learn more about the topic. As one member put it: "… [It was started] … as a way for people to build a network and share practices and learnings in an informal, low-barrier setting" (P3).

However, despite the clarity of its goals, it was not clear from the outset what the evolution of the organization would be and if it would exist for five years. One member put it this way:

"The initial focus was about learning and, likely, networking. But, I doubt there were expectations about what it would become and [it was] more about let's just get together and talk about a topic of interest and maybe we can learn some more." (P5)

The organization thus evolved in an organic way, with few initial expectations about its future.

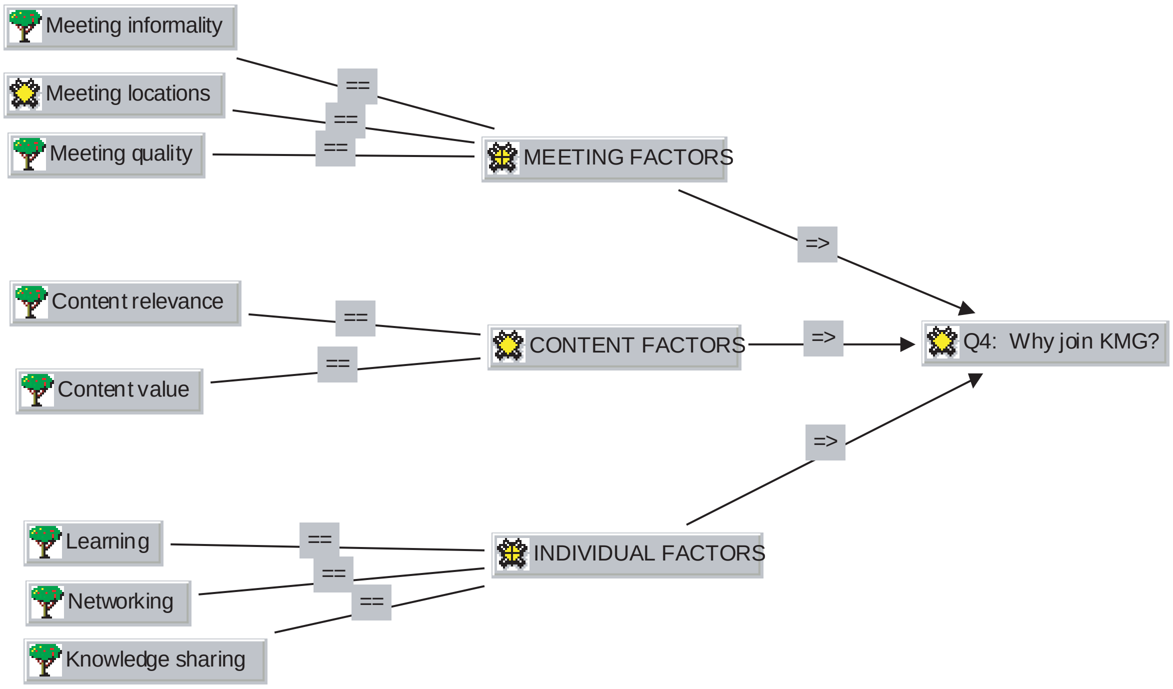
Q2: "Why do people join and participate in the organization?"

As noted in the previous question, knowledge sharing, networking and learning were important reasons to join the organization. One member said this:

"… [People join] … to learn …what KM is all about (everything from "what it is" to "how" and "why"), and how KM can drive their organizations to greater productivity, and help themselves in their efforts to manage their information and knowledge. To gain personal, realistic and first-hand experience and learnings from others in their same industry or area about KM. To network – personally with others sharing like interests and problems in the KM arena." (P6)

These primary variables (networking, learning and sharing) formed a cluster that was labeled Individual Factors. In addition, two other categories of variables were identified: Meeting Factors (i.e., characteristics of the meetings) and Content Factors (i.e., the characteristics of the knowledge exchanged at monthly meetings). For instance, positive meeting factors included the informality of the meetings, meeting locations, meeting quality and fostering a "fun" atmosphere.

Figure 1. Factors related to – Why join the organization?



Content factors included content relevance and content value. A model of these factors is shown in Figure 1.

One member summed up the reasons for joining this way:

"I came originally because a friend invited me. I have invited others. The loose structure makes it easy to participate; to come and go. The opportunities for networking are also valued. The communication about meetings and topics in advance of the sessions lets individuals decide when to participate. The atmosphere is inviting; questions and answers are valued." (P4)

Q3: Why do you think someone volunteers to work on the Executive Committee?

Reasons for participating on the EC ranged from very personal ones to more pragmatic considerations.

"I did it intuitively, because it felt right. Now I'm thinking about why it felt right, and here's what I believe. ...[I] tend to feel responsible for organizations in which I participate and ... believed it would be a good experience ... I thought it would get me more deeply networked with other KM practitioners. ... I figured I could help the group and add value. ... I continue to do it because, in addition to what's noted above, I really like everyone on the EC, we have a lot of fun, and it's a great group of people to work with." (P3)

Another member noted, "For me it is the desire to give back to the group and my profession; to support the continuation of the grassroots nature of the organization …" Another (P2) said that they had an "… interest in KM … [and a] … desire to contribute and lead …" (P4). Still another member said:

"Various motivators: (1) Deepen their social network. Get to know colleagues in broader ways — and they get to know you. (2) Professional recognition. The membership ascribes a certain status to those guiding a functioning organization. (3) Marketing purposes (e.g., "I am on the Executive Committee of the KMG"), [which] adds a level of credibility in talking about KM. (4) Deeper learning. ... Can tap a high level of knowledge and experience. (5) Pleasure of turning an idea into reality. It has certainly given me pleasure and a sense of accomplishment to having gone from nothing to a substantial something that has impacted people's careers and businesses." (P5)

Finally, one person saw the EC as a means to engage in sense making and deep learning as a sub-community within the larger community of practice:

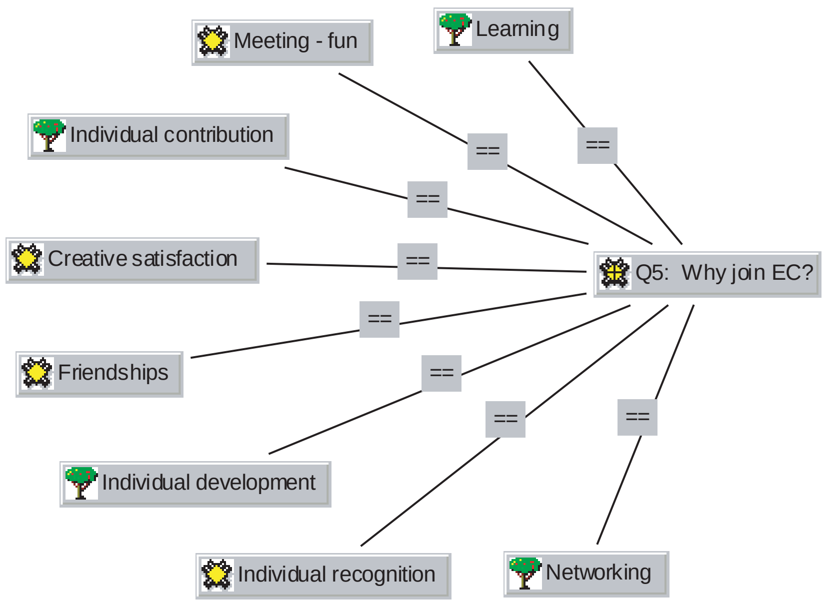
"Learning is social — [the] EC is a smaller social group than KMG that provides opportunities (occasionally) for debating, for sharing mental models and learning." (P7)

In summary, the factors that were most important included the quality of the experience, a desire to give back, intellectual stimulation and professional development. See Figure 2 for a model of the motivators to join the EC.

Q4: Why is the organization still functioning after five years;

and

Figure 2. Factors related to – Why join Executive Committee?



Q5: What are the factors that have led to the success of this organization?

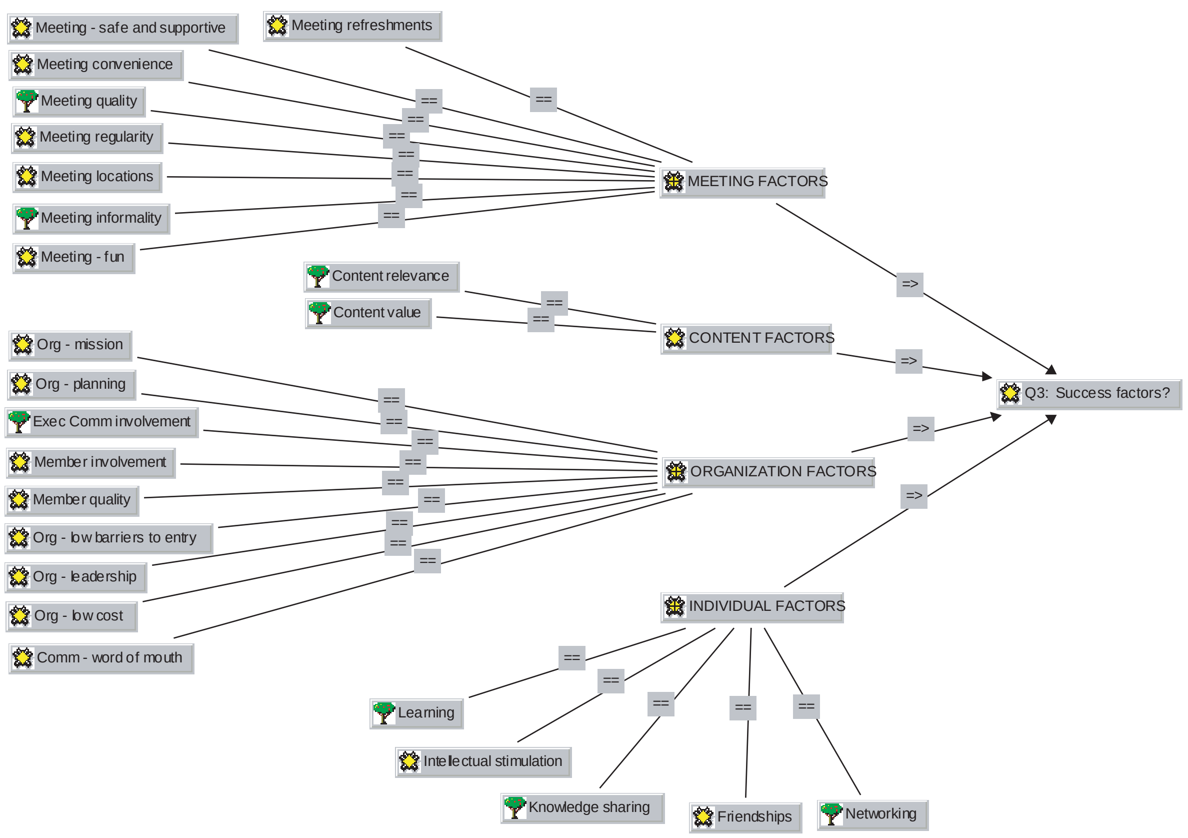
One of the key objectives of this study was to determine why the organization is still around after five years and in this sense is a "success." The critical success factors range from personal motivators to structural ones. For example, one member commented on the community aspects of the group:

"[It is successful] primarily because it ... meets the needs of participants as a "community." From a "community" perspective, it enables participants to be fully networked (CoP) with others in the same area, share experiences with others in like businesses or even just geographically co-located, or to participate as "interested parties" (CoI) or onlookers, feeling free to participate as interest and time permits. The personal touch, however, is [the] key to this organization's success." (P6)

Another member identified several positive aspects of the organization:

"Here are several factors I think are the main reasons KMG still exists after all this time ... Above all, KMG is focused on building on and extending learning around the broad topic of KM. ... the focus of the learning has first and foremost

Figure 3. Factors related to – Why is the organization successful?



been from a practitioner's viewpoint (e.g., practical things I can do tomorrow). This has kept the sessions very grounded. … A handful of people have continued to step forward to make sure the session topics reflected the interests and needs of those who were interested in attending KMG sessions. … With an emerging professional group, there is a need for affiliation. This plays out in many ways, such as just finding like minds; looking for jobs/projects so one can actually do KM and get paid … KMG has evolved because of an awareness and sensitivity to what is taking place in the field. Thus, topics have been timely and current … contributing to the value participants receive from attending meetings. No fees. No "official" membership. No administrative bureaucracy. Simply topics offered on certain dates and some minimal support infrastructure (Web site, YahooGroups). Essentially, nothing to interfere with the learning itself. …" (P5)

Still another person said:

"The group provides a safe environment for people to share ideas, no matter how controversial they are. People in the group have shared experiences and a history of sharing … and networks and friendships have formed between the members. … The topics are valuable and timely [and] focus on KM practices. The group consistently exceeds expectations of members. … I learn a lot of stuff that is immediately applied to my current situation. It makes me think. … It's fun … It's free. The EC has worked hard to make it a lasting program. Events are well planned and professional …" (P1)

The results of the content analysis show that several factors are responsible for the organization's success, according to the respondents. These findings have been grouped into four categories, based on an extension of the earlier categorization: Individual Factors, Content Factors, Meeting Factors and Organizational Factors. Organizational-level factors include leadership, EC involvement, barriers to entry, planning and member quality, among others. Figure 3 identifies the key variables in each category and illustrates the relationships among the variables.

DISCUSSION AND INTERPRETATION OF FINDINGS

The results of the interviews, the documents analysis, the content analysis and the surveys are synthesized into this case report and the findings are grouped according to the life cycle phases. Support is found for many of the research propositions appearing in Table 1.

Formation

This study has shown that a CoP can form around an idea or practice, in this case knowledge management. The initiating factor in this case was a presentation on the topic by a sponsoring organization. The costs to sponsor were low (e.g., less than a few hundred dollars). Based on the initial meeting, a subset of people from the group agreed to meet to explore the possibility of meeting again in the future on a periodic basis. The drivers for this new organization were to promote networking, learning and knowledge sharing. E-mail was the primary communication mechanism for the new group.

While the stated aims of the organization were to promote learning and networking, the community evolved in an organic way; that is, its features unfolded over time. In several ways, a CoP is a good example of a self-organizing system (Contractor, 1999; Houston 1999; Lorange, 1987). Self-organizing systems develop patterns out of a state of disorganization (Contractor, 1999), which aptly describes a CoP in its early stages. Its functions and structures develop over time in response to the environment, the available resources, and the goals and objectives of the members.

There are parallels here with new venture formation in the field of entrepreneurship and organizational life cycles (e.g., Cameron & Whetten, 1981; Quinn & Cameron, 1983). Like any start up, CoPs improvise procedures and policies until routines form (e.g., Nelson & Winter, 1982). In new venture organizations, structures are simple, there is little planning and control, and the primary focus is on turning ideas into reality (Dodge & Robbins, 1992; Flynn & Forman, 2001). CoPs share these same characteristics at this stage of development.

Survival and Early Growth

Following its inception, the KM group survived for a variety of reasons. The case study identifies several drivers, including organizational, individual, meeting, and content-related factors (see Figure 3). One of the key success factors in the organization category was having a clear sense of mission. In this case, the organization knew what it would focus on; for example, sharing KM practices and theory and promoting networking. Another key factor was the emergence of organizational champions who brought energy, drive and leadership to the group. They also brought assets in the form of social capital and access to resources. Without the extensive social networks of some key figures, the organization would not have had the connections necessary to grow and make it out of the formation stage. Furthermore, based on their positions within their respective organizations, these champions were able to get their organizations to commit modest resources in support of the meetings; that is, by providing food and space. Finally, the organizational champions brought sufficient knowledge of the domain of interest to foster a rich and creative intellectual environment. Several core members of the organization volunteered to make presentations until a network of "topic providers" was created. This collective knowledge base was certainly a critical success factor for the organization. Other factors in this category included event communication and planning, member participation and the low costs of membership (i.e., no costs and no dues).

In the second and third categories are grouped meeting and content-related factors. During the first year and beyond, significant time and effort was devoted to making the meetings relevant and convenient to attend. Topics were carefully selected by the core members prior to their announcement. The location of meetings was varied between the suburbs and the city to encourage diverse attendance. The general quality and consistency of the meetings was important to the group's early survival. The content was generally viewed as practical, relevant and value adding by the membership. Since this was the primary "product" offered by the CoP, we are not surprised by this result. Finally, there was a conscious desire to make the meetings informal and fun. This is consistent with research on the associations found between play and learning in work environments (e.g., Webster & Martocchio, 1992, 1993).

Finally, several individual factors were viewed as helping the organization survive and grow. One of the most important ones was intellectual stimulation. This finding is consistent with what may be viewed as a defining feature of a CoP; namely, the provision of an environment that allows for knowledge sharing and sense making. Making sense of the often conflicting theories and practices associated with KM is best done in a group where meaning can be tested, negotiated and refined. While such behavior is associated with and encouraged in universities, the reverse is true in most corporate environments. In the latter, there is a regression to the mean, strong pressure put on conformity, and usually little time to question corporate goals and objectives. While the learning organization (Argyris & Schon, 1978; Berends, 2003; Senge, 2003; Vera, 2004) is an ideal for many organizations, in practice, learning based on paradigmatic change is usually discouraged in favor of "getting the job done" or "fulfilling the client's needs." In contrast, a CoP offers an opportunity (albeit for a brief interlude) to question assumptions, refine ideas and sharpen vocabulary; that is, to learn. This finding is interpreted as another reason why CoPs have emerged as a functionally useful social form.

Late Growth and Maturity

Once the organization survived its first year of operation, several factors helped to ensure that it would continue to do so in the future. During the first year and beyond, the organization evolved key structures and processes to help it to grow. The most critical structure set up was the EC. This group was responsible for guiding the growth and development of the organization. Among the duties of the EC were planning, topic selection, finding host sites, review and evaluation, and setting policy and procedures. Several reasons cited for joining the EC include increased opportunities to learn, professional recognition, professional development, the opportunity for individual leadership, creative satisfaction and to make a contribution (see Figure 2). Also important was the "fun" atmosphere and friendships that developed. These factors served as potent motivators for the EC members as they took care of the numerous duties required to keep the organization functioning. Another closely related outcome among the EC members was the creation and adoption of roles in response to the evolving needs of the organization (see Table 4). This finding is consistent with what typically takes place in groups, usually in the context of formal organizations. Finally, the group established rules for admission to the EC, which were posted on the Web. For example, attendance and hosting requirements were set up for EC members. These criteria helped distinguish between those who were really committed to the organization and those who were not. For instance, some early EC members did not show up frequently to meetings nor did they significantly contribute to the welfare of the community. By publicizing the requirements, expectations for assigned tasks and roles were clear.

Another important factor that helped the organization grow and develop was the formation of routines. These included scheduling the meeting the same time each month (i.e., second Wednesday), holding it for the same duration (i.e., 7:45-9:45 a.m.), providing a similar structure to the meeting (e.g., first half hour devoted to networking, followed by announcements, the presentation and closing). EC meetings were also scheduled on the Friday immediately following the membership meeting to conduct after-action reviews and to plan future meetings. Meeting notices were sent out at approximately the same time each month. Taken together, these routines created a sense of security and permanence for the membership, despite the essentially virtual aspects of the community. In reality, the community had no physical assets, no financial resources, no space to convene, no offices and no paid human resources. It created its own reality through the use of e-mail, a Web site, virtual group workspaces, monthly meetings and its own routines and structures.

Although threaded discussions and other online activities were supported and encouraged by the community, for the most part, information technologies played a supportive but not dominant role in the organization's development. Information technologies served to coordinate the back-end activities in support of the human aspects of the experience; that is, the meetings where sense making and learning could occur. That being said, it is unlikely that the community could have continued to exist without e-mail and Web access to facilitate the planning, communication and coordination of meetings.

No organization continues to function unless it serves its members. The obvious benefits to members included learning about new topics and

KM practices, networking and opportunities for self-marketing. However, there were important implicit benefits. For example, the ideas of KM suffer from ambiguity. Members found the organization a "safe" place to test and share ideas, like one gets in a university classroom. In this sense, the organization provided an emotionally supportive environment for its members. Recognition was also built into the culture of this community. Iverson and McPhee (2002) observe that "Cultivation of knowledge can occur through three communicative actions: celebration, articulation and collaboration. The general point of celebration is to recognize knowledge accomplishments and problems solved …" (p. 3). It was not uncommon for members to receive public recognition at general and executive meetings. This produced the dual benefit of providing psychological reward for those doing the work and encouraging others to do the same.

Finally, there was a conscious effort on the part of the leadership of the community to choose the ways in which it would grow. Often times, organizations perceive growth as a "good thing" and simplistically make choices without regard to the consequences; not so with this CoP. For instance, while membership growth was an important consideration, the community did not want to grow without limits. Monthly meeting size was unofficially capped at 50 people. Holding larger meetings was problematic — it put a strain in the resources of the sponsoring organization and led to discussions of fees. Paying for space would have necessitated the creation of a dues structure for the community, which would have brought a whole set of administrative tasks, such as managing payments, invoicing, accounting, liability and so forth. The community chose not to incur these costs. Larger meetings also tend to become more formal and impersonal; the organization wanted to avoid this outcome. Another conscious decision of the community leadership was to limit commercialization. For instance, members were asked to refrain from making commercials at meetings (e.g., "buy my goods or services"). In addition, the EC decided not to sell its mailing list to any third parties, despite several requests from various organizations. In summary, this community chose how it wanted to grow in order to preserve an informal, yet rich, learning and sense-making context.

Decline or Renewal?

As of this writing, the CoP examined in this study is healthy and active. The members experience high satisfaction with the organization, and more than 93% of the respondents to the membership survey think the organization will continue for another five years. The question is: will it? Will it be able to adapt to changing conditions? The most dramatic change would occur if the theory and practice of KM simply diminishes in value and goes away. What would the community do then? Would it continue to meet as an affinity group based on member ties or would it organize around another practice issue and body of knowledge? Formal organizations often decline because they become rigid and inflexible. They are unable to adapt to changing conditions and are weighed down by extensive rules, policies, bureaucratic structures and cultures that are state maintaining. CoPs may suffer these same consequences, but further research is necessary to determine how and if this takes place. Perhaps what occurs with CoPs is not the result of over-structuring but increasing entropy and decreases in energy; that is, a CoP ceases to exist due to lack of member interest, loss of focus or insufficient resources.

Limitations and Next Steps

There are limitations to this study. First, this work represents a view of one organization over a five-year time period. Care must be taken in generalizing these findings to other organizational forms claiming to be CoPs. Second, since this work was exploratory in nature, the strengths of the associations found among elements were not measured. The next logical step is to replicate the results in other settings and to drill down into greater detail. Others are encouraged to test the propositions provided in this work and to use empirical methods that include hypothesis testing. One area for further research is to examine the strength of the interactions that bind the members. Weak ties suggest more of a network of practice (NoP), while strong ties suggest more of a CoP (Brown & Duguid, 2001). Further study using social network analysis would resolve the fuzziness around the issue.

To the practice minded, one of the findings of this study is that CoPs are relatively easy to set up and can be fostered with limited financial resources. The challenge is to find people willing to commit the time necessary to keep it going. On the other hand, CoPs can potentially reap big rewards, especially for corporations looking for ways to preserve and grow organizational knowledge. This study hopefully provides some practical insights about how to grow and sustain a community of practice over time.

SUMMARY AND CONCLUSION

This research has explored the formation, survival and growth of a CoP devoted to KM. Several factors that have contributed to the success of the organization over its lifetime have been identified. Future research needs to be done across several CoPs to verify these findings. Others are encouraged to frame and test hypotheses related to the strength of the associations identified in this work and to examine the life cycles of other CoPs. In closing, all organizational forms grow and contract and change over time. CoPs are no different in this regard. Rather than viewed as static and given, CoPs unfold in both expected and unexpected ways, just like formal organizations do. Just like people.

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REFERENCES

Ackerman, M.S., & Halverson, C.A. (2000). Reexamining organizational memory. *Communications of the ACM, 43*(1), 58.

Anand, V., Manz, C.C., & Glick, W.H. (1998). An organizational memory approach to information management. *The Academy of Management Review, 23*(4), 796.

Argyris, C., & Schon, D. (1978). *Organizational learning.* Reading, MA: Addison Wesley.

Barab, S.A., & Duffy, T.M. (2000). From practice fields to communities of practice. In D.H. Jonassen & S.M. Land (Eds.), *Theoretical foundations of learning environments* (pp. 25-55). Mahwah: Lawrence Erlbaum Associates.

Berends, H., Boersma, K., & Weggeman, M. (2003). The structuration of organizational learning. *Human Relations, 56*(9), 1035.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Brown, J.S., & Duguid, P. (1998). Organizing knowledge. *California Management Review, 40*(3), 90.

Brown, J.S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198.

Buysse, V., Sparkman, K.L., & Wesley, P.W. (2003). Communities of practice: Connecting what we know with what we do. *Exceptional Children, 69*(3), 263.

Cameron, K.S., & Whetten, D.A. (1981). Perceptions of organizational effectiveness over organizational life cycles. *Administrative Science Quarterly, 26*(4), 525.

Casey, A. (1997). Collective memory in organizations. *Advances in Strategic Management, 14*, 111-146.

Chandler, A.D. (1962). *Strategy and structure.* Cambridge, MA: MIT Press.

Contractor, N.S. (1999). Self-organizing systems research in the social sciences: Reconciling the metaphors and the models. *Management Communication Quarterly, 13*(1), 154.

Croasdell, D.C. (2001). IT's role in organizational memory and learning. *Information Systems Management, 18*(1), 8.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 69.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Demarest, M. (1997). Understanding knowledge management. *Long Range Planning, 30*(3), 374.

Dodge, H.R., & Robbins, J.E. (1992). An empirical investigation of the organizational life cycle. *Journal of Small Business Management, 30*(1), 27.

Dougherty, D., Borrelli, L., Munir, K., & O'Sullivan, A. (2000). Systems of organizational sensemaking for sustained product innovation. *Journal of Engineering and Technology Management, 17*(3,4), 321.

Drazin, R., Glynn, M.A., & Kazanjian, R.K. (1999). Multilevel theorizing about creativity in organizations: A sensemaking perspective. *The Academy of Management Review, 24*(2), 286.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215.

Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Flynn, D., & Forman, A.M. (2001). Life cycles of new venture organizations: Different factors affecting performance. *Journal of Developmental Entrepreneurship, 6*(1), 41.

Gioia, D.A., & Chittipeddi, K. (1991). Sensemaking and sensegiving in strategic change initiation. *Strategic Management Journal, 12*(6), 433.

Gioia, D.A., & Mehra, A. (1996). Sensemaking in organizations. *The Academy of Management Review, 21*(4), 1226.

Gray, B., & Ariss, S.S. (1985). Politics and strategic change across organizational life cycles. *The Academy of Management Review, 10*(4), 707.

Griffith, T.L. (1999). Technology features as triggers for sensemaking. *The Academy of Management Review, 24*(3), 472.

Gupta, Y.P., & Chin, D.C.W. (1992). Organizational life cycle and organizational strategic orientation: An empirical examination. *International Journal of Management, 9*, 215-227.

Gupta, Y.P., & Chin, D.C.W. (1994). Organizational life cycle: A review and proposed directions. *The Mid-Atlantic Journal of Business, 30*(3), 269.

Haire, M. (1959). Biological models and empirical history of the growth of organizations. *Modern Organization Theory*. New York: John Wiley & Sons.

Houston, R. (1999). Self-organizing systems theory: Historical challenges to new sciences. *Management Communication Quarterly, 13*(1), 119.

Iverson, J.O., & McPhee, R.D. (2002). Knowledge management in communities of practice. *Management Communication Quarterly, 16*(2), 259.

Jawahar, I.M., & McLaughlin, G.L. (2001). Toward a descriptive stakeholder theory: An organizational life cycle approach. *The Academy of Management Review, 26*(3), 397.

Lave, J. (1988). *Cognition in practice: Mind, mathematics, and culture in everyday life.* Cambridge, UK: Cambridge University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lorange, P., & Probst, G.J.B. (1987). Joint ventures as self-organizing systems: A key to successful joint venture design and implementation. *Columbia Journal of World Business, 22*(2), 71.

Mintzberg, H. (1984). Power and organizational life cycles. *The Academy of Management Review, 9,* 207-224.

Moorman, C., & Miner, A.S. (1997). The impact of organizational memory on new product performance and creativity. *Journal of Marketing Research, 34*(1), 91.

Moss, M. (2001). Sensemaking, complexity and organizational knowledge. *Knowledge and Process Management, 8*(4), 217.

Nelson, R., & Winter, S. (1982). *An evolutionary theory of economic change.* Cambridge, MA: Belknap Press of Harvard University Press.

Nissley, N., & Casey, A. (2002). The politics of the exhibition: Viewing corporate museums through the paradigmatic lens of organizational memory. *British Journal of Management, 13*, S35.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14.

Nonaka, I.O., & Nishiguchi, T. (2001). *Knowledge emergence: Social, technical, and evolutionary dimensions of knowledge creation.* New York: Oxford University Press.

Nonaka, I.O., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

Quinn, R.E., & Cameron, K. (1983). Organizational life cycles and shifting criteria of effectiveness: Some preliminary evidence. *Management Science, 29*(1), 33.

Rulke, D.L., & Rau, D. (2000). Investigating the encoding process of transactive memory development in group training. *Group & Organization Management, 25*(4), 373.

Senge, P.M. (2003). Taking personal change seriously: The impact of Organizational Learning on management practice. *The Academy of Management Executive, 17*(2), 47.

Smith, N.R., & Miner, J.B. (1983). Type of entrepreneur, type of firm, and managerial motivation: Implications for organizational life cycle theory. *Strategic Management Journal, 4*(4), 325.

Stein, E.W. (1995). Organizational memory: Review of concepts and recommendations for management. *International Journal of Information Management, 15*(1), 17.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85.

Swan, J., Scarbrough, H., & Robertson, M. (2002). The construction of 'communities of practice' in the management of innovation. *Management Learning, 33*(4), 477.

Thomas, J.B., Clark, S.M., & Gioia, D.A. (1993). Strategic sensemaking and organizational performance: Linkages among scanning, interpretation, action, and outcomes. *Academy of Management Journal, 36*(2), 239.

Thomas, J.B., Sussman, S.W., & Henderson, J.C. (2001). Understanding "strategic learning": Linking organizational learning, knowledge management, and sensemaking. *Organization Science, 12*(3), 331.

Vera, D., & Crossan, M. (2004). Strategic leadership and organizational learning. *The Academy of Management Review, 29*(2), 222.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *The Academy of Management Review, 16*(1), 57.

Walters, B., & Clark, J. (1996). Communities of interest. *Canadian Business*, Fall, S6.

Webster, J., & Martocchio, J.J. (1992). Microcomputer playfulness: Development of a measure with workplace implications. *MIS Quarterly, 16*(2), 201.

Webster, J., & Martocchio, J.J. (1993). Turning work into play: Implications for microcomputer software training. *Journal of Management, 19*(1), 127.

Weick, K.E. (1979). *The social psychology of organizing.* Reading, MA: Addison-Wesley.

Weick, K.E. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publications.

Wenger, E. (1998). *Communities of practice: Learning, meaning, identity.* Cambridge: Cambridge University Press.

Wenger, E. (2004). Knowledge management as a doughnut: Shaping your knowledge strategy through communities of practice. *Ivey Business Journal, 68*(3).

Wenger, E., McDermott, R., & Snyder, W.M. (2002). It takes a community. *CIO, 15*(15), 1.

Wijnhoven, F. (1999). Development scenarios for organizational memory information systems. *Journal of Management Information Systems, 16*(1), 121.

Wishart, N.A., Elam, J.J., & Robey. D. (1996). Redrawing the portrait of a learning organization: Inside Knight-Ridder, Inc. *The Academy of Management Executive, 10*(1), 7.

Yin, R.K. (1989). *Case study research: Design and methods.* London: Sage Publications.

ENDNOTES

[1] Ties among members of the community ranged from strong to weak.

[2] Additional information about the group may be found in appendices that accompany this document. Available on request from author at ews3@psu.edu.

[3] See Appendix 1 for a complete list of the topics presented over a five-year period. Special thanks to P. Hilt and J. Barrett for help in preparing this appendix.

[4] Developed and maintained by P. Hilt.

[5] Web site courtesy of the author.

[6] J. Barrett and the author.

[7] Managed by J. Barrett and M. Eichhorn.

[8] Special thanks to D.-A. Kotzur-Cerruti for her help with data collection from the membership.

[9] In a future study we would assess the characteristics of the non-respondents.

[10] Note: Respondents were allowed to make multiple selections; therefore, the percentages do not add up to 100%.

[11] Special thanks to Rebecca Riley and Suzanne Shaffer.

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Chapter 4.30
Knowledge Extraction and Sharing in External Communities of Practice

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INTRODUCTION AND BACKGROUND

Communities of practice (CoPs) may be described as groups whose members regularly engage in sharing and learning, based on common interests (Lesser & Storck, 2001). Traditional communities of practice exist within organizations and are centered on work functions. These CoPs may be self-organizing or corporately sponsored. They exist to encourage learning and interaction, create new knowledge, and identify and share best practices for the organization's processes (Wenger, 1998). The members of a community of practice may be collocated (within an office) or spatially dispersed (e.g., a group may interact via electronic chat). There may also be communities of practice that are not centered on work functions. For example, several online groups exist for enthusiasts of new technology, politics, environment, and so forth. These groups qualify as bona fide CoPs. We classify the CoPs discussed so far as active communities of practice because the members actively seek to learn and share from each other. In this work, however, we examine passive communities of practice in which the members do not actively interact with each other. This class of CoPs shares the core characteristics of traditional communities of practice—the members can learn from each other, and the organization can gain useful knowledge capital and best practices. Our discussions will be based on user communities using cable-TV viewers as a case in point. In contrast to work-centered CoPs whose members share knowledge and learn how to perform their work tasks better, members of user-centered CoPs learn how to maximize the utility from the product/service of interest. In both cases, a learning organization can extract useful knowledge capital and best practices to improve its processes and products/services. In this work, we use the case of cable-TV viewers to show how useful knowledge can be learned and shared in passive user-centered communities of practice. Our techniques will be based on data mining and knowledge discovery, which are introduced in the subsection that follows.

DATA MINING AND NAVIGATIONAL PATTERN DISCOVERY

The widespread use of computers and the increased abilities to collect and store massive amounts of data have led to phenomenal growth in the popularity and use of data mining techniques. Data mining is the analysis of data with the goal of uncovering hidden patterns. Historically, technological advances that improve the collection of data have led to new domains for data mining. For example, advances in bar code technology and the ability to collect and store transaction data logs led to the growth of association rule mining (Agrawal, Inielinski & Swami, 1993) and its many variants (Fayyad, 1998). More recently, the widespread use of the World Wide Web and the ability to collect and store Web logs of user sessions have driven research interest in Web usage mining (Cooley, Mobasher & Srivatava, 1997; Srivastava et al., 2000). An interesting problem in Web usage mining that has attracted the attention of several researchers is the discovery of traversal patterns of Web users (Chen, Park & Yu, 1998; Nanopoulos & Manolopoulos, 2000). Mining path traversal patterns involves identifying how users access information of interest to them and travel from one object to another using the navigational facilities provided. Tracking user-browsing habits provides useful information for service providers and businesses, and ultimately should help to improve the effectiveness of the service provided. Previous works on identifying path-traversal patterns have been directed at traversals between relatively static objects (e.g., Web pages). By static, we mean information that can be regenerated by the user as required. Thus, dynamic Web pages fall under our definition of static objects because the user may regenerate the dynamic Web pages on each visit.

In this research, our focus is on navigational patterns in environments where the objects are continuously changing in time (i.e., streaming content). An example of such a system is cable-TV where the program sequence is continuously changing. The viewers of cable-TV are able to navigate from one object (channel/station) to another. However, if viewers navigate away from a station/channel and later return to that channel, the content displayed may have changed. Thus, there is a strong temporal component in the systems studied in this research. The temporal component in our framework motivates new techniques to capture navigational patterns, as existing techniques in the literature do not take temporal semantic information into consideration. Our framework can be applied to identifying navigational patterns in any environment with streaming content. However, the discussions in this article will be motivated by cable-TV viewing patterns. The choice of cable-TV viewing patterns is due to recent technological innovations that enable the collection of anonymous logs of viewing data through digital video recorders attached to cable-TV receivers. The logs are kept anonymous to protect the privacy of the viewers. This is similar to the ethical standards that have long been adopted in analyzing Web and transaction logs. In the past, there has been very limited ways to collect data on the viewing patterns of cable subscribers. The advent of digital video recorders and the ability to track and report logs on the channels viewed by subscribers (on a second-by-second basis) opens up several interesting areas for data mining. Digital video recorders are growing in popularity (with Tivo Inc. reporting over 700,000 subscribers in the US in 2003 and a projection of over a million subscribers by the year-end), and a massive deployment is expected in the near future (Tivo Inc., 2003). Digital video recorders keep track of the channels viewed through the cable receiver. The view logs are uploaded to the service provider daily. The challenge is to extract interesting patterns from all the view logs submitted to the service provider.

There are several interesting questions that can be addressed by analyzing the view logs. For example, an advertiser may be interested in knowing if more viewers stay tuned during the commercial breaks of prime-time programs than for regular programming. It may also be of interest to know the advertising slot that is most effective; that is, is it more likely for an advert to be viewed if it is the first ad during the commercial break or if it has the last slot, middle slot, and so on. It may also be interesting to discover the percentage of viewers that return to a program once they tune off during a commercial break. Several other interesting patterns may also be discovered. In our framework, we propose a novel technique that categorizes the dynamic content of sites into distinct event sequences and then explores the navigational patterns of users relative to the distinct event sequences. The behavioral/navigational patterns discovered may be used to improve the program sequencing for future broadcasts. The analysis may also be given a spatiotemporal dimension so that appropriate programming is directed at users based on their locations and times of broadcast. Viewers may be grouped or profiled based on common navigational behavior. In interactive TV environments, this would enable personalized programming and program recommendations tailored to particular viewer groups or individual viewers.

RELATED WORK

Several authors have studied communities of practice (CoPs) in organizations (Brown & Duguid, 1991; Hildreth, Kimble & Wright, 2000; Lesser & Prusak, 1999; Lesser & Storck, 2001; Wenger, 1998; Wenger & Snyder, 2000). These works are centered on work-related CoPs and differ from user-centered CoPs discussed in this article.

There are strong similarities between the behavioral pattern discovery techniques discussed in this work and Web usage mining. Web usage mining is the application of data mining techniques to discover usage patterns from Web data (Srivastava et al., 2000). The objects in our framework (e.g., channels) may be viewed as Web pages. Also, a viewer can jump to any object/channel just like a Web user may navigate to any URL. However, mining, viewing patterns in our framework, has a stricter temporal component. It is not sufficient to know the order in which the objects are viewed. There is a need to know the information content of the objects at the periods the viewer navigates to, or away from, the object. The work by Yang, Wang, and Zhang (2002) proposes an event prediction algorithm for Web usage mining. Their approach is aimed at predicting when Web accesses would occur. This is an extension of earlier works that only identify the order in which Web accesses would occur. The problem they address is different from the problem addressed in this article since we are interested in the information content of the objects at the times they are visited. Furthermore, the objects we study have streaming information content. Several other researchers have proposed techniques for identifying frequent path traversal patterns (Chen et al., 1998; Borges & Levene, 2000; Heer & Chi, 2002; Nanopoulos & Manolopoulos, 2000; Pei et al., 2000). However, these approaches do not incorporate the temporal semantics we introduce in our framework. Tivo Inc. (2003) has developed audience measurement tools that are able to report viewing statistics. However, their tools (just like tools for measuring Web hits) do not explore navigational patterns of users.

FRAMEWORK

The general framework of the class of information systems covered in our work consists of independent sites with links connecting all sites. Unlike Web pages that are grouped together into Web sites with internal navigational ordering, our framework is made up of stand-alone sites that are interlinked to each other. Using our example of a cable-TV system, each channel/station represents a site in our framework. A viewer is able to navigate from one channel to another either by following the ordering of the cable channels or by specifying the desired channel.

We define a user session as the complete set of activities by a user from the time the system is entered until departure. In our example, a user session starts when the user turns on the cable-TV and ends when the system is switched off. The system consists of sites with streaming content that can be divided up into categorical episodes. An episode is an event sequence that makes sense in its domain of application. In our example, we may identify three broad categories for the episodes: programming, commercials, and shutdown. The programming category can be further divided into specific types of programs (e.g., movies, sitcom, sports, news, etc.), and the commercials can be further divided into slots (i.e., first commercial slot, second, etc.). The categories may be abstracted further so that individual programs and commercials are identified. The choice of abstraction is determined by the data-mining analyst.

The information displayed by each site in the system can be broken into event sequences that fall into one of the episode categories defined. Thus, for each site, its streaming content (for 24 hours a day) can be categorized into definite episodes with the associated start and end times for each episode. Further, for each user of the system, the viewing patterns must be categorized for every user session during a given day.

IDENTIFYING NAVIGATIONAL PATTERNS

The first step in our framework is data preprocessing. The content/program information for each of the sites has to be preprocessed into a format suitable for mining. Similarly, the user logs have to be preprocessed. Each user session is counted independently; that is, one subscriber may have multiple user sessions in a day, and each of the sessions would be independently considered in the framework. For example, given that time is represented in the 24-hour format, hh:mm:ss, and that the numbers 4 to 62 represent channels/stations available to the user, a typical user log would specify the channels/stations the user viewed from the start of a session to its end. Table 1 gives an example of a typical user log for one subscriber for a given day.

The logs record the viewing activity for each second of the day. The broken lines in Table 1 represent periods when there is no change in the channel viewed. From Table 1, we can identify two user sessions: the first starting at 12:15:00 and ending at 13:30:00, while the second session starts at 18:05:05 and ends at 18:30:00. Preprocessing the user log involves identifying all the user sessions and breaking each session into time brackets for the channels/stations viewed. The result of preprocessing the user log in Table 1 is shown below:

User session 1:
    Channel 10: 12:15:00 - 13:05:15
    Channel 32: 13:05:16 - 13:30:00
User session 2:
    Channel 31: 18:05:05 - 18:30:00

Table 1. An example of a user log

Time of Day	Channel Viewed
00:00:00	-
00:00:01	-
12:15:00	10
13:05:15	10
13:05:16	32
13:30:00	32
13:30:01	-
18:05:05	31
18:30:00	31
18:30:01	-
23:59:59	-

Table 2. A partial listing of a sample program categorization for a channel/site

Program	Time Slot
N1	12:00:00 – 12:15:00
C1	12:15:01 – 12:17:00
C2	12:17:01 – 12:18:00
C3	12:18:01 – 12:20:00
N1	12:20:01 – 12:35:00
S1	12:35:01 – 12:55:00
C1	12:55:01 – 12:57:00
C2	12:57:01 – 12:58:00
C3	12:58:01 – 13:00:00
S1	13:00:01 – 13: 30:00
CO	13: 30:01 – 13: 33:00

The program content for each site (channel/station) in the system is also preprocessed. The analyst specifies categories for each program. For example, given that a station airs its programs between 08:00:00 and 18:30:00 and, also, given the complete program schedule of the station. If the categories specified are as follows: N—news; S—sitcom; C—commercials; and M—movies, a program episode can be represented by its category and an identifier. For example, the first news episode can be represented as N1, the second N2, and so on. Similarly, the first sitcom may be represented as S1 and the second S2, and so forth. The identifiers are necessary if it is of interest to keep track of complete program episodes since a program episode may be interleaved with another episode (e.g., several commercial episodes may interleave a program episode). It may also be of interest to separate the program content into slots. (For example, the first commercial in a commercial break takes slot one—C1, the next commercial takes slot two—C2, and so forth. Commercials that are not embedded within other programs may also be separated into a category, e.g., CO in Table 2.) Further, the analyst may choose to capture different segments of a program into separate categories. For example, it may be interesting to differentiate how users respond to the first segment of a program from how they respond to other segments, especially if they did not view the earlier segments. The salient point here is that categories may be defined for every program grouping of interest. Finally, the preprocessed program content for our example will be in a format similar to the one shown in Table 2. If the channel (or site) preprocessed in Table 2 is Channel 10 (from Table 1), then it is easy to extract the categories viewed during user session 1 (from Table 1).

Once the usage logs have been transformed into user sessions and the program schedules have been transformed into event categories, data mining procedures may then be performed on the processed data. The mining problem addressed in this work is formulated as follows:

- How do the users of the system navigate between sites in response to the contents displayed by the sites?

Details of the proposed techniques for discovering these behavioral and navigational patterns are discussed in the next section.

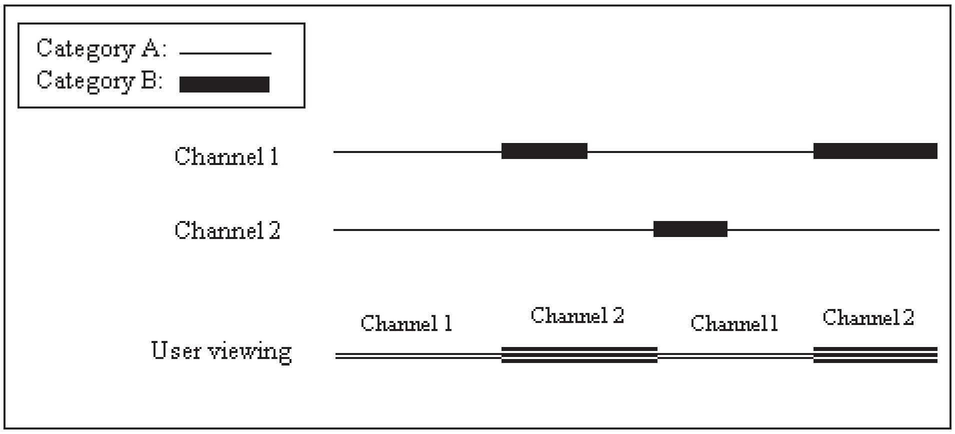
DISCOVERING EVENT-RELATED NAVIGATIONAL PATTERNS

This section examines the problem of identifying frequent navigational patterns of users relative to specific event categories (or collections of categories). For example, it may be of interest to know if viewers navigate away from a channel/station immediately after a news event begins, if they stay briefly before changing sites, or if they stay through the news event. It may also be of interest to discover if viewers navigate away at the commencement of a commercial break and whether they return to the same program once they navigate away. Figure 1 shows an example user navigation between two sites (channels). From Figure 1, it is easy to see that the user navigates away from program content that belongs to Category B, irrespective of the site/channel viewed. The data mining problem here is thus to determine all behavioral navigation patterns relative to program content that are frequently exhibited by various users of the system. Given that the user logs and program schedules (content) have been preprocessed into user sessions and categories, respectively, the next step in the framework is to define the behavioral predicates that would capture the users' navigational patterns in response to dynamic content categories.

The behavioral predicates chosen may include the following:

- Navigate away
- Stay through
- Stay briefly
- Return to the same program content (i.e., after navigating away)

Figure 1. An example of user navigation relative to event categories



The set of behavioral predicates considered in the framework depends on the interests of the analyst. Further, the quantitative time units attached to some of the predicates (e.g., the definition of briefly) are set by the analyst. Given a threshold confidence (e.g., 0.75), it is then possible to discover rules of the form: users of the system navigate away from program content in category B with x confidence (where x is a user defined threshold). It is also possible to capture navigational patterns of users in response to new program content in relation to the previous content they were viewing. An example of such a rule is: users of the system navigate away from content in category B given that they were previously viewing content in category C with x confidence (where x is a user defined threshold). The details of the data mining process are given in the paragraphs that follow.

Recall that all the user logs are preprocessed into independent user sessions. Each user session details the channels viewed and the viewing times. By examining each user session against the program categories airing at the sites/channels viewed, it is possible to extract the program categories viewed during each user session and the behavioral navigational patterns of the user during the session examined. Given that X is the set of categories over which a rule R is defined, then the set of active user sessions with respect to rule R, A, is made up of user sessions with events in each of the categories in X. For example, given the rule: users of the system navigate away from content in category B given that they were previously viewing content in category C with x confidence (where x is a user defined threshold), only user sessions with content in both categories B and C are active with respect to this rule (i.e., X = {B, C}). The confidence of a rule is calculated as the ratio of the support count of user sessions that satisfy the rule to the number of active user sessions with respect to that rule. The contribution of a user session to the support count of a rule is weighted and may range from 0 to 1. For example, if a user session encounters three instances of program content in category B and if in two of the three instances the user navigated away from the program content, then the contribution of this user session to the rule: users of the system navigate away from program content in category B with x confidence (where x is a user defined threshold) will be 0.67 (i.e., 2/3). The support count for the rule is then obtained by summing the support contributions of each user session for that rule. The outline of the algorithm is presented below.

INPUT:

- A set U of user sessions (obtained from preprocessing all the user logs)
- A set P of categorized program schedules for all the sites in the system
- A set B of behavioral predicates of interest
- An empty set R of all rules defined on the categories in P

OUTPUT:

Set of rules with associated confidence levels

PROCESSING:

FOR all $u \in U$ DO
Associate u with content categories by comparing its contents with relevant elements of P
Identify the rule set present in u with respect to B. If any rule found in u is not in R, add the rule to R.
Increment the count of active user sessions or all rules on program categories found in u.

FOR all rules $r \in R$ on categories found

in u DO
Calculate the support contribution of u to r
Add the support contribution to the total support for rule r
END FOR
END FOR

FOR all r∈R DO
Confidence of r = total support of r / number of active user sessions for r
END FOR

Given that U is the number of user sessions identified in he logs and is the average number of rules defined on program categories in the user sessions, then the algorithm has a time compexity of O(U). However, << U, thus the algorithm runs in O(U) time. (Note that rules are associated to user sessions if the behavioral predicates in the rule are present in the user session. This is analogous to constrained rule discovery using meta-rules.) The knowledge capital gained from the discovered patterns can be used by cable-TV companies and advertisers to improve their processes and produce better programming and scheduling. In interactive TV environments, the patterns can also be used to personalize programming and advertisements for individual viewers or viewer communities. The patterns may also be used to recommend programs of stations to viewers; thus individual viewers benefit from the collective knowledge of the viewing community.

CONCLUSION AND FUTURE TRENDS

This article abstracts external user communities as passive, user-centered communities of practice. Using a case of cable-TV viewers, we show that valuable knowledge capital can be learned from user-centered CoPs. The learned knowledge can be used to improve an organizations products and services and can also be filtered back to the user community to improve the overall user experience.

To achieve the learning of behavioral patterns from users, this article motivates a new domain for data mining that involves discovering user navigational patterns in information systems that disseminate dynamically changing (or streaming) content. The approach proposed in this work can be extended in several ways. For example, it may be of interest to separate ad-hoc and non-ad-hoc user sessions (i.e., some viewers may target certain programs while others may not). It may also be of interest to study the navigational behavior of users relative to the time of day the viewing occurred or navigational patterns relative to outlying content (e.g., a movie aired in a music channel). Several other extensions to the framework are also possible.

REFERENCES

Agrawal, R., Imielinski, T., & Swami, A. (1993). Mining association rules between sets of items in large database. *Proceedings of the ACM SIGMOD 1993 International Conference on Management of Data* (pp. 207-216). Washington, DC.

Borges, J., & Levene, M., (2000). A heuristic to capture longer user Web navigation patterns. *Proceedings of the 1st International Conference on Electronic Commerce and Web Technologies (EC-Web, LNCS 1875* (pp. 155-164.)

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-57.

Chen, M.-S., Park, J. S., & Yu, P. S. (1998). Efficient data mining for path traversal patterns. *IEEE Transactions on Knowledge and Data Engineering, 10*(2), 209-221.

Cooley, R., Mobasher, B., & Srivastava, J. (1997). Web mining: Information and pattern discovery on the World Wide Web. *IEEE International Conference on Tools with Artificial Intelligenc*e (pp. 558-567), Newport Beach, CA

Fayyad, U. (1998). Mining databases: Towards algorithms for knowledge discovery. *IEEE Data Engineering Bulletin, 21*(1), 39-48.

Heer, J., & Chi, E. H. (2002). Mining the structure of user activity using cluster stability. *Proceedings of the Workshop on Web Analytics, SIAM Conference on Data Mining.*

Hildreth, P., Kimble, C., & Wright, P. (2000). Communities of practice in the distributed international environment. *Journal of Knowledge Management, 4*(1), 27-38.

Lesser, E. L., & Prusak, L. (1999). Communities of practice, social capital and organizational knowledge. *Information Systems Review, 1*(1), 3-9.

Lesser, E. L., & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal, 40*(4), 831-841.

Nanopoulos, A., & Manolopoulos, Y. (2000). Finding generalized path patterns for Web log data mining. In J. Stuller et al. (Eds.), *ADBIS-DASFAA 2000, LNCS 1884* (pp. 215-228.) Berlin/Heidelberg: Springer-Verlag.

Pei, J., Han, J., Mortazavi-asl, B., & Zhu, H. (2000). Mining access patterns efficiently from Web logs. *Proceedings of the Pacific-Asia Conference on Knowledge Discovery and Data Mining (PAKDD'00),* LNCS 1805 (pp. 396-407).

Srivastava, J., Cooley, R., Deshpande, M., & Tan, P.-N., (2000, January). Web usage mining: Discovery and applications of usage patterns from Web data. *SIGKDD Explorations, 1*(2), 12-23.

Tivo Inc. (2003). Retrieved July 1, 2003, from http://www.tivo.com

Wenger, E. (1999, December). *Communities of practice: Learning, meaning and identity* (New ed.). In R. Pea, J. S. Brown, C. Heath (Eds.). Cambridge: Cambridge University Press.

Wenger, E., & Snyder, B. (2000). Communities of practice: The organizational frontier. *Harvard Business Review, 78*(1), 139-145.

Yang, Q., Wang, H., & Zhang, W. (2002, December). Web-log mining for quantitative temporal-event prediction. *IEEE Computational Intelligence Bulletin, 1*(1), 10-18.

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Chapter 4.31
Task-Based Knowledge Management

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INTRODUCTION

In modern organizations, the major role of knowledge management is supporting knowledge work. The concept of knowledge work assumes not only task performance, but also the review and evaluation of the work done in order to understand and learn from the experience. Knowledge work relies on a body of knowledge to support processes that address both the performance of work and the intellective aspects of the work activity (Zuboff, 1988). In this sense knowledge management becomes one of the most important mechanisms in implementing such support. In this article we present task-based knowledge management (TbKM) as an alternative approach to knowledge management (KM).

BACKGROUND

Most KM approaches focus on organizational knowledge and/or organizational processes and their management (e.g., Davenport & Prusak, 1998; Tiwana, 2000; Awad & Ghaziri, 2003). The TbKM approach addresses the management of knowledge work rather than knowledge. It is a bottom-up approach that focuses on the practicalities of work activities, as performed by individuals and groups. Thus TbKM is directed to supporting both:

- task performance to achieve organizationally defined outcomes; and
- work practices of actors including the generation and collection of experiential knowledge associated with task performance, as well as

single- and double-loop learning (Argyris & Schön, 1978).

The focus of TbKM is not directed towards automating any work practice. Task-oriented methods for knowledge-based systems were proposed in artificial intelligence projects to automate problem solving and reasoning by representing knowledge in a computable form (Chandrasekaran & Johnson, 1993). These approaches relied on capturing all organizational knowledge related to the task and creating a formally defined knowledge repository (Schreiber, Welinger & Breuker, 1993).

The TbKM approach provides an infrastructure for knowledge work where knowledge is a by-product of task performance. This infrastructure allows the knowledge worker to document the task instances in a way that is shareable with other actors performing that task. Thus TbKM is essentially an implementation of a knowledge work support system (KWSS) that systemically preserves knowledge of each instance of the task in a dynamic memory system. In order to support knowledge work, this memory includes the pragmatic outcomes as well as the knowledge created through task performance. Effective utilisation of this memory is facilitated by TbKM functionality such as reasoning, memory aids, explanation facilities, and learning capability. Moreover, the TbKM approach is consistent with reflective practice in that actors are encouraged to reuse and create knowledge through learning as an integral part of the task (Schön, 1991).

The task-based approach has been formalised as a theoretical framework that underpins our research. This approach has been used as an evolving framework analytically to diagnose research settings and determine the aspects of focus. Additionally, the framework has also been the core of the conceptual design for prototyping KM systems and KM development programs.

The task-based approach to knowledge management has evolved from a wide range of projects that have been undertaken and the practical requirements imposed by industry collaborators (Burstein & Linger, 2003, 2002; Linger & Burstein, 2001; Linger, Burstein, Zaslavsky & Crofts, 1999; Linger, Burstein, Ryan & Kelly, 2000; Fennessy & Burstein, 2000).

MAJOR ELEMENTS OF THE TASK-BASED APPROACH TO KNOWLEDGE MANAGEMENT

The TbKM approach focuses on knowledge work, not knowledge as the object of knowledge management. Thus the major elements of this approach are:

- a task focus
- a task-based model of knowledge work
- a community of practice
- an organizational memory
- task outcome
- knowledge work support

Task Focus

Underlying the TbKM approach is the focus on work practice. The approach aims to explore how the work is actually done, not how it is meant to be done or what individuals say they do. In this context, a task:

is a substantially invariant organizational activity with outcomes that include tangible outputs that are central to the organization's viability and the internal outcomes that are potential drivers of organizational change. (Burstein & Linger, 2003, p. 290)

In terms of this article, no distinction is made between an (organizational) activity and task, and the terms are used interchangeably unless indicated otherwise. Organizational activity, as used here, derives from Situated Activity Theory proposed by Iivari and Linger (1999, 2000) to characterize knowledge work. Such activity differs from the actions of individual actors, as the scope of the activity requires a number of actors for its completion.

For example, weather forecasting is organised around shifts that involve a number of forecasters. Each forecaster is given responsibility for particular forecast products, but each product needs to be consistent with the forecast policy that is set collectively by the shift. This example also highlights that such activity is socially situated in that all actors collectively engage in processes that enable them to gain a shared understanding of the activity. It is this understanding that enables each actor to intentionally complete their activity. Since the activity outcomes are organizationally determined, the actors' shared understanding of the activity also includes their understanding of the organizational imperatives that underlie the activity.

Task-Based Model of Knowledge Work

Task models produced for knowledge-based systems (KBS) development (see for example, Duursma, 1993) mapped the task into a generic task category (Chandrasekaran, Johnson & Smith, 1992). The intention was to generate a computational procedure based on Generic Task model represented as a hierarchical or tree model, including tasks, methods, and subtasks (Chandrasekaran & Johnson, 1993), that intended to mimic an expert's performance.

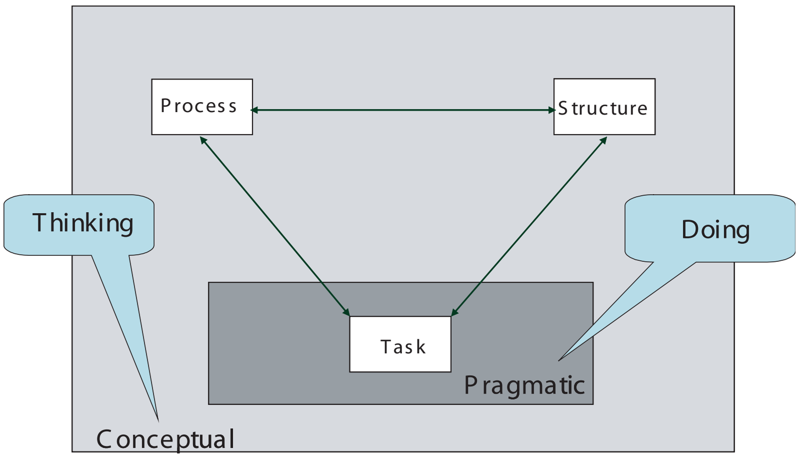
Such formal problem-solving methods are based on task structures that attempt to fully represent the problem-space and produce fully computable knowledge-level descriptions. For example, KADS and KADS-II European projects came up with a four-layered model of problem-domain knowledge (Schreiber et al., 1993). Although such knowledge-level descriptions made a major contribution in their analysis of task-oriented approaches to knowledge modelling, in many practical contexts the normative algorithms for solving real problems are "less useful than they seem" (Chandrasekaran & Johnson, 1993, p. 52).

The TbKM approach departs from the idea of generic representation of the task and its context. Organizational work, the task, is represented as two nested layers. The pragmatic represents actual work practice and the work that needs to be done. It is associated with the performance of the task, and is concerned with the efficient and effective execution of the task. The conceptual layer views the task from a more generalised, abstract perspective, expressed in terms of the overall goals and objectives of the task and related concepts and structures. The conceptual layer represents some aspects of the actors' understanding of the task in terms of models representing the structure of their knowledge and their knowledge of the process required to perform the task.

In a context of knowledge work, these layers correspond to doing (pragmatic) and thinking (conceptual) components of the activity as represented in Figure 1. From the point of view of knowledge management, we concentrate on the conceptual layer since the actors are knowledge workers who have the expertise to perform the task.

The model represents a generalisation of the task. We recognise two conceptual components associated with the task: a Structure and a Process. These two components come from the understanding of what concepts are involved in performing the task and how these concepts need to be applied. Task performance involves instantiating, and where necessary modifying, these generic components in a way that accommodates the current situation, and then executing the procedure. Reflection on and learning from task performance contributes to changes or improvements to the generic structure and process. In the context of knowledge work, specialising the structure and process, as well as reflecting on the instances of the task, is a fundamental feature of TbKM.

Figure 1. A task-based model of knowledge work (adapted from Linger & Burstein, 1997)



Each time a task is performed in a specific work context, the Structure and Process models are instantiated to reflect the specific work situation. Each instantiation then becomes a record of the task and cumulatively represents a task-based organizational memory (Ackerman & Mandel, 1995). The importance of this interpretation of the framework is that this memory is an essential part of the learning process. The historical evolution of these models is a representation of learning and a component of organizational memory (Spender, 1996).

A Community of Practice: CoP

Actors engaged in the task can be collectively termed a community, as they all have a professional interest in that work (Wenger, 1998; Brown & Duguid, 1991). In the TbKM approach, a community of practice is defined as a group of actors who are engaged directly in performing some aspects of the task. This conceptualisation of community is more restrictive than the commonly used definitions in the literature (e.g., Wenger, 1998). It is used deliberately to distinguish between members of the community and others who are potential stakeholders in the task or its outputs. However, actors are not restricted from participating in other communities within an organization through their engagement in other activities and tasks.

Restricting the community to actors engaged in task performance enables the community to establish and maintain the body of knowledge and shared meanings associated with the task. These are necessary elements to ensure the reliability and validity of each actor's contribution to the task. Moreover, each actor brings to the community contextual knowledge based on their other involvements within the organization. This enables computer-based knowledge management systems to be constructed as closed systems without the need for extensive contextual information to be included (Schatz, 1992).

Since the community is engaged in knowledge work, the actors have considerable autonomy in performing the task. However, as a community, working with other actors requires a degree of common understanding of the object of their work, the task, to ensure task outcomes meet organizational requirements. TbKM accommodates the idiosyncratic work practices of individual actors, but also provides the tools for the community to maintain its shared understanding of the task. Thus knowledge sharing is acknowledged as an integral part of work practices that still tolerates individual differences.

Organizational Memory

Each time the task is performed, it generates a collection of outcomes, related processes, and "stories" or narratives shared by the community (Czarniawska-Joerges, 1992). There is a potential of recording and preserving aspects of this experience in an organizational memory as instances and episodes of the task including the conceptual models that represent the individual and collective understanding of the task. As TbKM supports knowledge work, it needs to provide actors with the necessary tools to perform both the doing and thinking aspects of the task.

Instantiation of the whole range of tools to perform the task allows memory to be constructed as a by-product of task performance. Moreover, the more menial aspects of the task (doing) can be articulated and automated, the more time and space is left for the actor to be more involved with the tools for the intellective aspects of the task (thinking) without a punitive overhead. An example of this approach is in weather forecasting, where the forecast (and the rationale for the forecast) forms part of the memory that is used as input to future forecast preparation, as well as the basis for learning from past forecast performance.

Task Outcomes

Task performance must result in the organizationally defined outcomes that contribute to the organization's viability. In terms of TbKM, task performance also results in outcomes that relate the intellectual assets of the organization. These can be considered at two levels: individual and organizational. At the organizational level the outcomes contribute to the organizational productivity, through improved work practices, and knowledge assets in terms of contributions to organizational memory. Organizational outcomes also relate to effectiveness in terms of the organization's ability to deploy and exploit knowledge through knowledge sharing, reuse, and creation. At the individual level, task outcomes relate to the actor's ability to learn, use the knowledge assets productively, and contribute to and sustain the community of practice. TbKM is a heterogeneous approach in that it adopts a cognitive perspective when focussed on individual outcomes, but it has a social perspective when community or organizational aspects are in focus.

Knowledge Work Support System

We view technology as a very important enabler for knowledge management. This is consistent with the view expressed in mainstream KM research and practice (e.g., Alavi & Leidner, 2001; Davenport & Prusak, 2000). Task performance needs to be supported by a technological system that enables actors to produce tangible outputs. Much of IT development effort is directed to support the doing aspects of knowledge work. Less common is support for the thinking aspects. These support systems allow actors to engage in a joint cognitive process to evaluate, review, and reflect on task performance, as well as access and reuse past knowledge stored in memory. Memory can be deployed in processes that allow actors to understand and make sense of the task, as well as explore, innovate, and learn.

THE TBKM FRAMEWORK FOR ORGANIZATIONAL KNOWLEDGE MANAGEMENT

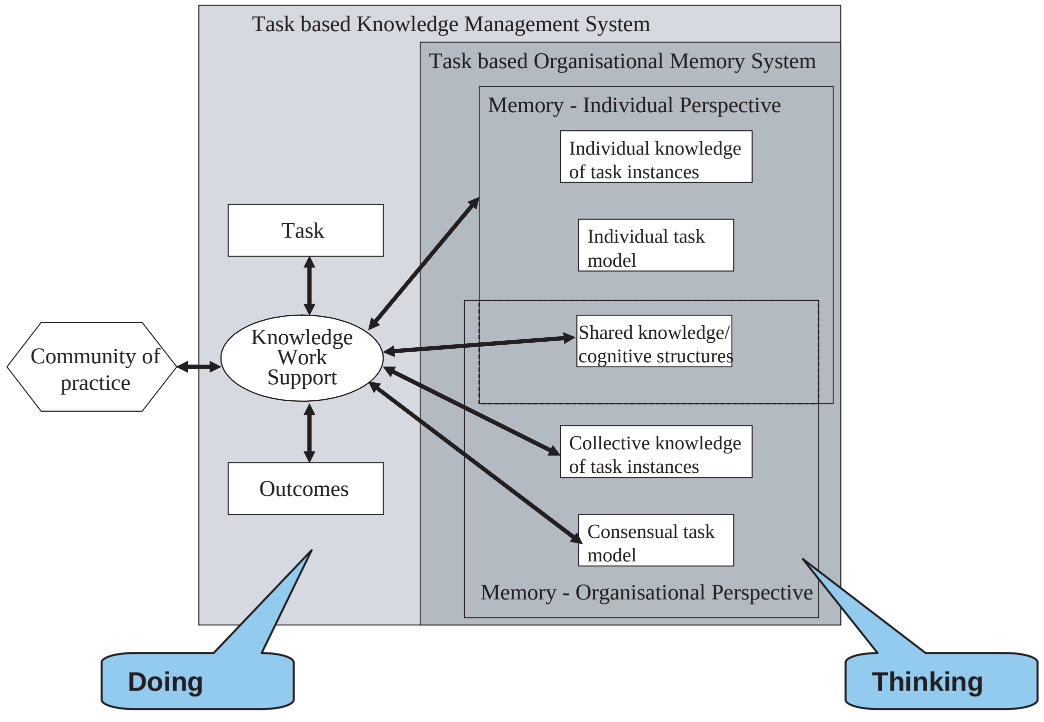
The TbKM approach to task performance is based on integrating production with knowledge processes. In this respect, technology, in the form of a knowledge work support system, mediates task performance by the community of practice. Figure 2 represents a TbKM system for organizational knowledge work.

In this framework the Knowledge Work Support (KWS) system is in the centre of two dimensions referred to as "doing" and "thinking" as in Figure 1. Thus in the vertical axis (Task, KWS, Outcomes) the KWS supports production, while in the horizontal axis (KWS, Memory) it supports knowledge processes.

The outcome of production is goods and/or delivery of services. By including the KWS system in the KMS, the task outcomes also potentially include improvement in the means of production of goods and delivery of services. Put differently, the functioning of the KWS system is concerned with organizational efficiency, its ability to supply market demands, as well as the organization's internal effectiveness including its ability to learn and create, share and reuse knowledge.

In the context of task-based KMS, the organizational memory system (OMS) needs to be a dynamic and multi-dimensional source of useful organizational knowledge. It needs to support

Figure 2. A model of a task-based knowledge management system (adopted from Burstein & Linger, 2003)



learning and other organizational knowledge processes, as well as accommodate individual perspectives. This contrasts with the more static view of OMS as a repository. We see it rather as an active component of an intelligent system supporting knowledge processes. The OMS contains the necessary information to perform the task, artefacts that express the actors' and CoP knowledge, and understanding of the task at the individual as well as collective and organizational levels. This material enables the OMS to support learning based on feedback, review, and evaluation. The diversity of the content of the OMS does not mandate any specific technology. In fact our approach is strengthened if different technologies are combined as it allows actors to express their understanding by constructing artefacts using inscriptions (Latour, 1990) that represent the task in a way that is consistent with the knowledge that underpins task performance.

FUTURE TRENDS

The TbKM framework explicitly supports knowledge work in the thinking and doing dimensions. Implicit in this formulation is the temporal dimension. The formulation of organizational memory in the thinking dimension allows the TbKM framework to represent temporal aspects of knowledge management in the form of past experiences. Moreover, this memory is a fundamental aspect of the thinking dimension and explicitly facilitates knowledge processes including double-loop learning (Argyris & Schön, 1978) to review work practices and for knowledge creation.

However, knowledge work is by definition a socially situated activity and implicitly assumes all actors, in the community defined by the task, interact and communicate. The challenge therefore is to explicitly extend the TbKM framework to incorporate another dimension—communicating. This would define knowledge management as existing within the three dimensions of thinking, doing, and communicating.

The TbKM framework currently assumes an organizational or enterprise context. This context is essential to situate the activities, the work practices, that are its focus. This bottom-up approach differentiates task-based knowledge management from the mainstream literature, but needs to be extended to explicitly incorporate the organizational perspective. To accommodate this perspective, we intend to extend the framework by adopting a three-level approach that deals with knowledge management at the micro, meso, and macro levels, as foreshadowed in Linger and Burstein (2001) and Linger and Warne (2001). The suggested approach accommodates the integration of organizational (macro), group (meso), and individual (micro) perspectives, as well as identifying capability (macro), collaboration (meso), and action (micro) as the discourse of these perspectives.

The TbKM framework as currently presented is grounded with the context of a specific organization. However, the imperative of the new (information or knowledge) economies requires consideration of inter-organizational as well as intra-organizational knowledge management strategies. This will require consideration of issues beyond work practices such as governance, collaborative arrangements, and the legal framework. In this context, the TbKM framework can be considered as a foundational structure for an inter-organizational knowledge management architecture.

CONCLUSION

The TbKM framework is general and applicable in any domain, as demonstrated by the diversity of the case studies we have undertaken (Linger et al., 1999; Linger et al., 2000; Fennessy & Burstein, 2000; Linger & Burstein, 2001; Linger

& Warne, 2001). Moreover, the generality of the framework is enhanced, as it does not prescribe any modelling formalism for any element of the framework. Rather, as the case studies illustrate, it is the task, and its underlying body of knowledge, that influences how elements are represented and modelled.

The framework provides a practical means for organizations to implement knowledge management regimes as it is applicable to any task that involves knowledge work. This flexibility derives from the fact that the framework is based on a theoretical understanding of knowledge work that allows TbKM to:

- add value to knowledge that the organization already has by explicitly recognising knowledge work;
- support actors performing the task, rather than automating it, in order to exploit knowledge processes;
- apply knowledge management on a scale that can be operationalised within a time scale that meets organizational imperatives;
- focus on knowledge creation and organizational learning rather than the self-limiting goal of organizational efficiency;
- produce outputs, in terms of products and services, while supporting the continuous improvements to these outputs and the means of their production;
- focus on work activities rather than modelling the organization; and
- integrate and support dynamic knowledge and production processes rather than view knowledge management in terms of a static knowledge repository.

In the literature there is a remarkable number of definitions of knowledge management, not least because of its currency and because of its perceived importance (Davenport & Prusak, 1998; Tiwana, 2000; Awad & Ghaziri, 2003). Our working definition is:

Knowledge management is a broad concept that addresses the full range of processes by which the organization deploys knowledge.

This definition is consistent with our premise that KM is about the management of knowledge work. This entails a conception of the actor as an professional (knowledge worker) working in a community of practice defined by the task. Each actor makes autonomous professional/ethical/moral judgements that are consistent with the task and its organizational context. Such judgements are an intrinsic part of the understanding of the task shared by the community.

The TbKM framework addresses all aspects of this definition. Moreover, TbKM reveals actual work practices in a way that allows organizations to integrate their production functions with learning. Thus the framework can be used diagnostically, to identify implicit knowledge management practices, and as an architecture to design the informational and technological infrastructure to support the organizational changes that underpin a knowledge management strategy.

REFERENCES

Ackerman, M.S., & Mandel, E. (1995). Memory in the small: An application to provide task-based organizational memory for a scientific community. *Proceedings of the 28th Hawaii International Conference on Systems Science* (pp. 323-332). IEEE Press.

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Angehrn, A., & Luthi, S. (1990). Intelligent decision support systems: A visual interactive approach. *Interfaces, 20*(6), 17-28.

Argyris, C., & Schön, D.A. (1978). *Organizational learning: A theory of action perspective.* Reading, MA: Addison-Wesley.

Awad, E.M., & Ghaziri, H.M. (2003). *Knowledge management.* Pearson International.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Burstein, F., & Linger, H. (2002, September 24-25). A task-based framework for supporting knowledge work practices. *Proceedings of the 3rd European Conference on Knowledge Management (ECKM2002)* (pp. 100-112), Trinity College Dublin, Ireland.

Burstein, F., & Linger, H. (2003). Supporting post-Fordist work practices: A knowledge management framework for dynamic intelligent decision support. *Journal of IT&P (Special Issue on KM), 16*(3), 289-305.

Chandrasekaran, B., Johnson, T.R., & Smith, J.W. (1992). Task structure analysis for knowledge modelling. *Communications of the ACM, 35*(9), 124-137.

Chandrasekaran, B., & Johnson, T.R. (1993). Generic tasks and task structures: History, critique and new directions. In J.-M. David, J.-P. Krivine, & R. Simmons (Eds.), *Second generation expert systems* (pp. 232-272). Berlin: Springer-Verlag.

Czarniawska-Joerges, B. (1992). *Exploring complex organizations: A cultural perspective.* Newbury Park, CA: Sage Publications.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Duursma. (1993). *Task model definition for task analysis process.* KADS-II Report, VUB AI Lab.

Fennessy, G., & Burstein, F. (2000). Developing a knowledge management system to support intermediaries in health care decision making. *Proceedings of the IFIP WG 8.3 Conference: Decision Support Through Knowledge Management* (pp. 122-136).

Iivari, J., & Linger, H. (2000, August). The characteristics of knowledge work: A theoretical perspective. *Proceedings of the Americas Conference on Information Systems (AMCIS'2000)*, Long Beach, CA.

Iivari, J., & Linger, H. (1999). Knowledge work as collaborative work: A situated activity theory view. *Proceedings of Hawaiian International Conference on Systems Science (HICSS'32)*. IEEE Press.

Latour, B. (1990). Drawing things together. In M. Lynch & S. Woolgar (Eds.), *Representation in scientific activity* (pp. 19-68). Cambridge, MA: MIT Press.

Linger, H., & Bustein, F. (2001). From computation to knowledge management: The changing paradigm of decision support for meteorological forecasting. *Journal of Decision Systems (Special Issue on Decision Systems in Action), 10*(2), 195-216.

Linger, H., Burstein, F., Ryan, C., & Kelly, J. (2000, December). Implementing a knowledge management system: The case of meteorological forecasting. *Australian Conference on Knowledge Management and Decision Support (ACKMIDS'2000)* (pp. 139-153). Melbourne: Australian Scholarly Publishers.

Linger, H., & Warne, L. (2001). Making the invisible visible: Modelling social learning in a knowledge management context. *Australian Journal of Information Systems (Special Issue on Knowledge Management),* (December), 56-66.

Linger, H., & Burstein, F. (1998). Learning in organizational memory systems: An intelligent decision support perspective. *Proceedings of the Hawaiian International Conference on Systems Science (HICSS'31).* IEEE Press.

Linger, H., & Burstein, F. (1997). Intelligent decision support in the context of the modern organization. *Proceedings of the 5th ISDSS International Conference,* Laussane.

Linger, H., Burstein, F., Zaslavsky, A., & Crofts, N. (1999). A framework for a dynamic organizational memory information system. *Journal of Organizational Computing and Electronic Commerce, 9*(2&3), 189-204.

Schatz, B.R. (1992). Building an electronic community system. *Journal of Management Information Systems, 8*(3).

Schön, D.A. (1991). *The reflective practitioner: How professionals think in action.* Aldershot, UK: Arena Ashgate Publishing.

Schreiber, G., Welinger, B., & Breuker, J. (Eds.). (1993). *KADS : A principled approach to knowledge-based system development.* London: Academic Press.

Spender, J.C. (1996). Organizational knowledge, learning and memory: Three concepts in search of a theory. *Journal of Organizational Change Management, 9*(1), 63-78.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Tiwana, A. (2000). *The knowledge management toolkit: Practical techniques for building a knowledge management system*. Englewood Cliffs, NJ: Prentice-Hall International.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge: Cambridge University Press.

Zuboff, S. (1988). *In the age of the smart machine, the future of work and power.* Oxford: Heineman.

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Chapter 4.32
Virtual Communities as Role Models for Organizational Knowledge Management

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ABSTRACT

Knowledge management serves to create value from an organization's intangible assets. Many organizations have adopted knowledge management practices in recent years. Some of those organizations have achieved success at knowledge management, but others have not. The focus of this chapter is on those organizations that have not been as successful at knowledge management as they originally planned. This chapter posits that organizations can look to virtual communities as role models for successful knowledge management because many of the features that have been identified in the literature as important for successful knowledge management are present in virtual communities. The very nature of virtual communities — their sense of community, the desire they create to share knowledge, the automatic archiving of knowledge for future use, etc. — are used in this chapter to support the claim that virtual communities can serve as role models for knowledge management in organizations.

INTRODUCTION

Organizations worldwide have embraced knowledge management as a way to create value from an organization's intangible assets, thus improving their bottom line (O'Dell & Grayson, 1998). Typically, organizations undertaking knowledge management initiatives treat knowledge as an important organizational resource, with the assumption that employees need incentives for sharing their knowledge with others in the organization (Gupta & Govindarajan, 2000). Under this model for knowledge management, there have been many success stories (e.g., Buckman Laboratories, The World Bank, Nucor Steel, KPMG Peat Marwick, Accenture, and Ford Motor Company). However, knowledge is often an individual, rather than organizational, resource residing within the minds of members of the organization, and the critical success factors of organizational culture, trust, and reward systems aligned with the principles of knowledge management remain difficult to attain in many cases. Organizations can expend significant resources to develop a culture, high levels of trust, and reward systems necessary for enabling effective knowledge management.

In contrast, virtual communities, which seem to emerge fairly effortlessly on the Internet, possess these critical success factors as inherent parts. Virtual communities are "social aggregations that emerge from the Net when enough people carry on public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace" (Rheingold, 2000). According to this definition, knowledge sharing is the very essence of virtual communities. Thus, it can be assumed that both a potent culture (along with at least some minimum level of trust) and incentives for sharing knowledge have developed within virtual communities. Otherwise, sharing would not occur and virtual communities would cease to exist.

A key question that emerges from this realization that virtual communities are essentially entities established for the sole purpose of knowledge sharing revolves around what virtual communities do that traditional organizations do not do to facilitate knowledge sharing. This serves as the general theme of this chapter, with specific research questions to address this theme detailed below.

It should be noted that knowledge sharing is selected as the focus of this study since it is a cornerstone of successful knowledge management (Davenport & Prusak, 1998; Hansen et al., 1999). A number of organizations have recognized the potential of knowledge sharing for enhancing organizational performance. Buckman Laboratories and Ford Motor Company have begun developing knowledge networks to facilitate knowledge sharing (Ruggles, 1998). American Management Systems has established knowledge centers where one of the center's four goals is to learn and share knowledge (Sensiper, 1997). KPMG Peat Marwick restructured its organization around its lines of business in order to facilitate knowledge sharing (Alavi, 1997). The World Bank reorganized to create horizontal relationships between staff in an effort to facilitate the sharing of knowledge (Valor, 1997).

Although some organizations have embraced virtual communities as a way to provide customer support (e.g., Microsoft), virtual communities and more traditional types of organizations are very different entities. As mentioned above, virtual communities are primarily concerned with social aggregations and personal relationships. Business organizations are primarily concerned with competing in the marketplace. Also, while organizations often have electronic components to supplement physical ones, virtual communities are strictly electronic. The typical model for knowledge management adopted by organizations, where knowledge is treated as a commodity, appears to be at odds with the critical success factors for knowledge management because this approach often results in those who possess knowledge seeking to keep it to themselves for personal leverage. In contrast, virtual communities seem to have already obtained the key characteristics for successful knowledge management. The specific research questions that this chapter seeks to answer, then, are:

1. What attributes of virtual communities show promise for knowledge management?
2. How can the attributes that make virtual communities successful at knowledge sharing be carried over to traditional organizations and used in knowledge management?

Because virtual communities exist only in cyberspace, technology is a fundamental part of them, and thus a fundamental part of the communication and knowledge sharing that occurs in virtual communities. The view of virtual communities as exemplars for knowledge management seems to counter recent work indicating that technology is more of an enabler of knowledge management than an essential component (Alavi & Leidner, 2001; Davenport & Prusak, 1998; Rubenstein-Montano et al., 2001). This chapter addresses the two primary research questions listed above while considering this "issue" of technology. Secondary research questions in this chapter include the following:

1. What is the role of technology in a virtual community versus a traditional organization?
2. What aspects of technology make it a better or worse enabler of knowledge management?
3. What barriers to knowledge management does technology add? What barriers does technology remove?

VIRTUAL COMMUNITIES

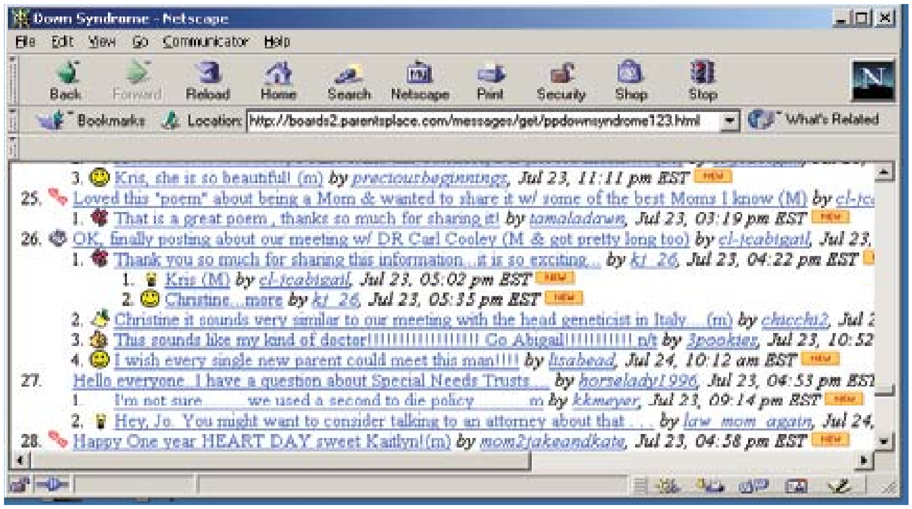
Internet sites have shifted from the static presentation of material to interactive communities, involving the members of the community in ongoing public dialog (Levitt et al., 1998). Sponsors of interactive sites hope such interaction will encourage individuals to spend more time at the site and return more frequently (Levitt et al., 1998). While information sharing over electronic networks, especially with relative strangers, has been examined in organizations (Constant et al., 1996), on the Internet sharing occurs outside of an organizational context in what are commonly termed "virtual communities" (VCs).

Virtual communities consist of people with shared interests or goals for whom electronic communication is a primary form of interaction (Dennis et al., 1998). Traditionally, the word "community" suggests a geographic area, such as a neighborhood (Wellman & Gulia, 1999), but the "virtual" part of the term "virtual community" indicates communities lacking a physical place as a home (Handy, 1995). Formally defined, VCs are groups of people that use a location on the Internet such as a listserv, chat room, newsgroup or bulletin board to communicate regularly. The groups have common practices and interests, and often have a notion of membership, formal or informal, and form personal relationships with others in the community. An example of a VC would be a Usenet newsgroup in which a group of people communicates regularly through the newsgroup and therefore forms personal relationships and bonds. VCs usually center on some common interest, hobby, or life event, such as surf fishing, collecting decorator plates, dealing with colon cancer, or raising a child with Down syndrome.

Not all virtual meeting forums can be considered VCs. For example, a bulletin board on the Web for selling used cars, where most of the postings simply advertise a car and do not have replies, and where people do not return after they sell or buy their car, would not constitute a VC. Authors have proposed certain minimum levels of interactivity in order for virtual spaces to qualify as VCs (Jones, 1997; Liu, 1999). These criteria are as follows: 80% of postings must have responses, a minimum of 15 different members must post over a three-day period, a minimum of ten postings a day per during any random three-day period must be posted, and at least 50% of the posters must post more than one time. It is important to note that individuals participate when they know many others are participating. Although the literature does not specify a particular frequency, a VC is generally understood to consist of persistently interacting members (Smith, 1999). VC sites can quickly fail when the membership, and therefore the usage, drops below some threshold (Ackerman & Starr, 1995).

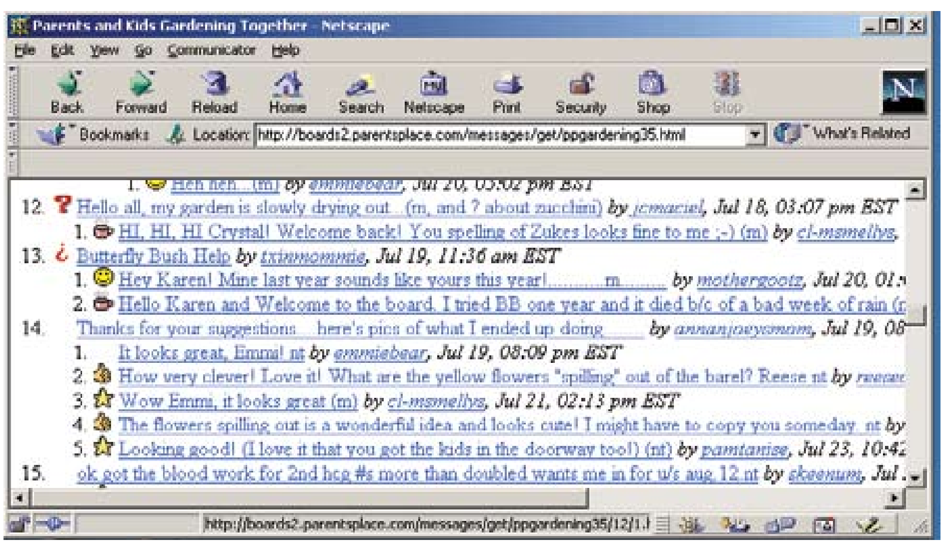
Figures 1 through 4 provide samples of VC exchanges, illustrating the types of knowledge shared in these communities, with specific examples identified below each figure.

Figure 1. Down Syndrome VC



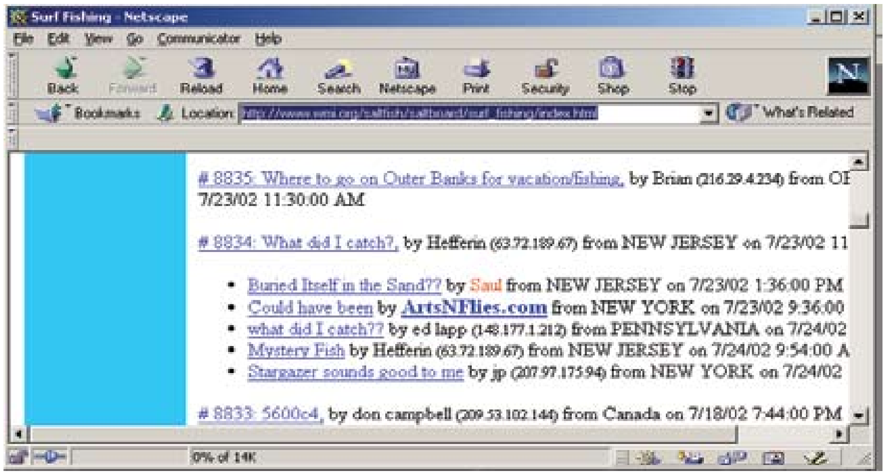
Explicit knowledge — "OK, finally a posting about out meeting w/ DR Carl Cooley"
Innovative knowledge — "we used a second to die policy"

Figure 2. Gardening VC



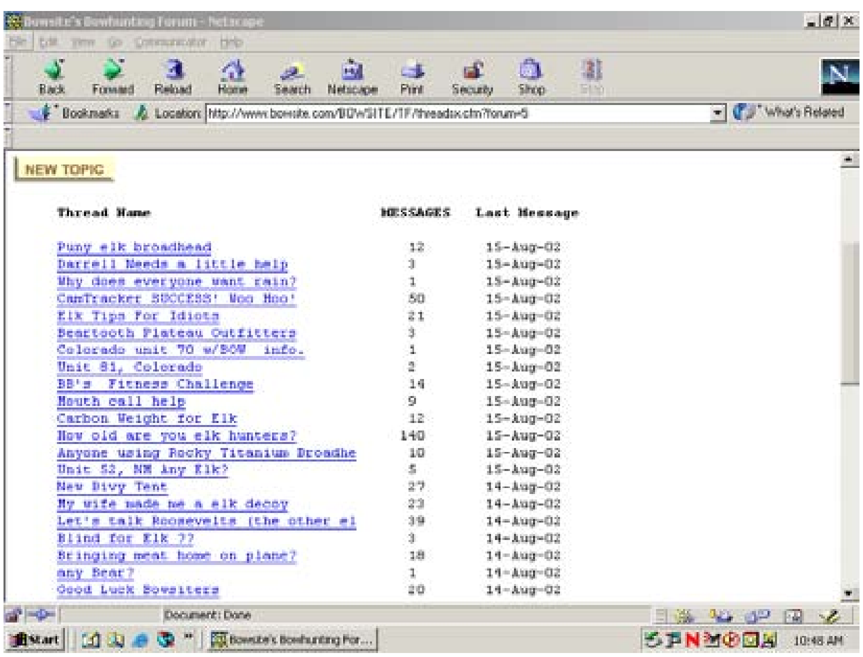
Explicit knowledge — "Mine last year sounds like yours this year!"
Feedback for previously shared knowledge — "Thanks for your suggestions ... here's pics of what I ended up doing... ."

Figure 3. Surf Fishing VC



Explicit and tacit (storytelling) knowledge — "Where to go on Outer Banks for vacation/fishing"
Explicit knowledge — "Could have been"

Figure 4. Bow Hunting VC



Tacit knowledge — "Why does everyone want rain?"
Explicit and tacit knowledge — "Mouth call help"

PROMISE OF VIRTUAL COMMUNITIES FOR ORGANIZATIONAL KNOWLEDGE MANAGEMENT

The description of VCs, and the included figures, given in the preceding section provides the basis from which the claim, "VCs can serve as role models for organizational knowledge management" is made. The overriding attribute of VCs that lends support to this claim is the fact that they are social aggregations established for the purpose of sharing knowledge. In organizations, the goal of KM is directly in line with the purpose of VCs — to get members of the organization to interact and share knowledge so the knowledge can be leveraged for organizational benefit. In addition to the fact that the primary purpose of VCs is to share knowledge, several specific features of VCs that lend themselves to knowledge management are discussed below. The features can be categorized as pertaining to members of the VC (people), interaction in the VC (communication), or means of communication in the VC (technology).

Communication

1. VCs are emergent communities that develop in a grassroots fashion (Rubenstein-Montano & Ridings, 2002). Conversations on a message board can grow naturally over time as knowledge of their existence and quality of conversation is disseminated. In this way, success of the VC is a result of direct need for the VC and the knowledge it generates. Site sponsors cannot "make" a site successful.
2. The definition of a VC indicates that social ties must exist between members of the VC for the online forum to be considered a VC. Thus, the social ties necessary to facilitate knowledge creation and sharing (Hansen, 1999) are in place when such creation and sharing occurs in a VC.
3. Members of the VC communicate when they want to, without pressure to communicate a certain number of times or at regular intervals. This feature of VCs allows members of the VC to generate and share knowledge when it is most appropriate and efficient for the member to do so. Thus, the knowledge sharing process is self-regulating and streamlined to some degree.
4. The focus of VCs is communication, with concern over how to profit from such communication as secondary, or at least transparent to VC members. That is, while VC sponsors depend upon the communities for revenue in some way, either in the form of selling advertising, selling products to members, providing market research, collecting subscriptions, or using them for customer support, seeking revenue does not change the underlying functioning of the VC as an online discussion forum. Focus of the VC remains on knowledge sharing.
5. The ongoing nature of discussion among users provides an incentive for members to repeatedly return to the VC to read others' comments and to respond, thus, continuing the process of knowledge generation and sharing. The very features that classify online entities as VCs — 80% of postings must have replies, a minimum of 15 different members must post over a three-day period, a minimum of ten postings per day per any random three-day period, and at least 50% of posters must post more than one time — dictate that ongoing discussion and repeat returns will be the norm.
6. The criteria for determining if virtual spaces qualify as VCs, membership levels, number of postings, and number of responses to postings (Jones, 1997; Liu, 1999), indicate that VCs are, by definition, successful in

knowledge dissemination (Rubenstein-Montano & Ridings, 2002). World Wide Web sites are public and therefore viewable by anyone with Internet access. Knowledge dissemination can occur regardless of whether individuals actively participate in the site (e.g., lurkers).

People

7. Members of VCs have direct control over the VC since their contributions and exchanges with other members serve as a part of the site's content (Levitt et al., 1998). Thus, VC members have a vested interest in the success of the VC.
8. VCs have low barriers to entry. Typically, individuals only have to click on a link, or enter a URL, possibly completing an online registration form. The infusion of people results in the infusion of new ideas and expertise, which are in turn shared with members of the VC.
9. Members of a VC are initially strangers to one another, allowing them to create any persona they choose. Members often choose to provide accurate information, but this is not required to participate in most VCs. The ability to remain unknown supports the need for anonymity, which has long been the focus of research on group decision-making (DeSanctis & Gallupe, 1985) and often leads to VC members feeling more comfortable participating and sharing knowledge with others in the VC.
10. Oversight and moderating of VCs tends to be somewhat transparent to users. Moderators, who vary from laizze-faire to heavy-handed, tend to adopt more of the laizze-faire attitude. This promotes an environment with some level of freedom from censorship and a sense of privacy (Levitt et al., 1998). Guidance that is visible to members of the VC tends to be in the form of knowledgeable responses to posted queries or gentle reminders to stay "on topic."
11. Oversight and moderation of VCs tends to be handled by individuals with some level of expertise in the domain area of the VC. This enables moderators to not only oversee interaction on the sight, but to provide knowledgeable responses (as mentioned above) on occasion. Moderators also allow other members of the VC to provide answers. This avoids the problem of the VC becoming dependent on the moderator to answer all questions, which is not consistent with the definition of "community." Allowing others to answer questions also increases the number of "experts" in the community, which is important for valuing the community overall.
12. Moderating responsibilities are typically assigned to more than one person so that moderating is coordinated and covered at all times.

Technology

13. The electronic nature of VCs makes storage of past discussions straightforward. VCs typically archive discussions and allow members to search archives when they are interested in retrieving knowledge that has already been generated by the VC.
14. VCs exist on the Internet and are therefore accessible from anywhere and anytime. This allows knowledge to get to the right people at the right time, which is an important part of knowledge management (O'Dell & Grayson, 1998).
15. The use of different technologies enables robust communication similar to that in face-to-face settings. Bulletin boards allow serial discussion, but chat rooms allow for real-time communication that includes

feedback and interruptions. Multimedia auditoriums allow for sharing of non-text knowledge such as video clips.

TRANSFERRING ATTRIBUTES OF VIRTUAL COMMUNITIES TO KNOWLEDGE MANAGEMENT IN TRADITIONAL ORGANIZATIONS

A number of attributes of VCs were identified in the preceding section as important reasons why VCs are successful at knowledge sharing. Some of these attributes are already a part of organizational knowledge management initiatives, and some may not be appropriate for an organizational setting. The VC attributes of particular interest, however, are those which are not typically adopted by organizations at present, but could be used to enhance knowledge management in traditional organizations. There are five attributes identified as critical for knowledge sharing success in VCs but not currently part of the typical organizational knowledge management initiative.

First, VCs were described as emergent communities. This counters the typical top-down establishment of work groups and teams in organizations. Formation of groups in a top-down fashion means members of the group are assigned to work together rather than allowing individuals to come together on their own, simply because they want to. While organizations cannot force the development of grassroots groups, they can work to nurture those that do develop without trying to control them in a heavy-handed manner. Organizations can also allocate space (physical or virtual) for gathering to talk about topics not related to work. Relationships that develop from these informal places may carry over to collaboration and knowledge sharing on work-related projects.

The second attribute of VCs, regarding social ties, can be handled in much the same way as nurturing grassroots groups. That is, employees should be encouraged, within reason, to develop personal relationships with other employees that do not necessarily revolve around work-related issues. Again, a location for social gathering can facilitate this and, in fact, many organizations already have this in place in the form of an employee lounge, cafeteria, or simple water-cooler/coffee pot. For social ties to develop, though, the organization must truly encourage such relationship building, with the focus on social and personal issues and not on work issues.

Third, there has been a trend in organizations to "encourage" knowledge sharing by mandating that individuals participate in communities of practice or write-up summaries of projects and contribute them to databases. This is very different from allowing individuals to contribute knowledge when they want to, without pressure to contribute a certain amount of knowledge. Rather than redesigning employee evaluations to account for how many times an individual contributes to an organizational knowledge base, businesses ought to illustrate how the knowledge base can help individual employees so they will want to participate on their own, perhaps include a reputation management system so participants will be benefiting by developing a better reputation without linking participation to specific employee evaluation processes. This would allow individuals to share knowledge only when they desire. Reputation has been shown to serve as a strong motivation to excel at a task (Nowak & Sigmund, 1998; Lotem et al., 1999) and there is no reason to assume such a motivating factor would be anything but successful for knowledge sharing.

This will require the implementation of new evaluation models in much the same way that the Internet has led to new business models. Although still evolving, the banner-ad model for Internet businesses is successful, not necessarily profit-wise, but in the sense that they enable countless people to view a site free of charge. The banner-ad model places the burden of revenue generation on advertisers rather than customers. Similarly, organizations can shift their focus from employees and the quantity of knowledge they share, to a support infrastructure that encourages knowledge sharing. Web sites that have adopted the banner-ad model gain through advertising, without requiring anything specific from users. Similarly, organizations can use a similar template and gain by filtering, organizing, updating, or "pushing" knowledge, without requiring employees to make predefined knowledge contributions.

Unfortunately, the idea of a reputation management system counters the concept of anonymity. Organizations can examine their culture and determine which approach is most appropriate for them — reputation-based or anonymous.

Fourth, in organizations, the focus is on money with communication and sharing as a way to achieve increased revenues. This makes sense for organizations since organizational self-interest depends on revenues. However, individual self-interest does not always revolve around wealth (Sloan, 2002) and VCs are capable of exploiting other drivers beyond self-interest. It is easy to say that organizations should focus on communication and knowledge sharing in their own right without considering economics, but this is an attribute of VCs that may not be realistic for organizations.

Fifth, because of the top-down approach and presence of managers typical in organizations, moderating any sites sponsored by the organization receives more oversight than typical VCs. This point spans several of the success factors of VCs that are lacking in organizations. Specifically, this can inhibit employee participation (especially when a sense of privacy is not engendered) and removes some of the control individuals have over which contributions are allowed to remain on the site for others to view. Several issues need to be addressed by organizations here. Since it is unlikely that management will be disbanded in order to create an organizational environment that better mimics the VC environment, resources ought to be allocated to building trust between management and staff. Also, oversight of organizational sites should shift toward the laizze-faire end of the scale rather than the heavy-handed end, and participants should have control over admissible content. If a reputation system is implemented as mentioned above, contributions should over time increase in quality and relevance so that oversight by a heavy-handed moderator will not be necessary.

The attributes of VCs already present in organizations, indicating what organizations are already "doing right," include: (1) the ongoing nature of discussion, (2) dissemination of knowledge, (3) individual control over their contributions (to some degree and depending on the organization), (4) low barriers to entry, (5) storage of knowledge in archives, (6) continual access to knowledge, and (7) multiple technologies for sharing knowledge. Most of these are straightforward, but I will comment on a couple of them. First, if knowledge is added to a company intranet site, it is disseminated the same way knowledge is disseminated in VCs. Second, individual control over contributions was discussed above, but can easily be adopted by organizations by allowing employees to upload information directly, with more transparent moderation similar to that of VCs. Significant scrubbing of submissions should not occur. Continual access to knowledge is easily achieved if employees can access intranet sites with knowledge from work, home, or while traveling.

The key feature of VCs, which may prove difficult to transfer to organizational KM, is that of anonymity. The World Wide Web is a much bigger place than a single organization, and fake information can be used to register for participation in a VC. However, in organizations a list of all employees is typically accessible via an intranet search, and anonymity may not be desirable if an individual is trying to obtain "credit" for participating in knowledge sharing. Even if anonymity is allowed by the organization, employees may not trust they are truly anonymous to superiors.

MODELING ORGANIZATIONAL KNOWLEDGE MANAGEMENT AFTER VCS

Table 1 summarizes the VC features discussed in the preceding two sections, and Figure 5 depicts how the three classes of VC features presented in this chapter relate to each other and influence organizational KM. As shown in Figure 5, technology serves as the basis upon which VCs can exist. People create the community, and communication among people sustains the community. The success of organizational KM rests upon these three classes of VC features.

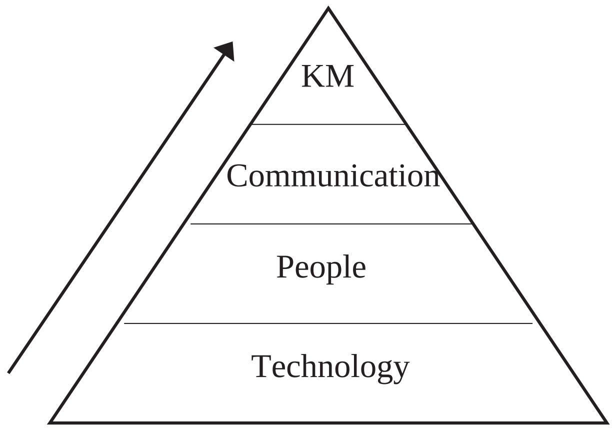
ISSUES AND CONCERNS

While the attributes of VCs that enable them to serve as role models for organizational knowledge management have been outlined above, VCs are not without limitations. Because knowledge sharing in VCs occurs strictly through technology, the emphasis is on sharing explicit knowledge. Some tacit knowledge may be shared (Rubenstein-Montano & Ridings, 2002), but the majority of knowledge shared will be explicit since it can be written down. Some have argued that tacit

Table 1. Applying VC features to organizational KM

Feature	NOT Currently Present in Organizational KM	Currently Present in Organizational KM	Probably Cannot be Easily Transferred to Organizational KM
Communication			
Emergent communities	**3**		
Social ties	**3**		
Self-motivation	**3**		
Ongoing discussion		**3**	
Successful knowledge dissemination		**3**	
Communication prioritized over money	**3**		**3**
People			
Vested interest by members		**3**	
Low barriers to entry		**3**	
Anonymity possible	**3**		**3**
Transparent oversight	**3**		
Technology			
Knowledge archiving		**3**	
Anywhere-anytime access		**3**	
Combinations of technologies		**3**	

Figure 5. VC features for organizational KM



knowledge is where much of the value added comes in (Sveiby, 2001), and this is lost if VCs emphasize explicit knowledge.

Also, quality control in VCs is questionable since anyone anywhere can contribute knowledge. The low barriers to entry and ability to create a fictional person mean there is no way to verify the expertise of contributors, and Internet fraud is becoming more commonplace (National White Collar Crime Center & FBI, 2000; National Consumers League, 2002). For example, web sites on which individuals have purposefully posted false stock information to drive up prices of stocks they own for personal gain have received a fair amount of media attention on. Also, comparison of two web sites — http://www.wto.org and http://www.gatt.org — illustrate how easy it is to publish false information online. Http://www.wto.org is the official web site for the World Trade Organization, but http://www.gatt.org appears the same as the official site with manufactured stories.

Because participation in VCs is technology dependent, only those with Internet access can contribute to a VC. Theoretically, this can limit the pool of available expertise. Enough people do have access that this probably is not a real concern, but it is mentioned for completeness. This is an issue that should not apply to organizations if we assume all relevant employees would have access to the company intranet. Of course, restrictive access rules for different classes of employees could lead to an artificial constraint on the amount of expertise available to others in the organization.

Lastly, some of the limitations of VCs for serving as knowledge management systems have been pointed out by Rubenstein-Montano and Ridings (2002). Fairly simple knowledge is shared, explicit rather than tacit knowledge is typically shared, and knowledge is archived by date rather than subtopic making location of stored knowledge difficult. Therefore, VCs cannot serve as a panacea for organizational knowledge management. Instead, they can serve as a starting point for future enhancements to organizational knowledge management.

FUTURE TRENDS

Both VCs and KM continue to evolve. In this section VC trends that can be applied to KM are presented. The first trend involves knowledge organization in VCs using semantic networks. Typically, knowledge is stored in VCs according to the date the content is added to the VC (Rubenstein-Montano & Ridings, 2002), but a newer approach for VCs is to use semantic networks. Semantic networks enable the organization of knowledge around topic areas. This is a change to knowledge organization that enhances search and retrieval of knowledge from storage locations. Consulting firms have already created knowledge management systems that employ semantic techniques for organizing knowledge about customers and their industries, projects, and competitors (Alavi, 1997).

Second, it is expected that emphasis will be on more anticipatory responses from the organization members who need to carry out the mandate of a faster cycle of knowledge-creation and action based on the new knowledge (Nadler & Shaw, 1995).

Third, community members must be able to find and bring to bear the relevant knowledge in the repository. In both today's VCs and knowledge management systems, the search engine is the main workhorse for finding stored knowledge. Search engines apply rudimentary natural language-understanding techniques. Over time, lessons learned about indexing and retrieval in case-based reasoning systems will be applied to KM. Furthermore, agents and distributed problem-solving technology will play an increasingly important role (Smith, 2000).

A couple of recent trends in KM involve enterprise portals and employee relationship management. Enterprise portals provide unified access across business units and enterprise boundaries to just about any resource an employee might need, including front-end and back-end resources, personal workspaces, and the World Wide Web. Individuals can customize their view of the enterprise portal (SAP & PriceWaterhouseCoopers, 2001). Employee relationship management (ERM) is aimed at getting employees, managers and senior executives on the same level and using the same vocabulary for increased productivity, efficiency and customer and market awareness (Ericson, 2002).

CONCLUSION

This chapter has outlined some of the key features of virtual communities that suggest they can serve as role models for knowledge management initiatives in traditional organizations. Because the primary purpose of virtual communities is sharing knowledge, there are prerequisites for the existence of a culture, along with at least some minimum level of trust, and effective incentives for facilitating knowledge sharing. The nature of virtual communities suggests that traditional organizations can look to virtual communities to learn what virtual communities do that traditional organizations do not do for facilitating knowledge sharing. However, there is no claim that virtual communities will serve as a panacea to solve all of the problems organizations face when implementing knowledge management. Instead, this chapter reviewed some of the features of virtual communities that show promise for improving upon current knowledge management practices in traditional organizations.

First, the chapter reviewed the attributes of virtual communities that support knowledge sharing and can thus help traditional organizations. These attributes include the presence of social ties, the emergent nature of virtual communities, the self-motivation present in members of virtual communities, the ongoing nature of discussion, low barriers to entry, community member control over content, some degree of anonymity, transparent oversight, anywhere-and-anytime access to the community, and technologies that enable robust communication.

The chapter then went on to note that traditional organizations already do many things "right" when it comes to knowledge management. However, since there is always room for improvement, organizations can adopt features of virtual communities that do not currently characterize them. Of the features of virtual communities that encourage knowledge sharing, those that traditional organizations do not typically possess, but that can be transferred to organizations to some degree include the following:

- Emergent, instead of top-down, development of communities for sharing knowledge.
- Development of social ties ought to be encouraged and nurtured.
- The emphasis on required contributions should be replaced by an emphasis on employee choice. Individuals should contribute knowledge when they feel self-motivated to do so. Perhaps a reputation system would serve as an effective motivator instead of employee evaluations that link knowledge contributions to pay raises and promotions.
- Exploit the drivers behind self-interest of employees to encourage knowledge sharing instead of placing the entire focus on wealth.

Although virtual communities cannot solve all of the problems of knowledge management that traditional organizations encounter, their very nature serves as a goal to which traditional organizations can strive.

REFERENCES

Ackerman, M.S., & Starr, B. (1995). Social activity indicators: Interface components for CSCW systems. *Proceedings of Computer Supported Cooperative Work Conference* (pp. 159-168).

Alavi, M. (1997). *KPMG Peat Marwick U.S.: One giant brain* (case #9-397-108). Boston: Harvard Business School Publishing.

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organization Science, 7*(2), 119-135.

Davenport, T., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Dennis, A.R., Pootheri, S.K., & Natarajan, V.L. (1998). Lessons from the early adopters of web groupware. *Journal of Management Information Systems, 14*(4), 65-86.

DeSanctis, G., & Gallupe, B. (1985). Group decision support systems: A new frontier. *Data Base, 16*(2), 3-10.

Ericson, J. (2002). Is ERM a Contender? *KM Magazine.* Retrieved July 23, 2002, from http://kmmag.com/articles/default.asp?ArticleID=954

Gupta, A.K., & Govindarajan, V. (2000). Knowledge management's social dimension: Lessons from Nucor Steel. *Sloan Management Review, 42*(1), 71-80.

Handy, C. (1995). Trust and the virtual organization. *Harvard Business Review, 73*(3), 40-48.

Hansen, M., Nohria, N., & Tierney, T. (1999, March/April). What's your strategy for managing knowledge? *Harvard Business Review,* 106-116.

Jones, Q. (1997). Virtual-communities, virtual settlements & cyber-archaeology: A theoretical outline. *Journal of Computer Mediated Communication, 3*(3). Retrieved from http://www.ascusc.org/jcmc/vol3/issue3/jones.html

Levitt, L.M., Popkin, L., & Hatch, D. (1998). *Building online communities for high profile Internet sites, ISOC 1998*. Retrieved March 2002 from http://www.magicpub.com/presentations/Isoc98/virtualcommunities.html.htm

Liu, G.Z. (1999). Virtual community presence in Internet relay chatting. *Journal of Computer Mediated Communication, 5*(1). Retrieved from http://www.ascusc.org/jcmc/vol5/issue1/liu.html

Lotem, A., Fishman, M.A., & Stone, L. (1999). Evolution of cooperation between individuals. *Nature, 400,* 226-227.

National Consumers League. (2002). *2001 Internet fraud statistics.* Retrieved June 27, 2002, from http://www.fraud.org/internet/2001stats.htm

National White Collar Crime Center and Federal Bureau of Investigation. (2000). Internet Fraud Complaint Center (IFCC) Six-Month Data Trends Report. Retrieved June 27, 2002, from http://www1.ifccfbi.gov/strategy/6monthreport.PDF

Nowak, M.A., & Sigmund, K. (1998). Evolution of indirect reciprocity by image scoring. *Nature, 393*, 573-577.

O'Dell, C., & Grayson, C. J., Jr. (1998). *If only we knew what we know.* New York: The Free Press.

Rheingold, H. (2000). *The virtual community.* Cambridge, MA: MIT Press.

Rubenstein-Montano, B., Liebowitz, J., Buchwalter, J., McCaw, D., Newman, B., & Rebeck, K. (2001). A systems thinking framework for knowledge management. *Decision Support Systems, 31*(1), 5-16.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40,* 80-89.

SAP & PriceWaterhouseCoopers. (2001). *The e-business workplace: Discovering the power of enterprise portals.* New York: John Wiley & Sons.

Sensiper, S. (1997). *American management systems: The knowledge centers* (case #9-697-068). Boston: Harvard Business School Publishing.

Sloan, A. (2002, June). The verdict is in: Greed isn't good. *The Washington Post, 195*, June 18, E3.

Smith, A.D. (1999). Problems of conflict management in virtual communities. In M. A. Smith & P. Kollock (Eds.), *Communities in cyberspace* (pp. 134-163). New York: Routledge.

Smith, R.G. (2000). The road ahead for knowledge management. *AI Magazine.*

Sveiby, K.E. (2001). A knowledge-based theory of the firm to guide strategy formulation. *Journal of Intellectual Capital, 2*(4).

Valor, J. (1997). *Information at the World Bank: In search of a technology solution (B)* (case #9-898-054). Boston: Harvard Business School.

Wellman, B., & Gulia, M. (1999). Virtual communities as communities. In M. A. Smith & P. Kollock (Eds.), *Communities in cyberspace* (pp. 167-194). New York: Routledge.

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Chapter 4.33
Virtual Teaming

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INTRODUCTION

Given the ongoing advances in technology and the consequent changes in the work environment with the introduction of a mobile workforce, it is inevitable that more activities will be undertaken by virtual teams.

As with any team, a virtual team is a group of people who share a common objective and combine to provide a variety of different and complementary skills in order to achieve that objective. Unlike traditional teams, they are not collocated and can be working from a variety of different geographical locations, which can be either office or home-based. Often, they work across different time zones, adding to the challenges involved in successfully bringing a team together.

BACKGROUND: THE STAGES OF TEAM DEVELOPMENT

Tuckman (1965) identified four stages of team development which detailed a process that all teams need to work through:

1. Forming: When teams first come together, knowing little about each other and the project.
2. Storming: When roles and responsibilities are being clarified, and team members are striving to establish their position within the team.
3. Norming: When trust is established between team members and communication becomes more open and honest.
4. Performing: When the team members undertake the tasks at hand.

Virtual teams go through the same stages, but this needs to be facilitated by a strong and competent team leader. Steps 1 and 2 are essential for trust to be established between the team members; therefore, team building sessions need to be scheduled to allow this to happen. Time has to be built into the schedule to enable the members to get to know each other and their respective roles within the team.

BUILDING A VIRTUAL TEAM

Bringing together a virtual team requires strong management, communication, and facilitation skills. Often, the team leader is the one common link in bringing the team together and ensuring that team objectives are successfully met.

Most traditional teams come together initially via a face-to-face kick-off meeting, where they get to know each other and agree on their "team charter". For the best results, this should still be done for all virtual teams as people tend to build trust faster once they have met their teammates. It is far more comfortable to meet virtually when you already know the person involved compared to dealing with just a faceless voice at the other end of a telephone call. This forming stage often continues beyond the initial formal meeting with the session extending to a team dinner or sociable drinks.

However, it is not always possible to bring the team together for an initial meeting, and this has to be carried out via other means. Where this is conducted remotely, for example, by means of a conference call, video conference, or e-meeting, the team leader should ensure that each team member is involved and gets an opportunity to introduce him/herself.

Team members should be encouraged to provide profile information in advance of the meeting, covering not only their contact details and skills, but also some personal facts and interests. Contact details should also include a photograph – putting a face to a voice often helps get over the problem of speaking to someone who you have never met.

It is recommended that, even if the team members only meet virtually, the team leader makes every effort to meet the team members face-to-face when first enrolling them into the team.

LEADING A VIRTUAL TEAM

When participating in a virtual team, it is essential that the team members get the opportunity to communicate and share ideas on a regular basis. Not only does the team leader need to be in regular contact with each team member to understand how they are performing, but the team members need to be proactively in regular contact with each other.

One advantage that team members have when they work in the same location is the opportunity of meeting informally over lunch or coffee, encouraging them to share information, report on progress and discuss problems, issues, and so forth. As this is not an option for a virtual team, communication has to be more formal and regularly scheduled. Processes need to be put in place to define the different communication methods and how and when to use them.

During formal team meetings, the team leader should ensure that each participant in the call reports on their progress. With large teams, this may mean splitting the team down into smaller, more manageable subgroups. A regular meeting schedule involving everyone at some level ensures that team members do not become isolated. This is a good forum at which to identify and share "quick wins" with team members to keep the momentum going. In addition to the formal meetings, the team leader should ensure that he/she has regular contact with individuals and subgroups outside the meeting schedule.

TOOLS AND TECHNOLOGY

A wide range of tools and technologies exist to support virtual teams. The level of functionality and sophistication of the tool set available to individual team members, irrespective of their location, is increasing rapidly, allowing them to easily and transparently communicate with each other. However, this puts an increasing reliance on the availability of a supporting infrastructure, from both an IT user support and training perspective.

Some of the tools available are:

- Broadband: The increasing coverage of broadband services allows mobile workers to have a permanent connection to office systems, irrespective of their location. This is particularly useful for home-based team members.
- Internet/Intranet: The increasing use of the Internet and provision of in-house intranets allows dispersed users to have access to common systems and information sources.
- Company Portals: The growth of role-based, personalized portals enables team members to log into their systems and obtain a common desktop from a variety of different locations. It also ensures that new team members can be set up with a common team work environment quickly and easily.
- E-mail: Team members can easily communicate via e-mail. Documents can also be passed between team members using this mechanism, but this could lead to problems with duplicate copies at different versions. It can also discourage sharing by allowing team members to store exclusive copies of documents in mail files. For that reason, the use of file servers or Web places for team documents should be encouraged.
- Videoconferencing: The use of videoconferencing allows team members to meet face-to-face from a distance. This works best when team members are based in office locations that have easy access to videoconferencing equipment, although it usually places restrictions on the number of participants and requires advance scheduling to ensure that the facility is simultaneously available from all locations.
- Instant Messaging: The use of instant messaging allows a dispersed team to remain in contact with each other. It is an excellent resource for quick, ad-hoc interchanges between individual team members and also for synchronous team discussions. It can reduce the feeling of isolation felt by some team members and can assist in making them feel part of a team. It can also help them identify when other team members are online, particularly when working across time zones.
- Web Place: A project Web place can provide the team with a shared workspace structured for their specific needs. It contains structured spaces for them to store content, discussion areas for them to communicate irrespective of location or time zone, and can also provide project-based facilities such as team diaries. It reduces the need for large documents to be passed around via e-mail and ensures that documents are easily accessible by team members. Access can be controlled by the team leader to ensure that content is accessible only by those team members requiring it.
- E-meetings: The availability of Web-based e-meeting tools allows teams to have scheduled and ad hoc meetings via nothing more sophisticated than a Web browser and a telephone. Most systems have the ability to white board ideas and share documents, allowing control to be passed between team members when required. This means that team presentations, demonstrations, and so forth can be seen by the team, and documents can be worked on collaborativel—regardless of location.

WORKING WITH THE RIGHT TOOL SET

The tools required to support the team in their activities should be selected once the requirements of the team have been identified. At no time should the team members feel that the technology is driving what they do. An effective technology is one that supports the team activities seamlessly and transparently. There should never be any doubt as to which tool should be used when.

As the team develops their team charter, they should define what the communication and storage requirements are to support them at each stage. Part of the charter should detail the rules of etiquette regarding usage of the systems. For example, items to be agreed could include:

- when to use e-mail as opposed to Web places;
- when to be available via instant messaging;
- how often to go into systems to check for new information;
- how long team members have to respond to questions; and so forth.

ADVANTAGES OF VIRTUAL TEAMS

- Virtual teams allow the team leader to bring together the best people for the job, regardless of their location and organization.
- Time spent by team members is used more effectively as less time is lost traveling.
- Travel and subsistence costs are reduced.
- Team members can work to their own schedules, allowing for people in different time zones to work together for a common cause. This can also allow for teams to be represented 24 hours a day.
- Team members get to know and work with colleagues outside of their immediate work groups. This can increase their personal networks and encourage the flow of knowledge and experience across boundaries.

EFFECTIVE TEAMING

As Opper and Fersko-Weiss (1992) stated of team behavior, "For the…team, the shift is from a mentality of working alone to one of being in a state of collaboration." Deborah Harrington-Mackin (1994) identified one of the attributes of a non-effective team—when the team has "focused on task activities to the exclusion of work on team member relationships."

One of the great strengths of a team is the ability of its members to work together and build on each other's ideas. In many respects, the techniques and tools required to achieve this for a virtual team are different to those of a more traditional, collocated team and can certainly prove more challenging. It is easy to promote an environment where each team member works in isolation rather than as part of a team. A skillful team leader is required to encourage an environment where team members build the relationships with each other to give them the impetus to collaborate on activities. This may mean that time has to be allowed for some team communications focused solely on building team trust rather than producing deliverables.

CONCLUSION AND FUTURE TRENDS

Virtual teams are becoming the norm in many organizations. While some members struggle with the concept of being part of a dispersed team, many find that the advantages outweigh the difficulties.

This is particularly true of the younger generation of employees who have grown up with and are more accepting of Web technologies.

For the organization, the ability to boost productivity by making best use of their expertise, wherever it resides, is of great benefit. For the employee, virtual teams open up opportunities to work within different teams, enabling them to increase skills and expertise by contact with a wider community. In turn, the organization gains a more skilled and satisfied workforce.

Virtual teams require a set of tools, selected and configured to meet their needs. The tool set used should be supportive rather than intrusive, responding to the varying needs of the team.

They also need to work within a framework of clearly defined processes and communication channels, facilitated by a competent and experienced team leader. When successfully achieved, a virtual team can bring all the benefits usually associated with team working, plus added benefits that only a virtual team can bring.

FURTHER READING

Buckman, R. H. (2004). *Building a knowledge driven organization.* McGraw-Hill.

Charles Steinfield Computers. (2002, March). *Realizing the benefits of virtual teams, 35.*

Fisher, K., & Fisher, M. D. (2001). *The distance manager: A hands-on guide to managing off-site employees and virtual teams.* New York: McGraw-Hill.

Godar, S. H., & Ferris, S. P. (Eds.). (2004). *Virtual and collaborative teams: Process, technologies and practice.* Hershey, PA: Idea Group Publishing.

Lipnack, J., & Stamps, J. (1997). *Virtual teams: Reaching across space, time and organizations with technology.* New York: John Wiley & Sons.

Nash, S. (1999). *Turning team performance inside out: Team types and temperaments for high impact results.* Palo Alto, CA: Davies-Black.

Pauleen, D. (2004). *Virtual teams: Projects, protocols & processes.* Hershey, PA: Idea Group Publishing.

References

Harrington-Mackin, D. (1994). *The team building toolkit: Tips, tactics and rules for effective workplace teams.* AMACOM.

Opper, S., & Fersko-Weiss, H. (1992). *Technology for teams: Enhancing productivity in networked organizations.* New York: Van Nostrand Reinhold.

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Chapter 4.34
Organisational Storytelling

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INTRODUCTION

In this article we consider some of the ways in which narrative approaches might contribute towards a better understanding of organisational knowledge management. The telling of stories has a long, rich, and varied tradition, stretching back hundreds of years. In the study of organisations, storytelling can be seen as part of a wider field of enquiry, Organisational Discourse, which seeks to ascribe meaning to social exchanges within organisations (Grant, Hardy, Oswick, & Putnam, 2004; Grant & Hardy, 2003). Narratives have been explicitly identified (Wensley, 1998; Denning, 2000; Ward & Sbarcea, 2001) as one of the ways in which knowledge might be exchanged in organisational settings, but only limited consideration has been given to the ways in which storytelling approaches can increase our understanding of the creation and dissemination of knowledge in organisations. In this article we reflect on what we might learn from the application of narrative processes, particularly organisational storytelling, and from narrative content, particularly organisational narrative knowledge, to assess the place of such storytelling in KM.

WHAT IS AN ORGANISATIONAL STORY?

Many of us are actors, and sometimes narrators, in organisational stories that are potentially rich in knowledge. We all think we can recognise a story when we see one, perhaps by recognising the story's content, or by recognising the process by which certain knowledge is being exchanged. In this section we consider definitions surrounding the relationship between what we see as "organisational storytelling" and organisational knowledge.

The first broad issue to consider is the distinction between narrative and story. This article will treat both terms synonymously within the context of KM, but the reader should be aware that some authors' definitions offer subtle and interesting distinctions (for example, Polkinhorne, 1988; Czarniawska, 1998; Boje, 2001; Gabriel, 2004).

Stories can be seen as one of the ways in which we can encode data about our environment, both personal and organisational. A particular strength of storytelling for KM lies in its capacity not only to represent such sets of data, but also to offer some insights into the complex interrelationships between such data elements. In an organisational context, these interrelationships might help us to make sense of the organisation (e.g., Weick, 1995).

We may define these stories according to the form that they take (content definitions), or the way in which we recognise their use (process definitions).

Narrative Defined by Content

If we define stories (including organisational stories) according to their content, we can recognise that they have certain characteristics (Pentland, 1999):

- a plot (for example, the employee who has made a mistake, but is forgiven by the boss, who praises and rewards her honesty)
- actors in the story (the employee, her boss, an important client, etc.)
- a sequence of events (the mistake, her discovery of the mistake, how she attempts to rectify the situation, her boss's discovery of the mistake, etc.)
- an outcome or closure (the boss rewards her honesty rather than firing her)—which is often embedded within some sort of "moral context"(for example, honest behaviour is rewarded)
- a wider recognisable context within which the story operates (for example, a multinational company with a fierce reputation).

The balance of these properties is not always equal, but might shift as the circumstances (either of the narrative or its purpose) might demand.

Narrative Defined by Process

In process definitions, the situational characteristics of the performance of the story are considered by some authors (e.g., Boje, 1991) to be as insightful as its content. From a KM perspective, such performances might be rich in tacit knowledge, only some of which will be evident from a story's transcript. Boje's operational definition of a story performance—"an exchange between two or more persons during which past or anticipated experience was being referenced, recounted, interpreted, or challenged" (p. 111)—is typical of such definitions. A more general definition might view stories, within an organisational context, as the socially constructed accounts of past events that are considered important or significant to members of an organisation (Feldman, 1990). Within such a definition, stories need not be factual; some argue that they are seldom so (Hansen & Kahnweiler, 1993), reflecting instead what those involved in the storytelling process believe should be true. Although some stories purport to convey "facts," such facts are not always straightforward to identify or interpret (Gabriel, 2004).

Within both classes of definition, it is clear that organisational stories are often extraordinarily rich in tacit knowledge (see, for example, Orr, 1990; Hernandez-Serrano, Stefanou, Hood, & Zoumas, 2002; Hoopes & Postrel, 1999; Meyer, Connell, & Klein, 2003). Such knowledge has the potential to be stored (and perhaps through constant retelling, even archived) within the "package" of a story, and transferred in a succinct yet rich way. In this respect, a better understanding of organisational storytelling can contribute some useful insights into the ways in which knowledge exchange, in particular informal knowledge exchange, might be effected within organisations.

A number of authors have acknowledged this potential. In one of the earliest descriptions of the use of organisational storytelling and KM, Denning (2000) describes his experiences within the

World Bank, illustrating the use of storytelling as an enabler of organisational change. Snowden (2002) has demonstrated ways in which knowledge might be exchanged, using examples drawn from a number of large organisations. Yet it is clear that many questions are not fully answered within this literature. What sort of knowledge particularly lends itself to being encoded and transferred in stories? Why use stories in preference to other media? What are the organisational processes that might be implemented to encourage the use of stories? In the following section we address these questions in the context of three significant aspects of organisational KM—the creation, storage, and transfer of knowledge.

KNOWLEDGE CREATION AND STORYTELLING

Much of the existing literature has concentrated on viewing stories primarily, sometimes even solely, as a way of storing existing knowledge. Can stories also be seen as a way of creating new knowledge? If so, where do such stories originate? Boje (2001) offers the view that stories begin as what he describes as "ante-narratives," which contain the fragments or seeds of a story that might then be used to create the story. Whilst such fragments might be based on organisational events, this need not necessarily be the case. Although an organisational story, in the context of KM, is rarely an invented story, in the sense of a work of pure fiction, we are not always looking at a precise telling (or retelling) of some aspects of "organisational history." Instead, we are hearing a subjective interpretation.

This lack of objective accuracy in the creation of organisational "knowledge" makes the study and utility of stories interesting when considering knowledge creation in practice; most managers would probably consider accuracy to be a key desirable characteristic of organisational information, yet as we have seen above, some authors have questioned the importance of this aspect, whilst others have instead stressed the "performative" aspects of the storytelling. For such authors, the question of "an objective truth" appears secondary to the reader's or listener's appreciation of the narrative. In essence, the story is in some sense "well told," in a way which evokes understanding and interpretation in the listener or reader, and as a consequence "the 'truth' of these stories…is not the issue" (Rayment-Pickard, 2000, p. 280). The knowledge we are creating is not necessarily a telling or reretelling of "what actually happened," but is instead a structuralist interpretation. "Facts," such as they are, will be woven into each story (by the teller) and interpreted (by both the teller and the listener), sometimes in a selective way to serve the purpose of the story.

This selectivity in the creation (and subsequent transfer) of knowledge is referred to as glossing (Weick, 1981; Boje, 1991) or "colouring" (Hansen & Khanweiler, 1993), and is often intended to emphasise or sell a particular point of view: "A gloss is akin to marginal notes or digression that can exaggerate, simplify, or shift the meaning of the experience" (Boje, 1991, p 117). Although we have already noted that the "truth" of the story may be secondary to its intended use, we might reflect on whether this emphasis on, or deliberate exclusion of, particular aspects of the story is consistent with the typical organisational aspiration for the management of knowledge. Although the notion of "literary licence" appears to be a common feature of storytelling—such that we might reflect, for instance, that "we're not getting the whole story here"—some might argue that such licence is not restricted to storytelling, and that it is ubiquitous across other knowledge-bearing media.

Lastly, a feature of storytelling that might help to explain its potential as a knowledge-creating medium is its receptiveness to casual or informal use in the organisation. Most organisational knowledge is created continuously, yet only stored and reported upon (or transferred) periodically, typically in some formal or semi-formal way. The informal nature of some organisational storytelling allows these episodes not only to occur more frequently, but also in more flexible organisational contexts. This aspect will be returned to when we consider knowledge exchange.

KNOWLEDGE STORAGE AND STORYTELLING

In looking at the definitional characteristics of stories in an earlier section of this article, we noted the importance of context to both process and content definitions. Stories require a cultural context within which their knowledge content can be embedded and stored, and can sometimes provide the listener with a shortcut to knowledge about an organisation's cultural climate, particularly for new members of the organisation (Martin, 1982).

In their work on the different types of stories commonly found in organisations, Martin, Feldman, Hatch, and Sitkin (1983) identify seven types of story, each of which might be viewed as representing unique yet recurring organisational themes, such as rule-breaking, intolerance, or a "them and us" culture. Each theme can be told with a positive or negative story outcome. She suggests three reasons for the ubiquity of these themes.

First is the dualities of behaviour inherent in all organisations, for instance the tension between the firm's values and those of its employees, or whether the same rules apply equally to all, or how those in control behave towards those with less power. "Organisational stories," argues Martin, "express tension created by dualities, perhaps reducing that tension by expressing it" (p. 448). In considering the story as a knowledge storage medium, it might encode hope (or denial) for resolution of the duality, as well as some predictive knowledge about past organisational behaviour.

Martin's second reason suggests that these themes occur as illustrations of self-preserving rationalisations of past organisational events. Drawing on attribution theory, in which individuals attribute success to their own actions, and failures to external forces beyond their control, she argues that this helps to explain both positive and negative versions of each story theme, as each provides an appropriate vehicle for either version. The acquisition of such knowledge also helps the listener position him/herself about appropriate behaviour to adopt in certain situations, for example, when "to look the other way" or "to keep your head down."

Lastly, she maintains that the stories endow each organisation with a certain "uniqueness," either uniquely good—"a sanctuary in an otherwise difficult world" (p. 451), or uniquely bad—"uniquely unworthy of its employees" (p. 452). As stories change, or endure, so they store important knowledge for the teller and listener about the prevailing culture of the organisation.

Gabriel (1991) views content themed not in terms of organisational cultural characteristics, but of more generically recognisable story themes—for example, epic, tragic, and comic—each having familiar narrative themes, whilst operating within an organisational context. In the epic, the hero struggles against an unfair or weak boss; in the tragic story, the hero is a victim, powerless in the face of the organisation; and in the comic story, there is an ambiguity, where the characters are shown enjoying, or suffering, an uneasy mix of pleasure and anxiety. Gabriel (1998) identifies a further seven story types, each centred around emotions such as injustice, humour, or romance. The knowledge stored within such stories therefore focuses more on the emotional characteristics of the organisation, and although he cautions against the interpretive difficulties in gauging the precise emotional content of each story, it seems reasonable to conclude that the emotional climate of the organisation might be stored in such stories, and indicated by their use.

A further aspect of knowledge storage associated with stories lies in their plots. Much of the tacit knowledge is held in a story's plot, such that we "know" what aspects of the story are sad, what constitutes a "happy" ending, even what signals an "ending" to the story. Czarniawska (2004) refers to the strength of plots, and that this strength is derived from the repetition of a few "strong plots":

…some plots are strong—or stronger than others—because they have been institutionalised, repeated through the centuries, and are well rehearsed…One should therefore speak of conventional rather than traditional plots, and of dominant rather than strong plots; they are 'strong' in a given time and place. (p. 3)

This emphasis on the contextual aspect of the strong plot appears very resonant with the concept of tacit knowledge, embedded within a familiar story. If each story contains a recognisable "package" of knowledge, so each plot helps to anchor the relevance of that package within an organisational and cultural context.

There appears to be some agreement in the literature that stories provide a valuable way in which organisational knowledge, particularly tacit knowledge, might be encoded. The following section considers how this knowledge might be transferred.

KNOWLEDGE TRANSFER AND STORYTELLING

In this section, we consider how knowledge that has been created and stored in stories could be effectively transferred through storytelling.

Storytelling might be viewed as a process in which an individual shares his or her knowledge with others, typically in a face-to-face spoken encounter, during which the story is told and listened to rather than, say, written or read. Such storytelling might be formal, perhaps as part of a formal presentation that might be organisation-specific or to a wider audience (Clark & Salaman 1998), or informal, perhaps arising from a chance meeting or prompted by events. The nature of such encounters, particularly but not exclusively informal encounters, means that the listener role can be more active—s/he can interrupt, ask for clarification, and express emotions such as approval, disbelief, and so forth about the knowledge being transferred. Such interaction might change the behaviour of the teller, who might modify the story and its knowledge content, in light of such feedback. In this way, the story and its content are less rigidly defined, more dynamic, and perhaps more informal. In some circumstances, the story might be deliberately designed to elicit a response, which may have political or otherwise charged meanings. Informal stories may be counter-cultural or sub-cultural, and their political dimension should not be underestimated, both as a means of reacting to dominant organisational control, and of making sense of the storyteller's and/or listener's place within it. For both formal and informal telling, there will be a selectivity (and, by implication, exclusion) in the process, either deliberate (for example in informal telling) or perhaps as a by-product of organisational structure, culture, or politics (for example, "this story is not to leave the fifth floor").

So far we have considered informal or formal processes of organisational storytelling. What motivates the storyteller to choose stories to transfer knowledge, and will such motivation be influenced by or influence the choice of formal or informal organisational story use?

The literature on this question presents two opposing views; on the one hand a willingness of knowledge sharers to exchange knowledge to their mutual benefit (e.g., Orr, 1990), and on the other a reluctance of knowledge carriers to deposit their knowledge due either to its "stickiness" (von Hippel, 1994) or to absence of incentive (Huber, 2000). Much of the motivational literature seems to have less relevance in the context of informal storytelling; organisational storytelling is an optional activity, with willingness on the part of teller and listener to be involved, and therefore little need for incentives in the "management" sense. The "stickiness" of the knowledge, often seen as an inhibitor of effective knowledge transfer, is much less problematic in storytelling; in some respects it might be regarded as an enabler of more efficient transfer of tacit knowledge, as stories are a "sticky" medium (Connell, Klein, & Meyer, 2004).

Although stories have an inherent capability to capture rich tacit knowledge, it is by no means certain that it is this characteristic that makes them the "medium of choice" among their users. Such tacit knowledge is often exchanged unconsciously, in a taken-for-granted way, during storytelling. Because the teller and listener share the context, the story can often be abbreviated into a particular type of informal story that Boje (1991) refers to as a "terse story."

I call this filling-in-the-blanks form terse storytelling. Much of the story that is told is not actually uttered. A terse telling is an abbreviated and succinct simplification of the story in which parts of the plot, some of the characters, and segments of the sequence of events are left to the hearer's imagination. (p. 115)

The knowledge exchange taking place makes efficient use of this tacit dimension:

…the terser the telling, the more the shared understanding of the social context, since insiders know what to leave to the imagination…The terser the telling, the less sharing of understanding of the social context can be detected by outsiders. (p. 116)

Most of the preceding observations about knowledge transfer and storytelling relate to informal stories. Formal stories, for example those used in presentations or sales pitches, are also used to exchange knowledge, and in these cases the motivation is often easier to discern. Drawing on the work of Bowen (1978), Connell et al. (2004) describe four motives for story use, based on two criteria: control of story content and selection of audience (see Table 1).

Educational stories are those directed to meet the needs of particular people, with content di-

Table 1. Motives for organisational story use (Connell et al., 2004)

		Selection of story audience	
		Story directed at the needs of particular people	People selected who would benefit from story
Control of story content	Specific meaning or message	EDUCATION	EFFECT
	No specific meaning or message	ENRICHMENT	ENTERTAINMENT

rected towards a specific meaning or message. If there is no specific meaning or message, the story is intended to enrich the understanding of the audience. If a story has a specific meaning or message, but its audience is not identified until after the story has been created, such stories are designed to achieve a particular effect. Finally, a story carrying no specific meaning or message, whose audience is selected to hear it after it has been created, is probably being told for entertainment, as when one selects an audience who would enjoy or appreciate hearing about some experience one has recently had. The intention of this "four Es" categorisation is to help practitioners reflect on how and why a story might be an effective knowledge transfer medium in a particular situation, rather than an attempt to "pigeon-hole" stories, which might span two categories or might be used in different ways in different situations. Clearly, such reflections will be more relevant in addressing the deliberate use of stories, where the intention is to manage the story content and recipient reaction.

Both formal and informal stories appear to take advantage of a palatable contextual framework for knowledge transfer. This distinction is not dependant on the "truth" of a story, as we have noted above; formal and informal stories can be equally "untrue." The structure of stories appears to be supportive of their use as a knowledge exchange medium, in particular because stories appear to encourage, or perhaps even invite, retelling.

FUTURE TRENDS

There is a sparseness of empirical support for many of the assertions claimed for narrative approaches to KM. Both "descriptive" and "prescriptive" studies, within different organisational structures, would help to shed more light upon the knowledge processes within organisational storytelling, and if such encounters could, or should, be "managed." Evidence is available from communities of practice such as those identified by Orr (1990) and Shaw, Brown, and Bromiley (1998). Snowden (2002) describes a "private collaboration space" within IBM, containing stories recording "significant mistakes and associated learning that would only be shared by a small trusted community" (Snowden, 2002, p. 20). There is also some limited empirical evidence of story use from voluntary organisations such as Alcoholics Anonymous (Steffen, 1995; Swora, 2001), and caregiving environments (Kirkpatrick, Ford, & Castelloe, 1997; Meyer et al., 2003), where stories may perform a unique or special knowledge-sharing role. It has yet to be seen if the potential for the use of ICT-enabled knowledge exchanges (Meyer et al., 2003; van der Hoof & de Leeuw van Weenen, 2004) will act as an inhibitor or accelerator of organisational storytelling.

If we consider stories as knowledge-flow facilitation devices, and if we seek to explore the ways in which they might be used as effective knowledge transfer devices, then we may need to consider occasions when organisations might be particularly receptive, perhaps even vulnerable, to stories, and also to consider physical locations which might promote, formally or informally, their use.

CONCLUSION

In this article, we have examined both "process" issues—why, when, where, and how stories might be used to create, store, and exchange knowledge—and also "content" issues—the nature of the knowledge, its potency, and its perceived validity. Organisational knowledge is inextricably bound up within the context of the story, and for such knowledge exchanges to be "managed" we need to reflect on ways in which organisations can influence or encourage (or perhaps even inhibit) a storytelling culture through both formal and informal mechanisms; such conscious and deliberate organisational action might be termed "narrative engineering" (Connell et al., 2004).

Organisational stories have significant potential to shed light upon the characteristics of the organisations in which they exist, not least because of the tacit knowledge which is often inextricably bound up within them. We have noted how the stickiness of this knowledge is a valuable characteristic of stories when transferring knowledge, but that the dynamic and unpredictable nature of storytelling offers a challenge to the manager attempting to harness its power.

REFERENCES

Boje, D.M. (1991). The storytelling organization: A study of story performance in an office supply firm. *Administrative Science Quarterly, 36,* 106-126.

Boje, D.M. (2001). *Narrative methods for organisational and communication research.* London: Sage Publications.

Clark, T., & Salaman, G. (1998). Telling tales: Management gurus' narratives and the construction of managerial identity. *Journal of Management Studies, 35*(2), 137-161.

Connell, N.A.D., Klein, J.H., & Meyer, E. (2003, September). Narrative, knowledge and communities of practice: What sort of stories do practitioners listen to, and tell? In S. Parkinson & J. Shutt (Eds.), *Proceedings of the British Academy of Management Conference* (pp. 1-8). Harrogate.

Connell, N.A.D., Klein, J.H., & Meyer, E. (2004). Narrative approaches to the transfer of organisational knowledge. *Knowledge Management Research and Practice, 2*(3), 184-193.

Czarniawska, B. (1998). *A narrative approach to organizational studies.* London: Sage Publications.

Czarniawska, B. (2004, June). Femmes fatales in finance, or women and the city. *Proceedings of "The End of Stories and the Limits of Storytelling" Conference* (pp. 1-36). University of Exeter, UK.

Denning, S. (2000). *The springboard: How storytelling ignites action in knowledge-era organizations.* Boston: Butterworth Heinemann.

Feldman, S.P. (1990). Stories as cultural creativity: On the relation between symbolism and politics in organisational change. *Human Relations, 43,* 809-928.

Gabriel, Y. (2000). *Storytelling in organizations: Facts, fictions and fantasies.* London: Sage Publications.

Gabriel, Y. (2004). The narrative veil: Truth and untruths in storytelling. In Y. Gabriel (Ed.), *Myths, stories and organizations.* Oxford: Oxford University Press.

Grant, D., & Hardy, C. (2003). Struggles with organizational discourse (introduction to special issue on OD). *Organization Studies, 25*(1), 5-13.

Grant, D., Hardy, C., Oswick, C., & Putnam, L. (2004). *The Sage handbook of organizational discourse.* London: Sage Publications.

Hansen, C.D., & Kahnweiler, W.M. (1993). Storytelling: An instrument for understanding the dynamics of corporate relationships. *Human Relations, 46,* 1391-1409.

Hernandez-Serrano, J., Stefanou, S.E., Hood, L.F., & Zoumas, B.L. (2002). Using experts' experiences through stories in teaching new product development. *Journal of Product Innovation Management, 19*(1), 54-68.

Hoopes, D.G., & Postrel, S. (1999). Shared knowledge, 'glitches' and product development performance. *Strategic Management Journal, 20,* 837-865.

Huber, G.P. (2000, July). Transferring soft knowledge: Suggested solutions and needed studies. In J. Edwards & J. Kidd (Eds.), *Proceedings of the KMAC 2000 Knowledge Management Conference* (pp. 12-22). Birmingham.

Kirkpatrick, M.K., Ford, S., & Castelloe, B.P. (1997). Storytelling: An approach to client-centred care. *Nurse Educator, 22*(2), 38-40.

Martin, J. (1982). Stories and scripts in organisational settings. In A. Hasdorf & A. Isen (Eds.), *Cognitive social psychology* (pp. 255-305). New York: Elsevier-North Holland.

Martin, J., Feldman, M.S., Hatch, M.J., & Sitkin, S.B. (1983). The uniqueness paradox in organisational stories. *Administrative Science Quarterly, 28*(3), 438-453.

Meyer, E., Connell, N., & Klein, J.H. (2003). Knowledge exchange within small teams, some preliminary empirical findings from two contrasting environments. In J.S. Edwards (Ed.)*, Proceedings of KMAC 2003, Knowledge Management Aston Conference 2003* (pp. 272-283).

Orr, J. (1990). Sharing knowledge and celebrating identity: War stories in a community culture. In D.S. Middleton & D. Edwards (Eds.), *Collective remembering: Memory in society* (pp. 169-189). Beverly Hills, CA: Sage Publications.

Pentland, B.T. (1999). Building process theory with narrative: From description to explanation. *Academy of Management Review, 24*(4), 711-724.

Polkinghorne, D.E. (1988). *Narrative knowing and the human sciences.* Albany, NY: State University of New York Press.

Rayment-Pickard, H. (2000). Narrativism. In R.M. Burns & H, Rayment-Pickard (Eds.), *Philosophies of history: From enlightenment to postmodernity*. Oxford: Blackwell.

Shaw, G., Brown, R., & Bromiley, P. (1998). Strategic stories: How 3M is re-writing business planning. *Harvard Business Review*, (May).

Snowden, D. (2002). Complex acts of knowing—paradox and descriptive self-awareness. *Journal of Knowledge Management, 6*(2).

Steffen, V. (1995). Stories as therapy. Life stories and myth in Alcoholics Anonymous. *Nordisk Alkohol Tidskrift, 12*(6), 273-281.

Swora, M.G. (2001). Narrating community: The creation of social structure in Alcoholics Anonymous through the performance of autobiography. *Narrative Inquiry, 11*(2).

van der Hoof, B., & de Leeuw van Weenen, F. (2004). Committed to share: Commitment and CMC use as antecedents of knowledge sharing. *Knowledge and Process Management, 11*(1), 13-24.

Ward, V., & Sbarcea, K. (2001). Voice: Storytelling is knowledge management. In J. Ranyard (Ed.)*, OR43 Keynote Papers, Proceedings of the OR Society Annual Conference* (pp. 129-143). Bath, UK.

Weick, K. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publications.

Wensley, A. (1998). The value of storytelling. *Knowledge and Process Management, 5*(1), 1-2.

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Chapter 4.35
Knowledge Transfer within Interorganizational Networks

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INTRODUCTION

Increasingly, knowledge is recognized as a critical asset, where a firm or an individual's competitive advantage flows from a unique knowledge base. The subsequent degree to which knowledge is then recognized and valued as a resource has been the theme of many papers on competitive advantage (Barney, 1991; D'Aveni, 1994; Nonaka & Teece, 2001; Prahalad & Hamel, 1990; Spender, 1996; Teece & Pisano, 1994). As a result, the ability to value and leverage external knowledge has become recognized as the basis of competitive advantage.

Gulati and Gargiulo (1999) suggest that membership in a networked community satisfies the need for knowledge as a way to help cope with environmental uncertainty. Consequently, inter-organizational networks or communities of practice represent a significant conduit for knowledge transfer to help manage this environmental uncertainty (Madhavan, Koka & Prescott, 1998).1 Researchers in organizational learning have effectively concluded that organizations participating in a networked community will realize superior economic gains from their increased access to knowledge relative to independent or non-aligned firms (Argote, 1999; Baum & Ingram, 1998; Carlsson, 2002; Darr, Argote & Epple, 1995).

Although the implications of membership in a network having any structure versus no membership (and therefore no structure) are generally accepted, the implications of the different structural types that these networks can assume are less understood. Networks can accommodate, for example, different levels of competition, different degrees of centralization, and different operational objectives.

Knowledge may or may not transfer within different types of networked communities, raising an important question: Given that network membership is accepted as preferable for knowledge transfer relative to non-membership, does the specific network type in question have an effect on the degree to which knowledge will or will not transfer? This is the guiding research question of this article.

Prior to an exploration of this question, it should be noted that a multi-entity network (or community of practice) is very different from a dyad, and therefore represents unique challenges with respect to research. Unlike a dyadic relationship, networked communities can take on a life of their own that supersedes the presence of any individual member. Simmel (1950), who studied social relationships, found that social triads (and relationships involving more than three entities) had fundamentally different characteristics than did dyads. First there is no majority in a dyadic relationship—there is no peer pressure to conform. In any group of three or more people, an individual can be pressured by the others to suppress their individual interests for the interests of the larger group. Second, individuals have more bargaining power in a dyad. This is not only true because of percentages, but if one member withdraws from a dyad, the dyad disappears—this is not true in a networked community. Finally, third parties represent alternative and moderating perspectives when disagreements arise. As a result of these differences, multi-entity networks are more complex to study and less understood than dyads.

MAIN FOCUS: FACTORS OF KNOWLEDGE TRANSFER

A foundational concept from the Knowledge-Based View of the Firm is that within the context of knowledge management, knowledge is viewed as moving unencumbered by and transferring without cost within and among organizations (Grant, 1997; Kogut & Zander, 1992, 1996); although knowledge is recognized as an asset, unlike other assets its transferability has no associated costs. As von Hippel (1994) described, this may not be the case.

Knowledge has been described as a "sticky" asset that is costly to acquire and difficult to transfer between locations, even within the boundaries of a single firm. This stickiness is caused by, among other factors, the form of knowledge being transferred (Is the knowledge in question explicit? Or is it tacit?), as well as different attributes of the source(s) and the recipient(s), such as their situational absorptive capacity, their respective levels of causal ambiguity, and the degree of trust or motivation shared between the source and the recipient (Szulanski, 1996; von Hippel, 1994). I will refer to this last attribute as the source-recipient relationship. In this section, these three established factors of knowledge transfer—absorptive capacity, causal ambiguity, and the source-recipient relationship—are examined in terms of their effects on inter-organizational knowledge transfer.

Absorptive Capacity

Organizations must possess some degree of absorptive capacity to first recognize and then realize any value from the external knowledge to which it is exposed as a member of a network. The concept of absorptive capacity has received a significant amount of research attention since Cohen and Levinthal's seminal work on the topic (1990). Their definition of the concept is the most widely cited,

…the ability of a firm to recognize the value of new, external information, assimilate it and apply it to commercial ends is critical to its innovative capabilities. We label this capability as a firm's absorptive capacity. (p. 128)

In a networked context, the absorptive capacity of the recipient organization is integral to the success of the knowledge transfer process. In his work examining the effectiveness of inter-organizational alliances, Walker argues that firms that emphasize their relationships with other firms will be more successful, in large part because of their ability to recognize and apply new knowledge (1995). The ability to "sense" new external knowledge and have the processes in place to then bring it internal to the organization quickly becomes a competitive advantage when translated into economic rents. This "sensemaking" is a critical function, which enables an organization to more effectively connect with its operating environment and allocate resources efficiently (Teece, 1998). Cohen and Levinthal (1990) and others (e.g., Lane & Lubatkin, 1998) suggested four types of commonalities, which represent the contributors to a recipient's overall level of absorptive capacity. These commonalities include language, knowledge base, process, and problem solving. If these commonalities are not present, absorptive capacity is considered to be low and knowledge transfer is less likely to occur.

Causal Ambiguity

The concept of causal ambiguity centers around "knowability" (the extent to which something can be known) and "knowness" (the extent to which something is known) of two sets of elements—(i) the organizational inputs and (ii) the causal factors that are used in combination to generate outcomes. Organizational inputs can be understood, for instance, as the raw materials used to manufacture a product, and the causal factors can be viewed as the processes used. When an organization does not know what combination of inputs and process factors cause the final outcome, its knowledge is, at best, causally ambiguous. For example, in the 1890s, Procter and Gamble had been manufacturing Ivory Soap (outcome) utilizing the same ingredients (inputs) and the same processes (causal factors). When an employee had inadvertently left one of the soap-making machines on during his lunch break, he returned to a frothy mixture unlike any soap mixture ever seen. Because none of the inputs had changed, P&G elected to package and distribute the soap as normal. Several months later, they were inundated with orders for the "floating soap". At this point, they were operating under causal ambiguity: having forgotten about the frothy accident several months before, they were unclear as to what input or causal factor could have generated the outcome of floating soap. Eventually the connection to the extra air in the soap-making process was discovered, and "It Floats" became an advertising slogan for Ivory Soap.

Causal ambiguity has been recognized as a factor in knowledge transfer difficulty across much of the research in organizational learning and knowledge management. For example, Wilcox-King and Zeithaml (2001) examined, in part, the tacitness of the knowledge in question as an indicator of causal ambiguity. Mosakowski (1997) developed a useful typology through which to examine the effects of causal ambiguity on the transfer of knowledge and decision making. Extending the work of Lippman and Rumelt (1982), Mosakowski determined that although increased causal ambiguity has the potential to increase competitive advantage by increasing the difficulties associated with imitation by competitors, increased causal ambiguity has the impact of decreasing knowledge transferability, and by association its application.

In the intraorganizational context, Szulanski (1996) found causal ambiguity to be an important contributor to knowledge transfer difficulty. Specifically, Szulanski identified "fundamentally irreducible" (or high) causal ambiguity as a factor in knowledge transfer failure.

Extending the logic of these findings, it can be stated that as causal ambiguity increases, the difficulty associated with knowledge transfer is also expected to increase.

Source-Recipient Relationship

There is uncertainty that exists within the context of the relationship between a knowledge source and a knowledge recipient. The basic premise here is that the knowledge recipient can put the received knowledge to more than one use. That is, the recipient can choose from multiple possible actions to follow once the knowledge has been received. Where the knowledge source can effectively reduce the potential action set of the recipient, uncertainty can be reduced. This reduction in uncertainty may occur as a result of contractual or legal obligations or through a mutually beneficial outcome. The alternative is also true—if the actions of the knowledge recipient cannot be known either because of lack of experience or threat of opportunistic behavior, the recipient action set is considered to be unbounded. In addition, the issue of network size is paradoxical—as the size of the network increases, the potential base of accessible knowledge increases. However, the decision to share knowledge becomes more complex because the knowledge source must consider multiple recipient action sets, translating into greater uncertainty and greater knowledge transfer difficulty. However, inter-organizational networks can mitigate the uncertainties related to initially unbounded action sets through governance policies and controls. As will be seen below, some network forms can effectuate trust or eliminate the need of trust, and thus can help reduce uncertainties and reduce knowledge transfer difficulty. The greater the uncertainty associated within this relationship, the greater the negative impact to inter-organizational knowledge transfer (Szulanski, 1996).

To briefly summarize this section, three established factors of knowledge transfer have been explored: absorptive capacity is considered to have a negative relationship with knowledge transfer difficulty, while causal ambiguity and the uncertainty embedded within the source-recipient relationship are considered to have a positive relationship with knowledge transfer difficulty.

TYPES OF INTER-ORGANIZATIONAL NETWORKS

The basic concept of an inter-organizational network is generally understood and has received significant research attention. A simple network can be defined as "nothing more (or less) than a system…consisting of objects and connections" (Casti, 1995)—generally referred to as 'nodes' and 'linkages' in Social Network Theory. When addressing the concepts of inter-organizational communities of practice, a fundamental distinction should be made between durable, permanent "networks" and temporary "networks" (Westlund, 1999). My concern is with the former case, and conceptually I am more aligned with the characterism put forth by Johnson (1995) that networks are a static form of infrastructure, which support and constrain dynamic activity.

Researchers have studied inter-organizational networked communities from different vantage points. Thorelli (1986) and Almeida, Song, and Grant (2002) studied membership in a network from the perspective of Transaction Cost Economics as a strategy occupying the space between complete organizational self-sufficiency with no inter-organizational transactions and a complete outsourcing strategy with exclusively market-based transactions. Allee (2002) proposed the concept of a "value network" as the basis for understanding the activities related to the creation of intangibles such as knowledge. Carlsson developed a generalized framework of networks organized for the purposes of strategic knowledge management (2002).

Although these studies developed and defined networks, they did not examine the of knowledge transfer within different types of networked communities. Therefore, the question regarding how knowledge transfer difficulty, and its associated factors, varies with inter-organizational network type remains unanswered.

I approached the study of inter-organizational network communities from a slightly different perspective. Using the established foundational theories of Transaction Cost Economics, the Knowledge-Based View of the Firm, and Social Network Theory, I differentiate network types using three established characteristics—centrality of authority, scope of operations, and intensity of competition. I use these characteristics to create an abstract model of inter-organizational networks and then explain different inter-organizational networks that exist in practice.

Centrality of Authority

In an intra-organizational (and inter-personal) context, the two basic structures of centralization and decentralization have been studied extensively (e.g., Adler, 2001; Galbraith & Merrill, 1991; Van den Bosch, Volberda & de Boer, 1991; Volberda, 1998). Researchers have then looked to inter-organizational networks as an organizing principle residing between pure market transactions and complete organizational self-sufficiency. However, once within the community, the question of centralization remains, specifically to what extent governance and decision-making authority is centralized or decentralized.

Williamson (1973, 1975) describes a centralized structure as providing the authority to address issues related to opportunistic behavior, information impactedness, and bounded rationality. A (formal or informal) centralized authority would also have the ability to mandate standardization of operations, language, policies, and so forth. Alternatively, a decentralized structure is described as one of peer group associations, without subordination, involving collective and usually cooperative activities. This type of structure is deficient in its ability to address opportunism and "free-rider" abuses. However, recent researchers have found a decentralized structure to be particularly well adapted to facilitate innovation and new knowledge creation, without the encumbrance of the weight of a formal centralized hierarchy. Alternatively, the former structure has been found to better facilitate the diffusion and implementation of existing knowledge (Adler, 2001; Galbraith & Merrill, 1991; Van den Bosch et al., 1991; Volberda, 1998).

Scope of Operations

In this article, "scope" is defined as the degree of operational differentiation among the members of a community. Members of "narrow scope networks" engage in similar processes and exhibit some commonalities of knowledge base, process, language, problem solving, and so forth. On the other end of the continuum, the participating organizations within "broad scope networks" generally engage in very different types of business processes and often have different knowledge bases, use very different descriptive languages, and experience different types of problem-solving environments.

Intensity of Competition

Within the context of Social Network Theory, an important component of network structure that has been found to have significant impact on how well knowledge does or does not transfer is the ties or linkages among participants (Dacin, Ventresca & Beal, 1999; Granovetter, 1985; Uzzi & Lancaster, 2003). The linkages that exist among participants have been described as being either 'embedded' (integrated) or at 'arm's length' (Dacin et al., 1999). Integrated ties:

> *…are considered to create behavioral expectations that…shift the logic of opportunism to a logic of trustful cooperative behavior in a way that creates a…basis for knowledge transfer. (Uzzi & Lancaster, 2003, p. 384)*

By contrast, linkages at 'arm's length' are:

…cool, impersonal, atomistic…motivated by instrumental profit seeking. (Uzzi & Lancaster, 2003, p. 384)

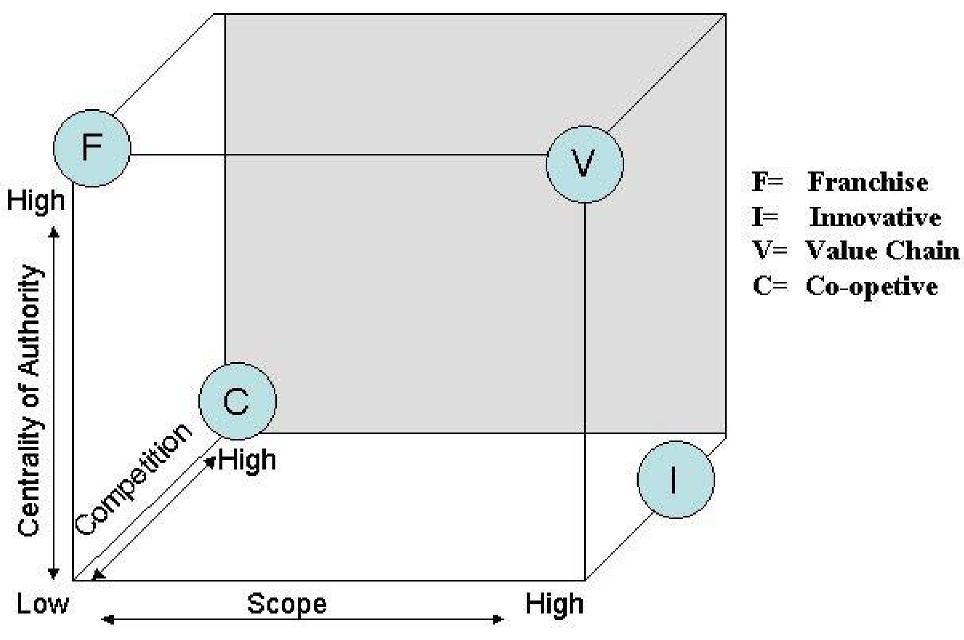
Although it may initially appear counterintuitive that organizations voluntarily join networks while maintaining 'arm's length' ties, consider VISA. Individual banks are fierce competitors, yet collectively benefit from the functionality of global payment card acceptance afforded by VISA—their relationships are "cool and impersonal," with linkages created for the purposes of decreased transaction costs. In addition, Powell, Koput, and Smith-Doerr (1996) found that as the technological sophistication of an industry increases, the intensity and number of competitive alliances also increases; although relationships are again "cool and impersonal," they come together to reduce the costs associated with R&D:

When there is a regime of rapid technological development, research breakthroughs are so broadly distributed that no single firm has all the internal capabilities necessary for success…Firms thus turn to collaboration to acquire resources and skills they cannot produce internally, when the hazards of cooperation can be held to a tolerable level. (1996, p. 117)

Using a more commonly accepted description of these integrated and arm's length linkages, I will refer to this characteristic as "intensity of competition" among the participants, with low intensity of competition equating to integrated linkages and high intensity of competition equating to arm's length linkages.

A graphical representation of these three network characteristics and the unique space occupied by four types of networks can be seen in Figure 1. These four types are explored.[2]

Figure 1. Types of inter-organizational networks



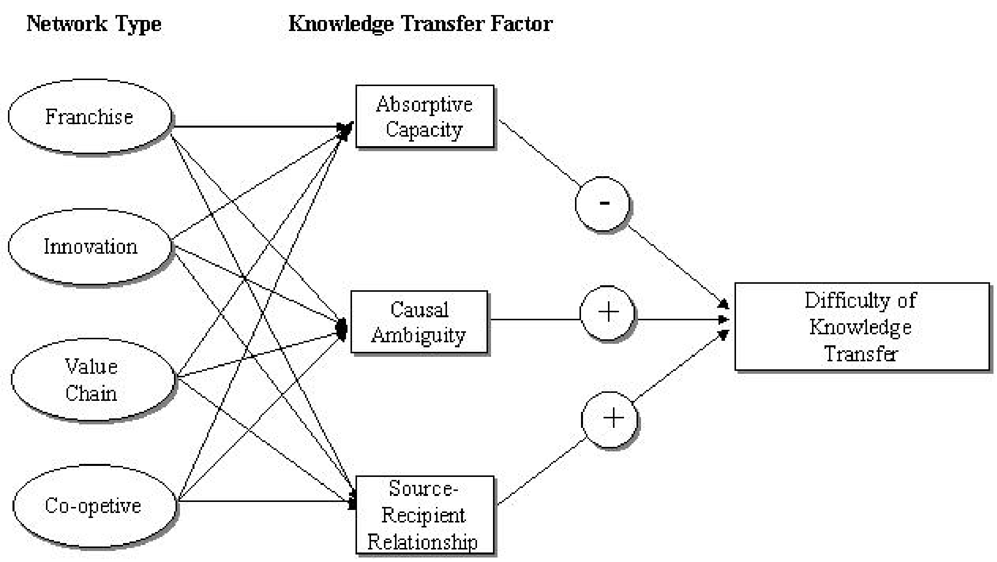
Three of the types identified in Figure 1 have already received some degree of research attention. These types include the franchise network (Argote, 1999; Darr et al., 1995; Thorelli, 1986), the value chain network (Dyer, 1997; Li, 2002; Thorelli, 1986), and the innovation network (Harris, Coles & Dickson, 2000; Harrison & Laberge, 2002). The value chain network type has been studied in three configurations, including dyadic (e.g., the manufacturer/supplier relationship), one-to-many relationships (e.g., the manufacturer with multiple suppliers), and N-to-N relationships (e.g., multiple manufacturers and multiple suppliers). A fourth type of interorganizational network, the co-opetive network, has had the least amount of formal treatment in the literature. The term "co-opetive" has been used to describe a situation where traditional competitors have agreed to cooperate to achieve a common objective (Brandenburger & Nalebuff, 1996; Loebecke, van Fenema & Powell, 1999; Shapiro & Varian, 1999). Using this accepted notion of "co-opetive," I extend this concept to define a co-opetive network as some formalized arrangement of N competitors collaborating to achieve some common objective.

A FRAMEWORK FOR CONSIDERATION

Based upon the discussion of knowledge transfer factors and the different types of networked communities above, I now put forth a framework to address the research question posed in the beginning of this article.

The model depicted in Figure 2 represents a framework to investigate how each of the four network types (franchise, innovation, value-chain, and co-opetive) affects the three factors of knowledge transfer difficulty (absorptive capacity, causal ambiguity, source-recipient relationship). As explored above, the respective relationships of each factor and knowledge transfer difficulty (the

Figure 2. Types of inter-organizational networks and factors of knowledge transfer



right side of the model) are relatively well established: an increase in absorptive capacity would be expected to lead to a decrease in knowledge transfer difficulty, an increase in causal ambiguity would be expected to lead to an increase in knowledge transfer difficulty, and more uncertainty in the source-recipient relationship would be expected to lead to an increase in knowledge transfer difficulty. It is the left side of the model or the relationships among the different network types and the factors of knowledge transfer that represent the greatest opportunity for further exploration.

Given the differences in the attributes of the networks—centralization, scope of operations, and intensity of competition—it would be reasonable to expect that each type would, in fact, experience each factor of knowledge transfer differently. For example, two of the characteristics of the franchise network are narrow operational scope and a hierarchical centralized structure. It could be argued that narrow scope provides a fertile environment for the four commonalities identified as necessary for absorptive capacity—language, knowledge base, process, and problem solving—while a strong hierarchical centralized structure has the ability to mandate standards governing, for example, service and quality. These standards would logically lead to the commonalities of process, knowledge, and language identified above—and therefore a high state of absorptive capacity. Similarly, the common processes that exist in a franchise community of practice would be expected to support a common knowledge of inputs and causal factors, both before and after outcomes associated with their use are known, thereby creating a low state of causal ambiguity. A related characteristic of causal ambiguity identified by Mosakowski (1997) is task complexity: the more complex tasks become, the more difficult it becomes to identify the specific cause and effect that each input or factor has on related outcomes. Where this complexity can be mitigated, causal ambiguity is reduced. Simon (1962) determined that a strong, centralized/hierarchical structure can mitigate task complexity through specialization of labor and standardization. Given the expected hierarchical centralized structure of the franchise community of practice, complexity of task is expected to be low, and again thereby contribute to low causal ambiguity. Finally, the franchise network is characterized by a low intensity of competition amongst the network members. Franchisees are generally stakeholders within a larger entity—they are economically interdependent. Adler (2001) and Kogut and Zander (1996) refer to this interdependence as "shared destiny." Shared destiny would help to mitigate actions related to opportunistic behavior and contribute to a bounded recipient action set. Another characteristic of a franchise community of practice is limited organizational scope, evidenced in part by a commonality of operational processes, again decreasing the uncertainty related to the knowledge in question. In addition, the franchise community of practice is generally considered to have strong central governance. A hierarchical centralized structure would include an authority for punishment associated with opportunistic behavior amongst the franchises. Assuming this threat of punishment is severe enough to prevent defection, trust (or at least trust-like behaviors) could be mandated. As a result, the recipient action set would again be considered to be bounded.

Using this logic, the franchise network type would be expected to demonstrate a high level of absorptive capacity, a low level of causal ambiguity, and limited uncertainty, leading to a bounded recipient action set. Given the expected relationships between each of these factors and knowledge transfer difficulty, the franchise network would be expected to exhibit limited knowledge transfer difficulty. Using similar logic, the relationships between each network type and each factor of knowledge transfer difficulty could be reasoned. These proposed relationships are shown in Table 1.[3]

Table 1. Proposed network type relationships

Factor/Network	**Absorptive Capacity**	**Causal Ambiguity**	**Source-Recipient Relationship Uncertainty**	**Knowledge Transfer Difficulty**
Franchise	High	Low	Low	Low
Innovation	Low	High	High	High
Value Chain	Low	Low	Low	Low-Med
Co-Opetive	High	High	High	Med-High

FUTURE IMPLICATIONS

Researchers have determined that the primary factors that affect knowledge transfer within and among firms include absorptive capacity, causal ambiguity, and the relationship between the source and the recipient (e.g., Cohen & Levinthal, 1990; Mosakowski, 1997; Szulanski, 1996). In addition, membership in some type of structured network has been generally accepted as superior to non-membership for the purposes of knowledge transfer (e.g., Argote, 1999; Darr et al., 1995; Powell et al., 1996). However, prior to this article, no researcher has attempted to frame or address the issues regarding how different network types affect these factors of knowledge transfer—and ultimately the transfer of knowledge itself—differently.

The theory developed in this article provides a framework through which to consider the differences that might exist among different network types regarding the transfer of knowledge. Understanding these differences, if they exist, would have implications for both practitioners as well as for researchers.

For practitioners currently operating within a networked community, this research study has several implications, including both descriptions of the phenomena as well as prescriptions for improvement. For example, if the states of the established factors of knowledge transfer provided in Table 1 are proven to be true, then the strengths and weaknesses of different network types could be considered and addressed in terms of their ability to facilitate the transfer of knowledge. Those individuals or organizations currently operating within a particular network type would be better prepared to anticipate potential challenges to the transfer of knowledge among network members, and proactively allocate resources appropriately.

CONCLUSION

For those engaged in knowledge management research, this article provides two potential contributions. First, although each of the three factors of knowledge transfer identified in Figure 2 are well established as unilateral contributors to the transfer of knowledge, this article provides a framework through which to investigate the relative effects of all three factors on knowledge transfer difficulty simultaneously. Through this framework, it may be determined that causal ambiguity strongly influences the transfer of knowledge within one network type, but is dominated by absorptive capacity within the context of a second network type.

Second, Grant (1997) explains the role of strategic alliances in the Knowledge-Based View of the Firm, from the perspective of resource (knowledge) acquisition and utilization efficiencies within the boundaries of the firm versus outside of the firm—analogous to the foundations of Transaction Cost Economics. However, the Knowledge-Based View of the Firm is currently void of any specificity regarding the general forms that these alliances assume and how these forms then affect knowledge transfer. This work may provide a basis to frame this specificity, thereby contributing to, and possibly extending, this foundational theory of knowledge management.

REFERENCES

Adler, P. (2001). Market, hierarchy and trust: The knowledge economy and the future of capitalism. *Organization Science, 12*(2), 215-234.

Allee, V. (2002). Value networks and evolving business models for the knowledge economy. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (pp. 605-621). Berlin: Springer-Verlag.

Almeida, P., Song, J., & Grant, R. (2002). Are firms superior to alliances and markets? An empirical test of cross-border knowledge building. *Organization Science, 13*(2), 147-162.

Argote, L. (1999). *Organizational learning. Creating, retaining and transferring knowledge*. Norwell, MA: Kluwer Academic Publishers.

Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Baum, J.A.C., & Ingram, P. (1998). Survival-enhancing learning in the Manhattan hotel industry 1898-1980. *Management Science, 44*(7), 996-1016.

Brandenburger, A.M., & Nalebuff, B.J. (1996). *Co-opetition.* New York: Doubleday.

Carlsson, S.A. (2002). Strategic knowledge managing within the context of networks. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (pp. 623-650). Berlin: Springer-Verlag.

Casti, J. (1995). The theory of networks. In D. Batten, J. Casti & R. Thord (Eds.), *Networks in action. Communication, economics and human knowledge.* Berlin: Springer-Verlag.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-153.

D'Aveni, R.A. (1994). *Hypercompetition.* New York: The Free Press.

Dacin, M., Ventresca, M., & Beal, B. (1999). The embeddedness of organizations: Dialogue and directions. *Journal of Management, 25*(3), 317-356.

Darr, E.P., Argote, L., & Epple, D. (1995). The acquisition, transfer and depreciation of knowledge in service organizations: Productivity in franchises. *Management Science, 41*(11), 1750-1762.

Dyer, J.H. (1997). Effective interfirm collaboration: How firms minimize transaction costs and maximize transaction value. *Strategic Management Journal, 18*(7), 535-556.

Galbraith, C.S., & Merrill, G.B. (1991). The effect of compensation program and structure on SBU competitive strategy: A study of technology-intensive firms. *Strategic Management Journal, 12*(5), 353-370.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *The American Journal of Psychology, 91*(3), 481-510.

Grant, R.M. (1997). The knowledge-based view of the firm: Implications for management practice. *Long Range Planning, 30*(3), 450-454.

Gulati, R., & Gargiulo, M. (1999). Where do interorganizational networks come from? *American Journal of Sociology, 104*(5), 1439-1493.

Hamel, G., Doz, Y.L., & Prahalad, C.K. (1989). Collaborate with your competitors—and win. *Harvard Business Review, 67*(1), 133-139.

Harris, L., Coles, A.M., & Dickson, K. (2000). Building innovation networks: Issues of strategy and expertise. *Technology Analysis and Strategic Management, 12*(2), 229-238.

Harrison, D., & Laberge, M. (2002). Innovation, identities, and resistance: The social construction of an innovation network. *Journal of Management Studies, 39*(4), 497-518.

Ivory.com. Retrieved January 29, 2003, from http://www.ivory.com/history.htm

Johnson, J. (1995). The multidimensional networks of complex systems. In D. Batten, J. Casti & R. Thord (Eds.), *Networks in action. Communication, economics and human knowledge*. Berlin: Springer-Verlag.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science, 3*(3), 383-398.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity and learning. *Organization Science, 7*(5), 502-519.

Lane, P.J., & Lubatkin, M. (1998). Relative absorptive capacity and inter-organizational learning. *Strategic Management Journal, 19*(5), 461-477.

Li, L. (2002). Information sharing in a supply chain with horizontal competition. *Management Science, 48*(9), 1196-1212.

Lippman, S.A., & Rumelt, R.P. (1982). Uncertain imitability: An analysis of interfirm differences in efficiency under competition. *Bell Journal of Economics, 13*(2), 418-439.

Loebecke, C., van Fenema, P.C., & Powell, P. (1999). Co-opetition and knowledge transfer. *The DATABASE for Advances in Information Systems, 30*(2), 14-25.

Madhavan, R., Koka, B.R., & Prescott, J.E. (1998). Networks in transition: How industry events (re)shape interfirm relationships. *Strategic Management Journal, 19*(5), 439-459.

Mosakowski, E. (1997). Strategy making under causal ambiguity: Conceptual issues and empirical evidence. *Organization Science, 8*(4), 414-442.

Powell, W., Koput, K., & Smith-Doerr, L. (1996). Inter-organizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 41*(1), 116-146.

Prahalad, C.K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review, 68*(3), 79-92.

Priestley, J.L. (2004). *Inter-organizational knowledge transfer difficulty: The influence of organizational network type, absorptive capacity, causal ambiguity and outcome ambiguity*. Unpublished doctoral dissertation, Georgia State University, USA.

Shapiro, C., & Varian, H.R. (1999). *Information rules: A strategic guide to the network economy.* Boston: HBS Press.

Simmel, G. (1950). Individual and society. In K.H. Wolff (Ed.), *The sociology of Georg Simmel.* New York: The Free Press.

Simon, H. (1962). New developments in the theory of the firm. *American Economic Review, 52*(2), 1-16.

Spender, J.C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17*(Winter Special Issue), 45-62.

Stuart, T. (2000). Interorganizational alliances and the performance of firms: A study of growth and innovation rates in a high-technology industry. *Strategic Management Journal, 21*(8), 791-812.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*(Winter Special Issue), 27-43.

Teece, D.J., & Pisano, G. (1994). The dynamic capabilities of firms: An introduction. *Industrial and Corporate Change, 3*(3), 537-556.

Teece, D.J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how and intangible assets. *California Management Review, 40*(3), 55-79.

Teece, D.J. (2001). Strategies for managing knowledge assets: The role of firm structure and industrial context. In I. Nonaka & D.J. Teece (Eds.), *Managing industrial knowledge: Creation, transfer and utilization* (pp. 125-144). London: Sage Publications.

Thompson, J. (1967). *Organizations in action.* New York: McGraw-Hill.

Thorelli, H.B. (1986). Networks: Between markets and hierarchies. *Strategic Management Journal, 7*(1), 37-52.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review, 61*(4), 674-699.

Uzzi, B., & Lancaster, R. (2003). Relational embeddedness and learning: The case of bank loan managers and their clients. *Management Science, 49*(4), 383-400.

Van den Bosch, F., Volberda, H.W., & de Boer, M. (1991). Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. *Organization Science, 10*(5), 551-568.

Volberda, H.W. (1998). *Building the flexible firm: How to remain competitive.* Oxford, UK: Oxford University Press.

von Hippel, E. (1994). "Sticky information" and the locus of problem solving: Implications for innovation. *Management Science, 40*(4), 429-438.

Walker, W. (1995). *Technological innovation, corporate R&D alliances and organizational learning.* Unpublished doctoral dissertation, RAND, Santa Monica, CA.

Westlund, H. (1999). An interaction-cost perspective on networks and territory. *The Annals of Regional Science, 33,* 93-121.

Wilcox-King, A., & Zeithaml, C. (2001). Competencies and firm performance: Examining the causal ambiguity paradox. *Strategic Management Journal, 22*(1), 75-99.

Williamson, O.E. (1973). Markets and hierarchies: Some elementary considerations. *American Economic Association, 63*(2), 316-325.

Williamson, O.E. (1975). *Markets and hierarchies: Analysis and antitrust implications.* New York: The Free Press.

ENDNOTES

1 For the remainder of this article, the term "network" will be used to designate an inter-organizational community of practice consisting of more than two organizations. Most of the logic used to develop arguments in this article are common to both inter-organizational as well as inter-personal communities of practice. Where specific logic or research applies to one or the other, these differences will be highlighted.

2 The author acknowledges that while other configurations of inter-organizational networks may exist, these networks are com-

mon in practice and three configurations have already received significant research attention.

3 A complete development of these propositions is included in Priestley (2004).

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Chapter 4.36
Intranet Use and the Emergence of Networks of Practice

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INTRODUCTION

Communities of practice (CoPs) are key to today's knowledge management (Schultze & Leidner, 2002; Von Krogh, 2002). Moreover, the capability of exchanging professional knowledge beyond distance has become a strategic asset for innovative firms. How can members of local CoPs exchange knowledge with remote colleagues and create networks of practice (NoPs)? This article contends that the use of information technology (IT), and more specifically, of intranet systems, is especially suited to link local CoPs to an overall network of practice.

BACKGROUND

Communities of practice are social groupings whose members work in the same material context, interact frequently, acquire common knowledge, and experience similar professional concerns (Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998). Members of CoPs work together and achieve activities that are for some similar and for others complementary (Gherardi & Nicolini, 2000). As they share the same work environment, they have frequent occasions to discuss directly about their job and unusual issues (Orr, 1990). Communities of practice unfold from a shared situation that creates a context favorable to direct encounters, mutual assistance in practice, and collective goals (Iverson & McPhee, 2002). Even though members of a CoP may not spontaneously name their workgroup a community, they usually acknowledge their membership to their occupational group and value its rules and principles.

CoPs display three distinguishing features: mutual engagement, joint enterprise, and common repository (Wenger, 1998).

- Mutual engagement: People join a CoP by committing themselves in actions whose meaning is mutually negotiated. Members of a CoP are related to each other through their mutual engagement in social practices.

- Joint enterprise: The community exists and provides social support and identity to its members to favor the achievement of common goals. These objectives may be explicit or not, officially defined or not, but members of the community engage themselves to complete them.
- Common repository: Over time, shared practices, repeated interactions, and the emergence of a shared culture provide traces of the community. Its members may refer to a common repository to deal with daily or more unusual issues. This repository may be material and concrete (files, forms) or more intangible (routines, specific idioms).

The network of practice extends the notion of CoPs beyond geographical distance. NoPs relate local CoPs whose respective members share occupational competences, job duties, and tasks, but who do not directly interact because of geographical distance (Brown & Duguid, 2000, 2001). As the literature on this notion is extremely recent, the appellation has not been stabilized yet. Some refer to "constellations of practice" or to "virtual communities of practice" (Gherardi & Nicolini, 2000). This article relies on the notion of "network of practice" as the most direct extension of CoPs beyond geographical distance. This phrase also explicitly accounts for the practice foundation of both communities and networks of practice.

People who are not collocated and do not necessarily know each other, but still achieve the same kinds of activities and experiment with similar identification processes belong to an NoP (Vaast, 2004). The relationships among members of an NoP are looser than the ones that characterize CoPs. Members of the NoP can nevertheless exchange on occupational issues. Although each local community displays idiosyncratic features, the overall network is characterized by shared knowledge, culture, and patterns of action. To some extent, the NoP also experiments mutual engagement, joint enterprise, and common repository.

The ways in which local CoPs may get connected to each other and favor the emergence of an NoP are, however, anything but obvious. Given that CoPs rely heavily on the sharing of a material context and on situated recurrent direct interactions, how may these local CoPs get connected into a network of practice?

It has been proposed that specific IS may favor CoPs (Brown, 1998) and may help spread knowledge among communities (Pan & Leidner, 2003). More specifically, the use of intranet systems seems especially suited to relate communities and networks of practice (Vaast, 2004).

INTRANETS, IDEAL TOOLS FOR COPS AND NOPS

Intranets are internal networks based on Web standards that aggregate and integrate various computing applications, such as e-mail, databases, groupware systems, or forums (Bansler, Damsgaard, Scheepers, Havn & Thommesen, 2000; Curry & Stancich, 2000; Ryan, 1998). Since 1995, intranets have represented a major growth area in corporate computing thanks to the availability of standard network technologies like Ethernet, TCP/IP, Web browsers, and servers. They have become increasingly more sophisticated and have integrated dynamic databases and various occupational applications. Intra-nets are private networks that favor flows of information and applications among members of an organization or parts of it (Newell, Scarbrough & Swan, 2001). Specific groups may implement and appropriate their own intranet, and protect it with passwords and various levels of security. Moreover, intranets may easily be customized to various contexts and end-user needs.

Key features of intranets seem appropriate to fulfill the needs of CoPs and NoPs:

Interoperability: Based on universal Web standards, intranets connect local computing networks and unify multiple software systems. Interoperability is useful to connect various local groups, to create room for communication, and to share applications among members of diverse communities.

Cost- and time-efficiency: The wide availability of standard TCP/IP protocols and of other network standards have recently made the implementation of intranets easy, fast, and reasonably priced. Basic intranets only require the availability of one server and of local computers equipped with a browser and connected to the network. Thus, even informal communities may implement and appropriate their own intranet. This ensures that the specific needs of occupational groups are taken into account in the system.

Flexibility: Typical of the new generation of information systems, intranets are also highly flexible and may include multiple applications. IT professionals as well as end-users may thus customize them to take into account the specific needs of their occupational groups. Flexible intranets may also be transformed and enriched over time. As agents become more familiar with the network, they can upgrade or introduce changes. Moreover, the flexibility of intranets makes it possible to adapt them, along with the emergence of an NoP from local CoPs. In particular, as the NoP emerges, communication features (through e-mail, FAQ or forum systems, chat) may become increasingly critical to create and maintain links among local communities.

Privacy: Intranets are private networks. Their design and architecture restrict access to authorized users. For instance, firewalls screen requests to the servers to make sure that they come from acceptable domain names and IP addresses. Mobile users may access the private network thanks to secure logon procedures and authentication certificates. Various levels of confidentiality also ensure that members of CoPs feel that their computing network is to be used only by peers and that outsiders will not intrude into the most private parts of the system (such as the ones that deal with occupational applications). Moreover, access rights and authentication procedures allow for differentiated uses by localized employees. For instance, an intranet may simultaneously present information relevant to all local CoPs and include sub-parts or folders dedicated to specific CoPs. Discriminate access in and among local communities favors the exchange of information and encourages the building of trust throughout the NoP.

User-friendliness: Based on hypertext interfaces and on graphical commands, most intranet systems are intuitive to use. Thus, no matter whether end-users are computer literate or not, they can easily learn how to make good use of the resources the intranet systems provide. As human-computer interactions are made easier and more intuitive, even members of CoPs who are not familiar with computers and computing networks may nevertheless consequently spontaneously appropriate their intranet. User-friendliness also favors end-users' willingness to improve features of the system and to adapt it to fit the communication needs of the NoP.

Two Examples of Intranet Use Creating Links Between CoPs and NoPs

The following examples show how an NoP emerges from the use of an intranet system by members of local CoPs.

Insurance Company Vendors

Thirty-five hundred vendors of an insurance company were geographically dispersed and worked in local teams of about 15 people. Vendors in any one team had many activities in common with vendors in other teams, but traditionally most felt that they were in competition with other teams from the same geographical area. The central headquarters of the company introduced an intranet system dedicated to these professionals. The intranet was not widely used at first, because of limited IT competencies of salespersons and because of the perceived competition among teams. Gradually however, newcomers started to use the intranet and transmitted their expertise in browsing the intranet to old-timers. Members of local teams thus socialized around the intranet. Also, over time, the intranet was used to exchange professional experiences among local teams. It then favored the emergence of a feeling of membership to the same occupation beyond geographical distance.

Buyers of a Railroad Company

Buyers of a railroad company (about 2,500 employees working in local teams) implemented an intranet site dedicated to their work. They directly fully integrated use of an intranet into their daily business. Buyers used the intranet to order supplies and to get information about their shipments. By making it possible for distant local buyers to aggregate their orders, use of the intranet reinforced a pre-existing trend towards the greater centralization of procurement. It also deeply affected work processes and tasks: buyers' practices became more transparent to the other departments of the railroad company. The intranet also made buyers become more aware that, even though they worked in dispersed local services, they all belonged to the same occupational group. Finally, exchanges of experiences and electronic messages resulted in new communications among distant colleagues and favored the exchange of professional experiences and mutual learning.

THE USE OF INTRANETS RELATES COPS AND NOPS

The use of intranets favors the overlapping of local CoPs. When members of various situated CoPs appropriate an intranet system, they become aware that their occupational group is not restricted to their local community. Thanks to common repositories, shared databases, and the possibility to exchange electronically, members of different CoPs start interacting with remote colleagues. Intranet systems allow members of distant communities who share professional concerns to exchange knowledge and experiences with each other. Local communities remain geographically separate and their respective members do not interact directly, but the use of an intranet contributes to the overlapping of local CoPs and to the emergence of NoPs, as it increases the visibility of shared practice and favors more frequent electronic communications.

Furthermore, the availability of an intranet dedicated to a specific occupation favors identification to this occupation thanks to the external and internal recognition of the work accomplished by these professionals. As the intranet is visible (if not entirely open, because of security issues) to the overall organization, it publicizes the occupation throughout the organization. On the other hand, the availability of common information and applications increases the feeling of occupational membership by members of local CoPs and thus also increases the internal recognition of the occupation.

Specific features of intranets strengthen the links among CoPs and favor the emergence of NoPs thanks to the geographical extension of mutual engagement, joint enterprise, and shared repertoire from the community to the network level. Table 1 presents these features.

FUTURE TRENDS

Managers should be especially careful in their attempt to implement and manage intranets to relate CoPs and NoPs. In particular, managers have to deal with three delicate dilemmas: initiative vs. control, sharing vs. competitive emulation, and official vs. emergent processes.

Table 1. Three dimensions of CoPs and NoPs favored by intranet use

	Intranet Applications and Features	***Links Between CoPs and NoPs***
Mutual Engagement	**Repertory:** Index of all users of the intranet, of all members of the profession.	Access to all members of the profession beyond geographical distance. Repertory with name, phone number, e-mail, localization, competences.
	Forum: Discussion application where any end-users freely ask questions, answer, and react.	Discussions on occupational topics taking place at the level of the NoP, and not just of the CoP. Complementary to direct conversations.
	FAQ: List of answers to usual questions. Answers made by experts on covered topics.	Members of local groupings have access to competent and validated knowledge from experts from the whole network.
	E-mail system: Link from the intranet to the e-mail system.	Members of local CoPs may electronically get in touch with remote colleagues. Related to the repertory feature.
Joint Enterprise	**Homepage:** First page of the site that provides information on the site and links to applications.	Presentation of the overall purpose of the work of local CoPs and NoPs. General information on the CoPs and the NoP.
	Occupational applications: Migration of these applications to the intranet.	Members of local CoPs accomplish parts of their job by using the intranet. Nourishes sense of commonality of work throughout the NoP.
	Newsletters: Updated news of interest to end-users. Usually with comments on the news.	Members get quick information regarding their occupation and interpretation of the information by competent members of the NoP.
Shared Repertoire	**Documentation:** Written official, technical, or professional documentation of interest to members of the occupation.	Unique point of entry to exhaustive and up-to-date documentation for all members of the NoP. Sharing of documentation at the level of the NoP and not only of the CoP.
	Databases of experiences: Static or dynamic databases of accounts of experiences by members of the profession.	Access to experiences from all over the NoP. Members of local CoPs get to know what their remote colleagues did. Sharing and mutual enrichment of experiences.
	Shared agenda: As in a groupware system, link to shared agenda of the overall NoP.	Beyond geographical distance, all members of the network get informed of common events and may take part in them.
	Experts: Experts on various topics offer concrete advice on the intranet.	Identification of experts from the whole network and not only to local experts. Access to the best advice on specific topics at the network level.

Defining the intranet too tightly and preventing the expression of local initiatives presents obvious drawbacks, as members of CoPs will not appropriate systems that are imposed on them and that they are unable to customize. However, if too much room is left for local initiatives, multiple fragmented intranet sites may be created which do not favor the establishment of links among CoPs. Alternate phases in the management of the intranet may thus prove useful to deal with this dilemma between initiative and control. Initially, light management—as well as relative freedom of implementation and use—favors the appropriation of the intranet. Later, more control encourages expected positive outcomes at the level of the overall NoP.

The sense of community in CoPs and NoPs provides support to their members, but it does not always encourage the search of improved practices or new knowledge. Healthy emulation among members of CoPs thus fosters the continuous improvement of work process and the pursuit of innovation. On the other hand, leaving too much room for competition and for the expression of political struggles in the CoPs or the NoPs is detrimental to the sharing of valuable knowledge. It therefore seems important to ensure that a basic level of knowledge, practices, and rules are established at the network level to make the dialog among local communities possible and to provide incentives for competition and sharing throughout the NoP, notably through different sections of the intranet.

The official management may be unaware of emergent and improvisational dynamics of change that contribute to the richness of real-world practices. The lack of official support, however, weakens the legitimacy and visibility of local CoPs or of the overall NoP. Coaches at various levels therefore appear as useful intermediaries between informal workgroups and the management. They make it possible to connect CoPs, NoPs, and the official management of the firm. Coaches may also help deal with the two preceding dilemmas. In particular, they may decide when and how to introduce more control or more freedom in the management of the intranet. They may also know how to favor the sense of community and the emulation among members of the network thanks to initiatives on the intranet.

CONCLUSION

Intranet features and use constitute useful links between CoPs and NoPs. They make their users aware that, beyond geographical distance, they belong to an overall occupational network. Intranet use also makes it possible to store and exchange information throughout the network and to improve professional practices.

One would expect these occupational networks to expand even more as technologies such as extranets become more available. The extension of networks of practice from the intra- to the extra-organizational level will undoubtedly present new challenges and opportunities to knowledge management.

REFERENCES

Bansler, J.P., Damsgaard, J., Scheepers, R., Havn, E. & Thommesen, J. (2000). Corporate intranet implementation: Managing emergent technologies and organizational practices. *Journal of the Association for Information Systems, 1*(10), 1-10.

Brown, J.S. (1998). Internet technology in support of the concept of “communities of practice.” *Accounting, Management and Information Technologies, 8*(4), 227-236.

Brown, J.S. & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning and innovation. *Organization Science, 2*(1), 40-57.

Brown, J.S. & Duguid, P. (2000). *The social life of information.* Boston: Harvard Business School Press.

Brown, J.S. & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Curry, A. & Stancich, L. (2000). The intranet—an intrinsic component of strategic information management? *International Journal of Information Management, 20*(4), 249-268.

Gherardi, S. & Nicolini, D. (2000). The organizational learning of safety in communities of practice. *Journal of Management Inquiry, 9*(1), 7-18.

Iverson, J.O. & McPhee, R.D. (2002). Knowledge management in communities of practice: Being true to the communicative character of knowledge. *Management Communication Quarterly, 16*(2), 259-266.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge, UK: Cambridge University Press.

Newell, S., Scarbrough, H. & Swan, J. (2001). From global knowledge management to internal electronic fences: Contradictory outcomes of intranet development. *British Journal of Management, 12*(2), 97-111.

Orr, J. (1990). *Talking about machines: An ethnography of a modern job.* Ithaca, NY: Cornell University Press.

Pan, S.L. & Leidner, D.E. (2003). Bridging communities of practice with information technology in pursuit of global knowledge sharing. *Journal of Strategic Information Systems, 12*(1), 71-88.

Ryan, B. (1998). *The corporate intranet: Harness the power of the next-generation intranet.* New York: John Wiley & Sons.

Schultze, U. & Leidner, D.E. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly, 26*(3), 213-242.

Vaast, E. (2004). The use of intranet: The missing link between communities of practice and networks of practice? In P. Hildreth & C. Kimble (Eds.), *Knowledge networks: Innovation through communities of practice* (pp. 216-228). Hershey, PA: Idea Group Publishing.

Von Krogh, G. (2002). The communal resource and information systems. *Journal of Strategic Information Systems, 11*(2), 85-107.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge: Cambridge University Press.

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Chapter 4.37
Knowledge Exchange in Networks of Practice

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INTRODUCTION

The concept of a community of practice is emerging as an essential building block of the knowledge economy. A community of practice consists of a relatively tightly knit group of members who know each other, work together face to face, and continually negotiate, communicate, and coordinate with each other directly. The demands of direct communication and coordination limit the size of the community, enhance the formation of strong interpersonal ties, and create strong norms of direct reciprocity between members (Brown & Duguid, 2000). These communities develop through the mutual engagement of individuals as they participate in shared work practices, supporting the exchange of ideas between people, which results in learning and innovation within the community (Brown & Duguid, 2000). However, typically not all of an organization's relevant knowledge resides within its formal boundaries or within its communities of practice. To remain competitive, organizations need to ensure that new knowledge found in the external environment is integrated with knowledge that is found within the firm (Cohen & Levinthal, 1990). Organizations must rely on linkages to outside organizations and individuals to acquire knowledge, especially in dynamic fields where innovation results from inter-organizational knowledge exchange and learning (Cohen & Levinthal, 1990).

BACKGROUND

Current research has focused on the role of communities of practice for encouraging knowledge exchange and innovation within organizations; however, we know much less about the role that members of communities of practice play in creating linkages to external knowledge sources. Previous research has found that organizational members may simultaneously be members of a community of practice as well as members of broader occupational communities (Van Maanen & Barley, 1984). These individuals perform the dual roles of generating local knowledge within an organizational community of practice while providing linkages to knowledge and innovations outside of the organization. These inter-organizational networks have been referred to as networks of practice. Networks of practice are social structures linking similar individuals across organizations who are engaged in a shared practice, but who do not necessarily know one another (Brown & Duguid, 2000). Although individuals connected through a network of practice may never meet one another face-to-face, they are capable of sharing a great deal of knowledge and may play a vital role in a firm's ability to acquire new knowledge.

While the participation of individuals in networks of practice is not a new phenomenon, the ability to access these networks has increased due to recent advances in information and communication technologies. Previous efforts to interact with others outside an organization's legal boundaries were often fruitless since they could be time-consuming or cumbersome, and individuals may not even have known whom to contact or how to find a relevant person. Furthermore, if management did not provide the resources to attend external conferences or other events, finding other like-minded individuals with whom to discuss work-related problems often proved difficult. However, communication technologies, such as cell phones, e-mail, IRC, chat rooms, bulletin boards, and so forth, have reduced the costs of informal inter-organizational communication. As a result, individuals may now easily access and discuss their work tasks with others outside their organization. These informal interactions are valued and sustained over time because the sharing of knowledge is an important aspect of being a member of a technological community or network of practice (Bouty, 2000).

Sharing knowledge across external organizational boundaries poses significant challenges to organizations attempting to manage their knowledge resources (Pickering & King, 1995). Through external sources, individuals gain access to knowledge not available locally and can interact informally, free from the constraints of hierarchy and local rules. However, accessing knowledge from external sources usually involves a high degree of knowledge trading and reciprocity. In order to receive help, individuals must be willing to give advice and know-how as well, some of which company management may consider proprietary (von Hippel, 1987). Of special interest to management is that individuals generally participate in networks of practice based on their own personal biases and preferences for others as opposed to what the formal organization dictates, and as a result, they may be exchanging knowledge with others who are working for direct competitors (Schrader, 1991). This makes the study of networks of practice of prime interest for researchers and practitioners.

PREVIOUS RESEARCH RELATED TO NETWORKS OF PRACTICE

Networks of practice are not a new phenomenon. They have existed for hundreds of years and have played an important role in the diffusion of knowledge through society. For example, the well-known term, invisible colleges, dates back to the 1640s when a group of 10 men who were well-educated within one field would meet informally in the taverns of London. These meetings later developed in 1660 into the Royal Society, the oldest scientific society in Great Britain (Price, 1963; Tuire & Erno, 2001). While there is considerable previous research on inter-organizational informal networks under a variety of names—such as scientific communities (Knorr-Cetina, 1981;

Polanyi, 1962), co-citation networks (Usdiken & Pasadeos, 1995), invisible colleges (Crane, 1972), epistemic communities (Haas, 1992; Holzner & Marx, 1979), thought-collectives (Fleck, 1935), paradigms (Kuhn, 1962), and occupational communities (Van Maanen & Barley, 1984)—a review of this literature reveals that research that explicitly focuses on knowledge sharing is quite limited. Below we present the relevant research and empirical studies that we found in our review. This research can be divided into two categories: (1) studies from the perspective of scientific communities and (2) studies from the perspective of high-technology firms.

Scientific Communities

Research on scientific communities suggests that knowledge sharing occurs between members as they engage in debate and discussion of each other's ideas and results, and through collaboration on joint research projects (Crane, 1972). Due to the universal nature of knowledge, shared language, and values within the scientific community, individuals can communicate relatively easily with one another (Tushman & Katz, 1980; Van Maanen & Barley, 1984). Thus, knowledge and innovations spread quickly across organizational, national, and cultural boundaries through these informal relationships. In many cases, these informal networks are more valuable for sharing knowledge than more formal channels, such as publications, since the results of failed experiments are rarely published, and learning about these can prevent their duplication.

In scientific communities, the central goals and values of the members are generally developed and spread throughout the network (Hagstrom, 1965). Strong norms that are well defined and socially imposed, such as reciprocity in knowledge sharing, respect for individuals' intellectual property rights, and honesty in research, facilitate knowledge exchange (Bouty, 2000; Liebeskind, Oliver, Zucker & Brewer, 1996). Trustworthy behavior and norms are enforced since the level of participation in the community is jointly determined by the community's members. Individuals who fail to follow the norms and implicit code of conduct can be excluded from participating in valuable exchanges with others (e.g., participation in research teams with leading researchers, access to the latest research findings, etc.). This exclusion can then negatively impact their career success (Tuire & Erno, 2001). As a result, the production and sharing of valuable knowledge is facilitated, allowing the frontier of knowledge to progress rapidly and at minimal cost

Structural studies of research-based communities of academic scientists have shown that these networks are generally characterized by a center and a periphery (Schott, 1988). The most important, visible, or active members are generally found in the center, and these individuals influence the direction of the development of the community's knowledge. The activities of the individuals in the core determine the community's dominating theoretical concepts, methods, and chosen research problems, which are then mediated through the community's links to individuals in the periphery (Schott, 1988). Through a process known as social contagion (Marsden, 1988), new members are socialized into the community and as such transform their personal identities, adapting their attitudes, behaviors, and values to those of the community (Holzner & Marx, 1979). Additionally, power is an integral part of scientific communities, with individuals often using knowledge strategies as components of power strategies (Holzner & Marx, 1979). Thus, the center of a scientific community is not only a realm of activity, but it also is a realm of identity and cultural values of the community (Schott, 1988; Tuire & Erno, 2001).

High-Technology Firms

Researchers have also taken the firm's perspective and focused on inter-organizational boundary spanning activity in high-technology firms. A major stream of this research began in the 1960s with an investigation into the communication patterns of scientists and engineers in R&D laboratories (see Flap, Bulder & Volker, 1998, for a review). One area within this research is why individuals communicate informally with others outside the organization. For example, von Hippel (1987) found that when specialist engineers could not find the required know-how in-house or in publications, they went outside their organization to their professional networks developed at conferences and other events. Further research has found that quite often professionals communicate with others in their professional networks in order to maintain contact with a reference group and to keep abreast of technological changes (Aiken & Hage, 1968). Allen (1970) has also found that low-performing individuals choose to go outside for help. He argues that this choice is a way to avoid paying a psychological price of loss of face that occurs when an individual asks a colleague who is not a friend for advice.

A second area of investigation has focused on the informal flow of knowledge across a firm's boundaries in a limited number of settings, such as semiconductor, specialty steel and mini-mill industry, and R&D operations (Carter, 1989; Schrader, 1991; von Hippel, 1987). This research provides evidence that participation by individuals in inter-organizational networks leads to knowledge sharing across a firm's legal boundaries that is generally not governed by firm contracts or other market mechanisms (Liebeskind et al., 1996). In many instances, this knowledge sharing may even include the exchange of confidential organizational knowledge, even with others who might even be working in rival firms (Schrader, 1991; von Hippel, 1987). Thus, it is argued that knowledge "leaks" across the firm's legal boundaries (Mansfield, 1985; von Hippel, 1988). Bouty's research (2000) raises a very interesting point though—confidentiality is socially constructed, and as one of her interviewees noted, there are "open secrets." Research by Jarvenpaa and Staples (2001) further touches on this aspect of socially constructed confidentiality since they find that the more individuals view their knowledge as personal expertise, the more individuals regard such knowledge as their own property and not that of the organization.

However, this research suggests that individuals do not just give the knowledge away to others outside their firm. Rather they consciously exchange knowledge with other carefully chosen individuals with whom they often have a long-term relation built on mutual trust and understanding (Bouty, 2000; Schrader, 1991). Research conducted by Schrader (1991) finds that individuals often expect that their chances of receiving valuable knowledge in return are likely to increase after they provide knowledge. Thus, participation in inter-organizational emergent networks results in reciprocity and dyadic exchange of knowledge (von Hippel, 1987), with knowledge sharing viewed as an 'admission ticket' to the ongoing 'back room' discussions within professional networks (Appleyard, 1996).

As a result, participation in inter-organizational networks leads to knowledge leaking in at the same time as it leaks out of the firm (Brown & Duguid, 2000). Research on the relationship between this knowledge exchange and performance at any level, however, is scant. One of the primary reasons is that it is very difficult for firms to manage and evaluate the benefits since it occurs "off the books" (Carter, 1989). Secondly, data regarding the sharing of potentially firm proprietary knowledge are difficult to collect due to their sensitive nature. However, there is some initial evidence of a positive relationship between knowledge trading and firm performance (Allen, Hyman & Pinckney, 1983; Schrader, 1991), between knowledge trading and project performance (Allen, 1977), and between knowledge trading and individual performance (Teigland, 2003; Teigland & Wasko, 2003).

AREAS FOR FUTURE RESEARCH

Networks of practice are proposed to be a valuable complement to intra-organizational face-to-face communities of practice. The implication is that in order to be competitive, organizations should focus on sponsoring participation in both traditional communities of practice and networks of practice, as well as stimulating the interaction between the two. This leads to several interesting areas in need of further research. One area that deserves attention addresses the question of why individuals participate and access knowledge in networks of practice. While the research within high-technology firms provides some initial suggestions—for example, the inability to find the required knowledge in-house, the desire to maintain contact with a professional reference group or long-term relations with close ties, to keep abreast of technological changes, and even to avoid loss of face—the ability to access knowledge through weak tie connections basically requires depending on the kindness of strangers (Constant, Sproull & Kiesler, 1996).

Prior research has emphasized the importance of shared language, values, and goals, as well as long-term relations built on mutual trust for knowledge exchange. Thus, another area of research should investigate the factors that lead to the creation of these facilitators within networks of practice, especially networks sustained through electronic communication. Future research should also investigate the relationship between network structure and knowledge sharing, how network structures change over time, and how network structure influences the cognitive aspects of shared language, values, and goals.

The studies reviewed above have also provided evidence that individuals in many instances participate in the exchange of confidential organizational knowledge, often making their own decisions to share knowledge without management's consensus or even awareness. As a result, knowledge "leaks" across an organization's boundaries, indicating additional areas for future research. For example, future research could investigate the factors leading to this leakage such as "open secrets," social construction of confidentiality, expectations of reciprocity, and so forth. Another factor to be investigated is that of commitment. Just as individuals have a certain degree of commitment to their organizations, they also have a degree of commitment to their profession or occupation (Van Maanen & Barley, 1984). In some professions, the degree of commitment to the profession can be so strong that the norms of the profession transcend the norms of the employing organizations. Finally, research on the relationship between knowledge leakage and performance at all levels is scant and is in need of significant research, especially due to management's concerns relating to the "leakage" of firm proprietary knowledge.

CONCLUSION

In conclusion, the purpose of this article was to direct our attention to networks of practice since current community of practice research has focused primarily on their role for encouraging knowledge exchange and innovation within organizations. While networks of practice are not a new phenomenon, a review of previous, related research reveals that the studies that explicitly focus on knowledge sharing are quite limited. As a result, we know much less about the role that members of communities of practice play in creating linkages to external knowledge sources and how participation in networks of practice influences performance at the firm, project, or individual level. Our review of the literature has also provided us with several areas for future research, and we hope that these suggestions, along with our review, will inspire researchers to further investigate networks of practice.

REFERENCES

Aiken, M., & Hage, J. (1968). Organizational interdependence and intra-organizational structure. *American Sociological Review, 33*(6), 912-930.

Allen, T.J. (1970). Communication networks in R&D laboratories. *R&D Management, 1*, 14-21.

Allen, T.J. (1977). *Managing the flow of technology.* Cambridge, MA: MIT Press.

Allen, T.J., Hyman, D.B., & Pinckney, D.L. (1983). Transferring technology to the small manufacturing firm: A study of technology transfer in three countries. *Research Policy, 12*, 199-211.

Appleyard, M.M. (1996). How does knowledge flow? Interfirm patterns in the semiconductor industry. *Strategic Management Journal, 17*(Special Issue), 137-154.

Bouty, I. (2000). Interpersonal and interaction influences on informal resource exchanges between R&D researchers across organizational boundaries. *Academy of Management Journal, 43*(1), 50-66.

Brown, J.S., & Duguid, P. (2000). *The social life of information.* Boston: Harvard Business School Press.

Carter, A.P. (1989). Know-how trading as economic exchange. *Research Policy, 18*, 155-163.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*, 128-152.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organization Science, 7*(2), 119-135.

Crane, D. (1972). *Invisible colleges: Diffusion of knowledge in scientific communities.* Chicago: University of Chicago Press.

Flap, H., Bulder, B., & Volker, B. (1998). Intra-organizational networks and performance: A review. *Computational & Mathematical Organization Theory, 4*(2), 109-147.

Fleck, L. (1935). *Genesis and development of scientific fact.* Chicago: The University of Chicago Press.

Haas, P. (1992). Introduction: Epistemic communities and international policy coordination. *International Organization, 46*(1), 1-37.

Hagstrom, W.O. (1965). *The scientific community.* New York: Basic Books.

Holzner, B., & Marx, J.H. (1979). *Knowledge application: The knowledge system in society.* Boston: Allyn & Bacon.

Jarvenpaa, S.L., & Staples, D.S. (2001). Exploring perceptions of organizational ownership of information and expertise. *Journal of Management Information Systems, 18*(1), 151-183.

Knorr-Cetina, K.D. (1962). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science.* Oxford: Pergamon Press.

Kuhn, T. (1962). *The structure of scientific revolution*. Chicago: University of Chicago Press.

Liebeskind, J.P., Oliver, A.L., Zucker, L., & Brewer, M. (1996). Social networks, learning and flexibility: Sourcing scientific knowledge in new biotechnology firms. *Organization Science, 7*(4), 429-443.

Mansfield, E. (1985). How rapidly does new industrial technology leak out? *The Journal of Industrial Economics, 34*(2), 217-224.

Marsden, P. (1988). Memetics and social contagion: Two sides of the same coin. *Journal of Memetics—Evolutionary Models of Information Transmission, 2*, 68-85.

Pickering, J.M., & King, J.L. (1995). Hardwiring weak ties: Interorganizational computer-mediated communication, occupational communities, and organizational change. *Organization Science, 6,* 479-486.

Polanyi, M. (1962). The republic of science. *Minerva, 2,* 54-73.

Price, D.J.D.S. (1963). *Little science, big science.* New York: Columbia University Press.

Schott, T. (1988). International influence in science: Beyond center and periphery. *Social Science Research, 17,* 219-238.

Schrader, S. (1991). Informal technology transfer between firms: Cooperation through information trading. *Research Policy, 20*, 153-170.

Teigland, R. (2003). *Knowledge networking: Structure and performance in networks of practice*. Published Doctoral Dissertation, Stockholm School of Economics, Sweden.

Teigland, R., & Wasko, M. (2003). Integrating knowledge through information trading: Examining the relationship between boundary spanning communication and individual performance. *Decision Sciences, 34*(2), 261-286.

Tuire, P., & Erno, L. (2001). Exploring invisible scientific communities: Studying networking relations within an educational research community. A Finnish case. *Higher Education, 4*2, 493-513.

Tushman, M., & Katz, R. (1980). External communication and project performance: An investigation into the role of gatekeepers. *Management Science, 26*(11), 1071-1085.

Usdiken, B., & Pasadeos, Y. (1995). Organizational analysis in North American and Europe: A comparison of co-citation networks. *Organization Studies, 6*(3), 503-526.

Van Maanen, J., & Barley, S.R. (1984). Occupational communities: Culture and control in organizations. In B.M. Staw & L.L. Cummings (Eds.), *Research in organizational behavior.* Greenwich, CT: JAI Press.

von Hippel, E. (1987). Cooperation between rivals: Informal know-how trading. *Research Policy, 16,* 291-302.

von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.

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Chapter 4.38

Using Agent Technology for Company Knowledge Management

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ABSTRACT

Emerging agent-based systems offer a new means of effectively managing knowledge to address complex decision processes, thereby enabling solutions to many real problems that have heretofore appeared intractable. This article presents an overview of expert system and agent technologies, and shows the latter as a powerful extension of artificial intelligence for systems development. To illustrate, a system developed first using an expert system approach and then an agent-based approach is used to identify the strengths and weaknesses of the agent-based approach. Last, the practical implications of a company adoption of agent-based technology for systems development are addressed.

INTRODUCTION

Expert systems have become the most important artificial intelligence technology since the early 1980s. Today, expert system (ES) applications are found widely in business and government, as ES development techniques and tool kits have multiplied. Many of the techniques applied to expert system development can be directly applied to the newly emerging field of Knowledge Management (KM). ES technology provides powerful tools to manage knowledge/expertise within specific domains. KM is the process of creating value from an organization's intangible assets. It deals with how best to leverage knowledge internally in the organization and externally to the customers and stakeholders. The focus is on how best to share knowledge to create value-added benefits to the organization. Simply put, KM is the process of capturing collective expertise and distributing it in a manner that produces a payoff (Liebowitz, 1999a, 1999b, 2000; Liebowitz & Beckman, 1998). The expert system, which provides a software representation of organizational expertise dealing with specific problems, is a useful mechanism to accomplish the knowledge-sharing task. However, traditional expert system development techniques have several shortcomings:

i. Expert systems are typically brittle, dealing poorly with situations that "bend" the rules. Further, the components of an expert system are not typically intelligent enough to learn from their many experiences while interacting directly with users. Thus, the rules encoded initially do not evolve on their own, but must be modified directly by developers to reflect changes in the environment.
ii. Expert systems are typically isolated, self-contained software entities. Very little emphasis is placed on tool kits that support interaction with other expert systems or external software components.
iii. As the system develops, functionality increases are accompanied by an ever-growing knowledge base in which inconsistencies and redundancies are difficult to avoid.
iv. Over time, portions of the process that initially required human intervention become well understood and could be totally automated, but there is no mechanism in place to support the transition from human-activated objects to autonomous objects.

These are exactly the types of shortcomings agent technology (AT) was developed to address. Today, as the system developer chooses between tools and techniques in addressing new system requirements, careful consideration must be given to the advantages of using an expert system versus enhancing it with an agent-based approach. The objective of this study is to analyze the added value of using AT, its significant features and characteristics that distinguish them from expert systems, and its strengths and weaknesses in systems development. The concepts are further illustrated through a case study in which the tradeoffs between these techniques are explored.

AGENTS AND WHAT THEY CAN DO FOR YOU

While no standard definition of an agent has yet emerged, most definitions agree that agents are software systems that carry out tasks on behalf of human users. Intelligent agents generally possess three properties: autonomy, sociability, and adaptability.

Autonomy means that an agent operates without the direct intervention of humans and has some control over its own actions and internal state. It is capable of independent action (Wooldridge & Jennings, 1995). An agent does not simply act in response to its environment; it is able to exhibit goal-directed behavior by taking the initiative.

Sociability refers to an agent's ability to cooperate and collaborate with other agents and possibly human users to solve problems. Agents share information, knowledge, and tasks among themselves and cooperate with each other to achieve common goals. The capability of an agent system is not only reflected by the intelligence of individual agents, but also by the emergent behavior of the entire agent community. The infrastructure for cooperation and collaboration includes a common agent communication language like the Knowledge Query Manipulation Language (KQML) (Finin, Labrou, & Mayfield, 1998) or the Foundation for Intelligent Physical Agent (FIPA) Agent Communication Language (FIPA, 2000).

Finally, adaptability refers to an agent's ability to modify its own behavior as environmental circumstances change. An agent learns from experience to improve its performance in a dynamic environment. That learning can be centralized, as performed by a single agent without interaction with other agents, or decentralized, as accomplished through the interaction of several agents that cooperate to achieve the learning goal (Cantu, 2000).

Agent technology represents a new and exciting means of decomposing, abstracting, and organizing large complex problems. Agents, as autonomous, cooperating entities, represent a more powerful and flexible alternative for conceptualizing complex problems. As attention is increasingly placed on distributed applications like mobile and Web-based systems, applications will not necessarily run from a central location. Communications can be costly in such environments. Direct routing of data to the recipient must be fast and efficient to make additional bandwidth available to others. Agent architectures provide a template for a distributed architecture that lends itself to many of these emerging applications. Agents can be used as mediators between heterogeneous data sources, providing the means to interoperate, using ontologies for describing the data contained in their information sources, and communicating with the others via an agent communication language (Broome, Gangopadhyay, & Yoon, 2002).

For problems characterized by dynamic knowledge, it is infeasible to predict and analyze all possible interactions among modules at design time. Flexible interaction among agents at run-time enables an agent-based system to effectively handle dynamic, unpredictable knowledge. Although knowledge of some problems is dynamic, the change is often local, affecting a subset of requirements. Therefore, some agents can be designated to deal with the dynamic knowledge of a problem, and the functionality of those agents can evolve, reflecting the changes encountered.

The inherent autonomy of agents enables the agent-based system to perform its tasks without direct external intervention. Agents cannot only react to specific events, but can also be proactive, polling the environment for events to determine the proper action in a given circumstance. Despite the increased level of autonomy in an agent-based system, however, the system itself may not be able to automate all levels of intelligent activity. Human users may be required to perform higher-level intelligent tasks. An intelligent distributed agent architecture that allows flexible interactions among participating agents maps well to applications, like expert systems, that require seamless integration with humans. Further, agent technology offers mechanisms for knowledge sharing and interoperability between autonomous software and hardware systems characterized by heterogeneous languages and platforms. Agents can be used as mediators between these various systems, facilitating interoperability.

ENHANCING EXPERT SYSTEMS WITH AGENT-BASED SYSTEMS

One way to better understand AT is to compare it with the more widely used expert systems. This does not imply that ES technology is obsolete or that ES development has nothing in common with agent-based system development. Nevertheless, in general there are some important distinctions between ES and agent-based systems, which make the latter ideal for integrating individual ESs with other ESs and other system types. Probably the most important distinction is that expert systems rely on the user to initiate the reasoning process and to accomplish any action associated with the recommendations provided by the system (Yannis, Finin, & Peng, 1999). The integration of human interaction, then, is assumed and has been greatly facilitated by development tool kits and environments. Agents, on the other hand, are inherently autonomous. That does not mean that the integration of human interaction is necessarily complex. The human is simply another agent in the society of agents. While the user roles vary dramatically between the two paradigms, both readily accommodate human interaction.

Another important distinction is that expert systems have a fixed set of rules that clearly define their reasoning process, while agents interact with their environment and adapt to new conditions. Thus, an application that characteristically incorporates dynamic changes in its data and rules is more naturally accommodated by agent-based techniques. Further, the expert system's knowledge base impacts the modularity and scalability of the system. As new functions are introduced into the system, the central knowledge base grows increasingly large. New rules risk conflicts with old, and changed rules potentially impact more functions than the developer may have planned. Agents, on the other hand, are extremely modular, like self-contained programs that can readily be reused across applications.

Finally, the social interaction inherent in agents facilitates mobile and distributed systems, with formal standards in place outlining interfaces between agents assumed to be heterogeneous in design. Expert systems, on the other hand, are fundamentally built as a cohesive product with a single overarching goal. Despite early emphasis on linking knowledge bases and integrating expertise, those goals are rarely achieved, perhaps because of the issues of combining knowledge bases without the benefit of a standard interface technique. Further, the system components are rarely reused outside the system for which they were built. In fact, it is quite common to throw away one prototype and completely rebuild the next version from scratch. Thus, tools are built with an emphasis on rapid prototyping rather than on facilitating component reuse.

AT WEAKNESSES

Most AT weaknesses can be traced back to lack of maturity. While agent concepts were under discussion as far back as 1985 (Minsky, 1985), applications have been slow to develop, due in part to a lack of mature system development tool kits that enable agents to represent and reason about their actions. A number of systems are now available or under development (Barbaceanu, 2001; Traverse, 2001), but they still suffer from a general immaturity.

A second weakness is the lack of software engineering techniques specifically tailored to agent-based systems. Although there are software development techniques such as object-oriented analysis and design, the existing approaches fail to adequately capture an agent's flexible, autonomous problem-solving behavior, the richness of an agent's interactions, and the complexity of an agent system's organizational structures; thus they are unsuitable for agent-based systems. If agents are to realize their potential, it is necessary to develop software engineering methods appropriate for developing such systems (Wooldridge, Jennings, & Kinny, 2003).

A third weakness is the general difficulty associated with decomposing goals and tasks in ways that balance the computation and communication requirements, avoid or reconcile conflicts, and still achieve the initial objective. Finally, the issue of privacy is particularly relevant for a system in which software components act independently across a distributed environment. While standards are under development for insuring that agents are locked out of systems where they are unwelcome, such standards generally require cooperative agents that do not intentionally attack an unreceptive host. As discussed by other authors (Lu & Guimaraes, 1989), whether or not to use ES technology in systems development is one major consideration. Once that decision has been made, various ES development approaches must also be considered (Yoon & Guimaraes, 1993).

Last, as the previous discussion indicates, the software developer must consider numerous issues in determining whether an agent-based approach is appropriate for a given application. In the final analysis, the system requirements must drive these choices. To illustrate the choice of using an agent-based approach over a strictly ES-based approach, a case study is presented next.

REVERSE MORTGAGE ADVISOR (REMA) CASE STUDY

REMA Background

A reverse mortgage is a special type of home loan that allows a homeowner to convert the equity in his or her home into retirement income. The equity, built up over years of home mortgage payments, can be paid to the homeowner in a lump sum, in a stream of payments, or a combination of the two. Unlike a traditional home equity loan or second mortgage, repayment is not required as long as the borrowers continue to use the home as their principal residence (HUD, 2001). While reverse mortgages have long been seen as a means of increasing the income of the poor or elderly, they have more recently been proposed as a mechanism for tapping home equity for a variety of options and at various stages in the life cycle (Rassmussen, Megbolugbe, & Morgan, 1997). In either case, "because each reverse mortgage plan has different strengths — and because fees and fraud can catch unsuspecting customers — experts say seniors should either shop smart with these tricky loans or not shop at all" (Larson, 1999). The Internet already plays an important role in supporting the dissemination of information about reverse mortgages. In an effort to increase public awareness of this unique loan opportunity, federal regulators, consumer advocates, and loan companies have all developed Web sites (AARP, 2001; FannieMae, 2001; HUD, 2001; Reverse, 2001) to supplement the publications and training currently available through more traditional media. Such Web sites provide information on mortgage options and sources, answers to frequently asked questions, and even "calculator" functions to help "shoppers" estimate the amount of loan for which they are eligible. The use of Web sites, however, can be quite daunting, particularly for the potential reverse mortgage client who is over 62 and of limited income. The REMA project was initiated to increase the accessibility of reverse mortgage information.

REMA I: A Traditional Expert System Approach

REMA I is an expert system designed to provide a structured approach to determining whether an individual qualifies for a reverse mortgage. Unlike the traditional Web site, users are not left to their own devices as they sort through information to better understand their loan options. Instead, REMA I provides advice on Web sites to visit and recommended loan types. It is meant to supplement the Web-based technologies that precede it.

System Architecture

REMA I was developed using Multilogic's Resolver® and Netrunner® tools. Resolver® is a knowledge-based system development tool that combines a powerful rule editor with a flexible visual decision tree interface and inference engine. While it supports backward and forward chaining, linear programming, fuzzy logic, and neural net reasoning, REMA used the default goal-driven backward chaining technique. Resolver® greatly facilitated the coding process, supporting not only the encoding of the initial logic representation, but the debug process as well. Once REMA was developed, the executable was ported to Netrunner®, the engine that supports Web-top publication of Resolver® applications. Figure 1 provides a conceptual illustration of the final application, though in fact, the knowledge base and inference engine are located in Resolver® and their output is located in Netrunner® at the time the application runs. The decision process was initially represented as a decision tree. One branch of that tree is depicted in Figure 2. The decision tree was then converted into a series of 34 "if-then" statements, similar to the sample rule in Figure 2. Each of the 34 rules resulted in the recommendation of one or more of 16 possible outcomes. The knowledge base represents the 34 rules the experts follow when providing advice to potential reverse mortgage consumers.

Queries provide links to local Hypertext Markup Language (HTML) files that provide reverse mortgage training. Those files may, in turn, reference additional information in HTML files at other sites provided by government agencies, consumer advocates, or loan companies. Those links are provided to the Web server through Netrunner®.

System Interface

Figure 3 illustrates a sample interface screen used to gather input for the system. Note that in addition to providing answers to fixed questions, the user may choose to view hypertext about home ownership issues (as illustrated in the bottom

Figure 1. REMA architecture

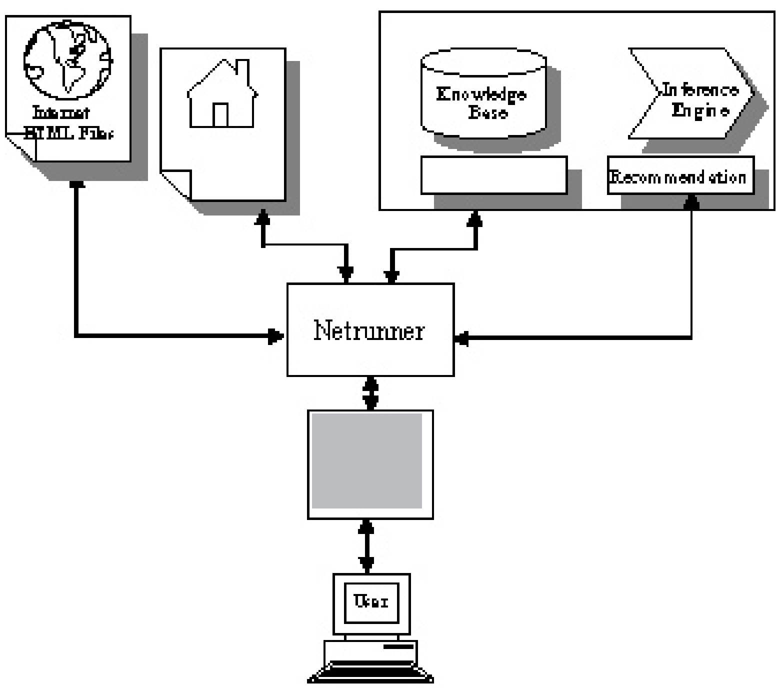
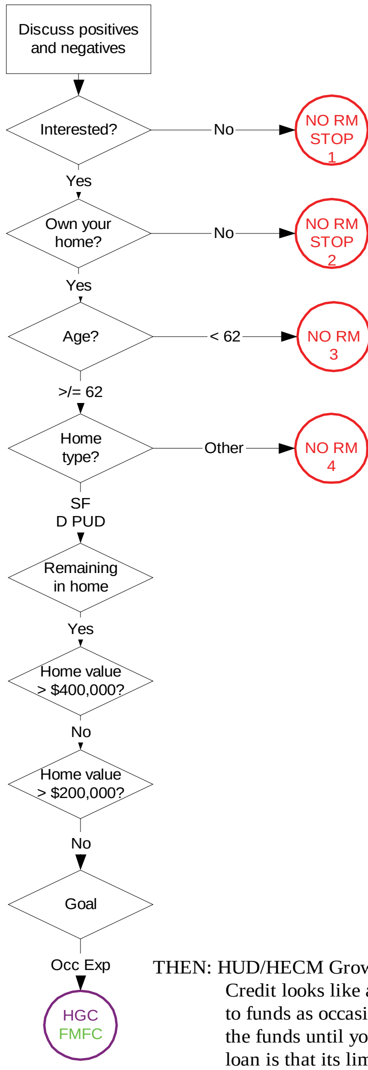


Figure 2. Decision tree illustrating generation of one of REMA's decision rules



RULE NUMBER: 12

IF: What [type of home] do you own? Single Family Dwelling OR Detached Planned Unit Development

and Do you hope to [remain] in your home for the rest of your life? Yes

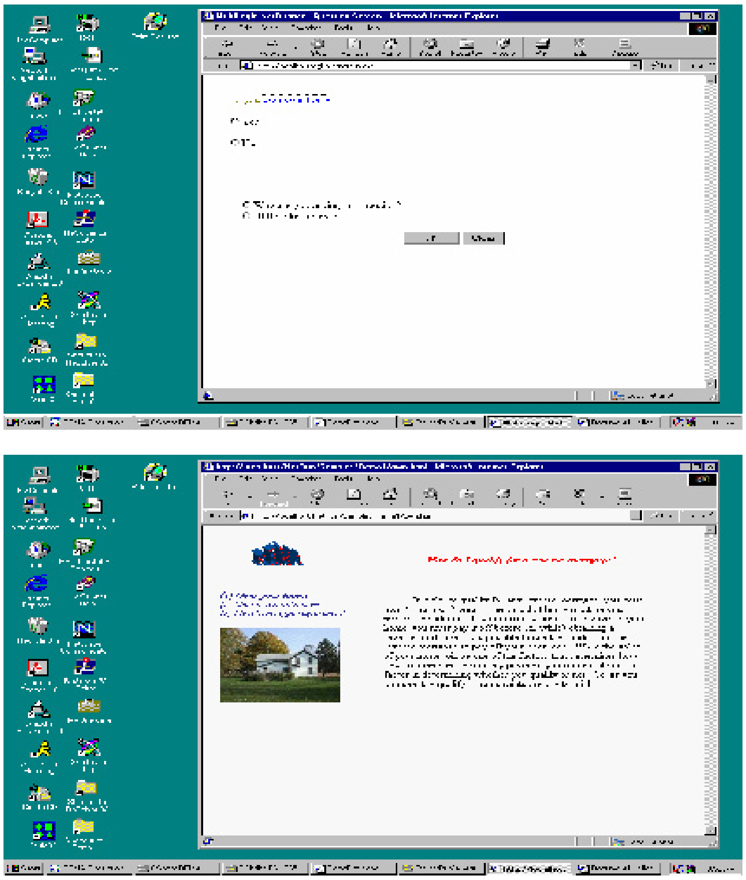
and What is the approximate [value of your home] UNDER $200,000

and Which [goal] most accurately describes your objective in seeking out a Reverse Mortgage loan? I need help when occasional expenses arise that I can't meet.

THEN: HUD/HECM Growing Credit Line: The HUD Growing Line of Credit looks like a good option for you. It will give you access to funds as occasional expenses arise. You don't pay interest on the funds until you actually use them. A nice feature of this loan is that its limit automatically increases as you grow older. That makes the HUD loan a particularly nice option.-Confidence = 8/10

and FANNIE MAE Fixed Credit Line: Fannie Mae's Fixed Line of Credit looks like a good option for you. With this loan, you will have access to funds as you need them, but you won't have to pay interest on the funds until you actually use them....-Confidence = 6/10

Figure 3. The top screen illustrates a query screen used to gather input. The bottom screen illustrates the results of selecting the hypertext link while viewing the query screen.



screen in Figure 3), view the rules associated with the question (by clicking on "Why are you asking this question?"), or return to a previous state by undoing the last answer. The UNDO option is useful if, for example, users find they are not old enough to qualify for a loan, but would still like to continue the analysis. The user must backtrack and modify the age answer to continue.

REMA I Shortcomings

As is common in the life cycle of an expert system, upon completing REMA I, the current system's shortcomings were identified for improvement in future iterations. The current version is clearly at an early stage of development, so it was expected that the developer would want to "grow the system" by incorporating more than the initial three loan companies selected for Phase 1. However, several of the problems identified indicate that the expert system design may not be best for meeting overall project objectives. The "build a little, test a little" approach associated with expert systems was quite useful in facilitating discussions with experts, but the outcome of those discussions indicates an alternative design option should at least be considered before moving to the next development phase.

First, beyond the original assessment of loan qualifications, a cost-benefit analysis is the primary basis for selecting the optimal loan type. While many of the rules for determining whether a user qualifies for a given loan are easily expressed in symbolic terms, the cost-benefit analysis is a computational rather than symbolic algorithm. In order to take full advantage of the Resolver□ tools, the cost-benefit analysis was replaced with a number of rules-of-thumb. For example, if the applicant's home is very expensive, the Freedom plan is usually best. Otherwise, the HUD and FannieMae options are best. One problem is that the concept of "expensive" varies from state to state. The REMA I rules were stated crisply (with "expensive" arbitrarily set to $400,000, for example), and at a minimum should be replaced with fuzzy rules. Ideally, however, the exact loan size, interest rates, application fees, and so forth should be used to provide accurate assessments. These inaccuracies must be avoided in future developments. In some cases, systems (like FannieMae's MorNet) are available to compute exact costs and benefits. While the original objective of the project was not to replace these previously developed computational systems, but to augment them with a training system, the longer term objective should most assuredly move toward a combination of the two types of systems. Otherwise, the advice portion of REMA will be inaccurate, which could have adverse legal implications. An agent-based design would more naturally accommodate the seamless integration of other software packages, while expert systems have very little support for interfacing with other expert systems.

Next, in generating REMA I, the developers discovered that both the rules for providing recommendations and the Web sites used for training users were extremely dynamic. A complete redesign of the decision tree and training files was required between building the baseline system, based on books and Web site information, and the current iteration, based on discussions with the experts. It was not just because tables of costs and benefits changed, though that did cause some system reconfiguration. Additionally, over a very brief period, Congress passed new regulations regarding applicant qualification requirements; companies opted out of the list of reverse mortgage providers; other companies restructured their programs to focus on different target audiences; and as always, Web pages appeared and disappeared across the Internet without notice to the sites that referenced them. Again, expert systems technology was not meant to accommodate such a dynamic environment.

Finally, the training aspect of the system was not as powerful as one might hope. This is due, in part, to the fact that the training simply took the form of instructional text. It certainly was an improvement over the baseline, in which users were on their own to wander the Web looking for relevant documentation. Instead, REMA I focused the Web searches addressing those specific issues of which a prospective applicant should be aware. An online system of this sort, however, has the potential of being a tutor, keeping up with a user's previous searches and expressed preferences to even further tailor the training process. It has a potential for notifying the user as better options arise in this dynamic loan environment. But reaching this potential requires greater autonomy than is typical of expert systems.

The easiest choice for Phase II of system development would be to continue building the next iteration of the current expert system. The next iteration would require: (1) an update of references to outside Web sites; (2) current system assessments from experts; (3) correction of any recently modified data for the HUD, FannieMae, and Freedom Plan options currently represented; (4) incorporation of at least one new loan source; (5) fuzzification of current crisp rules-of-thumb for loan source selection; and (6) incorporation of the MorNet expert system for calculating costs and benefits for those companies it covers. The general system architecture would continue as depicted in Figure 1. However, for the reasons outlined above, instead of enhancing the current ES-based REMA, a decision was made to first explore the use of an agent-based approach to the problem.

REMA II: AN AGENT-BASED APPROACH

System Architecture

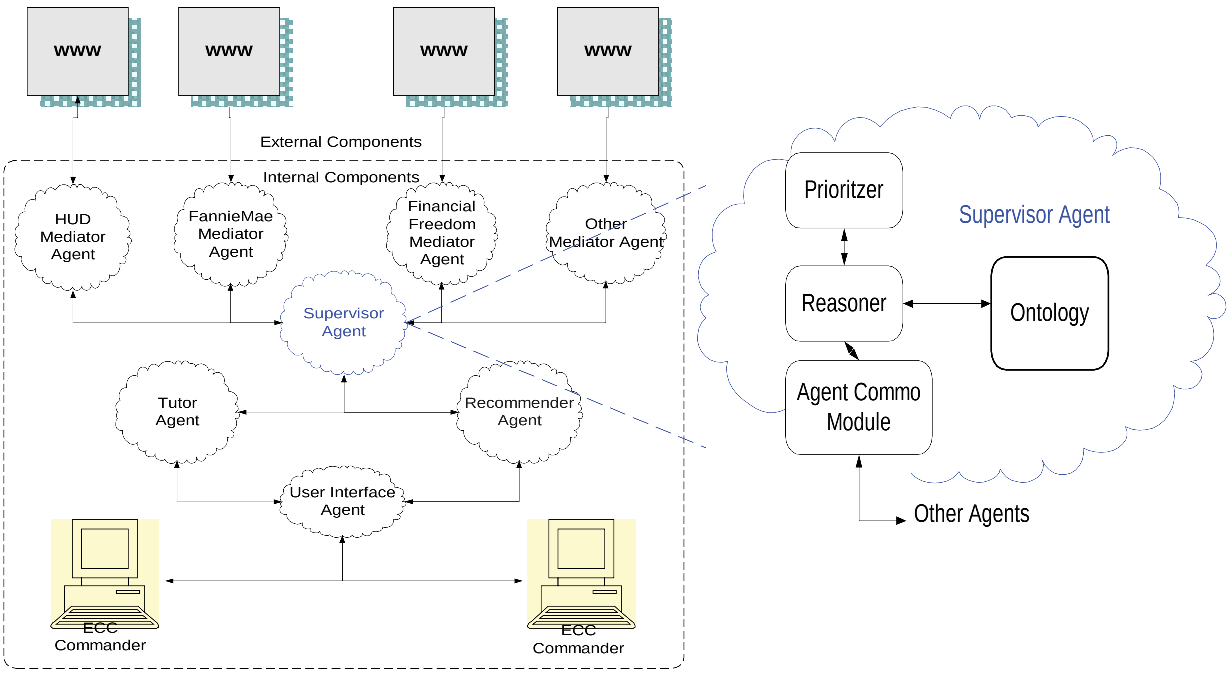
Agents are specific, goal-oriented abstractions of task requirements in systems. From the discussion of the current REMA I system presented in this article, we derive a set of system requirements that agents must implement. These are:

i. Mediating between multiple external agencies including HUD and Fannie Mae to ensure that external information contained in the system remains current.
ii. Translating between external information collected by the mediation with the external agencies (above) and the internal information on user characteristics and goals.
iii. Recommending the appropriate course of action to the user based on rules and expertise contained in the system.
iv. Interfacing with the user to guide him or her through collection of user characteristics and present the system recommendations to him or her.
v. Supervision of the entire process to ensure that the asynchronous collection of information from external agencies is assimilated and incorporated in the recommendations of the system and the information presented to the user.

The above system requirements, as derived from the design of the existing system, form the basis for an agent-based approach. The agent-based approach to REMA consists of multiple Mediator Agents, Tutor Agent, User Interface Agent, Recommender Agent, and Supervisor Agent, as shown in Figure 4.

Individual Mediator Agents are responsible for maintaining the most current information for calculating the costs and benefits of an individual company's reverse mortgage plan. These agents are responsible for interfacing with the external agencies that provide critical information about the programs available for REMA users and ensure that such information is available to the users of REMA. User Interface Agents collect and maintain information on the user's goals and personal characteristics, required for a reverse mortgage application. They are responsible for interaction with the user, and provide guided input of user goals and characteristics in addition to presenting users with the final results and recommendations of the REMA system. The User Agent receives information from the user, through the user interface, and presents user characteristics and goals to the Tutor Agent to determine which internal and external information is most required to teach the principles of reverse mortgages. A Recommender Agent incorporates user characteristics and the most recent loan company information in performing a cost-benefit analysis to determine the best loan source of those available. This information is passed back to the User Interface Agent with information on options that are available to the user given their characteristics and goals. Finally, a Supervisor Agent is responsible for the overall

Figure 4. Agent architecture for REMA



function of the agent system and performs critical meta-functions to prioritize data requests, supply the most recent loan company data, and interpret terminology from heterogeneous sources to consistent internal agents by providing and interpreting a shared ontology of concepts contained in the REMA system.

System Interface

REMA II is initialized with the user being assigned representation in the system through a User Interface Agent. This agent interacts with the user and collects information about the user through an interactive questionnaire. Information about the user is passed to the Tutor Agent who is responsible for matching the goals and characteristics of the user with information from the Mediator Agents to find the appropriate agency that may fulfill user needs. The Mediator Agents, under supervision of the Supervisor Agent, constantly and asynchronously, update their information of the most current programs that are available from the various agencies they interface with. Upon performing the matching, the Tutor Agent generates a match between the internal information provided by the user and the external information available from the financial agencies, through the Mediator Agents. These results are transferred to the Recommender Agent, which maintains the knowledge about courses of action based on specific information received by the Tutor Agent. The Recommender Agent maintains an active, in-memory representation of the decision tree illustrated in Figure 2. Upon receiving user-specific information, it can select the rules that are fired and present those rules and the associated explanations for the recommendations as the action-specific knowledge that is pertinent given the users' characteristics

Figure 5. Use-case diagram for agent-based REMA

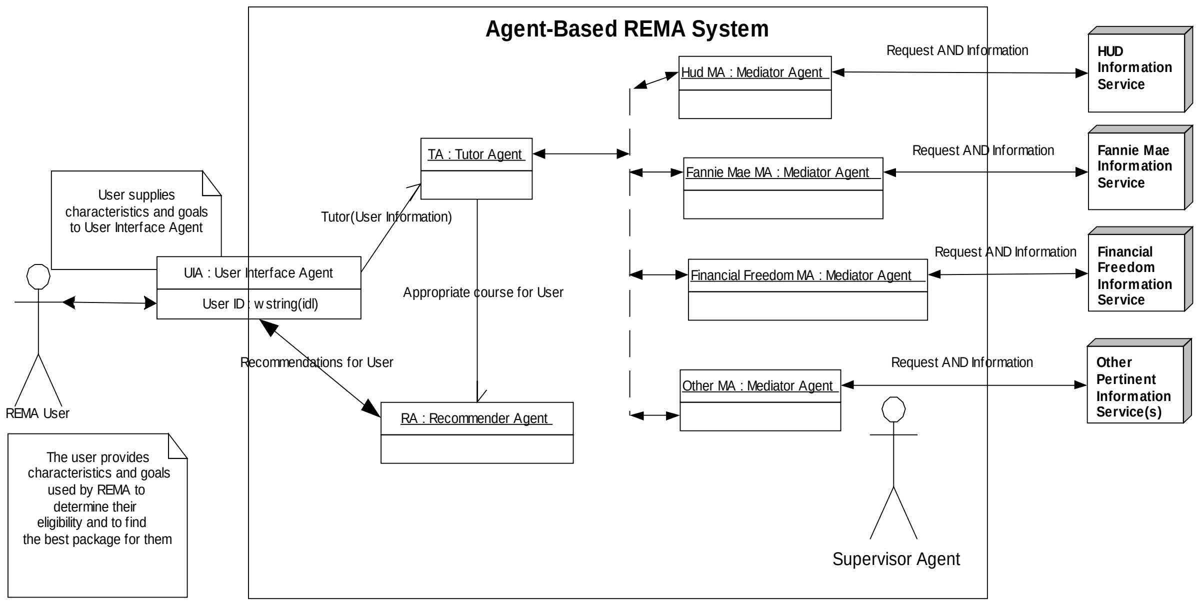
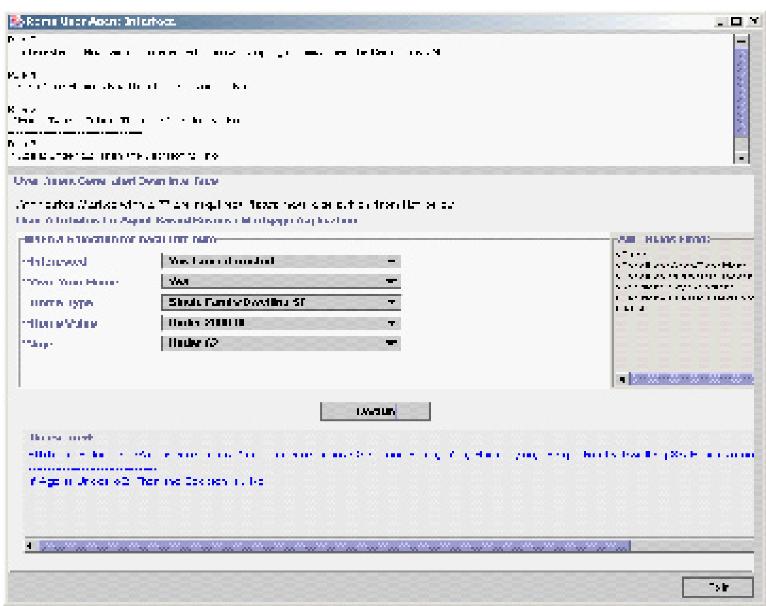


Figure 6. Sample interface screen of agent-based REMA



and goals. The Recommender Agent sends this knowledge, as specific recommendations for the user, to the User Interface Agent who is responsible for presenting the recommended course of action(s) to the user.

The overall flow of information and user-system interaction is presented in the Use-Case Diagram in Figure 5. The diagram shows the boundaries of the system and its interactions with external agencies, in addition to the oversight role of the supervisory agent.

Figure 7. REMA II rule in eXtended Markup Language (XML) format

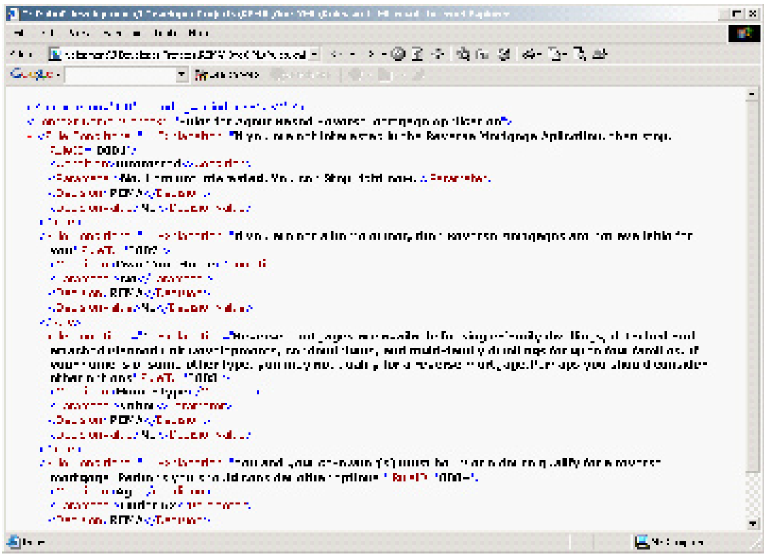


Figure 6 shows a sample screen generated for the REMA II user. The top panel shows the rules that are part of REMA II, allowing the user to gain more knowledge about the explanations offered. Each rule, as illustrated in Figure 7, contains a set of conditions and a matching result, or decision value, for the REMA application. Each rule also contains a user-friendly explanation to provide textual explanation of the rule to the user in a human interpretable manner. The User Agent Interface takes input from the user on various attributes, in terms of the parameters that are acceptable to REMA. For example, in answer to the question "Do you own your own home?," the user can only reply "Yes" or "No." After input of all required parameters, the user asks the system to advise him or her by clicking the decide button, and the rule space is searched and the result is displayed to the user.

ASSESSMENT OF ES VS. AGENT-BASED APPROACHES

ES Approach: Strengths and Opportunities

As outlined in Table 1, the enhanced expert system approach is best when meeting quick turnaround requirements. Multilogic's Resolver® and Netrunner® tools greatly facilitate the system development process, and the consistency of design further insures efficiency. The resulting system will most certainly continue to support faster decision making and improved consistency, less demand on experts, and improved public understanding of the reverse mortgage process. Further, it will continue to support direct-access local HTML files or inserting new ones. Because of its Web emphasis, the system continues to broaden the audience for reverse mortgage training over previ-

Table 1. Analysis of the strengths, weaknesses, opportunities, and threats associated with the agent-based approach and the expert system approach

	Agent Based Approach	Enhanced Expert System Approach
Strengths	Faster decision making. Improved consistency. Less demand on experts. Improved reverse mortgage understanding. Supports better focused web searches. Rules reflect changes in the environment. Other ES work more easily incorporated. Recommendations/training adapt to user.	Effective development tools. Faster decision making. Improved consistency. Less demand on experts. Improved reverse mortgage understanding. Supports better focused WEB searches.
Weaknesses	Limited sites with XML/ontology standard. Limited agent development tool kits.	Accurately addressing the cost-benefit analysis will render the expert system tools less effective. Dynamic data and rules, controlled outside. Training limited to informational text. Knowledge base isolated from WEB data. Does not incorporate other ES work.
Opportunities	Access information directly from source. Easily incorporate new training topics. Reach a broader audience. Formalize expert's process. Autonomous recommendations.	Access information directly from source. Easily incorporate new training topics. Reach a broader audience. Rapid prototype effective use of experts. Formalize expert's process.
Threats	Websites volatile, with distributed control. Changing interface standards. Insufficient training data.	Inaccurate recommendations costly. Potential legal impact from misinformation.

ous brochure and booklet techniques. Finally, its "build a little, test a little" techniques have been shown to make effective use of the limited time of experts in the field, while essentially serving to formally document a process that is not currently well documented.

ES Approach: Weaknesses and Threats

The major shortcoming of this approach, however, is that it fails to resolve the three problem issues identified in developing REMA I. While a link to MorNet will improve the computational component of system recommendations as new loan companies are added, those insertions will continue to be computational, rather than symbolic, in nature. The value of the more established tool sets associated with expert systems will be less noticeable than if the entire task were heavily symbolic in nature. Further, while this approach will incorporate changes to the current data and rules, bringing the system up to date, it does not address the fact that the rules and data will change again. The static nature of the expert system limits its ability to adapt to the dynamic reverse mortgage process it represents or the dynamic Web environment in which it resides. Its lack of advanced communication or interoperability tools limits its ability to incorporate the functionality of other expert systems or Web sites into its knowledge base. As a result, the system will require frequent manual updates or risk, providing inaccurate information that could cost its users money. Such losses may, in turn, carry negative legal implications. Finally, its lack of autonomy restricts the training function to the display of informational text rather than a full-blown tutor that learns about the user as it progresses or, on its own initiative, notifies the user of changes in loan options.

Agent-Based Approach: Strengths and Opportunities

Possessing the properties of autonomy, sociability, and adaptability, agent technology provides the potential for greatly enhancing the capabilities of the REMA system. As illustrated in Table 1, the strengths and opportunities of an agent-based system parallel in many ways those of the expert system approach. The system will most certainly continue to support faster decision making, improved consistency, less demand on experts, and improved public understanding of the reverse mortgage process. Further, it will continue to support direct access to a variety of loan sources by linking into their Web sites. Because of its Web emphasis, it continues to broaden the audience for reverse mortgage training over previous brochure and booklet techniques. The agent-based approach, however, has several additional strengths. First, it more specifically addresses the three problem areas identified at the end of Phase I:

1. Agent-based systems deal equally well with problems of a computational or symbolic nature.
2. It better addresses the dynamic nature of the reverse mortgage process. Rather than establishing fixed rules that must be intentionally modified by the developer at regular intervals, information agents are established to seek and substitute relevant parameters from regulated Web sites as appropriate.
3. The learning component of agent-based systems supports incorporating a well-designed tutoring system that is both diagnostic, discovering the nature and extent of the user's knowledge, and strategic, planning its responses based on its findings about the learner. Also, while the three alternative loan sources are, in fact, representative of the available alternatives, future work must incorporate more companies.

The agent-based approach provides a natural mechanism for incorporating new loan companies with minimal impact on previous software components. The ontology component of the supervisor agent requires updates as new loan sites are added, but it minimizes the effort in mediating between heterogeneous data sources. Finally, the autonomous nature of the agent facilitates an ongoing search for the best possible loan. Thus, the agent can provide information about a new or improved loan source without waiting for the user to think of querying for improvements.

Agent-Based Approach: Weaknesses and Threats

While agent development environments are available, they are generally not as mature as those for expert systems, so system development will generally be more time consuming. The interface to remote Web sites could be facilitated by the use of the XML standard and an ontology to resolve varied terminology across heterogeneous formats; however, these standards are relatively new, and most of the sites of interest are HTML-based instead. It will therefore be important to establish a working relationship with sites across which data is shared; otherwise, the volatility of the data and the distribution of control will render the project ineffectual. Since the standards are relatively new and not widely in force, the developer risks having a new standard move in and replace the one on which the system is based. Finally, while the agent-based approach supports the development of an adaptive tutor/advisor, most learning algorithms require large amounts of data, which may be initially difficult to obtain.

Recommendation for Next Phase of Development

Because of the dramatic increases in functionality associated with the agent-based approach, it is recommended that the fully functional system be built on the agent-based prototype, REMA II, rather than on the REMA I expert system. The only reason for selecting an expert system approach would be to support a fast-turnaround incremental improvement on the current system. Given current availability of a prototype system for immediate use, the plan that best incorporates the dynamic and heavily computational components of the advisor and the user-adaptive, self-initiating components of the tutor is preferred.

PRACTICAL IMPLICATIONS

A critical question for system development managers is, "Under what circumstances would it likely be better to use AT instead of the presently more widely used ES technology for the development of specific applications?" AT is extremely promising, and it behooves all system development managers to understand its potential and limitations and perhaps begin to experiment with AT for possible adoption in the future. However, there are limitations. There are situations where the use of AT will not be efficient in terms of system development cost and implementation time. Systems development managers must remember that presently AT is still at a relatively early stage of adoption in industry at large. The availability of systems developers competent with the technology is relatively limited. Also, there is a lack of systems development tool kits and shells, which today are commonly found for the development of ES. As discussed previously in this article, the fact that AT is useful for addressing relatively more complex application requirements makes the systems development analysis and design tasks correspondingly more complex, requiring software engineering methods that are still under development. In a similar fashion, the ability of AT to bridge the gap between distributed application components may raise questions about user privacy, data integrity, and human control over the agent-based system. Nevertheless, increasingly there are applications that will require the use of AT. The following conditions are likely to call for the use of AT in system development:

1. Applications requiring flexible decision making beyond fuzzy logic and/or the relatively strict rules required by ES.
2. Applications that require enough intelligence for direct system interaction with end users and for system learning from the experience

itself, whereby the rules will evolve on their own without the need for modification by systems developers.

3. Applications that require a flexible and complex integration of two or more ES and/or systems of other types.

As the business community puts greater importance on the role of knowledge management in capturing collective expertise and distributing it in a manner that produces a payoff, the use of agent-based technology will have increasingly significant business implications. With the dramatic increase in Internet activity over the past five years, agents can play an important role in monitoring, filtering, and recommending information, using user profiles to personalize their support. Agent Mediators can facilitate the exchange of data among heterogeneous sites, maintaining an ongoing record of variable site formats and mapping information seamlessly into a format more easily understood by their users. Network Management Agents can focus on increasing throughput and minimizing delay by adapting protocols to the current hardware and workload environment. In general, complex problems can be decomposed into smaller, segmented problems that can be more easily resolved. All of these advances open decision support and e-commerce opportunities to a wider community, and facilitate tapping more widely distributed knowledge bases to improve quality. Such advances are already within reach for many application areas. However, the ability to reach the full potential of these advances relies on continued development of software engineering methods specifically tailored to agent-based systems, software development tools, and security mechanisms that accommodate a widely distributed, mobile computing environment.

The effective use of agent technology enables developers to gain significant advantages over existing technologies in achieving their knowledge management goals. An increased level of software system autonomy limits the user burden for direct intervention and can relieve communication requirements in a bandwidth-limited environment. The distributed decision-making process can increase robustness, and because tasks are performed in parallel, overall system efficiency increases. The approach facilitates developing mediators that can integrate heterogeneous and legacy systems without requiring a single data representation structure. Further, the techniques support incremental development of complex systems via independent reusable components.

The REMA case illustrates some of the many powerful enhancements achieved by using agent techniques where expert systems were originally envisioned. To system designers/developers, one of the most compelling arguments for using only ES is the ready availability of software development tools to support this more mature development technique. Although there are many issues to be addressed for agent technology to realize its full potential, the technology has advanced at a fast rate due to the significant research effort in both academia and industry. Many of the components to build effective agents are moving beyond research communities and coming into common use in the immediate future. With their arrival we now have a powerful integrator for Web-based systems, with the more traditional types of systems (including ES) thus providing a strong infrastructure for managing corporate knowledge.

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REFERENCES

AARP. (2001). Retrieved from www.aarp.org

Barbaceanu, M. (2001). *The agent building shell: Programming cooperative enterprise agents.* Retrieved from www.eil.utoronto.ca/ABS-page/ABS-overview.html

Broome, B., Gangopadhyay, A., & Yoon, V. (2002, July). CAER: An ontology-based community of agents for emergency relief. *Proceedings of the 6th World Multi-Conference on Systemics, Cybernetics and Informatics,* Orlando, FL.

Cantu, F. (2000). *Reinforcement and Bayesian learning in multiagent systems: The MACS project.* Working Paper.

FannieMae. (2001). *Our business is the American dream.* Retrieved from www.fanniemae.com.

Finin, T., Labrou, Y., & Mayfield, J. (1998). KQML as an agent communication language. In J.M. Bradshaw (Ed.), *Software agents.* Boston: MIT Press.

FIPA. (2000). *FIPA specification repository*. Retrieved from www.fipa.org/repository.

HUD. (2001). *Homes and communities.* Retrieved from www.hud.gov.

Larson, M. (1999). *Shopping for a reverse mortgage: Few products, lots of tricky choices*. Retrieved from www.bankrate.com/brm/news/loan.

Liebowitz, J. (2000). *Building organizational intelligence: A knowledge management primer.* Boca Raton, FL: CRC Press.

Liebowitz, J. (Ed.). (1999a). *Expert systems with applications: An international journal.* Amsterdam: Elsevier.

Liebowitz, J. (Ed.). (1999b). *Knowledge management handbook.* Washington, DC: CRC Press.

Liebowitz, J., & Beckman, T. (1998). *Knowledge organizations: What every manager should know*. Boca Raton, FL: CRC Press.

Lu, M., & Guimaraes, T. (1989). A guide to selecting expert systems applications. *Journal of Information Systems Management,* (Spring), 8-15.

Minsky, M. (1985). *The society of mind.* New York: Simon and Schuster.

Rassmussen, D., Megbolugbe, I., & Morgan, B. (1997). The reverse mortgage as an asset management tool. *Housing Policy Debate, 8*(1), 173-194.

Reverse. (2001). *Independent information on reverse mortgages for consumers, their families, professional advisors, and nonprofit counselors.* Retrieved from www.reverse.org.

Traverse, M. (2001). *Agent-based programming environments.* Retrieved from xenia.media.mit.edu/~mt/childs-play-pp.html.

Wooldridge, M., & Jennings, N.R. (1995). Intelligent agents: Theory and practice. *The Knowledge Engineering Review, 10*(2), 115-152.

Wooldridge, M., Jennings, N.R., & Kinny, D. (2003). The Gaia methodology for agent-oriented analysis and design. *International Journal of Autonomous Agents and Multi-Agent Systems, 3.*

Yannis, L., Finin, T., & Peng, Y. (1999). Agent communication languages: The current landscape. *IEEE Intelligent Systems and Their Applications, 14*(2).

Yoon, Y., & Guimaraes, T. (1993). Selecting expert system development techniques. *Information and Management,* (24), 209-223.

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Chapter 4.39
Knowledge Sharing in Legal Practice

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INTRODUCTION

Given the reliance on knowledge-based resources over traditional assets, the professional context serves as a heightened environment in which to investigate knowledge sharing. Within legal practice, the success of a law firm is connected to the firm's ability to leverage knowledge (Sherer, 1995), and this has led to a call for knowledge management to be a business imperative within legal practice (Parsons, 2004; Rusanow, 2003).

An underlying assumption within much of the knowledge management literature is that knowledge sharing is universally beneficial and to be encouraged both within and across organizations. However, in legal practice, sharing is often difficult to achieve or counter to current professional practice. This issue is most salient when considered in the context of the often-contradictory results observed by larger law firms implementing information technologies to increase knowledge sharing throughout their organization. In the remainder of this article, four perspectives that employ a logic of opposition (Robey & Boudreau, 1999) are used to explore the often contradictory outcomes observed when using information technology to increase knowledge sharing by considering factors both impeding and enhancing sharing within legal practice.

BACKGROUND

Despite the recognition of the importance of knowledge in the various professions, a deliberate effort to manage knowledge within the legal profession is a more recent development (Parsons, 2004; Rusanow, 2003).

Knowledge management initiatives are often implemented with the intent of improving aspects of the knowledge management problematic, and this is invariably associated with the implementation of information technology to assist or enable such initiatives (Grover & Davenport, 2001). Knowledge sharing has been identified as a key process in leveraging knowledge assets (Jarvenpaa & Staples, 2000; Nahapiet & Ghoshal, 1998), and within professional practice knowledge management, initiatives are often directed towards improving knowledge sharing throughout the organization (Weiss, 1999). Knowledge sharing in a legal context is typically motivated by a desire to share legal knowledge, but there is a growing interest in extending such efforts to knowledge of the client, industry, staff skills, key stakeholders, and the firm's market and financial position.

Within legal practice, inconsistent findings have been observed with respect to technology-based initiatives aimed at increasing knowledge sharing throughout the firm (Cabrera & Cabrera, 2002; Gottschalk, 1999; Hunter, Beaumont, & Lee, 2002; Terrett, 1998). For many firms the implementation of information technology represents the arrival of 'knowledge management' within the organization. This view positions information technology as a determinant or enabler of radical organizational change that once implemented transforms the organization to one where key processes such as knowledge sharing are not only possible but also inevitable. This deterministic logic of the organizational impacts of information technology has been critiqued and an alternate, more complex relationship purported between information technology and organizations that is emergent and reciprocal in nature (DeSanctis & Poole, 1994; Hirschheim, 1985; Kling, 1980; Markus & Robey, 1988; Orlikowski, 2000; Orlikowski & Robey, 1991; Schultze & Leidner, 2002; Walsham, 1993). These authors point to the possibility for different conceptualizations to the logic of determination for the relationship between organizations and technology. The logic of determination explains change as the result of variation in a set of predictor variables that account for the orderly relationships among the variables in a theoretical model; in contrast the logic of opposition is more suitable for accounting for contradictory outcomes by considering forces both promoting and impeding change (Robey & Boudreau, 1999).

Knowledge Sharing in Legal Practice

Institutional theory, organizational politics, organizational culture, and organizational learning draw upon a logic of opposition and are employed in the remainder of this article to account for the contradictory outcomes of information technology by considering the forces both enhancing and impeding knowledge sharing within legal practice. For the following discussion, these theoretical lenses are directed towards medium (300-750 lawyers) and large (greater than 750 lawyers) law firms in order to highlight the competing forces both enhancing and impeding knowledge sharing. These forces are anticipated to manifest in smaller firms, but to a lesser degree since many of these competing forces are influenced by the size of the practice, the level of geographic dispersion, the nature of the growth strategy (internal expansion or acquisition), and the nature of the competitive environment. Within the legal profession, larger firms are quickly becoming the norm as firms expand through rapid growth fueled by acquisition. Accompanying this growth is an increasing reliance on professional management beyond the traditional collegial shared management from which many of these firms originated. This tension has provided a heightened environment in which to consider the contradictory consequences of efforts to use information technology to improve knowledge sharing and a unique opportunity to highlight how alternate conceptualizations can be used to embrace these contradictions in practice.

Institutional Theory

Institutional theory points to the importance of historical and professional traditions and enduring values that are supported by the organization (Robey & Boudreau, 1999). Institutional theories have historically explained why organizational structures and values endure, despite strong reasons and efforts aimed at changing them (Robey & Boudreau, 1999).

Institutions consist of cognitive, normative, regulative structures and activities that provide stability and meaning to social behavior. Institutions are transposed by various carriers—cultures, structures, and routines—and they operate at multiple levels of jurisdiction. (Scott, 1995, p. 33)

Contemporary institutional theory exhibits a logic of opposition, recognizing that while the institutional environment presents normative forces that pressure conformity to maintain legitimacy, a wide variety of organizational responses may be manifest, and change in this context must be considered in terms of the structural factors both enhancing and impeding change (Robey & Boudreau, 1999).

Shifts in the discourses surrounding the wider institutional context of the legal profession have given rise to new conceptualizations of professionalism and partnerships. A new archetype has been proposed that characterizes professional practice through an amalgamation of components of professionalism and partnership□referred to as the P2 form to highlight the differences between the familiar M-form (Greenwood, Hinings, & Brown, 1990) and the recently proposed managerial professional business (Cooper, Hinings, Greenwood, & Brown, 1996). The P2 form emphasizes a fusion of ownership and control, where managerial tasks revolve among the owners with minimal hierarchy and strong links with clients and the local office. Managerial professional business (MPB) in contrast emphasizes effectiveness and efficiency, with client service and competition serving as the guiding force for a formalized central management team. Within the MPB form, there is increased specialization among lawyers, and integration is accomplished using hierarchy, cross-functional teams, and rules and procedures.

The increased focus on client needs while reducing forces within the firm for sharing increases the outside pressure to share. That is, clients are driving many of the knowledge management initiatives within law firms as they demand increased accountability, and are not willing to pay for 'reinventing the wheel' and are therefore demanding that firms ensure that their lawyers are sharing knowledge. From management's point of view, having the client receive mixed advice because internally the lawyers are not sharing is viewed very negatively. At the same time these clients are realizing that the firm has considerable additional knowledge that is relevant to their business so they are further demanding that the firm share that information with them. Management is eager to satisfy such requests since they wish the client to treat the firm as a 'trusted advisor' on a host of matters in a long-term relationship with the firm (Hunter et al., 2002). This produces competing demands on individual lawyers to hoard their knowledge on the one hand since they see this as guaranteeing their position within the firm by providing their specialized service to the client, while on the other hand knowing that their position also depends on how well they perform with others who also work for the same client.

The need for increased sharing usually begins with the development of a knowledge repository that is centrally administered. This is consistent with the MPB form since it assists in the goal increasing managerial influence throughout the firm. This is particularly important as firms typically consist of multiple offices of national and international affiliates. Centralized technologies based upon knowledge repositories might offer the ability to share knowledge, while at the same time affect institutional norms and cross-organizational boundaries that impede the very sharing that these technologies are intended to support. The very arrival of a specialized knowledge management group or a chief knowledge officer while demonstrating management support for such initiatives as increased knowledge sharing may also effectively separate the practicing lawyers from involvement with knowledge management initiatives within the organization.

The MPB form places significant emphasis on economic performance and efficiency, and this often conflicts with professional and personal expectations of work such as the connection to the public good or the desire for more personal time. The impinging on professional autonomy and representative democracy of the traditional P2 form conflicts with notions of hierarchical control and bureaucracy. Since the MPB form is essentially layered on top of the existing P2 form, there are inherent contradictions that arise, as these forms co-exist within the same organization.

Accounting for contradictory outcomes of information technology employing an institutional theory perspective highlights the dual consideration of the normative pressures on these organizations to not change in order to maintain legitimacy (e.g., highlighted by the factors constituting the P2 form) and forces enhancing change as in the case of the factors implicated in addressing increased pressure from clients (e.g., the MPB form).

Organizational Politics

Organizational politics draws our attention to opposing forces in the form of political resistance to change that must be balanced by negotiation and compromise; change emerges from groups with incompatible opposing interests politically jockeying for position, using information technology as a resource to such political ends along the way (Robey & Boudreau, 1999). Interestingly, it is not assumed that political conflicts can be resolved and that power struggles may be enduring aspects of the political climate. Organizations are regarded as arenas where the contributions and rewards of various parties are sometimes aligned, often misaligned, and occasionally realigned (Bacharach, Bamberger, & Sonnenstuhl, 1996). Professional management establishes an interesting power dynamic within the law firm. Traditionally, management was a shared responsibility and almost an afterthought, or at least something in addition to individual legal practices that had to be performed. The partners were essentially all at the same level, and all the other lawyers wished to be partners someday. However, formal management, while providing a central authority to facilitate sharing throughout the firm, also impedes that process by introducing a power dynamic that was not present when management responsibilities were shared. Before there was no 'us' and 'them', while now there is a clear distinction. Ironically, knowledge management in legal practice may drive a wedge between those demanding that sharing occur and those whom they wish to share (Hunter et al., 2002).

One of the underlying tenets of legal practice has been that 'knowledge is power', since progression within the firm is perceived to be based upon competitive advantage arising from withholding certain knowledge from others (Terrett, 1998). This power to essentially refuse to share was legitimated since there was a professional expectation of autonomy so one could not be forced to share. This autonomy was extends to the relationship with clients whereby individual lawyers essentially 'owned' particular clients, so there was no pressure to share with others since the individual lawyer could directly serve the needs of the client. The key metric for performance under this 'one-on-one' relationship with clients was the billable hour, and this was not negatively affected by knowledge hoarding as the client's needs were met and any inefficiencies resulting from 'reinventing the wheel' were rewarded since the lawyer was paid on a hourly basis. It is detrimental for lawyers to share under this regime since they potentially lose power and income. Incentives and metrics that focus exclusively on individual performance tend to impede knowledge sharing in this context, since they do not account for the positive externalities or recognize the additional value at the group or firm level that can result from such sharing. Consideration for metrics that encourage knowledge sharing focus on factors surrounding mentorship (e.g., student recruitment), industry-level measures that depend on the overall performance of the firm (e.g., market share), or group-level measures (e.g., customer satisfaction with legal team or peer recognition). Varied incentive structures attempt to encourage individual performance while aligning individual goals with those of the group or firm. That is, incentives make explicit the value associated with sharing among the group or firm.

The shifting power from individual lawyers to a central authority has eroded individual autonomy that has further contributed to changing power dynamics, so lawyers are now more mobile, with alternate career paths emerging apart from remaining with the firm for life by progressing to becoming a partner. In conjunction with this is the emerging practice of parachuting individual lawyers into the firm in a lateral move rather than the traditional vertical progression. These individuals are intended to bring a valuable knowledge base and a following of key clients. This climate may at first seem to not be conducive to knowledge sharing (e.g., reduced loyalty), but there may be other political forces at work. For example, attaching oneself to such 'stars' may prove extremely beneficial, and the infusion of new talent may enhance sharing as new practices are adopted.

The push from clients for increased cost accounting has shifted the legal practice of lawyers towards more attention being paid to financial cost considerations for the client and not exclusively on their legal requirements. Information technology in the form of extranets that permit secure access by clients to their ongoing legal files has tended to solidify this practice and shifted the power from the lawyers to the client, as they demand increased transparency and real-time updates on the progress of their file. A parallel power dynamic is evidenced in a reliance on information systems aimed at increasing sharing between law firms (Gottschalk, 2001; Khandelwal & Gottschalk, 2003).

The political considerations within a law firm highlight the competing forces for sharing that accompany an increased reliance on formal management. This view also points to the role of incentives in adequately addressing the positive externalities that can accompany group- and firm-level sharing while countering the individual pressures to hoard knowledge. Finally, the political perspective directs our attention to the increased pressure from clients for increased sharing to facilitate improved transparency and real-time updates, and the need for management to counter existing practices that discourage such sharing.

Organizational Culture

Organizational culture demonstrates the importance of recognizing that technology alone will not overcome resistance stemming from cultural persistence and that further steps will need to be taken to address these concerns in the long term (Robey & Boudreau, 1999). Information technologies are considered cultural artifacts that come to symbolize various beliefs, values, and assumptions (Robey & Boudreau, 1999). Three views of organizational culture have been identified: (1) integration—where culture is unified and consistent, and thus opposing organizational change; (2) differentiation—where conflicts occur at the boundaries between subcultures; and (3) fragmentation—where opposing and irreconcilable interpretations may be entertained simultaneously within and across subcultures, and thus culture is viewed as inherently ambiguous and contradictory (Martin, 1992).

The integration perspective points to areas of strong consensus where values, assumptions, and behaviors are shared, and highlights difficulties in implementing change due to cultural drag, thus producing friction between existing patterns and emerging ones (Robey & Boudreau, 1999). Lawyers are not generally viewed as great information sharers, owing to a career progression based upon acquiring a unique knowledge base and thus facilitating a culture of knowledge hoarding rather than sharing (Rusanow, 2003). Time-based billing further encouraged a reluctance to share since sharing required additional time for which the lawyers could not justify billing to clients, and lawyers were reluctant to dedicate 'non-billable' hours to sharing when they could be working for clients. Information technology in the integration perspective is therefore used to essentially force knowledge-sharing practice by 'culturing' lawyers in knowledge management (Rusanow, 2001). These efforts are then aligned with incentives that contribute to producing an essentially homogenous sharing culture for the firm over time.

The differentiation perspective suggests that even though a homogenous culture may exist within a group, there may be significant differences between groups, even within the same organization or area of specialization. Subcultures shape assumptions about what knowledge is worth managing, expectations of who must share and who can hoard or control specific knowledge, and contributes to the context for social interaction which influences how knowledge will be shared (De Long & Fahey, 2000). Subcultures have significant implications for knowledge sharing since common subcultures are essential for knowledge sharing, without which the tacit knowledge that provides the background understanding for explicit knowledge is not available (Heaton & Taylor, 2002). This implies that where practices are common, sharing can occur (Brown & Duguid, 1991). Using this perspective it is clear that even within the same firm, lawyers may not be able to share their knowledge because their areas of practice are so different. This would explain why it might be easier for lawyers to share with lawyers in another firm than with lawyers in their own firm. Sub-cultural differences are not always a threat, as such differences can also serve as the impetus for a more constructive dialogue, highlighting the complexities that arise in sharing across and even within subcultures.

The fragmentation perspective provides that any cultural symbol can be interpreted in different ways and irreconcilable interpretations can exist simultaneously (Robey & Boudreau, 1999). Even the technological artifact may embody certain cultural features that may affect the use of that technology in practice, and this can be expected to vary between individuals using the same technological artifact. Using technologies to increase sharing under the fragmentation perspective would imply that depending on how the cultural symbol of the technology is interpreted, it may increase or decrease levels of sharing. For example, if the information technology is seen as representing a centralized management culture that is divorced from the more collegial environment in which lawyers are accustomed, then this is likely to reduce sharing significantly. However, if the technology is seen to promote a customer-focused legal practice that is aligned with a preferred collegial culture, then sharing is likely to increase.

Since many of these firms have pursued an aggressive growth strategy fueled by acquisitions, the result is a firm that does not grow its own culture so much as it inherits numerous cultures from the acquired firms. Part of that acquisition is a legacy information technology situation that likely is inextricably linked with the culture of the acquired organization. Attempts to change the existing system or to introduce new systems are likely going to be viewed as a direct assault on the very culture of the firm. Such changes are also counter to the professional culture of lawyers. A collegial environment that provides the lawyer with considerable autonomy in their practice that is essentially self-regulated and underpinned with a connection to the public good and mentorship characterizes this professional culture. Any changes that adversely affect this professional culture are likely to be met with resistance. Within this professional culture are entwined legitimate legal reasons for not sharing such as protection of client confidentiality and intellectual property rights. The ability to segregate knowledge in this context can outweigh the benefits gained by sharing such knowledge with others within the firm.

Organizational culture offers considerable insight into the forces both impeding and enhancing knowledge sharing within legal practice. Multiple acquisitions and the considerable autonomy afforded to individual lawyers and offices on how they operate have left these larger firms severely fragmented. Efforts to increase knowledge sharing in this context must address the multiple cultural differences represented. By appealing to the professional cultures of these lawyers, considerable inroads can be made. The collegial context in which they were trained and the reliance on mentorship all provide unifying connections that can facilitate sharing both within one office and across the offices of these large organizations.

Organizational Learning

Organizational learning considers how organizations learn new responses and why they often fail to learn, while learning organizations achieve higher performance through their ability to learn from past experiences (Senge, 1990). Information technology through the organizational learning lens can have a role to play in both enabling and disabling organizational learning (Robey & Boudreau, 1999).

Learning relies upon an organizational memory, which can be defined as understandings shared by members of an organization about its identity, mental maps, and routines for thought and action (Fiol & Lyles, 1985). While such benefits can accrue for learning, organizational memory may be a poor guide for future action if things change, and therefore organizations must spend considerable time updating their memory (Fiol & Lyles, 1985). The prevailing technology-focused view of knowledge management in legal practice is aimed at capturing the organizational memory in a knowledge repository that can then be shared throughout the firm. However, looking at the constituent aspects of organizational memory, it is unlikely that such aspects could be captured so conveniently.

Legal practice has a strong tradition of mentorship that serves as the basis for learning and firm profits. This mentorship model is built upon the firm's ability to leverage the professional skills of the senior partners with the efforts of the juniors. The underlying motivation for many of the knowledge management initiatives within legal practice is that by improving knowledge management processes such as sharing, the firm will be able to better leverage junior lawyers while simultaneously increasing the effectiveness of the senior partners. While information technology can contribute significantly to knowledge sharing efforts by providing alternate communication channels or the availability of information that was not previously easily accessible, these changes do not necessarily provide the improved learning envisioned to originate from increased sharing. For example, even though e-mail may provide a new channel between senior partners and juniors, juniors may be reluctant to avail of that channel and thus maintain institutional norms, whereby juniors do not have direct access to senior partners.

The mentorship model is the preferred mode of learning with respect to the formalized relationship between junior lawyers and their more senior mentors. This relationship facilitates considerable sharing between the junior and the senior mentor, but the sharing is predominately unidirectional, with the junior lawyer being on the receiving end. This is likely an excellent learning model for the juniors, but may also impede sharing in other aspects. The mentorship model relies on the junior lawyer performing work for the mentor who then bills the client at their senior rate; in return the junior lawyer receives the case experience and guidance needed to progress in the firm. However, it is easy to envision with the forces already discussed in play that such a learning relationship can be shifted so that the junior is essentially performing the work without the benefits of the mentorship. Similarly, this model pairs mentor to junior, often to the exclusion of other lawyers, thus potentially reducing sharing opportunities that would be available if the junior worked with a range of lawyers. Mentorship at the more senior level is not generally as formalized; and when viewed through the increased pressures for individual performance and a reliance on a more centralized management, it is not hard to envision how such mentoring opportunities quickly are moved to the background in favor of short-term gains.

Firm-wide information systems that provide the lawyers with access to best practices, legal precedents, lists of experts, and a searchable knowledge base may in fact be contributing to the erosion of mentorship opportunities. By relying on the information systems as the source of such insights, the lawyers may be robbing themselves of the opportunity to both mentor and be mentored, and the associated benefits of such relationships.

Despite these challenges, the mentorship model appears to be one of the strengths of professional practice, albeit at risk of erosion within certain professional management- and technology-focused environments. The ability to formalize the mentorship model beyond the junior lawyers appears to offer considerable potential for addressing the competing forces both impeding and enhancing knowledge sharing within legal practice.

FUTURE TRENDS

The theoretical perspectives presented draw upon a logic of opposition that sheds new light on the contradictory findings of the effects of technology on knowledge sharing within law firms. Structuration theory (Giddens, 1984) may be a useful theoretical position to take in this regard since the concept of duality of structure points to a reciprocal connection between action and structure. A structuration view of information technology directs our attention to organizational consequences of these technologies as being produced and reproduced through human action (Orlikowski, 2000; Orlikowski & Robey, 1991; Schultze & Orlikowski, 2004).

Legal practice provides a heightened environment in which to investigate the forces both enabling and constraining knowledge sharing. Many of the implications are unique to the legal context of larger firms, but given the growing prominence of geographically dispersed service organizations that rely almost exclusively on their knowledge for their survival and the increased use of information technology to support these practices, the experience in these larger law firms may very well represent things to come for many organizations.

Future studies drawing upon a conceptualization of technology that simultaneously enables and constrains knowledge sharing over time would appear to be particularly beneficial to the field of knowledge management.

CONCLUSION

This article highlights the difficulty in offering prescriptive advice on how to use information technology to increase knowledge sharing within law firms, since any action aimed at increasing knowledge sharing can over time simultaneously produce the opposite effect. There are often good reasons why key aspects of legal practice are counter to knowledge sharing, so expecting lawyers to fundamentally change their practice in order to improve knowledge sharing is problematic if not considered in the context of the range of forces both enabling and constraining such sharing.

Institutional theory highlights the dual consideration of the normative pressures on these organizations to remain the same in order to maintain legitimacy and forces enhancing change in order to remain competitive. The professional institution of a law firm provides certain expectations for conduct, appearance, and practice which if not met severely affect the credibility of the firm. However, competitive pressures fueled by rapid expansion through acquisition have placed strong opposing forces that are shifting these firms to rely on centralized professional management approaches. The customer-centric view this shift entails has produced a push for increased sharing within the firm to produce a consistent and more transparent story for the client, while simultaneously reducing the sharing as individual lawyers see their value to the client as being guaranteed by hoarding their knowledge.

Organizational politics draws our attention to political resistance that impedes knowledge sharing that must be balanced with negotiation and compromise. Legal practice with its reliance on collegial shared management has traditionally relied on power originating from seniority in the firm, but this power is shifting towards professional managers for decisions on how the firm should operate. Firm-wide information systems are seen to both improve professional practice by increasing sharing, while at the same time serving to push a wedge between the lawyers and management that in turn impedes sharing.

Organizational culture points to the role that multiple acquisitions and professional autonomy have played in producing fragmented cultures for these larger firms. Professional cultures might serve as a link between these diverse organizational cultures by appealing to their collegial background and reliance on mentorship. Information technology in this context can be seen as a cultural artifact, and as such any attempt at changing or replacing the technology can be seen as a challenge to the organizational or professional culture that the technology espouses.

Organizational learning highlights the role played by the mentorship model in legal practice. The emerging professional management and a reliance on information systems for improved sharing may in fact be eroding this mode of learning within these large law firms. The mentorship model still appears to offer the most promise for improved knowledge sharing within legal practice, if combined with new approaches to mentorship that draw upon the available technologies and match professional expectations for practice.

The contradictory results observed by law firms when using information technology to improve knowledge sharing throughout their organizations provides an opportunity to employ alternate theoretical positions that instead of treating these findings as a problem embraces them and offers an explanation as to why they were observed. There are other theoretical positions that draw upon a logic of opposition (and other logics) that may prove useful in considering additional aspects of knowledge management in legal practice. This article provides insight into many of the opposing forces that arise within legal practice, and while not an exhaustive list, it is hoped that this will serve as the basis for further work.

REFERENCES

Bacharach, S.B., Bamberger, P., & Sonnenstuhl, W.J. (1996). The organizational transformation process: The micropolitics of dissonance reduction and the alignment logics of action. *Administrative Science Quarterly, 41*, 477-506.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*(1), 40-57.

Cabrera, A., & Cabrera, E.F. (2002). Knowledge-sharing dilemmas. *Organization Studies, 23*(5), 687-710.

Cooper, D.J., Hinings, B., Greenwood, R., & Brown, J.L. (1996). Sedimentation and transformation in organizational change: The case of Canadian law firms. *Organization Studies, 17*(4), 623-648.

De Long, D.W., & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *Academy of Management Executive, 14*(4), 113-127.

DeSanctis, G., & Poole, M.S. (1994). Capturing the complexity in advanced technology use: Adaptive structuration theory. *Organization Science, 5*(2), 121-147.

Fiol, C.M., & Lyles, M.A. (1985). Organizational learning. *Academy of Management Review, 10*, 803-813.

Giddens, A. (1984). *The constitution of society: Outline of a theory of structuration.* Berkeley: University of California Press.

Gottschalk, P. (1999). Knowledge management in the professions: Lessons learned from Norwegian law firms. *Journal of Knowledge Management, 3*(3), 203-211.

Gottschalk, P. (2001). Predictors of inter-organizational knowledge management: Lessons learned from law firms in Norway. *Knowledge and Process Management, 8*(3), 186-194.

Greenwood, R., Hinings, C.R., & Brown, J. (1990). "P2-form" strategic management: Corporate practice in professional partnerships. *Academy of Management Journal, 33*(4), 725-755.

Grover, V., & Davenport, T.H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Heaton, L., & Taylor, J.R. (2002). Knowledge management and professional work. *Management Communication Quarterly, 16*(2), 210-236.

Hirschheim, R.A. (1985). *Office automation: A social and organizational perspective.* Chichester, UK: John Wiley & Sons.

Hunter, L., Beaumont, P., & Lee, M. (2002). Knowledge management practice in Scottish law firms. *Human Resource Management Journal, 12*(2), 4-21.

Jarvenpaa, S.L., & Staples, D.S. (2000). The use of collaborative electronic media for information sharing: An exploratory study of determinants. *Journal of Strategic Information Systems, 9*(2-3), 129-154.

Khandelwal, V.K., & Gottschalk, P. (2003). Information technology support for interorganizational knowledge transfer: An empirical study of law firms in Norway and Australia. *Information Resources Management Journal, 16*(1), 14-23.

Kling, R. (1980). Social analyses of computing: Theoretical perspectives in recent empirical research. *Computing Surveys, 12*, 61-110.

Markus, M.L., & Robey, D. (1988). Information technology and organizational change: Causal structure in theory and research. *Management Science, 34*(5), 583-598.

Martin, J. (1992). *Cultures in organization: Three perspectives.* Oxford, UK: Oxford University Press.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Orlikowski, W. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*(4), 404-428.

Orlikowski, W., & Robey, D. (1991). Information technology and the structuring of organizations. *Information Systems Research, 2*(2), 143-169.

Parsons, M. (2004). *Effective knowledge management for law firms.* Oxford, UK: Oxford University Press.

Robey, D., & Boudreau, M.-C. (1999). Accounting for the contradictory organizational consequences of information technology: Theoretical directions and methodological implications. *Information Systems Research, 10*(2), 167-185.

Rusanow, G. (2001). Culturing lawyers in knowledge management. *Knowledge Management Asia-Pacific, 1*(1), 1-11.

Rusanow, G. (2003). *Knowledge management and the smarter lawyer.* New York: ALM Publishing.

Schultze, U., & Leidner, D.E. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly, 26*(3), 213-242.

Schultze, U., & Orlikowski, W. (2004). A practice perspective on technology-mediated network relations: The use of Internet-based self-serve technologies. *Information Systems Research, 15*(1), 87-106.

Scott, W.R. (1995). *Institutions and organizations.* Thousand Oaks, CA: Sage Publications.

Senge, P.M. (1990). *The fifth discipline.* New York: Currency Doubleday.

Sherer, P.D. (1995). Leveraging human assets in law firms: Human capital structures and organizational capabilities. *Industrial and Labor Relations Review, 48*(4), 671-691.

Terrett, A. (1998). Knowledge management and the law firm. *Journal of Knowledge Management, 2*(1), 67-76.

Walsham, G. (1993). *Interpreting information systems in organizations.* Chichester, UK: John Wiley & Sons.

Weiss, L. (1999). Collection and connection: The anatomy of knowledge sharing in professional service firms. *Organizational Development Journal, 17*(4), 61-77.

Chapter 4.40
Knowledge Management in Law Firms

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Law enforcement is of concern to law firms. A law firm can be understood as a social community specializing in the speed and efficiency in the creation and transfer of legal knowledge (Nahapiet & Ghoshal, 1998). Many law firms represent large corporate enterprises, organizations, or entrepreneurs with a need for continuous and specialized legal services that can only be supplied by a team of lawyers. The client is a customer of the firm, rather than a particular lawyer. According to Galanter and Palay (1991, p. 5), relationships with clients tend to be enduring:

Firms represent large corporate enterprises, organizations, or entrepreneurs with a need for continuous (or recurrent) and specialized legal services that could be supplied only by a team of lawyers. The client 'belongs to' the firm, not to a particular lawyer. Relations with clients tend to be enduring. Such repeat clients are able to reap benefits from the continuity and economies of scale and scope enjoyed by the firm.

Law firm knowledge management is the behaviors and processes by which a group of lawyers increases and maintains their personal and collective actionable knowledge to compete, to increase performance, and to decrease risk. By extension, a knowledge strategy is the intended action, the plan, or the road map, for those behaviors and processes (Parsons, 2004).

LAWYERS AS KNOWLEDGE WORKERS

Lawyers can be defined as knowledge workers. They are professionals who have gained knowledge through formal education (explicit) and through learning on the job (tacit). Often, there is some variation in the quality of their education and learning. The value of professionals' education tends to hold throughout their careers. For example, lawyers in Norway are asked whether they got the good grade of "laud" even 30 years after graduation. Professionals' prestige (which is based partly on the institutions from which they obtained their education) is a valuable organizational resource because of the elite social networks that provide access to valuable external resources for the firm (Hitt, Bierman, Shumizu, & Kochhar, 2001).

After completing their advanced educational requirements, most professionals enter their careers as associates in law. In this role, they continue to learn and thus, they gain significant tacit knowledge through "learning by doing." Therefore, they largely bring explicit knowledge derived from formal education into their firms, and build tacit knowledge through experience.

Most professional service firms use a partnership form of organization. In such a framework, those who are highly effective in using and applying knowledge are eventually rewarded with partner status and thus, own stakes in a firm. On their road to partnership, these professionals acquire considerable knowledge, much of which is tacit. Thus, by the time professionals achieve partnership, they have built human capital in the form of individual skills (Hitt et al., 2001).

Because law is precedent driven, its practitioners are heavily invested in knowing how things have been done before. Jones (2000) found that many attorneys, therefore, are already oriented toward the basic premises of knowledge management, though they have been practicing it on a more individualized basis, and without the help of technology and virtual collaboration. As such, a knowledge management initiative could find the areas where lawyers are already sharing information, and then introduce modern technology to support this information sharing to make it for effective.

Lawyers work in law firms, and law firms belong to the legal industry. According to Becker et al. (Becker, Herman, Samuelson, & Webb, 2001), the legal industry will change rapidly because of three important trends. First, global companies increasingly seek out law firms that can provide consistent support at all business locations, and integrated cross-border assistance for significant mergers and acquisitions as well as capital-market transactions. Second, client loyalty is decreasing as companies increasingly base purchases of legal services on a more objective assessment of their value, defined as benefits net of price. Finally, new competitors such as accounting firms and internet-based legal services firms have entered the market.

In this book, the notion "lawyer" is used most of the time. Other notions such as "attorney" and "solicitor" are sometimes used as synonyms in this book. In reality, these words can have different meanings, together with notions such as "barrister," "counselor," and "advocate." In Norwegian, a distinction is made between a lawyer ("jurist") and a solicitor ("advokat"). There is no need to make such distinctions in this book.

Lawyers are knowledge workers. To understand the organizational form of lawyers as knowledge workers employed in companies such as law firms, there is a need to recognize the dual dependent relationship between knowledge workers and the organization. On the one hand, for the purpose of channeling the motivation and effort of employees to serve the interests of the firm, management will seek to exploit knowledge workers' need to rely on the organization for resources (for example, advanced computer software and hardware that are available at a high cost) to accomplish their work tasks. On the other hand, management depends on knowledge workers for their esoteric and advanced knowledge, and their ability to synthesize theoretical and contextual knowledge. Management, therefore, need to meet these employees' aspirations and expectations. As for knowledge workers, they need to depend on the organization as the locale to develop contextual knowledge and to create new knowledge. However, their ability to apply theoretical knowledge in other contexts, that is, in other organizations, means that to a certain extent, they are also able to pursue a limited form of marketization. This enables them to reap market-level rewards for their expertise (May, Korczynski, & Frenkel, 2002).

KNOWLEDGE CATEGORIES

To get started on this job, legal industry knowledge has to be understood. Edwards and Mahling (1997) have suggested that law firms have four categories of knowledge: administrative, declarative, procedural, and analytical knowledge, as defined earlier in this book. These knowledge categories are all important to the law firm. While any law firm needs to maintain efficient administrative records, there does not appear to be any significant possibility for gaining strategic advantage in the firm's core competency of providing sound legal advice to its clients by using these records. The detailed administrative knowledge they contain is essential to the operation of the law firm, but does not contribute to the substantive content. Declarative, procedural, and analytical knowledge offer greater possibilities for creating strategic value to the firm.

Edwards and Mahling (1997) present a case drawn from the case collection of one of the authors to illustrate the differences in strategic value among procedural, declarative, and analytical knowledge. In the early 1990s, one of the authors, at the time engaged in the practice of law, represented a corporate client as seller in several sales of corporate businesses and real estate. At the time, buyers of businesses and real estate had become concerned about their possible liability for pollution existing on property when they purchased it. The U.S. federal laws governing the legal responsibility of landowners for environmental contamination on their property had been adopted a few years earlier, and their full impact on sale of businesses was just beginning to be understood.

The relevant declarative knowledge was an understanding of several related state and federal laws and agency regulations governing liability for environmental contamination. The relevant procedural knowledge, in part, was to know how to transfer the environmental licenses and permits used by a given business to a new owner, and how to transfer the real estate as an asset. The relevant analytical knowledge was to understand what risks the buyer of a contaminated property faced (legal and financial), and what contractual protections the seller could reasonably give to the buyer.

Law firms are interesting in themselves from both a knowledge and a management perspective. From a management perspective, law firm partners own a typical law firm. Among themselves, the partners appoint a board and a managing partner. In addition, they hire a chief executive officer (CEO) to run all support functions in the firm such as financial management (CFO), knowledge management (CKO), and information technology management (CIO).

Jones (2000) found that top-down directives are complicated in the legal industry. In large U.S. and UK law firms, the power can be spread among as many as 150 partners, most of who have different specialty areas, different work and management styles, and vastly different groups under their control. Earning a consensus is not an easy proposition, especially when the funding for new initiatives such as knowledge management initiatives is coming directly out of the partners' yearly income. At the same time, partners are the ones who have the most to gain if their firm is able to manage knowledge effectively to keep lucrative clients on board, and draw new ones through new services.

The human capital embodied in the partners is a professional service firm's most important resource. Their experience, particularly as partners, builds valuable industry-specific and firm-specific knowledge that is often tacit. Such knowledge is the least imitable form of knowledge. An important responsibility of partners is obtaining and maintaining clients. Partners build relationships with current and potential clients and, over time, develop social capital through their client networks. Therefore, the experience a professional gains as a partner contributes to competitive advantage (Hitt et al., 2001).

Partners with education from the best institutions, and with the most experience as partners in particular legal areas represent substantial human capital to the firm. As partners, they continue to acquire knowledge, largely tacit and firm specific, and build social capital. This human capital should produce the highest-quality services to clients and thereby, contribute significantly to firm performance. The job of partner differs from that of associate, and new skills must be developed. Partners must build the skills needed to develop and maintain effective relationships with clients. Importantly, partners in law firms serve as project and team leaders on specific cases and thus, must develop managerial skills.

Partners own the most human capital in a firm, and have the largest stakes using the firm's resources to the greatest advantage. One of the responsibilities of partners is to help develop the knowledge of other employees of the firm, particularly its associates. Associates at law firms need to learn internal routines, the situation of important clients, and nuances in the application of law (Hitt et al., 2001).

Information technology support for knowledge management in law firms has to consider the very special knowledge situation in each law firm. Edwards and Mahling (1997) argue that knowledge is dispersed among many different members of the firm, and others outside the firm may contribute to knowledge. Law firm knowledge has a wide variety of sources, both inside and outside the firm. Much administrative knowledge is generated by the members of the firm as billing records for their services. The firm's administrative staff creates other administrative information. Attorneys are the major source of analytical, declarative, and procedural knowledge. Legal assistants have some declarative knowledge based on their experience. Declarative knowledge can also be found in publicly available sources intended for research purposes, primarily books, online subscription research sources, and CD-ROM resources. The quantity of publicly available research material for any given topic depends significantly on the size of the market for the information. The more specialized the legal area, the smaller the potential market for material, and the less that is usually widely available. Experienced legal assistants are usually an invaluable source of procedural knowledge, since much procedural work is delegated to them. Legal assistants are common in countries such as the U.S. and UK, but they are seldom found in law firms in countries such as Norway and Sweden.

Experienced legal secretaries may have a significant amount of procedural knowledge for transactions they handle often. Law firms in Norway employ many secretaries. It is common to find more than one secretary for every three lawyers in a law firm.

The role of others, outside the law firm, in generating analytical and procedural knowledge needs to be noted. While much of the useful procedural and analytical knowledge resides in firm employees, it is likely that there are sources outside the firm as well. One belief frequently expressed in the knowledge management literature is the view that learning is social: people learn in groups. These groups are known in the literature as communities of practice.

Communities of practice have been defined as groups of people who are informally bound to one another by exposure to a common class of problem. It is quite likely that the communities of practice for the lawyers in the firm include other members of professional associations such as bar associations. These groups usually have a number of committees devoted to practice areas, such as environmental law. In Norway, Den Norske Advokatforening (Norwegian Lawyers Association) has such committees.

Generally, the idea of communities of practice developed in the organizational learning movement. The idea posits that knowledge flows best through networks of people who may not be in the same part of the organization, or in the same organization, but have the same work interests. Some firms have attempted to formalize these communities, even though theorists argue that they should emerge in self-organizing fashion without any relationship to formal organizational structures (Grover & Davenport, 2001).

A few more technologically advanced lawyers may use the Internet, or such subscription services as Counsel Connect in the U.S. on the World Wide Web, as a sounding board for analytical and procedural issues in a community of legal practice. These external sources can provide knowledge in the form of informal conversations, written newsletters and updates, briefs filed in relevant litigation, and other forms.

An obvious problem in law firms is that knowledge is not consistently documented. Much administrative information is captured in electronic form as part of the firm's billing records. Other administrative data resides in the firm's payroll and benefits records and file and records management systems. Much of the firm's declarative knowledge resides in the memories of the firm's attorneys, and in their work product. At the same time, the firm has access to publicly available declarative knowledge in the form of published reference works.

Much procedural knowledge is documented throughout the firm's files in the form of completed records of transactions that provide guidance about what legal documents were necessary to complete a certain type of transaction. The knowledge of procedure reflected in these documents is often implicit rather than explicit. Explicit procedural knowledge is contained in a collection of written practice guides for popular areas like real estate transactions. These guides include standard checklists of items necessary to complete a particular transaction for the kinds of transactions that occur frequently.

Analytical knowledge resides primarily in attorneys' heads. Analytical knowledge is occasionally documented in client files through the notes of an attorney's thought processes. More often, it is reflected in the completed contract documents or other transaction documents by the inclusion of specific clauses dealing with a particular topic. The analytical knowledge reflected in completed documents is very often not explicit, in the sense that it is often not clear from the face of the document what analytical issues are dealt with in the document.

Another law firm problem is that knowledge is often shared on an informal basis. Certain methods of sharing knowledge, at least within the firm, have traditionally been part of large law firm culture. One of the most important ways of sharing knowledge has been through the process of partners training associates to perform tasks. In larger firms, the practice of hiring young, bright law-school graduates who were trained, supervised, and rewarded by a partner has been followed throughout most of this century. The method focuses on transmitting knowledge from more experienced attorneys to less experienced attorneys, as distinguished from transmitting it to other partners in the firm, or to legal assistants and other support staff.

This attorney training customarily has relied on informal methods of transmitting knowledge, such as rotating young attorneys through a series of practice groups within the firm. Much of this informal training takes place via collaborative work on documents such as contracts and pleadings. Some of it occurs through informal consultation between a senior attorney and a junior attorney about the best way to handle a specific task. These consultations may be carried out by face-to-face discussions, e-mail, or telephone conversations. No attempt is usually made to capture the substance of the training through these informal methods, even where a form of communication such as e-mail may often be used that could produce documentation. It is important to note that this training often takes place under intense time pressure. Further, in an hourly billing system, there is often little or no financial incentive to produce documentation that cannot be billed directly to a client.

In addition to problems of knowledge dispersion, inconsistent documentation, and informal knowledge sharing, Edwards and Mahling (1997) argue that if knowledge has been documented, it is contained in a mixture of paper and electronic formats, and located in dispersed physical locations. Administrative information typically exists in a combination of print and electronic formats. A large firm would customarily maintain computerized databases for key matters such as tracking lawyers' hourly billings, for its client contact data, and for staff assignments to projects, but would usually generate paper invoices to clients. The data physically resides in the firm's computer network and in paper files.

Declarative, procedural, and analytical knowledge is often documented in attorney work product such as briefs, memoranda, and actual legal documents such as contracts, wills, and instruments of transfer. Work product documents typically are created in electronic form, but are customarily stored in print-format client files. The electronic-format materials are stored in standalone personal computers or on the network. Paper materials are located throughout the firm's offices.

Where knowledge has been documented in a law firm, often only a few simple tools exist to facilitate the retrieval of knowledge by topic. Attorney work files are usually indexed by client name and matter name, but their contents are seldom indexed for subject matter in more than the most general way. An attorney creating a particular item of work product may place it in a firm's standards database, maintained in electronic format. These standard documents can then be used by other lawyers as examples or models. In a typical installation, the standard forms library is stored on the network, and is physically available to those who have network access. The standard forms library allows access to individual documents by name, but subject matter classification is often limited to what can be included in a descriptive DOS-format file name. Retrieving material from the forms library, thus, usually requires tedious sequential search and review of the contents of the library.

Access to the procedural and analytical knowledge embodied in client files is difficult, at best, for those not familiar with the files. The client files are often not indexed by subject matter, making it difficult to locate procedural or analytical knowledge on a particular topic if the contents of the file are not already familiar. Document management systems do support network-wide searches for documents in electronic form by selected attributes such as document author name, or keywords appearing in the document. In the absence of a consistent system of classifying the document's contents by subject or topic, however, keyword searches by topic produce incomplete retrieval of all relevant documents.

Even if knowledge is documented by work product such as a memorandum to file, access to the implicit procedural and analytical knowledge embodied in the firm's files is often difficult, at best. Client files that are indexed according to a subject-based system may offer some help in searching for analytical knowledge. A large transaction, however, may include dozens of analytical issues, and it is unlikely that all of them would be indexed. Procedural knowledge is unlikely to be indexed at all. This means that the user must often rely on the ability to search by keywords for relevant fact patterns to retrieve relevant procedural or analytical knowledge.

Some knowledge in a law firm raises issues of security and confidentiality. There are few confidentiality concerns with declarative knowledge. This type of knowledge is meant to be public and readily accessible to all. Analytical and procedural knowledge within the firm can, however, raise issues of security and client confidentiality. Attorneys in the firm have professional ethical obligations to their clients to maintain the confidentiality of information furnished by the client. While these ethical obligations are customarily interpreted to permit sharing the information among the firm's members and staff, appropriate precautions still must be taken to avoid disclosures outside the firm.

KNOWLEDGE MANAGEMENT MATRIX

To identify knowledge management applications, we can combine knowledge levels with knowledge categories. Core knowledge, advanced knowledge, and innovative knowledge is combined with administrative knowledge, declarative knowledge, procedural knowledge, and analytical knowledge in Figure 1. We have created a knowledge management matrix with 12 cells for IS/IT applications.

The knowledge management matrix can first be used to identify the current IS/IT that support knowledge management in the firm, as illustrated in Figure 2.

Now the knowledge management matrix can be applied to identify future IS/IT as illustrated in Figure 3. The systems do only serve as examples, they illustrate that it is possible to find systems than can support all combinations of knowledge categories and knowledge levels.

Software and systems suitable for knowledge management in a law firm can now be identified using the knowledge management matrix. In Figure 4, examples of software to support systems in Figure 3 are listed.

Let us look at one example in Figure 4. Knowledger is listed as potential software in the innovative-analytical knowledge location. This is an ambitious location of a software product that has yet to demonstrate its real capabilities in knowledge firms. According to the vendor, Knowledge Associates (http://www.knowledgeassociates.com), Knowledger 3.0 is complete knowledge management software that can be integrated with other systems in the firm. Knowledger is Web based, and supports the firm in categorizing internal and external knowledge, as well as helps with linking incoming knowledge to existing knowledge.

Let us look at one more application in the most demanding location of innovative-analytical knowledge. There we find something called

Figure 1. Knowledge management matrix

Levels / ***Categories***	**Core Knowledge**	**Advanced Knowledge**	**Innovative Knowledge**
Administrative Knowledge			
Declarative Knowledge			
Procedural Knowledge			
Analytical Knowledge			

Figure 2. Knowledge management matrix for the current IS/IT situation

Levels / ***Categories***	**Core Knowledge**	**Advanced Knowledge**	**Innovative Knowledge**
Administrative Knowledge	Accounting system Hours billing Clients database E-mail Word processing Spreadsheet Salary system	Competence database Client firm information Internet	
Declarative Knowledge	Library system Electronic law-book Electronic legal sources	Law database	
Procedural Knowledge	Case collection Document standards Procedural standards Document examples	Internal databases Intranet Public databases	
Analytical Knowledge	Law interpretations	Groupware	

Summation. Summation is a system for document handling for use in large court cases (http://www.summation.com). In the large court case of Balder in Norway, law firm Thommessen Krefting Greve Lund (TKGL) used Summation in 2001. The Balder case is a dispute between Exxon and Smedvig about the rebuilding of an offshore vessel costing 3 billion Norwegian crones. TKGL had more than 2,500 binders when the court case started in the city of Stavanger. All these documents were scanned into a database for use by Summation. When lawyers from TKGL present material in court, they submit it from their laptops. When new information emerges in court, then it is registered in Summation. When TKGL lawyers are to trace technical and financial developments for Balder, they make a search in the Summation database.

Another law firm is also using Summation. The law firm Bugge Arentz-Hansen Rasmussen (BA-HR) has the task of finding money after the late shipowner, Jahre. The money is expected to be found in banks in countries where there are no taxes. The hunt for Jahre funds has been going on for almost a decade, and BA-HR has developed a large Summation database enabling BA-HR lawyers to present important information in the court in the city of Drammen.

A third example of Summation use can be found in the U.S. The Justice Department used Summation in its legal struggle with Microsoft. It has been argued that Summation helped the Justice's lead prosecutor, David Boies, piece together the most damaging information for Microsoft. In presenting its defense, which ended on February 26 in 2001, Microsoft relied more than Justice did on a low-tech overhead projector.

According to Susskind (2000, p. 163), six kinds of expert systems can play an important role in law firms in the future:

- Diagnostic systems. Those systems offer specific solutions to problems presented to them. From the facts of any particular case,

Figure 3. Knowledge management matrix for desired IS/IT situation

Levels / *Categories*	**Core Knowledge**	**Advanced Knowledge**	**Innovative Knowledge**
Administrative Knowledge	Accounting system Hours billing Clients database E-mail Word processing Spreadsheet Salary system *Electronic diary* *Electronic reception* *Office automation* *Message system*	Competence database Client firm information Internet *Videophone* *Video conference* *Quality system* *Financial services* *Intranet* *Net agent* *Electronic meetings*	*Client statistics* *Lawyer statistics* *Recruiting system* *Scanning* *Quality assurance* *Benchmarking* *Customer relationships* *Net-based services* *Electronic diary* *Mobile office* *Executive information*
Declarative Knowledge	Library system Electronic law-book Electronic legal sources *Document management* *Legal databases* *Commercial databases*	Law database *Electronic library* *Electronic law-book* *Extranet* *International legal sources*	*Law change base* *Precedence base* *Conference system* *Intelligent agents* *Artificial intelligence* *Portals* *Work flow systems*
Procedural Knowledge	Case collection Document standards Procedural standards Document examples *Planning system* *Standards archive* *Publishing system*	Internal databases Intranet Public databases *Experience database* *Image processing* *Document generation* *International law base* *Public web access*	*Video registration* *Case system* *Online services*
Analytical Knowledge	Law interpretations *Voice recognition* *Case interpretations*	Groupware *Intelligent agents* *Client monitoring* *Extranet* *Discussion groups* *Video conference*	*Expert register* *Expert system* *Research reports* *Subject database* *Data warehouse*

as elicited by such a system, it will analyze the details and draw conclusions, usually after some kind of interactive consultation. These systems are analogous to the medical diagnostic systems that make diagnoses on the basis of symptoms presented to them. An example of a diagnostic system in law would be a taxation system that could pinpoint the extent to which, and why a person is liable to pay tax, doing so on the basis of a mass of details provided to it.

- Planning systems. In a sense, planning systems reason in reverse, for these systems are instructed as to a desired solution or

Figure 4. Knowledge management matrix for software supporting desired IS/IT situation

Levels ***Categories***	**Core Knowledge**	**Advanced Knowledge**	**Innovative Knowledge**
Administrative Knowledge	Microsoft Word Microsoft Excel Microsoft Outlook SuperOffice Timex Concorde XAL DBMS SuperOffice Microsoft Office Oracle Agresso Powermarkt Uni økonomi Datalex Justice Data Systems GroupWise Alta Law Office ESI Law	Microsoft Access Lotus Approach Corel Paradox Infotorg IFS Rubicon Concorde K-link Akelius dokument Windows NT Explorer CheckPoint Firewall RealMedia Advisor klient Completo Advokat Visma Business Advokat	Intranet Internet Extranet WAP PDA/Palm KnowledgeShare IFS Business performance Mikromarc 2 statistic IFS Front Office Psion Nomade Netscape Netcaster
Declarative Knowledge	NorLex CarNov RightOn Lovdata NORSOK	Lovdata Celex BibJure Shyster Finder Prjus BookWhere	Hieros Gamos Eudor Abacus Law Lawgic Netmeeting Lov chat LegalSeeker KG Agent Lotus K-station Domino Workflow
Procedural Knowledge	Jasper Karnov Mikas Aladdin ePaper Action Request System DocuShare CyberWorks Training Learning Space	Lotus Domino Domino.Doc DOCS Open HotDocs Adobe photoshop EUR-Lex ODIN eCabinet	Justice Autonomy LegalSeeker Expert Legal Systems Hieros Gamos Real Media Amicus Attorney
Analytical Knowledge	PDA/Palm Lotus LearningSpace Lotus Quickplace Lotus Sametime IBM Content Manager IBM Enterprise Portal Voice Express Collaborative Virtual Work Search Sugar Vchip	Lotus Notes iNotes Lotus K-Station Jasper Novell GroupWise Microsoft Exchange Netscape Communicator JSF Litigator's Notebook Empolis K42 Legal Files	Summation Knowledger Lotus Raven Shyster XpertRule Miner Expert Choice Dragon Dictate

outcome, and their purpose is to identify scenarios involving both factual and legal premises that justify the preferred conclusion. In tax law, a planning system could recommend how best a taxpayer should arrange his affairs so as to minimize his exposure to liability. The knowledge held within planning systems can be very similar to that held within diagnostic systems; what is quite different is the way that knowledge is applied.

- Procedural guides. Many complex tasks facing legal professionals require extensive expertise and knowledge that is, in fact, procedural in nature. Expert systems as procedural guides take their users through such complex and extended procedures, ensuring that all matters are attended to and done within any prescribed time periods. An example of such a system would be one that managed the flow of a complex tax evasion case, providing detailed guidance and support from inception through to final disposal.
- The intelligent checklist. This category of system has most often been used to assist in auditing or reviewing compliance with legal regulations. Compliance reviews must be undertaken with relentless attention to detail, and extensive reference to large bodies of regulations. Intelligent checklists provide a technique for performing such reviews. They formalize the process. In taxation, an intelligent checklist approach could be used to assist in the review of a company's compliance with corporation tax.
- Document modeling systems. These systems, also referred to as document assembly systems, store templates set up by legal experts. These templates contain fixed portions of text, together with precise indications as to the conditions under which given extracts should be used. In operation, such a system will elicit from its user all the details relevant to a proposed document. This is done by the user answering questions, responding to prompts, and providing information. On the basis of the user's input, the system will automatically generate a customized and polished document on the basis of its knowledge of how its text should be used.
- Arguments generation systems. It is envisaged that these systems are able to generate sets of competing legal arguments in situations when legal resources do not provide definitive guidance. Rather than seeking to provide legal solutions (as diagnostic systems strive to do), argument generation systems will present sound lines of reasoning, backed both by legal authority and by propositions of principle and policy. These lines of reasoning will lead to a range of legal conclusions. Such systems would help users identify promising lines of reasoning in support of desired outcomes while, at the same time, advancing other arguments that may need to be refuted.

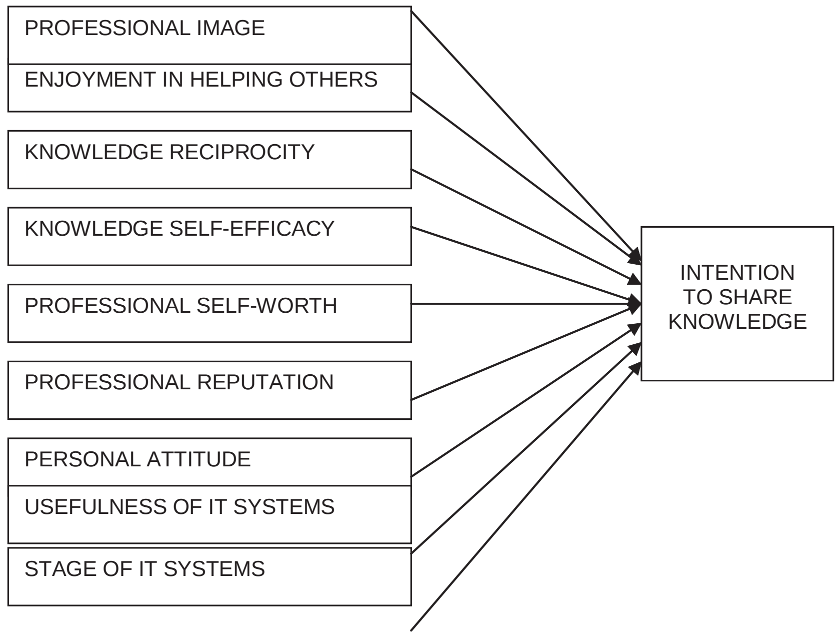
RESEARCH MODEL FOR KNOWLEDGE SHARING

The objective of this section is to deepen our understanding of the factors that increase or lessen employees' tendencies to engage in knowledge-sharing behaviors. Figure 5 depicts our research model. Intention to share knowledge is the dependent variable in the model.

Professional Image

In most organizations today, the importance of image is increasing as traditional contracts between organizations and employees based on length of service erode. In such working environments, knowledge contributors can benefit from showing others that they possess valuable expertise. This earns them respect and a better image. Therefore,

Figure 5. Research model for determinants of knowledge sharing intentions



knowledge sharers can benefit from improved self-concept when they share their knowledge. According to Kankanhalli et al. (Kankanhalli, Tan, & Wei, 2005), employees have been found to share their best practice due to a desire to be recognized by their peers as experts. People who provided high-quality knowledge have been found to enjoy better prestige in the workplace. Hence, this discussion suggests a positive relationship between image and intention to share knowledge.

Hypothesis 1: The more a lawyer's image is improved by knowledge sharing, the greater the intention to share knowledge will be.

Enjoyment in Helping Others

This benefit is derived from the concept of altruism. Altruism exists when people derive intrinsic enjoyment from helping others, without expecting anything in return. According to Davenport and Prusak (1998), altruism implies that a knowledge seller may be so passionate about his or her knowledge that he or she is happy to share it whenever he/she gets a chance. This seems to be the case with many university professors. Many knowledge sharers are motivated in part by a love of their subject and to some degree, by altruism, whether for the good of the organization or based on a natural impulse to help others.

Altruism exists when people derive intrinsic enjoyment from helping others, without expecting anything in return. Although there may be very few instances of absolute altruism (involving absolute lack of self-concern in the motivation for an act), relative altruism (where self-concern plays a minor role in motivating an act) is more prevalent. Knowledge sharers may be motivated by relative altruism based on their desire to help others. According to Kanhanhalli et al. (2005), prior research shows that knowledge contributors gain satisfaction by demonstrating their altruistic behavior. Such satisfaction stems from their intrinsic enjoyment in helping others. Knowledge sharers who derive enjoyment in helping others may be more inclined to share knowledge.

Hypothesis 2: The greater enjoyment a lawyer finds in helping others, the greater the intention to share knowledge will be.

Knowledge Reciprocity

Reciprocity has been highlighted as a benefit for individuals to engage in social exchange. According to Davenport and Prusak (1998), reciprocity implies payment in terms of knowledge. A knowledge seller will spend the time and effort needed to share knowledge effectively, if the person expects the buyer to be a willing seller when he or she is in the market for knowledge. Reciprocity may be achieved less directly than by getting knowledge back from the same person. In firms structured as partnerships, such as law firms, knowledge sharing that improves profitability will return a benefit to the sharer, now and in the future. Whether or not a knowledge seller expects to be paid with equally valuable knowledge from the buyer, the knowledge seller may believe that being known for sharing knowledge readily will make others in the company more willing to share with him or her. That is a rational assumption, since his or her reputation as a seller of valuable knowledge will make others confident of his/her willingness to reciprocate when he/she is the buyer and they have knowledge to sell: The knowledge seller's knowledge credit is good.

Reciprocity has been highlighted as a benefit for individuals to engage in social exchange. It can serve as a motivational mechanism for people to contribute to discretionary databases. Reciprocity can act as a benefit for knowledge contributors because they expect future help from others in lieu of their contributions. According to Kankanhalli et al. (2005), prior research suggests that people who share knowledge in online communities believe in reciprocity. Further, researchers have observed that people who regularly helped others in virtual communities seemed to receive help more quickly when they asked for it.

Furthermore, Kankanhalli et al. (2005) found a significant, positive relationship between reciprocity and usage of electronic knowledge repositories by knowledge contributors. These arguments suggest a positive relationship between reciprocity and intention to share knowledge.

Hypothesis 3: The more a lawyer expects knowledge reciprocity, the greater the intention to share knowledge will be.

Knowledge Self-Efficacy

Self-efficacy relates to the perception of people about what they can do with the skills they possess. When people share expertise useful in the organization, they gain confidence in terms of what they can do, and this brings the benefit of increased self-efficacy. This belief can serve as a self-motivational force for knowledge contributors to share knowledge. Knowledge self-efficacy is typically manifested in the form of people believing that their knowledge can help solve job-related problems, improve work efficiency, or make a difference to their organization.

Conversely, if people feel that they lack knowledge that is useful to the organization, they may decline from sharing knowledge because they believe that their contribution cannot make a positive impact for the organization.

These arguments suggest a positive relationship between knowledge self-efficacy and sharing by knowledge contributors that was found to be significant in the study by Kanhanhalli et al. (2005).

Hypothesis 4: The higher knowledge self-efficacy perceived by a lawyer, the greater the intention to share knowledge will be.

Professional Self-Worth

In an ongoing interaction setting such as knowledge sharing in an organization, appropriate feedback is very critical. When others respond in the way that we have anticipated, we conclude that our line of thinking and behavior are correct; at the same time, role taking improves as the exchange continues according to role theory, which is the cornerstone of the symbolic interactionist perspective on self-concept formation. According to Bock et al. (Bock, Zmud, & Kim, 2005), this process of reflected appraisal contributes to the formation of self-worth that is strongly affected by sense of competence, and closely tied to effective performance.

Therefore, Bock et al. (2005) found that employees who are able to get feedback on past instances of knowledge sharing are more likely to understand how such actions have contributed to the work of others, and/or to improvements in organizational performance. The understanding would allow them to increase their sense of self-worth accordingly. That, in turn, would render these employees more likely to develop favorable attitudes toward knowledge sharing than employees who are unable to see such linkages. Defining this cognition as an individual's sense of self-worth from their knowledge-sharing behavior leads to the fifth hypothesis.

Hypothesis 5: The greater the sense of self-worth through knowledge sharing behavior is, the greater the intention to share knowledge will be.

Professional Reputation

In order to share knowledge, individuals must think that their contribution to others will be worth the effort, and that some new value will be created, with expectations of receiving some of that value for themselves. These personal benefits or private rewards are more likely to accrue to individuals who actively participate and help others. Thus, the expectation of personal benefits can motivate individuals to contribute knowledge to others in the absence of personal acquaintance, similarity, or the likelihood of direct reciprocity (Wasko & Faraj, 2005).

According to Wasko and Faraj (2005), social exchange theory posits that individuals engage in social interaction based on an expectation that it will lead, in some way, to social rewards such as approval, status, and respect. This suggests that one potential way an individual can benefit from active participation is the perception that participation enhances his or her personal reputation in the firm. Reputation is an important asset that an individual can leverage to achieve and maintain status within a collective. Results from prior research on electronic networks of practice are consistent with social exchange theory, and provide evidence that building reputation is a strong motivator for active participation. Wasko and Faraj (2005) came to the same conclusion in their empirical study of knowledge contributions in electronic networks of practice.

Hypothesis 6: The more a lawyer can improve his or her reputation by sharing knowledge, the greater the intention to share knowledge will be.

Personal Attitude

Intention to engage in a behavior is determined by an individual's attitude toward that behavior. Here, attitude toward knowledge sharing is defined as the degree of one's positive feelings about sharing one's knowledge (Bock et al., 2005). This leads to the seventh hypothesis.

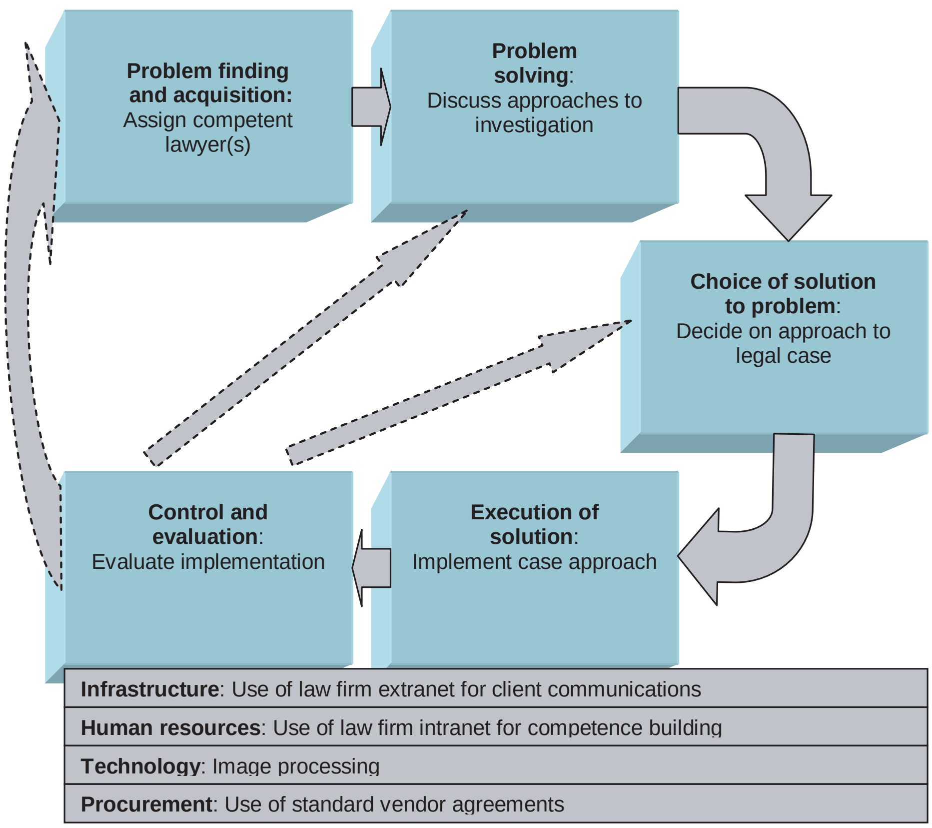
Hypothesis 7: The more favorable a lawyer's attitude toward knowledge sharing is, the greater the intention to share knowledge will be.

Usefulness of IT Systems

Information technology can play an important role in successful knowledge management initiatives (Kankanhalli et al., 2005; Wasko & Faraj, 2005). However, the concept of coding and transmitting knowledge is not new: training and employee development programs, organizational policies, routines, procedures, reports, and manuals have served this function for many years. What is new and exciting in the knowledge management area is the potential for using modern information technology (e.g., extranets, intelligent agents, expert systems) to support knowledge creation, sharing, and exchange in an organization and between organizations. Modern information technology can collect, systematize, structure, store, combine, distribute, and present information of value to knowledge workers.

The value of information presented to knowledge workers can be studied in terms of the organization's value configuration. A law firm has the value configuration of a value shop (Gottschalk, 2006). In the value shop, lawyers need information to access client problems, find alternative solutions to problems, select an optimal solution, implement the solution, and evaluate the

Figure 6. Law firm as value shop with activity examples



implementation. In this value creation, IT systems can help gain access to new cases, help find relevant court rulings, retrieve relevant documents, collect views from opposing sides, and support quality assurance of the work.

A law firm as a value shop is an organization that creates value by solving unique problems. Knowledge is the most important resource. A value shop is characterized by five primary activities: problem finding and acquisition, problem solving, choice, execution, and control and evaluation, as illustrated in Figure 6.

Hypothesis 8: The more a lawyer finds useful information in IT systems, the greater the intention to share knowledge will be.

Stage of IT Systems

The ambition level using knowledge management systems can be defined in terms of stages of knowledge management technology, as illustrated in Chapter I. When a firm reaches higher stages in the model, knowledge workers contribute information to the systems. At Stage 3, document systems and other information repositories are based on knowledge workers' contributions in electronic form. In our final hypothesis, we suggest that knowledge workers that are used to sharing information in IT systems will be more inclined to share their knowledge.

Hypothesis 9: The more higher-stage IT systems are available to a lawyer, the greater the intention to share knowledge will be.

The Case of Eurojuris

Eurojuris is a leading network of law firms in Europe, covering 610 different cities/locations in 17 countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Liechtenstein, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and UK. Eurojuris groups some 5,000 lawyers.

Each country has a national Eurojuris association that selects as members medium-sized independent law firms well established in their country, and who satisfy Eurojuris selection criteria. The objective is to provide to companies, corporations, public authorities, and private clients direct legal advice and local representation all over Europe.

When clients consult their nearest Eurojuris law firm, they have access to legal and commercial advice not only all over Europe, but also worldwide. The local Eurojuris lawyer will contact the appropriate lawyer abroad, or provide the client with details of the legal practitioners that the client needs to contact.

All Eurojuris law firms are well-established and reputable firms in their community. They are carefully selected, and abide by defined quality standards relating to fees, mandatory professional indemnity insurance, knowledge of foreign languages, promptness, and confidentiality. All firms maintain their professional independence (Eurojuris, 2005).

In 1994, Eurojuris pioneered the quality policy for legal services with a system of quality standards to be applied to Eurojuris firms. It was the so-called 10 commandments that every firm has to respect. This was the first step towards quality that enabled the network to harmonize its cooperation in Europe, a great benefit to its clients. Largely inspired by the Eurojuris UK/LawNet quality standards, the rules evolved towards the ISO standards that have the advantage of being internationally recognized and controlled by an objective external body (Cyberfax, 2005).

Eurojuris firms became certified from 1996 onwards. Hereafter, some national organizations made the certification mandatory for their membership, which is the case for the UK, France, and Norway. Firms in Germany, Italy, and Belgium also received their ISO certificate.

In 2000, a member of the Board was appointed to be specifically in charge of the quality policy. In 2001, the General Assembly voted for a set of quality rules for the Eurojuris national associations. In 2003, Interjuris/Group Eurojuris was the first association to be rewarded with the ISO certification. In 2005, Eurojuris International was awarded the ISO 9001 certification. It is still not over, since it was hoped that in Berlin during the 2005 congress of the network, it could be announced that more than 50% of the network is involved with the ISO certification (Cyberfax, 2005).

Knowledge management has been at the top of the agenda of Eurojuris for a long time. Substantial investments in information technology and knowledge management systems are made to support lawyers as knowledge workers.

Europe does not have a single legal system. The method of conducting business varies from one country to another. Using local expertise from qualified lawyers, who are based on the spot where the client's problem arises, can be an effective way to serve the client or the correspondent lawyer. The local lawyer can draw on his knowledge of local authorities and procedures, speaks the language, and is able to act effectively and promptly in his own environment. Using a relevant and local law firm also avoids the extra costs of traveling expense. It may sometimes be inappropriate to use a large firm from the state capital when immediate advice may be more usefully and cost-efficiently obtained at a decentralized location anywhere in Europe.

Empirical studies of Eurojuris Norway were conducted some years ago (Gottschalk, 2005). Information was collected on software and systems used to support interorganizational knowledge management among law firms. Eurojuris law firms used Lotus Notes very extensively in their cooperation. Lotus Notes is an application covering both level II (person-to-person) and level III (person-to-information) in the stages-of-growth model for knowledge management technology. This result implies that Eurojuris law firms in Norway had already advanced to levels II and III. This result was confirmed by e-mail being ranked second after Lotus Notes, while end-user tools, such as word processing, had dropped to third place in a ranking of most important IT tools. The conclusion from these studies indicated that Eurojuris law firms are advanced both in terms of knowledge management and in terms of knowledge management systems.

Research Methodology

To test the proposed research model, we adopted the survey method for data collection, and examined our hypotheses by applying multiple regression analysis to the collected data. Our unit of analysis was the individual.

We developed the items in the questionnaire by adapting measures that have been validated by other researchers. Our dependent variable-intention to share knowledge was adapted from Bock et al. (2005). One part of the scale is measuring intention to share explicit knowledge, and the other part of the scale is measuring intention to share implicit knowledge.

Items are listed in Figure 7. Reliability in terms of Cronbach's alpha was .92 and .93 for the two scale parts, respectively, in the research conducted by Bock et al. (2005).

The first independent variable, professional image, was measured on a scale adapted from Kankanhalli et al. (2005). Similarly, enjoyment in helping others was adopted from the same authors. Both Kankanhalli et al. (2005), and Wasko and Faraj (2005) have measured knowledge reciprocity, but in different ways, so both scales are included in the instrument. Knowledge self-efficacy is from Kankanhalli et al. (2005), while professional self-worth is from Bock et al. (2005), and professional reputation is from Wasko and Faraj (2005).

Usefulness of IT systems was measured in terms of systems providing useful access, help,

Figure 7. Questionnaire items on intention and perceptions provided to survey respondents

Construct	Items in the survey instrument	Reliability
Intention to share knowledge Bock et al. (2005)	*Intention to share explicit knowledge*	.92
	I will share my documents in the firm more frequently in the future	
	I will provide my methods to firm members more frequently in the future (new)	
	I will contribute work reports to firm members more frequently in the future (new**)**	
	I always provide my models for members of my firm	
	Intention to share implicit knowledge	. 93
	I intend to share my experience in the firm more frequently	
	I will always provide know-where and know-whom at colleagues' request	
	I will try to share my expertise in the firm more frequently	
Professional image Kankanhalli et al. (2005)	**Sharing my knowledge improves my image within the firm**	.89
	Sharing my knowledge improves others recognition of me	
	When I share my knowledge, the people I work with respect me	
	People in the firm who share their knowledge have more prestige	
Enjoyment in helping others Kankanhalli et al. (2005)	**I enjoy sharing my knowledge with others in the firm**	.96
	I enjoy helping others by sharing my knowledge	
	It feels good to help someone else by sharing my knowledge	
	Sharing my knowledge with others gives me pleasure	
Knowledge Reciprocity Kankanhalli et al. (2005) Wasko and Faraj (2005)	Reciprocity by Khankanhalli et al.	.85
	When I share my knowledge, I expect somebody to respond when I'm in need	
	When I contribute knowledge, I expect to get back knowledge when I need it	
	I believe that my queries for knowledge will be answered in the future	
	Reciprocity by Wasko and Faraj	.95
	I know that others in the firm will help me, so it's only fair to help others	
	I trust someone would help me if I were in a similar situation	
Knowledge self-efficacy Kankanhalli et al. (2005)	**I have the expertise needed to provide valuable knowledge in the firm**	.96
	It makes a difference to the firm whether I add to the knowledge others have	
	Few other lawyers in the firm can provide more valuable knowledge than I can	
	I have confidence in my ability to provide valuable knowledge to others	
Professional Self-Worth Bock et al. (2005)	**My knowledge sharing helps other members in the firm solve problems**	.91
	My knowledge sharing creates new business opportunities for the firm	
	My knowledge sharing improves work processes in the firm	
	My knowledge sharing increases productivity in the firm	
	My knowledge sharing helps the firm achieve its performance objectives	
Professional reputation Wasko and Faraj (2005)	**I earn respect from others by sharing my knowledge**	.90
	I feel that participation improves my status in the profession	
	I participate to improve my reputation in the profession	
Personal attitude Bock et al. (2005)	**My knowledge sharing with others in the firm works fine**	.92
	My knowledge sharing with others in the firm is enjoyable	
	My knowledge sharing with others in the firm is valuable to me	
	My knowledge sharing with others in the firm is a wise move	
	My knowledge sharing with others in the firm is harmful to me (reversed)	

and information in the five primary activities of a law firm as a value shop. Questionnaire items are listed in Figure 8. All items were derived from previous empirical studies, by Gottschalk (2005), of Eurojuris Norway.

Stage of IT systems was measured both by the current stage and the stage 5-years ago. Questionnaire items are listed in Figure 9. These items were derived from research conducted by Gottschalk (2005). They found that most law firms in Australia

Figure 8. Questionnaire items on value shop activities provided to survey respondents

Use of IT systems for:	*My use of IT systems in lawyer collaboration in the firm provides me:*	*Reliability*
Problem access	**Access to new assignments** **Access to new clients** **Access to new cases** **Access to new projects** **Access to profitable cases** **Access to challenging cases**	.98
Problem solutions	**Help to solve difficult cases** **Help to find relevant laws** **Help to find relevant court rulings** **Help to analyze documents** **Help to draft documents** **Help to find experts in the field**	.92
Solution choice	**Information from relevant laws** **Information from relevant court rulings** **Information from relevant documents** **Information from relevant conclusions** **Information from relevant client advice** **Information about important views**	.94
Solution execution	**Solutions to client problems** **Clarification on opposing side** **Views from participating lawyers** **Views from clients** **Views from opposing side** **Information resolving issues with client**	.95
Execution evaluation	**Quality assurance of closed cases** **Evaluation of work quality** **Learning from own closed cases** **Learning from other's closed cases** **Ideas on how to better solve client cases** **Ideas on how to make a case more profitable**	.95

Figure 9. Questionnaire items on technology stages provided to survey respondents

Please indicate with one check mark the description that most closely fits your firm's projects for information technology to support knowledge management in the firm in 2005:

- ( ) *End-user tools* will be made available to lawyers. This means a capable networked PC on every desk or in every briefcase, with standardized personal productivity tools (word processing, presentation software) so that documents can be exchanged easily throughout the firm. A widespread dissemination and use of end-user tools among lawyers in the firm is to take place.
- ( ) *Information about who knows what* will be made available to lawyers. It aims to record and disclose who in the organization knows what by building knowledge directories. Often called 'yellow pages', the principal idea is to make sure knowledgeable people in the firm are accessible to others for advice, consultation, or knowledge exchange. Knowledge-oriented directories are not so much repositories of knowledge-based information as gateways to knowledge.
- ( ) *Information from lawyers* are repositories of knowledge-based information that will be stored and made available to colleagues. Here data mining techniques can be applied to find relevant information and combine information in data warehouses. One approach is to store project reports, notes, recommendations, letters, and other documents from each lawyer in the firm. Over time, this material will grow fast, making it necessary for a librarian or knowledge manager to organize it.
- ( ) *Information systems solving knowledge problems* will be made available to lawyers. Artificial intelligence will be applied in these systems. For example, neural networks are statistically oriented tools that excel at using data to classify cases into categories. Another example is expert systems that can enable the knowledge of one or a few experts to be used by a much broader group of lawyers who need the knowledge. A third example is case-based reasoning where the system finds a similar case and comes up with a recommended solution for the current case.

Please indicate with one check mark the description that most closely fits your firm's projects for information technology to support knowledge management in the firm in 2000:

- ( ) *End-user tools* were made available to lawyers. This means a capable networked PC on every desk or in every briefcase, with standardized personal productivity tools (word processing, presentation software) so that documents can be exchanged easily throughout the firm. A widespread dissemination and use of end-user tools among lawyers in the firm took place.
- ( ) *Information about who knows what* was made available to lawyers. It aimed to record and disclose who in the organization knows what by building knowledge directories. Often called 'yellow pages', the principal idea is to make sure knowledgeable people in the firm are accessible to others for advice, consultation, or knowledge exchange. Knowledge-oriented directories are not so much repositories of knowledge-based information as gateways to knowledge.
- ( ) *Information from lawyers* are repositories of knowledge-based information that was stored and made available to colleagues. Here data mining techniques can be applied to find relevant information and combine information in data warehouses. One approach is to store project reports, notes, recommendations, letters, and other documents from each lawyer in the firm. Over time, this material grows fast, making it necessary for a librarian or knowledge manager to organize it.
- ( ) *Information systems solving knowledge problems* was made available to lawyers. Artificial intelligence is applied in these systems. For example, neural networks are statistically oriented tools that excel at using data to classify cases into categories. Another example is expert systems that can enable the knowledge of one or a few experts to be used by a much broader group of lawyers who need the knowledge. A third example is case-based reasoning where the system finds a similar case and comes up with a recommended solution for the current case.

and Norway develop according to the four-stage model for the evolution of information technology support for knowledge management.

NEW TECHNOLOGIES FOR LEGAL WORK

Mountain (2001) has posed the question: Could new technologies cause great law firms to fail? In her article, she addresses the question why law firms ought to invest in online legal services when studies to date show that there is no correlation between law firm technology capabilities and profitability. She divides online legal services into two types: digital delivery and legal Web advisors. The framework set out by Clayton Christensen in his book, The Innovator's Dilemma, is used to explain how legal Web advisors is a disruptive technology that law firm competitors (i.e., accounting firms, dot-coms, and corporate clients) are beginning to harness to erode law-firm margins. Unless law firms reinvent themselves as technology organizations, they could find themselves increasingly marginalized. Large law firms need to develop legal Web advisors, and should consider spinning off technology subsidiaries to do so. Small law firms need to link up with online advisory services on an application service provider basis.

Mountain (2001) finds that 15 years ago, artificial intelligence (AI) was set to radically change the face of the legal profession as we know it. As it turned out, neither expert systems nor any other kinds of AI lived up to their potential at that time. They required huge investments and provided marginal perceived payoffs. Eventually, both fell under the weight of their own start-up requirements. Today, AI has been reincarnated in the form of legal Web advisors. Legal Web advisors offer interactive legal advice delivered via extranets without human intervention, using questions to collect facts, and then using decision-tree analysis to produce answers. Some of the world's largest law firms in London, England are pushing ahead with developing legal Web advisors, despite the absence of a link between law firm profitability and use of technology. Why would the London firms, who bill out their services at the highest hourly rates in the world, involve themselves in such risky, low margin endeavors? The answers lie in the disruptive power of these new technologies.

According to Mountain (2001), legal Web advisors were pioneered in London in 1994 when the law firm, Linklaters, introduced a browser-based product called Blue Flag. Blue Flag is now a suite of products covering regulatory compliance, derivatives documentation, employee share plans, funds, share disclosure, and transaction management. Within months, another London law firm, Clifford Chance, followed with NextLaw, a Web-accessible online service that helps assess the legal and regulatory risks of e-commerce, and reportedly required an investment of more than 1 million pounds sterling. Today, there are approximately a dozen online legal services in the UK and Australia, and the pace of their introduction is accelerating. The revenue model, to date, has been to charge these services out by subscription, and then to have lawyers leverage from these online services to attract value added legal work.

Blue Flag is an interesting example. Blue Flag is a legal risk-management service designed to provide packaged legal advice on European financial and banking regulatory issues (hence the name Blue Flag). This service is designed to appeal to those concerned with legal compliance working in fund management, securities houses, investment, and commercial banks, and provides step-by-step legal advice on tap to subscribers for a fixed annual fee. Not surprisingly, having established the service, Linklaters have now extended it to cover other (non-European) jurisdictions where they have expertise. The benefits to clients of this Blue Flag type of system are clear. Consider the following fictional scenario (Terrett, 2000, p. 123):

An in-house lawyer works in a large corporate organization. The company is considering a purchase of a major overseas rival. The lawyer in question has been asked to present a paper to the board on the legal implications of this move. In-house lawyers, being generalists rather than specialists, might be tempted to instruct a firm of respected lawyers to be certain that they have all of the pertinent issues covered. However, they are also likely to be concerned about the resultant bill. Thus, they turn to Blue Flag. Here they can search for relevant information in the knowledge that it has been produced by a highly reputable firm of solicitors, they can print it out and present it to the Board and file it as though it were any other piece of legal advice. The task is completed more quickly and at no additional cost to the company. It is hardly surprising that the service is proving so successful. How have Linklaters achieved this in such a small space of time? They were very fortunate to have already produced much of the content that makes up the site and have it readily available in electronic form. All that was required *was a degree of innovative thinking about how the information could be delivered to clients (i.e., via the Web rather than CD-ROM or paper).*

Online legal services can be placed in two different categories: digital delivery services and legal Web advisors. Digital delivery services deliver human legal product by digital means: the simplest example is the use of e-mail to distribute legal documents. Both law firms and application service providers (ASPs) offer digital delivery. ASPs are companies that deliver software across the Internet by subscription instead of a packaged product. Many large London firms have opted for in-house capability instead, and host their own transactions through branded extranets (Web sites that provide a private body of information to a limited number of external organizations). Examples are Clifford Chance's Fruit Net, Allen & Overy's Newchange Dealroom, and Andersen Legal's Dealsight. Like e-mail, extranets will eventually become an invisible part of the technology infrastructure, and will not form a basis of competitive advantage.

Legal Web advisors, on the other hand, offer interactive legal advice delivered via extranets using artificial intelligence. Legal Web advisors use AI in a more cost-effective and pragmatic fashion than did the systems of 15 years ago. For example, they do not attempt to work independently of lawyer input. Lawyers and knowledge engineers work together to describe the order in which information is obtained and used to determine a solution. The software leads the client from one question to another using a decision tree system. This type of system uses a sequence of decisions based on user input to classify the problem before moving through nodes and subnodes to the problem solution. Once the client has completed the path and has answered all the relevant questions, the software produces output. This output is not in the form of a legal opinion; instead, it is in the form of "You need to do A, B, C, D, and E." It is more similar to the advice a lawyer gives to a friend at a party than it is to traditional legal advice. It provides 90% of the answer in situations where the client does not care about the other 10% and is not willing to pay for it. The distinction between digital delivery and legal Web advisors may blur in the future as online legal services become increasingly sophisticated.

In our perspective of knowledge management ambition, legal Web advisors represent knowledge management level IV. Expert systems are applied to give clients direct access to an information system that can develop and recommend a solution to the client's problem. The system is based on a thorough process, where lawyers and knowledge engineers worked together to describe the order in which information is obtained and used to determine a solution.

REFERENCES

Becker, W. M., Herman, M. F., Samuelson, P. A., & Webb, A. P. (2001). Lawyers get down to business. *The McKinsey Quarterly,* (2),45-55.

Bock, G. W., Zmud, R. W., & Kim, Y. G. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly, 29*(1), 87-111.

Cyberfax. (2005). Eurojuris International becomes the first international legal network ISO Certified. *The Eurojuris Newsletter, 15*(2).

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Edwards, D. L., & Mahling, D. E. (1997). Toward knowledge management systems in the legal domain. In *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work Grou*p (pp. 158-166). The Association of Computing Machinery ACM.

Eurojuris. (2005). Retrieved from http://www.eurojuris.net

Galanter, M., & Palay, T. (1991). *Tournament of lawyers, the transformation of the big law firms.* Chicago: The University of Chicago Press.

Gottschalk, P. (2005). *Strategic knowledge management technology.* Hershey, PA: Idea Group Publishing.

Gottschalk, P. (2006). *E-business strategy, sourcing and governance.* Hershey, PA: Idea Group Publishing.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Hitt, M. A., Bierman, L., Shumizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resourced-based perspective. *Academy of Management Journal, 44*(1), 13-28.

Jones, E. (2000). Remaking the firm: How KM is changing legal practice. *Knowledge Management Magazine.* Retrieved from http://www.kmmag.com

Kankanhalli, A., Tan, B. C. Y., & Wei, K. K. (2005). Contributing knowledge to electronic knowledge repositories: An empirical investigation. *MIS Quarterly, 29*(1), 113-143.

May, T. Y., Korczynski, M., & Frenkel, S. J. (2002). Organizational and occupational commitment: Knowledge workers in large corporations. *Journal of Management Studies, 39*(6), 775-801.

Mountain, D. (2001). Could new technologies cause great law firms to fail? *Journal of Information, Law and Technology*, (1). Retrieved from http://elj.warwick.ac.uk/jilt/

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Parsons, M. (2004). *Effective knowledge management for law firms.* UK: Oxford University Press.

Susskind, R. (2000). *Transforming the law.* UK: Oxford University Press.

Terrett, A. (2000). *The Internet—business strategies for law firms.* Law Society Publishing.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quarterly, 29*(1), 35-57.

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Chapter 4.41
Knowledge Management in Professional Service Firms

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INTRODUCTION

For professional service firms, such as consultants, accountants, lawyers, architects, and engineers, knowledge is a capacity to act. Knowledge can be used to take action and to serve the client. As market pressures increase, so does the demand for securing and exploiting knowledge for the firm. In addition, a shortage of high-potential professional service providers has increased the 'war for talent' in which firms compete in employing the most talented professionals. These situations are exacerbated by the decrease in lifelong loyalty, a traditional value within professional groups, and the departure and retirement of professionals, often the most experienced ones.

For professional service firms, the main assets are intellectual, not physical, and they have to seek new ways to leverage their professional intellect. It is therefore not surprising that the emergence of technology-enabled knowledge management (KM) has attracted much attention from those firms. The special relevancy of KM to professional service firms is clear: "…in professional services, we are selling the expertise of our people" (Townley, 2002, p. 4; see also Chait, 1999; Foy, 1999). If knowledge is the 'product' or the dominant ingredient, it is worth it to manage that asset, and to establish and manage systematically the acquisition, synthesis, and sharing of insights and experiences. Indeed consultants are seen as the earliest and most successful adopters of KM (Simmons, 2004; Terrett, 1998; Skyrme, 1999).

The core business of these firms is to provide highly developed knowledge-based services grounded on the existence of intellectual assets. "Thus, it makes sense that managing those assets effectively is now looked at as a vital aspect of maintaining competitiveness" (Davis, 1998, p. 11). Intellectual assets exist in various forms, and their exploitation is only restricted by the capacity and readiness of humans to do so. Quinn, Anderson, and Finkelstein (1996) observed:

The capacity to manage human intellect—and to convert it into useful products and services—is fast becoming the critical executive skill of the age. As a result, there has been a flurry of interest in intellectual capital, creativity, innovation, and the learning organization, but surprisingly little attention has been given to managing professional intellect. (p. 71)

BACKGROUND: PROFESSIONAL KNOWLEDGE

Much debate has taken place in recent years on what constitutes knowledge and knowledge management. In this respect comprehensive analyses is provided of this topic by researchers such as Drucker (1988), Swan, Scarborough et al. (1999), Tidd and Driver (2001), and Schultze and Leidner (2002). However, far less has been written about the nature of professional knowledge. Some understanding can be gained by examining the levels at which it operates. According to Quinn et al. (1996), professional knowledge operates at four levels as follows:

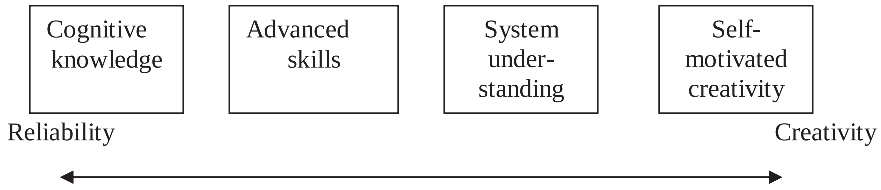
- Cognitive knowledge (know-what): This is the basic mastery of a discipline that professionals achieve through education and training.
- Advanced skills (know-how): This is the ability to apply cognitive knowledge into effective execution in a complex real world.
- Systems understanding (know-why): The deep knowledge of cause-and-effect relationships underlying a discipline, expressed as highly trained intuition.
- Self-motivated creativity (care-why): This is the will, motivation, and adaptability for success, enabling renewal of knowledge in the face of today's rapid changes.

To perform their knowledge work, professionals in the first instance acquire cognitive knowledge (know-what) by undergoing education. To advance their knowledge, to reach the know-why stage, they enter into a period of training in a professional firm, usually in the form of articles of clerkship, under the supervision of an experienced professional. As further knowledge is gained, they are able to demonstrate systems understanding (know-why) and self-motivated creativity (care-why). For professionals, the value of knowledge increases markedly as they move up the knowledge scale from cognitive knowledge to self-motivated creativity. Figure 1 shows the various forms of professional knowledge on a scale.

Evans and Volery (2000) defined the nature of services being able to be offered by professional service providers as intelligence, consulting, counseling, relationship networking, education, and training.

- Intelligence: The provision of quality information to sharpen, improve, or support the 'cleverness' of clients in situations such as decision making. Professional knowledge is required to structure and present the information so that is has optimum utility for clients.
- Consulting: The customization of information to satisfy the particular circumstances of a client. Consulting requires the ability to apply and transfer a high level of professional knowledge to the client.
- Counseling: Acting as mentor to the client, the service provider works with the client to structure, identify, and recommend appropriate approaches to the client's problems. High levels of professional experience, knowledge, and motivation are required and provide a good example of a 'care-why' knowledge type.

Figure 1. Professional knowledge and value



- Relationship networking: The ability of the service provider to bring clients into contact with other clients or parties that may have the potential to provide them with business benefits. At these meetings, exchanges take place in the form of information, ideas, experiences, and so forth.
- Education and training: Similar to counseling but in a more formal and structured setting, the service provider imparts knowledge, information, and skills to clients.

To understand the nature of professional services, they should be compared with the nature of products. This was done by Alexander and Hordes (2003) as reflected in Table 1.

It can be deduced that professional knowledge services are intangible in nature in that they do not have the physical dimensions and components of products. It is therefore not usually possible for a client to see, touch, or feel the professional service he or she is about to receive. Furthermore, the production and consumption of services occurs simultaneously. Usually this requires the service provider and client to be present during the conveying of the service. A further characteristic makes professional knowledge services heterogeneous—that is, neither homogenous nor of a standardized quality. The context in which services are demanded and delivered constantly change.

Table 1. Distinction between products and services

Dimension	**Product**	**Service**
Production	Built	Performed
Production Costs	Uniformity	Uniqueness
Involvement	Rarely	Usually
Quality Control	Compare output to specification	Compare expectation to experience
Poor Quality Procedure	Recall	Apologize and atone
Moral and Skill Level	Important	Vital

KNOWLEDGE MANAGEMENT

According to a well-recognized paper by Hansen, Nohria, and Tierney (1999), professional service firms employ two very different KM strategies. The authors used the consulting business as an example, but pointed out that the approach can be generalized across all professional service firms. According to them, some professional service firms concentrate on the codifiable knowledge of their employees and try to capture, store, and reuse it. In the codification approach, also called "people-to-documents" approach, knowledge is made independent of the individual who developed it and is reused for various purposes, for example within other consulting projects, for other industries, or in other countries.

The application of this strategy results in a repository of systematically encoded knowledge for subsequent distribution and usage. Because the approach exhibits a flow of knowledge into and out of a central repository, the approach could be named "integrative" (Zack, 1998, p. 92). This school of thought aims to codify and reuse knowledge to improve efficiency. As knowledge is transferred into documents and/or files and can be handled as knowledge products, the approach is akin to a "product-centered" KM approach (Mentzas, Apostolou, Young, & Abecker, 2001).

In other professional service firms, the most valuable knowledge is believed to be closely tied to the person who developed it. This knowledge is mainly transferred by direct person-to-person contact; the approach is therefore called a "personalization" approach (Hansen et al., 1999). As supporting communication processes among people is its main focus, it could be named an "interactive" approach (Zack, 1998) or "process-centered" approach (Mentzas et al., 2001). The approach is anchored in organizational learning theory and aims to build up organizational memory by facilitating learning processes. Strictly speaking the personalization strategy is not 'really' about the management of knowledge, but more about management of communication and conversation between people.

The main characteristics of codification and personalization strategies are summarized in Table 2.

The two approaches, codification and personalization, are not mutually exclusive (Hansen et al., 1999; Earl, 2001; Zack, 1998) but must be combined appropriately. However, the approaches give distinct hints about the use of information and communications technology (ICT) to support KM.

Codification focuses on identifying and explicating knowledge into knowledge objects in

Table 2. The two main KM approaches

Approach 1	**Approach 2**	**References**
codification	personalization	Hansen et al., 1999
people-to-documents	people-to-people	Hansen et al., 1999
integrative	interactive	Zack, 1998
product-centered	process-centered	Mentzas et al., 2001
knowledge as object	knowledge embedded in people	Wasko & Faraj, 2000
knowledge as object	knowledge as process	Garavelli, Gorgolione, & Scozii, 2002

order to give access to knowledge to all employees of the professional service firm. Extraction processes are implemented to identify specific knowledge and experiences, and make them more generic. Sometimes special roles like "knowledge harvesters" (DeVoss, 2000) or "catalysts" (Fitter, 2000) are defined to establish responsibilities for identifying, systemizing, editing, and documenting valuable knowledge in the form of checklists, precedents, or forms. The knowledge objects are then stored in databases that allow flexible and fast access and retrieval. Various ICT-enabled functions support the access, such as:

- classification systems to retrieve objects by keywords;
- full-text search features;
- topic maps to visualize content and relations between items; and
- push features, which alert a user when certain knowledge items are changed or when they are added to a specific topic.

Personalization fosters communication and conversation between employees of a professional service firm—across time, space, and hierarchy. Conservative habits within firms sometimes hinder free conversation across hierarchies or lines of business. Especially in large and globally distributed firms, employees can lose opportunities to exchange ideas and suggestions. ICT is therefore used to connect people and to mediate communication using features such as:

- expert finder systems containing profiles of employees so that their special expertise can be retrieved or they can be contacted for advice;
- communities of practice are built with the use of ICT, where employees with similar professional interests (e.g., consulting services for retail industry, auditing of banks) can meet and have discussions in an electronic environment;
- use of electronic blackboards, group calendars, or mailing lists to establish and support groups of employees working together;
- conference systems fostering personal contact and face-to-face communication.

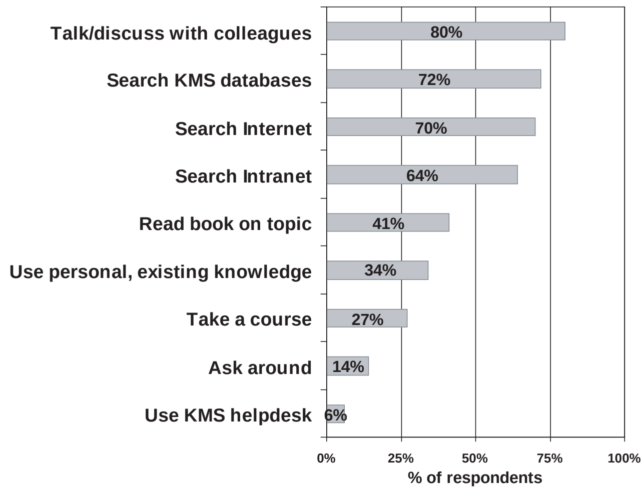
The literature reflects several comprehensive descriptions of how ICT can be used in innovative ways to support KM in professional consultancy service firms. They include Alavi (1997), Bartlett (1996), Christensen and Baird (1997), Ezingeard, Leigh, and Chandler-Wilde (2000), Heisig, Spellerberg, and Spallek (2003), Hirsh, Youman, and Hanley (2001), Manville (1999), Martiny (1998), Tallman, Horwitch, and Armacost (2002), Vorbeck and Habbel (2001), and Vorbeck, Heisig, Martin, and Schütt (2003). The large extent of publications may partly be driven by the desire of consultancies to promote their services to other firms doing KM projects by demonstrating their KM competencies through the media of publications.

In addition to describing KM systems, empirical data is available on how KM systems are used by professionals. An analysis of the KM system in one consultancy provides insight into the knowledge usage patterns of consulting professionals (Kautz & Mahnke, 2003). The case organization is a large global consulting firm with more than 100,000 employees located in more than 100 countries. The KM initiative of the firm started in 1995, with the case analysis being conducted in 2000. Figure 2 gives the knowledge sources professionals used when they need knowledge or information about a specific topic.

Kautz and Mahnke (2003) also identified serious problems and factors causing non-adoption of KM systems:

- The KM system is not used as the primary store of knowledge.
- Mostly general information is searched within the KM databases.

Figure 2. Information sources used by consultants



- Only half of the users are participating in knowledge networks.
- Usage is limited by professionals' lack of time.
- Participation in development of KM systems is low.
- Various functions of KM systems are not used heavily.

Other empirical findings from broader samples indicate more clearly that "lack of time," "lack of sharing culture," and "lack of general understanding of knowledge management" are the major barriers to KM initiatives (e.g., Ruggles, 1998; KPMG, 2003). It can therefore be concluded that technological issues may not be the dominant ones when supporting KM in professional service firms. Moreover, various cultural barriers need to be overcome to foster knowledge sharing (Disterer, 2003). For example it has been found that sharing knowledge is an "unnatural" behavior for many (Quinn et al., 1996; Barua & Ravindran, 1996; Holloway, 2000; Colier et al., 1996). People issues are seen to be critical for successful knowledge sharing: "In fact, if the people issues do not arise, the effort underway is probably not knowledge management. If technology solves the problem, yours was not a knowledge problem" (Ruggles, 1998, p. 88).

Linked to knowledge sharing is the question of what role incentives and rewards play in encouraging professionals to share their tacit knowledge. Laupase and Fink (2002) found from a series of case studies of management consulting firms that reward systems did motivate consultants to share knowledge with each other. The most effective scheme was found to be sharing knowledge in informal meetings and offering non-financial, intrinsic rewards. Consultants were found to be most comfortable in an informal environment, as they felt it was easier to engage and to ask further follow-up questions. They were also more in favor of intrinsic rewards, such as being recognized, encouraged to participate in decision making, and feeling a sense of belonging.

However, an opposing view to the preparedness of knowledge sharing exists. In professional service firms, employees compete directly with each other through their special knowledge, gifts, and talents. It might be part of the individual culture of the high-performing employees that they compete for the best positions in their career paths because they like to compete and to excel on principle (Quinn et al., 1996). Thus, with internal competition knowledge workers would be very cautious to openly share their knowledge with colleagues, because they would possibly give up individual advantages. Furthermore, they are often rewarded to build a unique expertise in a certain area and to provide that expertise to clients, rather than to share it with colleagues. Additionally, many professional service firms bill services to the clients based on chargeable hours. This approach tends to devalue an activity that is not 'billable', like helping colleagues with their professional problems.

As seen above, various individual and social barriers must be taken into account when initiating and establishing KM in professional service firms. Disterer (2003) categorized those barriers and gives a list of possible actions to foster knowledge sharing. These range from cultural actions like building trust and mutual understanding and support for give-and-take attitudes within the firm (to build up a knowledge-friendly culture), organizational actions to form groups of people working on similar issues, and human resource (HR) management to provide incentives and rewards to the professionals in order to enhance knowledge sharing.

A recent survey by the American Productivity and Quality Center (APQC) gives some insights about how top consulting firms organize their KM activities (Simmons, 2004). The survey shows that the most efficient firms do have a core KM team that centrally develops strategies, directs and coordinates activities, facilitates projects, and builds central systems like search engines and portals. Beside these central functions, the actual knowledge work is carried out in the decentralized business lines. The cost for all KM operations was found to be a median 0.5% of the revenue.

FUTURE TRENDS

It is expected that one major trend will be providing clients direct access to the knowledge base of professional service firms. Databases with 'lessons learned' and 'best practices' are shared with clients in order to raise customer loyalty. Ongoing information services to clients generated by software agents and pushed to clients will improve the client relationship. In the legal area, some examples are known where law firms are providing document assembly generators to enable clients to build up contracts on their own (Parnham, 2002).

Technology-enabled client services, mainly delivered through e-mail or on the Web, will consolidate existing client relationships, for example through more frequent interactions, and also invigorate them by the addition of new forms of client value. Fink (2001) investigated the evolution of professional accounting firms and found that "KM provides the opportunity to develop entrepreneurial versus the administrative capabilities of the firms" (p. 494). Opportunities identified included knowledge support and knowledge brokering. However, risks such as the reduction of context and a shift of power to the client were also acknowledged.

Integrating internal content of a knowledge base with external content will be a further challenge. Software agents will search through external databases and build references to internal knowledge objects. For better access to the knowledgebases, mobile access for those professionals working at the clients' premises will have to be implemented.

CONCLUSION

The management of knowledge in professional service firms deserves much attention since knowledge is the key resource of these firms. Effective KM systems therefore need to be developed and utilized. This article has shown that the value of professional knowledge increases over time, which in turn increases the urgency to have it captured and made available to those with lesser knowledge and/or experience. However, the nature of professional knowledge (intangible, perishable, heterogeneous) poses particular challenges to implementing KM systems.

It is clear that ICT has opened up many opportunities to supporting the KM activities of professional service firms. However, a number of strategic choices have to be made and importantly the use of ICT has to be supported by effective HR management. Essentially there are two approaches to KM, the codification or product approach and the personalization or process approach. Whatever approach is used, there are many obstacles that need to be overcome before KM systems are operational and become fully utilized. Success is largely dependent on the human element within the firms. Issues such as incentives and rewards for knowledge sharing need to be identified and resolved within the firms.

Many case studies have been published on leading professional firms and their experiences with KM. Valuable lessons can be learned from them. Furthermore, more developments are on the horizon which will ensure that the topic of KM in professional service firms will remain topical for years to come.

REFERENCES

Alavi, M. (1997). *KPMG Peat Marwick U.S.: One great brain.* Harvard Business School Case 9-397-108.

Alexander, J.A., & Hordes, M.W. (2003). The service marketing challenge: How to defy obstacles and better promote your offerings. *Professional Service Journal, 3*(17). Retrieved October 5, 2004, from www.internetviz-newsletter.com/PSJ/e_article000198268.cfm?x=b11,0

Bartlett, C.A. (1966). *McKinsey & Company: Managing knowledge and learning.* Harvard Business School Case 9-396-357.

Barua, A., & Ravindran, S. (1996). Reengineering information sharing behavior in organizations. *Journal of Information Technology, 11*(3), 261-272.

Chait, L.P. (1999). Creating a successful knowledge management system. *Journal of Business Strategy, 20*(March), 23-26.

Christensen, C.M., & Baird, B. (1997). *Cultivating capabilities to innovate: Booz Allen & Hamilton.* Harvard Business School Case 9-698-027.

Collier, B., DeMarco, T., & Fearey, P. (1996). A defined process for project postmortem review. *IEEE Software, 3*(4), 65-72.

Davis, M.C. (1998). Knowledge management. *Information Strategy, 15*(1), 11-22.

DeVoss, D. (2000). Knowledge harvesters dig deep. *Knowledge Management Magazine, 8.* Retrieved September 29, 2004, from www.destinationkm.com/articles/default.asp?ArticleID=877

Disterer, G. (2002). Social and cultural barriers for knowledge databases in professional service firms. In D. White (Ed.), *Knowledge mapping and management.* Hershey, PA: Idea Group Publishing.

Disterer, G. (2003). Fostering knowledge sharing: Why and how? In A.P.D. Reis & P. Isaias (Eds.), *Proceedings of the IADIS International Conference E-Society,* Lisbon.

Drucker, P. (1988). The coming of the new organization. *Harvard Business Review, 66*(1), 45-53.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 8*(1), 215-233.

Evans, D., & Folery, T. (2000). Online business development services for entrepreneurs: An exploratory study. *Proceedings of the ICSB World Conference,* Brisbane.

Ezingeard, J.N., Leigh, S., & Chandler-Wilde, R. (2000). Knowledge management at Ernst & Young UK: Getting value through knowledge flows. *Proceedings of the 21st International Conference on Information Systems,* Brisbane.

Fink, D. (2001). Knowledge management in small and medium sized professional accounting firms: Progress and challenges. *Wirtshaftsinformatik, 43*(5), 487-496.

Fitter, F. (2000). Catalysts for knowledge. *Knowledge Management Magazine, 7.* Retrieved September 29, 2004, from www.destinationkm.com/articles/default.asp? ArticleID=882

Foy, P.S. (1999). Knowledge management in industry. In J. Liebowitz (Ed.), *The knowledge management handbook.* Boca Raton.

Garavelli, A.C., Gorgolione, M., & Scozii, B. (2002). Managing knowledge transfer by knowledge technologies. *Technovation, 22*(5), 269-279.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge. *Harvard Business Review, 77*(2), 106-116.

Heisig, P., Spellerberg, F., & Spallek, P. (2003). Knowledge management: The holistic approach of Arthur D. Little Inc. In K. Mertins, P. Heisig, & J. Vorbeck (Eds.), *Knowledge management—concepts and best practices* (2nd ed.). Berlin: Springer-Verlag.

Hirsh, C., Youman, M., & Hanley, S. (2001). Creating knowledge-based communities of practice—lessons learned from KM initiatives at AMS. In R.C. Barquin, A, Bennet, & S.G. Remez (Eds.), *Knowledge management: The catalyst for e-government, management concepts.* Vienna.

Holloway, P. (2000). Sharing knowledge—and other unnatural acts. *Knowledge Management Magazine, 1,* 17-18.

Kautz, K., & Mahnke, V. (2003). Value creation through IT-supported knowledge management? The utilization of a knowledge management system in a global consulting company. *Informing Science, 6,* 75-88.

Knowles, C. (2002). Intelligent agents without the hype: Why they work best with well structured content. *Business Information Review, 19*(4), 22-28.

KPMG. (2003). Insights from KPMG's European knowledge management survey 2002/2003. KPMG Consulting, NL.

Laupase R., & Fink, D. (2002). Do reward systems encourage tacit knowledge sharing in management consulting firms? *Proceedings of Information Resources Management Association International Conference,* Seattle.

Manville, B. (1999). A complex adaptive approach to KM: Reflections on the case of McKinsey & Company. *Knowledge Management Review, 8*(May), 26-31.

Martiny, M. (1998). Knowledge management at HP Consulting. *Organizational Dynamics, 27*(2), 71-77.

Mentzas, G., Apostolou, D., Young, R., & Abecker, A. (2001). Knowledge networking: A holistic solution for leveraging corporate knowledge. *Journal of Knowledge Management, 5*(1), 94-106.

Parnham, R. (2002). Lawyers in the know. *The European Lawyer,* (October), 20-22.

Quinn, J.B., Anderson, P., & Finkelstein, S. (1996). Managing professional intellect: Making the most of the best. *Harvard Business Review,* (March-April), 71-80.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice*. California Management Review, 40*(3), 80-89.

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly, 26*(3), 213-242.

Simmons, L. (2004). Benchmarking with the best consultancies. *Knowledge Management Review, 6*(6), 28-31.

Skyrme, D.J. (1999). Knowledge management: Making it work. *The Law Librarian, 31*(2), 84-90.

Swan, J., Scarborough, H. et al. (1999). Knowledge management—the next fad to forget people? *Proceedings of European Conference on Information Systems,* Copenhagen.

Tallman, S., Horwitch, M., & Armacost, R. (2002). *Bain & Company—CP/KM experts.* Retrieved September 29, 2004, from www.bain.com/bainweb/PDFs/cms/Marketing/10709.pdf

Terrett, A. (1998). Knowledge management and the law firm. *Journal of Knowledge Management, 2*(1), 67-76.

Tidd, J., & Driver, C. (2001). *Technological and market competencies and financial performance. From knowledge management to strategic competence* (pp. 94-125). London: Imperial College Press.

Townley, C. (2002). Let's treat knowledge like the people they are. *Professional Review, 2*(4), 4.

Vorbeck, J., Heisig, P., Martin, A., & Schütt, P. (2003). Knowledge management in a global company—IBM global services. In K. Mertins, P. Heisig, & J. Vorbeck (Eds.), *Knowledge management—concepts and best practices* (2nd ed.). Berlin: Springer-Verlag.

Vorbeck, J., & Habbel, R. (2001). Sophisticated information technology to promote knowledge sharing and communication—Booz Allen & Hamilton. In K. Mertins, P. Heisig, & J. Vorbeck (Eds.), *Knowledge management.* Berlin: Springer-Verlag.

Wasko, M.M., & Faraj, S. (2000). IT is what one does: Why people participate and help others in electronic communities of practice. *Journal of Strategic Information Systems, 9*(2), 155-173.

Zack, M.H. (1998). *Managing codified knowledge.* Retrieved September 29, 2004, from www.cba.neu.edu/~mzack/articles/kmarch/kmarch.htm

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Chapter 4.42
Knowledge Management in Civil Infrastructure Systems

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INTRODUCTION

This article reviews current research and practice of knowledge management (KM) in the management of Civil infrastructure systems. Civil infrastructure systems, such as energy systems (electric power, oil, gas), telecommunications, and water supply, are critical to our modern society. The economic prosperity and social well being of a country is jeopardized when these systems are damaged, disrupted, or unable to function at adequate capacity. The management of these infrastructure systems has to take into account critical management issues such as (Lemer, Chong & Tumay, 1995):

- the need to deal with multiple, often conflicting objectives;
- the need to accommodate the interests of diverse stakeholders;
- the reliance of decision making on uncertain economic and social issues;
- the constraints in data availability; and
- the limitations posed by institutional structure.

BACKGROUND

KM approaches can play a central role in facilitating the effective management of these infrastructures. While well-designed information systems can get the right information to the decision maker at the right time, the age of the components of the infrastructure and a lack of available and usable records leads to utility managers frequent inability to take proactive measures to prevent system failures. Further, these infrastructures are interdependent, and managers at the various utilities and agencies need to work together to mitigate the risk of such threats and vulnerabilities. Analyzing each individual infrastructure system and the knowledge derived from managing each individual infrastructure becomes insufficient when managers have to make decisions at the intersection of multiple disciplines in a multihazard context. Sharing of information and ideas become critical to help detect and mitigate hazards and plan the recovery and response strategy.

Traditionally, utilities (especially the water utility) have been rich in "raw data but poor in the aggregated information derived from these data" (Rosen et al., 2003). Transforming the data into knowledge necessitates an understanding of the quality of the data and the aggregation measures used. KM approaches provide the basis for the development of relationships between different data structures and decision makers and by developing a higher level understanding of how information and process knowledge relate to one another.

Perez (2003) identified four common trends in the utility industry: the diminishing workforce, growing competition within the public sector, deterioration of employee loyalty, and increasing public involvement in government. Due to the concern about the potential negative impact of these trends on the ability to retain and share the institutional knowledge they currently possess, utilities have sought to find a method to efficiently maintain and improve the knowledge level of utility management.

Rosen et al. (2003) also point out that utilities lack a mechanism to aggregate, analyze, and restructure information in order to create knowledge. In general, many potential data users within a utility are not aware of a significant amount of the available data. Besides, in most cases, data are stored at multiple areas for the needs of the users. An organized directory of the entire data rarely exists. This creates redundancy of data and inefficiency of data retrieval.

Utilities have been recognizing the benefits of adopting KM strategies in their organizations. Foremost among these include the reduction in lost knowledge from downsizing and restructuring. Improving efficiencies of operations and workflow and improving customer satisfaction are also cited as reasons for moving toward a KM environment. Privatization of public and municipal utilities and increased regulation requires utilities to maintain a better handle of these physical and intellectual assets and liabilities.

However, there are several barriers impacting the access and use of information within a utility. These include a lack of awareness of what information (both internal and external) is available; difficulty in obtaining data access; lack of appropriate software for accessing, analyzing, and interpreting data; and the lack of complete historical data about the utility infrastructure and GIS base maps. In addition, the traditional "paper centric" nature of many utilities and lack of a

central repository of information make it harder to access information that is available within a utility. Further, "a large array of critical information for the utility is maintained in the heads of a few critical people" (Rosen et al., 2003).

These problems may be compounded in the future with new security requirements that are likely to restrict the flow of information. While the absence of complete historical data is a problem that is not easily fixed, information stored on paper can have implications that are both positive and negative. It is likely to be more secure than data stored electronically while the cost of use and maintenance is likely to be higher. It is necessary to find a solution that makes information available to utility managers so that they can do their job more effectively while also controlling access to the information more effectively.

EXAMPLES OF KM APPLICATIONS IN UTILITIES

The American Water Works Association (AWWA) Research Foundation completed a study in 2003 that investigated the feasibility of application of KM in the utility industry, specifically in drinking water utilities (Rosen et al., 2003). In this study, a review of 20 case studies related to utility management literature indicated that the primary areas of interest in upgrading information and knowledge management are:

- Supervisory Control and Data Acquisition (SCADA);
- Laboratory Information Management Systems;
- Geographic Information Systems (GIS);
- Maintenance Management Systems;
- Customer Relationship Management (CRM) and Tracking Systems; and
- Enterprise-wide Information Systems to tie other systems together.

The first five areas are operational systems focused on automation of specific department's current workflow and needs. The last area emphasizes synergy in the use of data. Currently, applications of KM in utilities are very limited, but the following case studies briefly demonstrate how KM approaches can be successfully applied to utilities.

- Columbus Water Works serves drinking water and treats wastewater for almost 200,000 residents in the Columbus, Georgia region. A data warehouse was implemented to act as a central source of all information from all of their applications. The star schema database adopted in this case consists of six primary "stars", including customers, employees, inventory, measurements, work orders, and accounting. A star schema allows for each sector data to be independent but also allows for integration of data through the central data warehouse. The utility reported that the main benefit is cost control, and it allows them to collect and distribute information between applications, better manage expenses, monitor data trends over time, and explore any unexpected variations.
- The OTAY Water District provides water and/or sewer facilities to about 100,000 people in San Diego County. They are using a new information management system, Myriad viewing software, allowing employees direct access to maps on their laptop, eliminating the need for the GIS department to reply to requests for drawings from employees in different departments.
- The Canadian electricity company, Ontario Hydro, is responsible for providing access to the 16,000 Material Safety Data Sheets (MSDSs) on the hazardous materials used at the utility to all employees. These sheets originated at the 2,100 companies that produced the hazardous chemicals and were then sent to Ontario Hydro. Since there has been a concern about the employees getting the most accurate information about the data due to losing MSDSs or spilling oil on them, Spicer's Imagination imaging soft water was implemented and linked to their existing database allowing for images to be scanned or faxed, which facilitates viewing the MSDSs for the employees.
- Michigan Consolidated Gas Company distributes natural gas to approximately 1.2 million residential, commercial, and industrial customers. IBM developed and implemented a system, Interactive Voice Response (IVR), which integrated the utility's voice and data systems. The IVR provides information to customers, including balance and payment histories, budget, billing, enrollment, payment agreements, service requests, and repair status. This automated service increased productivity in customer

relations allowing the personnel more time to handle other issues.
- In 2003, the North Miami Beach Public Services Department was in the process of implementing a knowledge base for its water utility (Perez, 2003). In its early development stage, knowledge management focused on explicit knowledge sharing between internal subunits. The water utility operation was divided into three different segments including water production, water quality, and water distribution. All explicit knowledge in each segment, such as monthly operating reports, facility permits, record drawings, consultant studies and reports, and equipment data management sheet, was created in electronic format so that captured knowledge did not disappear. By placing the database for each segment within a secure network, critical information can be shared by the staff, improving efficiency of work by significantly reducing the amount of time spent on searching and retrieving a document.

The aforementioned cases illustrate that a variety of information technologies and systems are employed to support KM initiatives. What is important to note is that KM is not viewed as a technology solution; rather, it is planned as a set of management processes that utilize appropriate information technologies in an effective manner.

IMPACT OF THE INTERDEPENDENCIES BETWEEN UTILITIES

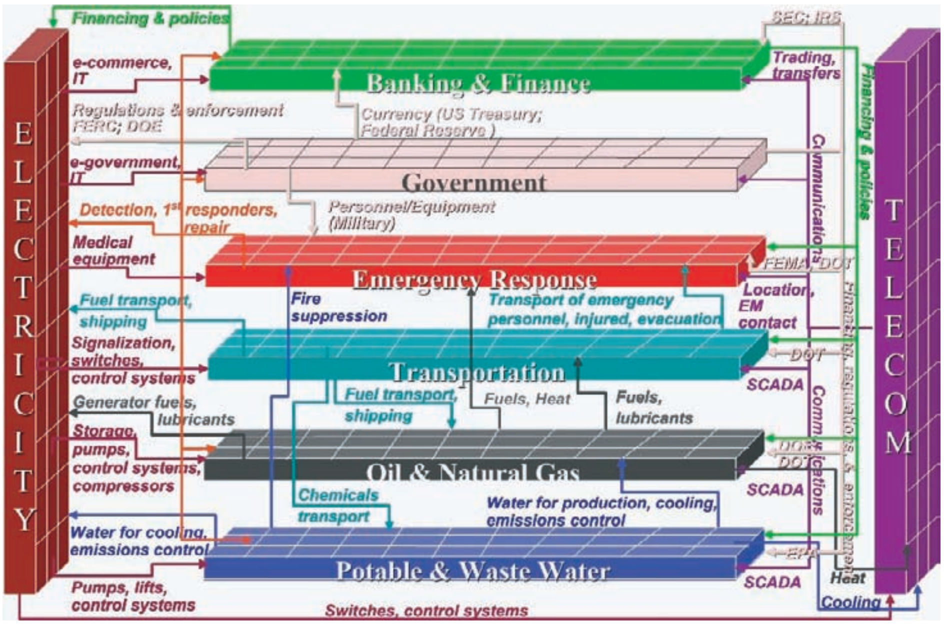
The August 2003 electrical blackout in the Northeast USA emphasized that the functioning of any utility is dependent on the effective functioning of other utilities. For instance, after the blackout, residents of New York's many high-rise buildings lost water, since electric pumps are required to get water to the upper floors. The blackout also compromised the water supply in Detroit, Michigan and Cleveland, Ohio in at least two ways: first, by decreasing the pressure in water pumps, allowing bacteria to build up in municipal water systems and, second, by effectively shutting down sewage treatment facilities (Johnson & Lefebvre, 2003). Some communication utilities, including telephone service and Internet communications could not operate properly as they had an inadequate level of electricity back-up systems.

KM ACROSS CIVIL INFRASTRUCTURES

Figure 1 illustrates how the utilities are interwoven with each other for their proper operation. Even with the growing interdependency between these utilities, there are few communication routes between utilities. More importantly, information sharing or knowledge management paradigm across utilities is rare. Developing KM initiatives to support utility managers without considering the interdependencies may lead to decisions that emphasize local efficiency instead of global efficiency of the utility. Knowledge management processes across utilities will help the managers to respond rapidly to reduce the adverse consequences due to malfunction of dependent utilities, or even to plan ahead before incidents in order to eliminate the cascading effects. Moreover, once knowledge is shared between utilities, a solution for the global optimum for profit maximization and/or service reliability can be sought by strategically managing their resources instead of developing locally optimal solutions solely for each utility's profit.

The issue of interdependence can be demonstrated using the case of Colorado Springs Utilities, an innovative water utility in the western US. This case study demonstrates how information sharing between utilities can simultaneously

Figure 1. Infrastructure interdependency (Heller, 2002)



improve efficiency of operation and reduce costs of operation (Heller, 2001; Jentgen, 2004). The energy and water quality management system (EWQMS) of Colorado Springs Utilities is conceptually an extension of electric utilities' energy management systems (EMSs), which include power generation control and real-time power systems analysis.

Some aspects of the EWQMS are substantially more complicated than EMS. For example, in an EWQMS where hydropower is an option, decisions about pumped storage are coupled with the selection of electricity sources to exploit time-of-day electricity pricing. Alternatively, if spot market prices are exorbitant, hydropower might best be used to generate electricity for sale. Whereas EMS's power generation control has a short-term load-forecasting component, the EWQMS has two sets of demands to predict and satisfy: one for electricity and one for water. In addition, scheduling decisions also consider the following aspects:

- what quantity of raw water from which source is subject to water rights, quantity, and quality constraints, given variable pumping costs;
- what quantity of water is to be treated at which plant, given variable treatment costs; and
- which pumps are to be used for distribution, collection, and wastewater treatment and which ones should be taken off-line for maintenance.

The Colorado Springs Utility estimated that the cost reduction using the aforementioned approach would be worth more than $500,000 per year, not including windfalls from higher electricity prices. Heller, Von Sacken, and Gerstberger

(1999) also discuss the concept of shared resources as a means of achieving regional eco-efficiency. In this context, "information system boundaries are extended to coordinate the shared production, consumption, treatment, or reuse of electricity, water, and wastewater resources among regional utilities and manufacturing facilities" (Heller, 2001).

BARRIERS TO THE PROPER APPLICATION OF KM IN UTILITIES

Many utility organizations are moving toward a KM approach to take advantage of the usefulness of information. However, implementing KM processes requires a significant change in a utilities organizational culture to be successful. For instance, the perception that data belong to one part of the organization to the exclusion of others must be changed. This cultural change is often more difficult than the investment and challenge of gathering and organizing all of the required information.

There is a general consensus that no single system will result in an effective KM initiative. Introducing KM processes will require careful thought and reorganization of workflow. Because management of a utility consists of various different business practices from laboratory operations to customer relations, careful studies regarding information structures and potential data transfer protocols and available information tools must be implemented before a KM initiative is launched.

A very low level of recognition regarding the need for information sharing and knowledge management framework across utilities is one of the significant barriers. Although the need to analyze the interdependencies between utilities were emphasized through the President's Commission Study (PDD 63, 1998), the mechanisms of these interdependencies is still not clearly known and is currently under investigation by researchers, including those at the Sandia National Laboratories, Argonne National Laboratory, and several universities.

The September 11, 2001 terrorist attacks and the blackout in the northeast US in August 2003 have propelled interest in further investigating these interdependencies. A report after the August 2003 blackout indicates that almost half of the companies that participated in a survey regarding the impact of the August 14th power failure were willing to invest their money to reduce the risk of their business to utility service outage in order to continue their business (Stoup, Slavik & Schnoke, 2004).

While it is possible to invest in information technology and systems to help reduce the risk of service outage, it is not possible to engineer a system that takes care of all possible eventualities. Because of interdependencies between utilities and causes for service outage are likely to be specific to a single utility, as well as pairs or groups of utilities, it is necessary for managers at these utilities to analyze interdependencies and to identify vulnerabilities. One approach to facilitate this analysis is the use of focus groups or brainstorming sessions with utility managers. Consecutive meetings of this group may help identify what data must be shared between utilities and what KM system can be structured in order to reduce risk to service outage due to outages in interdependent utilities.

Another concern is security of information. Utilities tend to hesitate sharing their internal information with others especially since September 11, 2001. Only minimal information is made available on the Web. The structure or topology of the utility network and information about operations is not disclosed to the public. While this trend may hinder the development of well-structured information systems to solve problems among utilities, it is necessary to find ways in which information and process knowledge can be shared without creating sources of vulnerability. This could be through predetermined and secure channels of communication.

KNOWLEDGE MANAGEMENT CONCEPTS RELEVANT TO MANAGEMENT OF CIVIL INFRASTRUCTURE

In managing critical infrastructures, the ability to capture and reuse tacit knowledge (Polanyi, 1967) is vital given the changing nature of threats, especially those that are intentional and human induced. Standard operating procedures and documented methods may not provide an appropriate guide under novel situations. In such a scenario, the decision maker needs support in the form of access to information about prior incidents and how they were handled. Further, given the interdependence between critical infrastructures, access to information about events in related utilities becomes important.

Each organization within an infrastructure works in a relatively unique manner based on its organizational culture and traditions. When comparing organizations in different infrastructures, the situation becomes more complex given disparate engineering set-ups and regulatory regimes. Information sharing about interdependencies is a starting point and is likely to be acceptable if the system links are designed with appropriate levels of security. In addition, given such a dynamic environment, the ability to "capture" discussions to glean ideas becomes extremely valuable.

The role that KM can play is one of accumulating knowledge from employees to make the organization work better. In the context of managing critical infrastructures, the purpose is to learn from each incident across infrastructures to enable a decision maker to handle a current or future unique incident for which there is not a standard operating procedure available.

Knowledge management is therefore about changing the way work is done. When threats are constantly changing, mere understanding of current threats and methods to mitigate them are not sufficient. It is necessary to have a process in place where the organization learns from each incident and develops strategies to improve the way in which vulnerabilities are assessed, disasters mitigated, and failures managed. KM processes create a structure that enables reflection of events, analysis of data, and procedures to facilitate learning and making more effective the decision-making process of utility managers. However, as Nidumolu, Subramani, and Aldrich (2001) point out "to be successful", KM initiatives "need to be sensitive to features of the context of generation, location and application of knowledge". The operating procedures, technology and information systems, and organizational culture will collectively impact the knowledge management efforts in infrastructure management.

CONCLUSION

The purpose of KM processes in civil infrastructure management is to assist owners to provide services economically and reliably. Utilities have to operate in an environment constrained by customer service requirements, regulations, shareholder expectations, and an aging infrastructure. Civil Infrastructure managers need the capabilities provided by KM approaches to help them manage more effectively.

However, implementing KM processes goes beyond deploying specific types of information technologies and systems. Systems that support the sharing of information and process knowledge within civil infrastructures must be coupled with changes to operating and managerial procedures. These changes have to take into account the interdependencies between related infrastructures as well as the security risks imposed by release of critical information. It is necessary for the owners and top-level managers at critical infrastructures to take a much closer look at this issue so that they can allocate the appropriate resources to implement effective knowledge management processes.

REFERENCES

Heller, M. (2001). Interdependencies in civil infrastructure systems. *The Bridge, 31*(4), 9-15.

Heller, M. (2002, February 14). Critical infrastructure interdependencies: A system approachs to research needs. *Infrastructure and Information Systems, National Science Foundation, Presentation to National Academy Committee on Science and Technology for Countering Terrorism: Panel on Systems Analysis and Systems Engineering.*

Heller, M., Von Sacken, E.W., & Gerstberger, R. L. (1999). Water utilities as integrated businesses. *Journal of the American Waterworks Association, 91*(11), 72-83.

Jentgen, L. (2004). *Implementation prototype energy and water quality management system.* London: IWA.

Johnson, J., & Lefebvre, A. (2003). *Impact of Northeast Blackout continues to emerge.* Retrieved May 9, 2005, from http://www.wsws.org/articles/2003/aug2003/blck-a20.shtml

Lemer, A. C., Chong, K. P., & Tumay, M. T. (1995) Research as a means for improving infrastructure. *Journal of Infrastructure Systems, 1*(1), March, 6-15.

Nidumolu, S. R., Subramani, M., & Aldrich, A. (2001). Situated learning and the situated knowledge web: Exploring the ground beneath knowledge management. *Journal of Management Information Systems, Summer, 18*(1), 115-150.

PDD 63 (Presidential Decision Directive 63). (1998). *An analysis of the consequences of the August 14th 2003 power outage and its potential impact on business strategy and local public policy.* Retrieved May 9, 2005, from http://www.terrorism.com/homeland/pdd63.htm

Perez, A. L. (2003, June 15-19). Knowledge management for public utilities: A strategic approach for the retention of intellectual capital. *Proceedings of the 2003 American Water Works Association Annual Conference*, Anaheim Convention Center, Anaheim, CA

Polanyi, M. (1967). *The tacit dimension.* Garden City, NY: Doubleday.

Rinaldi, S. M., Peerenboon, J. P., & Kelly, T. (2001, December). Identifying, understanding, and analyzing critical infrastructure interdependencies. *IEEE Control Systems Magazine,* 11-25.

Rosen, J. S., Miller, D. B, Stevens, K. B., Ergul, A., Sobrinho, J. A. H., Frey, M. M., & Pinkstaff, L. (2003). *Application of knowledge management to utilities. Denver: American Water Works Associations Research Foundation (AWWARF).*

Stoup, G. M., Slavik, M. R., & Schnoke, M. S. (2004). *An analysis of the consequences of the August 14th 2003 power outage and its potential impact on business strategy and local public policy.* Retrieved May 9, 2005, from http://www.acp-international.com/southtx/docs/ne2003.pdf

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Chapter 4.43
Knowledge Management in Healthcare

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ABSTRACT

Healthcare organizations are facing many challenges in the 21st Century due to changes taking place in global healthcare systems. Spiraling costs, financial constraints, increased emphasis on accountability and transparency, changes in education, growing complexities of biomedical research, new partnerships in healthcare and great advances in IT suggest that a predominant paradigm shift is occurring. This shift is necessitating a focus on interaction, collaboration and increased sharing of information and knowledge which is in turn leading healthcare organizations to embrace the techniques of Knowledge Management (KM) in order to create and sustain optimal healthcare outcomes. This chapter describes the importance of knowledge management systems for healthcare organizations and provides an overview of knowledge management technologies and tools that may be used by healthcare organizations.

INTRODUCTION

Knowledge Management (KM) is an essential tool in today's emerging healthcare system. Hospitals that seek to deploy KM systems need to understand the human element in the process. Earlier, success factors were only restricted to a few healthcare variables such as patient care and cost, but over the years, technology (both clinical and administrative) has evolved as a differentiating variable, thus redefining the doctrines of competition and the administration of healthcare treatments. For example, in today's healthcare environment we are now treating patients with an emphasis on prevention and managing the patient through good health throughout their life. Such an approach requires significant investment in knowledge assets. One of the key objectives of a KM system is to insulate a hospital's intellectual knowledge from degeneration (Elliot, 2000).

Most hospitals are unaware of their acquired knowledge base. Further, knowledge capital is often lost from a hospital through employee attrition, high turnover rates, cost-saving measures and improper documentation (Chase, 1998). Specific KM tools and metrics help focus the hospital on acquisition, retrieval and storage of knowledge assets both tangible and/or other for activities such as learning, strategic planning and decision making (Oxbrow, 1998). This goes a long way in crafting a coherent and well-designed growth plan for the hospital (Allee, 1997, 1999). KM treats intellectual capital as a managed asset. Improved patient care is directly proportional to a hospital's intellectual assets. The tactical expertise and experience of individual workers should be fully captured and reflected in strategy, policy and practice at all levels of the hospital management and patient care activity (Conklin, 1998). The intangible asset of knowledge of the employee can nurture radical innovation in advance planning, change management, hospital culture and well balanced approaches. Fostering a knowledge-sharing attitude and competency of patient care processes are vital for any KM program in healthcare (Burca, 2000; Matheson, 1995). Hospitals managing and sharing their knowledge assets effectively will have benefits of cycle time reduction, cost reduction, improved return on investment, higher satisfaction index, and better medical and paramedical education levels (Antrobus, 1997; Atkins et al., 2001).

KNOWLEDGE MANAGEMENT

Knowledge Management (KM) is an emerging, interdisciplinary business model dealing with all aspects of knowledge within the context of the firm, including knowledge creation, codification, sharing and how these activities promote learning and innovation (Choo, 1998). Unfortunately there's no universal definition of KM, just as there's no agreement as to what constitutes knowledge in the first place (Beckman, 1999). For this reason, it's best to think of KM in the broadest context:

KM is a discipline that promotes an integrated approach to identifying, managing, and sharing all of an enterprise's information assets, including database, documents, policies and procedures, as well as unarticulated expertise and experience resident in individual workers (Wickramasinghe, 2003). There are many dimensions around which knowledge can be characterized such as storage media, accessibility, typology and hierarchy. Each of these dimensions is explained in this chapter (Brailer, 1999; Broadbent, 1998; Skyrme, 2001, 1999, 1998; Davenport & Prusak, 1997, 1998).

Knowledge Storage Media

There are several media in which knowledge can reside including: the human mind, an organization, a document and/or a computer. Knowledge in the mind is often difficult to access; organizational knowledge is often dispersed and distributed; document knowledge can range from free text to well-structured charts and tables; while computer knowledge can be formalized, sharable and often well structured and well organized. In order to effectively manage KM it is important to pay careful attention to the most useful storage media.

Knowledge Accessibility

Intellectual and knowledge-based assets fall into one of three major categories (Nonaka, 1994;

Nonaka & Nishguchi, 2001; Sharma & Wickramasinghe, 2004):

- Tacit (human mind, organization): accessible indirectly only with difficulty through knowledge elicitation and observation of behavior.
- Implicit (human mind, organization): accessible through querying and discussion, but informal knowledge must first be located and then communicated.
- Explicit (document, computer): readily available, as well as documented into formal knowledge sources that are often well organized, often with the help of IT.

In order for effective KM to ensue, it is necessary to understand these categories of knowledge as well as their subtle nuances.

Knowledge Typologies

Typologies are defined, characterized and described in terms of knowledge type-conversion, structural features, elementary properties, purpose and use, and conceptual levels. Knowledge typologies play an integral role in a robust KM system.

Knowledge Hierarchy

A further dimension considers the premise that knowledge can be organized into a hierarchy. Several authors draw distinctions between data, information and knowledge (Allee, 1997; Devenport & Prusack, 1998; Leonard, 1998).

- Data: Facts, images and sounds.
- Information: Formatted, filtered and summarized data.
- Knowledge: Instincts, ideas, rules and procedures that guide action and decisions and are context dependent.

Strictly speaking, KM is a process that identifies and creates knowledge assets. In healthcare, KM optimally utilizes these assets to fulfill the core healthcare objectives. Knowledge assets in hospitals are intangible but they can be defined as knowledge that a medical/paramedical/nonmedical person has with respect to patient care, medical needs, operating environment and technologies, something that he or she can utilize in routine medical and healthcare management. KM identifies and maps intellectual assets within the hospital, thereby generating precious knowledge capital for competitive advantage within the medical institution. Since knowledge is dynamically imbedded in organizational and healthcare networks and processes as well as in the staff that use them, hospitals need to have a built-in KM system that "crisscrosses" with its healthcare networks (Jackson, 2000). The result is that employees will then be better informed and continuously updated on the latest tools and best practices. It is important that the techniques adopted to enable KM must take into account some basic factors such as the type of hospital, its culture and its needs to ensure a successful KM system for a healthcare setting (Gokce, 2002; Johnson, 1998; Keeling & Lambert, 2000).

THE NEED FOR KM IN HEALTHCARE

The health sector is large, accounting for between 6% to 12% of GDP across OECD countries. Though the use of healthcare services varies between nations, public expectations of them globally have risen dramatically everywhere since 1950 and the trend is still upwards. Fresh demands arise from the appearance of new drugs and the invention of new technology, from advances in prevention and diagnosis as well as therapy, and from new categories of demand, such as care of the elderly (Eisenberg, 2002). The health sector is complex and includes a range of key actors: patients, providers, practitioners, payers, purchasers, pharmaceutical industry, and professors. The interaction among these actors shapes what counts as relevant knowledge as well as how it is produced, mediated, and used (Conner, 2001). Further, the domain of medical knowledge has expanded to such a degree that a human mind can no longer retain it all. There are now some 20,000 medical journals in the world. A professor of medicine spends on average one day a week to remain abreast of studies in his/her field of interest as well as for his/her research. What can a generalist physician do? How much time can he/she devote to "keeping up"? In France, there are some 7,000 prescription drugs based on some 3,500 active ingredients. A physician has the right to prescribe them all. Can he/she be familiar with all of them? He/she must also be aware of some 300 medical references, some 800 biological tests, more than 1,000 imagery tests, and more than 1,500 surgical interventions. If he/she prescribes six drugs, he/she must also be aware of some 720 potential sources of interaction. The figure reaches 3,328,800 if 10 drugs are prescribed. In addition to the therapeutic value of each molecule, the physician should also know their price and potential effect on specific population groups (diabetics, the obese, children, the elderly, etc. The growth in knowledge has necessarily led to specialization, which too has meant "balkanization" and lack of coordination, especially in hospitals but also in private practice (Halpern, Perry & Narayan, 2001; Dean, 2002). As knowledge is shared, responsibility and decisions about treatment should be shared as well (Eisenberg, 2002). Hospital Information Management (HIM) professionals, like other healthcare personnel, have always sought, used, and valued knowledge about their practice. Managers hire experience because they understand the value of knowledge that has been developed and proven over time. Unfortunately, they are bombarded each day with information in the form of e-mails, voice mails, faxes, reports, memos, and so on — much of which is repetitive or simply not useful. On the other hand, the same professionals spend a great deal of time looking for the information they need by accessing the Web, sending e-mails, making phone calls, and scouring computerized reports. It is in this process that KM can make a difference. Studies have shown that managers get two-thirds of their information from face-to-face meetings or phone conversations. Only one-third comes from documents or other knowledge bases. Unlike material assets, which decrease in value as they are used, the value of knowledge increases with use. For example, new ideas on records storage or retrieval breed other new ideas, and shared knowledge stays with the giver while it enriches the receiver (Jadad, Haynes, Hunt & Browman, 2000). The potential for new ideas arising from the store of knowledge in any healthcare organization is to provide a common entry point for corporate knowledge, such as formularies, clinical road maps, and key financial indicators (Einbinder, Klein & Safran, 1997). Thus what we can see is that the need for KM in healthcare is critical and becomes significant when it begins to focus on the needs of individual users, departmental indicators, and key processes in order to capture and display relevant, useful, and usable knowledge in a customized fashion (Sorrells & Weaver, 1999a, 1999b, 1999c).

APPROACHES TO CAPTURE, STORE AND SHARE KNOWLEDGE

For companies that need to leverage their corporate knowledge, the following four initiatives may help you establish a knowledge sharing system of your own. These initiatives draw upon a predominate, repository model but are also relevant to other models (Morrissey, 1998).

Build the Infrastructure Using Appropriate Technology

Technology enables connectedness to take place in ways that have never before been possible. Harnessing intellectual capital can be expedited through a network-computing infrastructure. Technology has emerged to support each different approach to knowledge management. Document management systems expedite document storage and retrieval. Web-casts allow synchronous communication between experts while discussion groups enable asynchronous interaction. Learning management systems track an employee's progress with continuous learning while data warehousing mines powerful SQL databases, which organize and analyze highly structured information. Paramount to the successful use of these technologies is naturally a flexible, robust IT infrastructure (Sharma & Wickramasinghe, 2004).

Build a Conceptual Infrastructure with Competencies as the Backbone

Technology is important in harnessing intellectual assets, but integrated solutions encompass more than that. You must rethink the conceptual infrastructure of your business. For example, you may need to: ensure intellectual assets reflect your vision and values; articulate the theoretical framework for your processes; establish a taxonomy or categorization scheme to organize your information; create cross references that reflect relationships between entries; or index your information using attributes or meta-tags. The notion of competence plays a critical role in knowledge indexing and sharing. Karl Erik Sveiby, noted Swedish expert on managing and measuring knowledge-based assets, observes, "The concept of competence, which embraces factual knowledge, skills, experience, value judgments and social networks is the best way to describe knowledge in the business context." Once competencies or target proficiencies are defined, they become the backbone, which connects users to useful, relevant knowledge.

Create a Repository of Reusable Components and Other Resources

Before the Industrial Revolution, products were handcrafted; each piece was unique and couldn't be reused. The genius of the Industrial Revolution centered on making reusable parts and components became standardized and interchangeable. The Information Revolution is similar. Instead of crafting a unique solution each time, knowledge sharing creates a warehouse of "stored parts" — e.g., standardized and interchangeable components which can be reused and adapted: skills, best practices, models and frameworks, approaches and techniques, tools, concepts, specific experiences, presentation aids, white papers, etc. Adding to this, resources such as directories of experts indexed by their field can help you gain access to knowledge outside of your core competencies.

Set High Standards for Quality and Usability

Ensure that your information complies with high quality standards because it is the foundation upon which to build a knowledge-centric healthcare organization. In addition, it is important to make sure that the system meets the users' needs, which may involve reworking or restructuring information. Leonard Caldwell observed: "Critical information must first be reorganized so that information is presented in a way that mirrors users' needs and parallels a thought process occurring within a job function or task." Establishing consistent patterns helps end-users find information quickly. Online coaching can provide users with tips and techniques on how to modify, customize, or tailor information. Leveraging organizational knowledge is not an option — it is an imperative if one is to flourish in the marketplace. It can lead into a new phase of quality and innovation. It will reduce cycle time and gives a competitive advantage as a company. The synergy will also contribute to growth as individuals. Companies who have the foresight to manage their knowledge capital now will have an advantage in the future (Herbig, Bussing & Ewert, 2001).

KM TOOLS AND TECHNOLOGIES

The paraphernalia of the information revolution — computers, communications networks, compact discs, imaging systems and so on — are now widely expected to make a vital contribution to helping doctors and other medical professionals do their work better (Gokce, 2002). New information technologies include:

- Electronic patient records, which are more up to date, easier to access, and more complete than paper ones;
- Standardized medical terminologies and languages, both within and across natural language communities;
- Methods and tools to support faster dissemination of information via the Internet that leads to new scientific understanding of diseases and their treatment;
- More timely and reliable methods and tools to support better communication and coordination among members of healthcare teams;
- A creative approach to KM can result in improved efficiency, higher productivity and increased revenues in practically any business function.

The technical goal of KM initiatives is to give the organization the ability to mine its own knowledge assets, which could include creating such tools as a centralized search capability, automatic indexing and categorization, content analysis and preparation, data analysis, and customizable features integrated in a digital dashboard. Process improvement is a precursor to providing a knowledge-centered environment. Before an organization can foster collaboration and knowledge sharing, the organization must possess an understanding of information flows and of the overall knowledge infrastructure. There is no such thing as the perfect KM product. Instead, different tool sets can be integrated with the organization's legacy systems (Heathfield & Louw, 1999). Technical issues that KM projects must address include:

- Setting up electronic delivery strategies for information
- Identifying information sources and services
- Building decision support tools and data-mining templates
- Establishing enterprise-wide business rules
- Implementing process improvement techniques

Knowledge Mapping

Knowledge management is rapidly becoming a critical success factor for competitive organizations. Carrying out knowledge management effectively in an industrial environment requires support from a repertoire of methods, techniques and tools, in particular knowledge engineering technology adapted for knowledge management. Knowledge mapping creates high-level knowledge models in a transparent graphical form. Using knowledge maps, management can get an overview of available and missing knowledge in core business areas and make appropriate knowledge management decisions. Knowledge mapping is a good example of a useful knowledge management activity with existing knowledge acquisition and modeling techniques at its foundations (Strawser, 2000). Knowledge mapping is a technique rather than a product. A knowledge map could be used as a visual example of how information is passed from one part of an organization or group to another and is usually a good place to start understanding what types of intellectual assets the organization has at its disposal. Most organizations that have implemented KM applications provide a context and framework for the way knowledge is gained. KM is usually an integral part of continuous quality improvement or total quality management projects. Several consultants offer knowledge-mapping methodologies (Heathfield & Louw, 1999).

Process-Based Knowledge Map

A process-based knowledge map is essentially a map or diagram that visually displays knowledge within the context of a business process. In other words, the map shows how knowledge should be used within the processes and sources of this knowledge. The overview of the business process is prepared before the knowledge and the sources are mapped to this process. Any type of knowledge that drives the process or results from execution of the process can be mapped. This could include tacit knowledge (knowledge that resides in people such as know-how, experience, and intuition) and explicit knowledge (codified knowledge that is found in documents); customer knowledge; knowledge in processes; etc.

Intelligent Agents

In the early days of online information retrieval systems, individuals met with search intermediaries who were trained to use the online systems. The intermediaries were often knowledgeable about the information seeker's area of interest. Today, technology in the form of personal computers and the Internet provides users with the means to access the online databases from their own offices. However, distributed sources of online information, e.g., the World Wide Web (WWW), compound the problem of information searching. Both novice and experienced users still need support with the search process and the integration of information. To address this problem, agents have been developed for information management applications. The goal of intelligent search agents is to allow end-users to search effectively, be it either a single database of bibliographic records or a network of distributed, heterogeneous, hypertext documents. The approaches range from desktop agents specialized for a single user to networks of agents used to collect data from distributed information sources. Intelligent agents use a combination of profiling techniques, search tools, and recognition algorithms to "push" information to the decision maker on a regular basis. Because intelligent agents use a standard Web analogy, users can quickly set up "net casts" of internal information to automatically receive knowledge bases when they become available. For example, a physician can request that lab results be forwarded to his or her individual dashboard as soon as the lab has completed the procedure. One cautionary note: using push technologies can result in an information flood if filters are not configured to reduce unwanted or unnecessary data (Strawser, 2000).

Web Browsers

Web browsers such as Microsoft's Internet Explorer are practical because of their cost and relative ease of use, and they have become the preferred presentation layer for accessing knowledge bases. The productivity potential inherent in browsers is similar to that of wireless phones. The freer the knowledge worker is of place, time, medium, and device, the less time is spent on the process of messaging, and the more time is available for results. The less time spent on process, the shorter the knowledge cycle, which can be a significant productivity advantage (Strawser, 2000).

KM Applications

Most new KM applications consist of two major elements (often integrated into one interface): a means for employees looking for specialized knowledge to hook up with other people in the organization with the same knowledge (usually via a web application), in other words, an easy way for employees to tap into tacit knowledge resources (people); and a means for employees looking for specialized knowledge to search relevant documents/data (also usually via a web application), in other words, an easy way for employees to tap into explicit knowledge. KM applications are usually designed to support a particular information set in an organization, such as length-of-stay margin management, physician profitability, or accounts receivable recovery. Some consulting firms offer a base set of templates as a core application, focusing on desktop applications, whereas others have developed information sets that provide encyclopedic knowledge of a particular healthcare segment, such as physician issues (Strawser, 2000).

Workflow Applications

In the software world, and in particular in the imaging subset of that world, the need arose to send a particular (bit-mapped) document to a particular workstation or users on a network. This simple routing and distribution was called "workflow." It was quickly learned that these work items could be "tracked," which allowed the accumulation of data about not only where an item had been but also on what happened to it along the way. Who worked on it, how long it was there, the status it had leaving a point, and where it went next was starting to look much more like the manufacturing model. If data was also accumulated about the workers in this operation (how many did they complete, to what status, how long did it take for each) the model was complete. Workflow applications, such as Lotus Notes or Outlook 2000, also play an important role in a KM implementation. For example, a KM solution based on Office 2000 could serve as a nurse triage application, integrating automatic call distribution and transaction-processing systems, in concert with a knowledge base of typical responses to patient questions and symptoms (Strawser, 2000). These described technologies and tools can be exploited to create data banks, knowledge banks and a KM software as shown in Table 1, which will be a great help for providing better solutions for healthcare.

These data banks can be readily accessed through a network (Internet or intranet) if the user has at his/her disposal a workstation, software, and passwords that give access to these networks

Table 1. Data banks, knowledge banks and KM software

Data banks	(Involving text and images as well as figures), which act as medicine's memory to be used for research (clinical, pharmacological, epidemiological, etc.).
Knowledge banks	(Bibliographies, sites for exchanges among professionals, etc.), which make it possible to have access at any moment to the state of the art and can help in making a medical decision (diagnosis or treatment).
Software	To help with diagnosis and prescribing which does not replace the physician but acts to extend their knowledge.

and their different sites. The system should be made flexible so that it can be adaptable in time and space, and can be customized: each physician can, when he/she wishes, consult one of the banks or receive specific information on the fields which he/she has chosen in advance. Access need not be limited to physicians alone, but can also be made available to health professionals and the public, and the latter could adapt behavior to help prevent the onset of illness. Of course, these data banks have to be organized, updated continuously and meet users' expectations by allowing them to ask questions and to engage in discussions among themselves, so that it is always possible to evaluate the quality of the information consulted (Fitchett, 1998). The knowledge bank can make it possible to consult experts located elsewhere and to transmit images and other elements of a patient's file to a colleague to obtain an opinion, a practice currently known as "tele-medicine" (Hansen & Nohria, 1999). Software can help to offer software diagnostic and prescription aids to extend this knowledge (Confessore, 1997; Wyatt, 2000; Timpson, 1998).

CONCLUSIONS

Until recently, most of the knowledge experience and learning about KM had been accessible to only a few practitioners. However, during the past three years an explosion of interest, research, and applications in KM has occurred. There is some concern among the practitioners that KM might suffer a fate similar to business reengineering, artificial intelligence, and total quality management. That is, interest in the discipline must last long enough to iron out the bugs while simultaneously delivering significant business value. The irony is that just when the discipline works well, potential users often have lost interest in the fad, point to the inevitable early failures, and thus miss out on the real benefits. Unless the very ambitious and interesting KM initiatives in healthcare evolve differently, even if they work in a technical sense, they will not work in the economic sense and the healthcare system will continue to be what it is today: an immense apparatus for reimbursing healthcare costs. However, there will still be a health/social services network and a medical profession that is familiar with the tools and power of the Internet. The experience will not be totally negative, even if it is likely to reach goals that are different from those set at the outset. Although considerable progress has been achieved in KM across a broad front, much work remains to fully deliver the business value that KM promises. Ultimately, in order to realize the enormous potential value from KM, organizations must motivate and enable creating, organizing and sharing knowledge.

This chapter has served to highlight the need for healthcare in general to embrace the strategies, protocols, tools, techniques and technologies of knowledge management in order to contend with key challenges pertaining to access, quality and value of healthcare delivery. The following chapters in the book will highlight specific areas within the healthcare industry and key issues regarding knowledge management that are pertinent. This will serve to develop a detailed understating of the essential requirements for creating knowledge-based healthcare organizations.

REFERENCES

Allee, V. (1997). *The knowledge evolution: Building organizational intelligence*. London: Butterworth-Heinemann.

Allee, V. (1999). Knowledge management: Moving the care model from a "snapshot" to a "story." *Health Forum Journal.* Retrieved from http://www.healthforum.com/hfpubs/asp/ArticleDisplay.asp?PubID=7&Article ID=1305&Keyword=knowledge

Antrobus, S. (1997). Developing the nurse as a knowledge worker in health - learning the artistry of practice. *Journal of Advanced Nursing, 25*(4), 823-829.

Atkins, J., Cooper, L., Hughes, E., Kingston, P., & Mayne, A. (2001, January). The healing power of KM. *Knowledge Management, 1.*

Beckman, T. J. (1999). The current state of knowledge management. In J. Liebowitz (Ed.), *Knowledge management handbook.* New York: CRC Press.

Brailer, D. J. (1999, January). Management of knowledge in the modern health care delivery system. *Joint Commission Journal on Quality Improvement, 25*(1), 1999.

Broadbent, M. (1998). The phenomenon of knowledge management: What does it mean to the information profession? *Information Outlook, 2*(5), 23-36.

Burca, S. (2000). The learning healthcare organization. *International Journal for Quality in Healthcare, 12* (6), 457-458.

Chase, R. L. (1998). Knowledge navigators. *Information Outlook, 2*(9), 18.

Choo, C. W. (1998). *The knowing organization: How organizations use information to construct meaning, create knowledge, and make decisions.* New York: Oxford University Press.

Confessore, S. J. (1997). Building a learning organization: communities of practice, self-directed learning and continuing medical education. *Journal of Continuing Education in the Health Professions, 17*(1), 5-11.

Conklin (1996). Capturing organizational memory. In R. M. Baecker (Ed.), *Groupware and computer-supported cooperative work* (pp. 561-565). San Mateo, CA: Morgan Kaufmann.

Conner, M. (2001). Developing network-based services in the NHS. *International Journal of Health Care Quality Assurance including Leadership in Health Services, 14*(6-7), 237-244.

Davenport, T. H., & Prusak, L. (1997). *Information ecology: Mastering the information and knowledge environment.* New York: Oxford University Press.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dean, B. (2002). Learning from prescribing errors. *Quality and Safety in Healthcare, 11*(3), 258-260.

Einbinder, J. S., Klein, D. A., & Safran, C. S. (1997). Making effective referrals: A knowledge management approach. *Proceedings AMIA Annual Fall Synposium* (pp. 330-334).

Eisenberg, H. (2002). *Transforming hospitals into knowledge management centres* [presentation]. Retrieved from http://www.syntrek.com/kmppt/

Elliot, S. (2000). Sharing knowledge & best practices: The hows and whys of tapping your organization's hidden reservoirs of knowledge. *Health Forum Journal.* Retrieved from http://www.healthforum.com/hfpubs/asp/ArticleDisplay.asp?PubID=7&ArticleID=1343&Keyword=knowledge

Fitchett, J. (1998). Managing your organization's key asset: Knowledge. *Health Forum Journal.* Retrieved from http://www.healthforum.com/hfpubs/asp/ArticleDisplay.asp?PubID=7&ArticleID=12869& Keyword= knowledge

Gokce, C. (2002, July/August). Knowledge management in the NHS. *Managing Information, 9*(6).

Halpern, S., Perry, S. C., & Narayan, S. (2001, January/February). Developing clinical practice environments supporting the knowledge work of nurses. *Computers in Nursing, 19* (1), 17-23.

Hansen, M. T., & Nohria, N. (1999). Thomas Tierney. What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Heathfield, H., & Louw, G. (1999, June). New challenges for clinical informatics: Knowledge management tools. *Health Informatics Journal, 5*(2), 67-73.

Herbig, B., Bussing A., & Ewert, T. (2001). The role of tacit knowledge in the work context of nursing. *Journal of Advanced Nursing, 34* (5), 687-695.

Jackson, J. R. (2000). The urgent call for knowledge management in medicine. *The Physician Executive, 26* (1), 28-31.

Jadad, A. R., Haynes, B. Hunt, D., & Browman, G. P. (2000). The Internet and evidence-based decision-making: A needed synergy for efficient knowledge management in health care. *CMAJ, 162* (3), 362-365.

Johnson, D. E. L. (1998, July). Knowledge management is new competitive edge. *Health Care Strategic Management, 16*(7), 2-3.

Joyce, L. (2000). Translating knowledge into good practice. *Professional Nurse, 16*(3), 960-963.

Keeling, C., & Lambert, S. (2000). Knowledge management in the NHS: Positioning the healthcare librarian at the knowledge intersection. *Health Library Review, 17*(3), 136-143.

Kenner, C. (2002). *Knowledge management and nursing education*. Retrieved from http://eknowledgecenter.com/articles/1011/1011.htm

Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation.* New York: Oxford University Press.

Leonard, D. (1998). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Matheson, N. W. (1995). Things to come: Postmodern digital knowledge management and medical informatics. *Journal of the American Medical Informatics Association, 2*(2), 73-8.

Morrissey, J. (1998). Principles of knowledge management. *Modern Healthcare, 28*(7), 42.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5*, 14-37.

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge emergence*. Oxford: Oxford University Press.

Nutkis, D. S. (1997, November). Webcasting: Knowledge management coming to health care providers. *Surgical Services Management, 3*(11), 18-21.

Nutley, S. M., & Davies, H. T. O. (2001). Developing organizational learning in the NHS. *Medical Education, 35,* 35-42.

O'Conner, G. T., et al. (1996). A regional intervention to improve the hospital mortality associated with coronary artery bypass graft surgery. *Journal of the American Medical Association, 6*(4), 55-73.

Odden, J. R. (1998). Developing Web-based knowledge management systems for healthcare call centers. *Journal of Healthcare Information Management, 12*(2), 87-95.

OECD. (2000). Knowledge management in the learningsociety, *OECD.* Retrieved from www.brint.com/km

Open Clinical. (2000). *The medical knowledge crisis and its solution through knowledge management* [draft white paper]. Retrieved October 25, 2000, from http://www.openclinical.org/docs/whitepaper.pdf

Oxbrow, N., & Abell, A. (1998). Putting knowledge to work: What skills and competencies are required? In *Knowledge management: A new competitive asset.* Washington, DC: SLA State-of-the-Art Institute.

Pfeffer, J., & Sutton, R. I. (2000). *The knowing-doing gap: How smart companies turn knowledge into action.*

Sharma, S., & Wickramasinghe, N. (2004). A framework for building a learning organization in the 21st century. (forthcoming). *International Journal of Innovation and Learning.*

Skyrme, D. J. (1998, March). Knowledge management: Solutions: The role of technology. *ACM SIGGROUP Bulletin, Special Issue on Knowledge Management at Work.*

Skyrme, D. J. (2001). *Capitalizing on knowledge: From e-business to k-business*. Butterworth-Heinemann.

Skyrme, D. J., & Amidon, D. M. (1999). The knowledge agenda. In J. D. Cortada & J. A. Woods (Eds.), *The knowledge management yearbook* (pp. 108-125). Butterworth-Heinemann.

Sorrells, J. J. (1999). The role of the chief nurse executive in the knowledge-intense organization of the future. *Nursing Administration Quarterly, 23*(3), 17-25.

Sorrells, J. J., & Weaver, D. (1999a, July/August). Knowledge workers and knowledge-intense organizations, Part 1: A promising framework for nursing and healthcare. *Journal of Nursing Administration, 29*(7/8), 12-18.

Sorrells, J. J., & Weaver, D. (1999b, September). Knowledge workers and knowledge-intense organizations, Part 2: Designing and managing for productivity. *Journal of Nursing Administration, 29*(9), 19-25.

Sorrells, J. J., & Weaver, D. (1999c). Knowledge workers and knowledge-intense organizations, Part 3: Implications for preparing healthcare professionals. *Journal of Nursing Administration, 29*(10), 14-21.

Strawser, C. L. (2000). Building effective knowledge management solutions. *Journal of Healthcare Information Management, 14*(1), 73-80. Retrieved from http://www.himss.org/asp/ContentRedirector.asp?ContentID=948

Timpson, J. (1998). The NHS as a learning organization: Aspirations beyond the rainbow? *Journal of Nursing Management, 6*(5), 273-274.

Wickramasinghe, N. (2003). Practising what we preach: Are knowledge management systems in practice really knowledge management systems? *Business Process Management Journal, 9*(3), 295-316.

Wyatt, J. C. (2000). Clinical questions and information needs. *Journal of the Royal Society of Medicine, 93*(4), 168-171.

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Chapter 4.44
Healthcare Knowledge Management

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INTRODUCTION

The healthcare environment is changing rapidly, and effective management of the knowledge base in this area is an integral part of delivering high-quality patient care. People all over the world rely on a huge array of organizations for the provision of healthcare, from public-sector monoliths and governmental agencies to privately funded organizations, and consulting and advisory groups. It is a massive industry in which every organization faces a unique combination of operational hurdles. However, what every healthcare system has in common is the high price of failure. Faced with the prospect of failing to prevent suffering and death, the importance of continuously improving efficiency and effectiveness is high on the agenda for the majority of healthcare organizations (Brailer, 1999). Taking also into consideration that the amount of biological and medical information is growing at an exponential rate, it is not consequently surprising that knowledge management (KM) is attracting so much attention from the industry as a whole.

In a competitive environment like the healthcare industry, trying to balance customer expectations and cost requires an ongoing innovation and technological evolution. With the shift of the healthcare industry from a central network to a global network, the challenge is how to effectively manage the sources of information and knowledge in order to innovate and gain competitive advantage. Healthcare enterprises are knowledge-intensive organizations which process massive amounts of data, such as electronic medical records, clinical trial data, hospitals records, administrative reports, and generate knowledge. However, the detailed content of this knowledge repository is to some extent "hidden" to its users, because it is regularly localized or even personal and difficult to share, while the healthcare data are rarely transformed into a strategic decision-support resource (Heathfield & Louw, 1999). KM concepts and tools can provide great support to exploit the huge knowledge and information resources and assist today's healthcare organizations to strengthen healthcare service effectiveness and improve the society they serve.

The key question which remains is the following: How can we make knowledge management work in healthcare? The answer is given in the following sections.

THE HEALTHCARE INDUSTRY: A BRIEF OVERVIEW

The health care industry is one of the largest single industries all over the world and the largest one in the United States. It has increased by over 65% since 1990 and is expected to double by the year 2007.1 The IT industry is strategically positioned to become a powerful ally to the healthcare industry as it strives to adopt well-managed cost-efficient strategies. Advanced information technologies can give healthcare providers the opportunity to reduce overall healthcare expenses by lowering the costs of completing administrative and clinical transactions. Nevertheless, in comparison to other industry sectors, the healthcare industry has been slow to embrace e-business solutions and other advanced information technologies, as presented in Table 1.

The same study revealed that the healthcare industry spends substantially more on overhead and computer facility maintenance than other industry sectors. In 1997, for instance, the healthcare industry allotted 12% of its budget to maintain existing infrastructure—6% more than the industry norm. The high level of investment in this area by healthcare organizations indicates that many providers operate with the aid of old systems, which require constant repair and maintenance.

At this stage, it is worth emphasizing that the healthcare context differs from other information systems application domains in that it often concerns sensitive and confidential information and leads to critical decisions on people's lives (or quality of life). Thus, stakeholder conflicts have more of an impact than in other areas such as business, trade, and manufacturing. Healthcare is an area with quite intense differences of values, interests, professional backgrounds, and priorities among key stakeholders. Given the complex-

Table 1. Percentage of IT implementation in industry (Computer Economics, 1999)

Industry Sector	% in Place
Transportation	57.2
Banking and Finance	52.9
Insurance	48.1
State & Local Government	37.5
Trade Services	36.8
Retail Distribution	35.5
Process Manufacturing	34.9
Discrete Manufacturing	33.3
Wholesale Distribution	33.3
Utilities	26.9
Federal Government	25.0
Healthcare	21.8
Professional Services	21.7

ity of the context, health informatics in general cannot simply focus on technical or information systems aspects alone. It has to take account of their relationship with clinical and managerial processes and practices, as well as deal with multiple stakeholders and organizational cultures and accompanying politics.

Concluding, it should be stressed that healthcare is not only a significant industry in any economy (Folland, Goodman, & Stano, 1997), but also a field that needs effective means to manage data as well as information and knowledge. Managed care has emerged as an attempt to stem the escalating costs of healthcare (Wickramasinghe & Ginzberg, 2001) and improve the quality of services.

THE BACKGROUND OF KM IN HEALTHCARE

An increasing concern with improving the quality of care in various components of the healthcare system has led to the adoption of quality improvement approaches originally developed for industry. These include Total Quality Management (Deming, 1986), an approach that employs process control measures to ensure attainment of defined quality standards, and Continuous Quality Improvement (Juran, 1988), a strategy to engage all personnel in an organization in continuously improving quality of products and services. Nowadays, the importance of knowledge management is growing in the information society, and medical domains are not an exception. In Yu-N and Abidi (1999), managing knowledge in the healthcare environment is considered to be very important due to the characteristics of healthcare environments and the KM properties. We should always keep in mind that medical knowledge is complex and doubles in amount every 20 years (Wyatt, 2001).

The healthcare industry is nowadays trying to become a knowledge-based community that is connected to hospitals, clinics, pharmacies, physicians, and customers for sharing knowledge, reducing administrative costs, and improving the quality of care (Antrobus, 1997; Booth, 2001). The success of healthcare depends critically on the collection, analysis, and exchange of clinical, billing, and utilization information or knowledge within and across the organizational boundaries (Bose, 2003).

It is only recently that initiatives to apply KM to the healthcare industry have been undertaken by researchers. Firstly, in the second half of the 1980s, several authors tried to apply artificial intelligence (AI)—with doubtful success—to medicine (Clancey & Shortliffe, 1984; Frenster, 1989; Coiera, Baud, Console, & Cruz, 1994; Coiera, 1996). MYCIN is probably the most widely known of all medical (and not only) expert systems thus far developed (Shortliffe, 1976). And this is despite the fact that it has never been put into actual practice. It was developed at Stanford University solely as a research effort to provide assistance to physicians in the diagnosis and treatment of meningitis and bacteremia infections. PUFF, DXplain, QMR, and Apache III are also some of the most well-known medical expert systems that were developed and put into use (Metaxiotis, Samouilidis, & Psarras, 2000).

De Burca (2000) outlined the conditions necessary to transform a healthcare organization into a learning organization. Fennessy (2001) discussed how knowledge management problems arising in evidence-based practice can be explored using "soft systems methodology" and action research. Pedersen and Larsen (2001) presented a distributed health knowledge management (DKM) model that structures decision support systems (DSSs) based on product state models (PSMs) among a number of interdependent organizational units. The recurrent information for the DSS comes from a network-wide support for PSMs of the participating organizations.

Ryu, Hee Hp, and Han (2003) dealt with the knowledge sharing behavior of physicians in hospitals; their study investigated the factors affecting physicians' knowledge sharing behavior within a hospital department by employing existing theories, such as the Theory of Reasoned Action and the Theory of Planned Behavior. Torralba-Rodriguez and colleagues (2003) presented an ontological framework for representing and exploiting medical knowledge; they described

Table 2. Important Web sites dedicated to KM in healthcare

Web Site	Description
www.nelh.nhs.uk/knowledge_management.asp	The National Electronic Library for Health has a link dedicated to knowledge management. It describes how to manage explicit knowledge and outlines revolutions in KM in healthcare.
www.who.int	The World Health Organization has launched the Health Academy, which aims to demystify medical and public health practices, and to make the knowledge of health specialists available to all citizens through Web-based technology. The academy will provide the general public with the health information and knowledge required for preventing diseases and following healthier lifestyles.
www.cochrane.org	The Cochrane Collaboration is an international non-profit and independent organization, dedicated to making up-to-date, accurate information about the effects of healthcare readily available worldwide. The major product of the collaboration is the Cochrane Database of Systematic Reviews, which is published quarterly.
www.AfriAfya.org	AfriAfya, African Network for Health Knowledge Management and Communication, is a consortium formed by well-known agencies such as Aga Khan Health Service in Kenya, CARE International, SatelLife HealthNet, PLAN International, and the Ministry of Health in Kenya to harness the power of information and communication technology for community health.
http://www.hc-sc.gc.ca/iacb-dgiac/km-gs/english/kmhome.htm	The goal of knowledge management at Health Canada is to use the knowledge that resides in the department□in the minds of its staff, in the relationships they have with other organizations, and in their repositories of information□to fulfill their mission: to help the people of Canada maintain and improve their health.
http://www.ucl.ac.uk/kmc/index.html	The Knowledge Management Centre is part of the School of Public Policy of University College London (UCL). The Knowledge Management Centre's aim is to improve clinical practice, patient outcomes, and health service innovation and efficiency by promoting better health knowledge management by serving as a resource center and making efficient use of its resources internally and across a network of collaborators.

an approach aimed at building a system able to help medical doctors to follow the evolution of their patients, by integrating the knowledge offered by physicians and the knowledge collected from intelligent alarm systems. Also, Chae, Kim, Tark, Park, and Ho (2003) presented an analysis of healthcare quality indicators using data mining for developing quality improvement strategies.

Reviewing the literature, it is concluded that a KM-based healthcare management system should have the following objectives (Shortliffe, 2000; Booth & Walton, 2000):

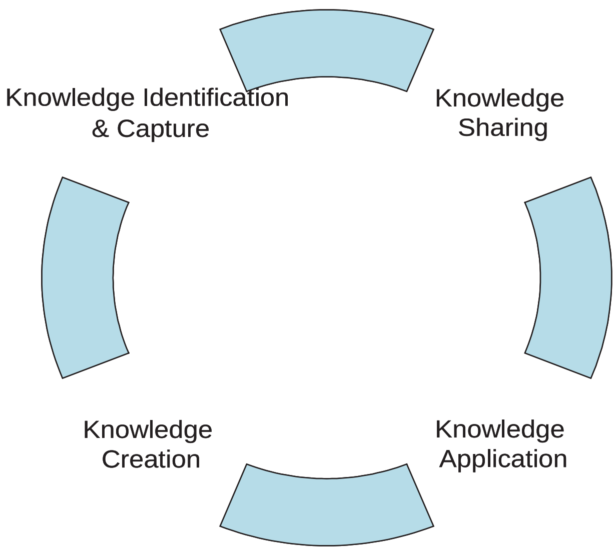
- To improve access to information and knowledge at all levels (physicians, hospital administrators and staff, consumers of health services, pharmacies, and health insurance companies) so that efficiencies and cost reductions are realized.
- To transform the diverse members (care recipients, physicians, nurses, therapists, pharmacists, suppliers, etc.) of the healthcare sector into a knowledge network/community of practice.
- To enable evidence-based decision making to improve quality of healthcare.

Table 2 presents important Web sites dedicated to the promotion and application of KM to healthcare.

THE KNOWLEDGE MANAGEMENT PROCESS IN HEALTHCARE

In order to examine whether knowledge management can really succeed in healthcare, we can analyze this proposition in terms of examining the knowledge management process and the likelihood of success for the healthcare organizations in achieving these steps in the process. The KM process consists of four key stages, as shown in Figure 1 (Schwartz, Divitini, & Brasethvik, 2000).

Figure 1. The knowledge management process cycle



Knowledge identification and capture refer to identifying the critical competencies, types of knowledge, and the right individuals who have the necessary expertise that should be captured. Then, this captured knowledge is shared between individuals, departments, and the like. The knowledge application stage involves applying knowledge—which includes retrieving and using knowledge—in support of decisions, actions, and problem solving, and which ultimately can create new knowledge. As new knowledge is created, it needs to be captured, shared, and applied, and the cycle continues.

Knowledge Identification and Capture in Healthcare

One way to identify the critical knowledge that should be captured and determine the experts in the healthcare organization who have the knowledge on a specific issue (e.g., disease, therapy) is to conduct a knowledge audit. The knowledge audit helps to identify the types of knowledge needed and the appropriate sources (e.g., patient records, medical research literature, medical procedures, drug references) in order to develop a knowledge management strategy for the organization.

On the other hand, the use of intranets is suggested as basic tools for the capture of implicit knowledge. St Helens & Knowsley Health Informatics Service—which covers 320,000 patients—designed and developed an intranet structure with the aim to generate the potential to capture organizational implicit knowledge (Mimnagh, 2002). The real challenge has been to create a health- community- wide intranet that implements directory services, communities of practice, and lessons learnedt in a way which builds on existing activity and looks for the synergistic effect of adding a KM focus to ongoing work.

Vast amounts of medical knowledge reside within text documents, so that the automatic extraction of such knowledge would certainly be beneficial for clinical activities. Valencia-Garcia and colleagues et al. (2004) presented a user-centered approach for the incremental extraction of knowledge from text, which is based on both knowledge technologies and natural language processing techniques. The system was successfully used to extract clinical knowledge from texts related to oncology and capture it.

Concluding, a key question is whether people would be willing to give up their competitive edge to have their knowledge captured via online repositories, lessons learned, best practices, and the like. This possible dilemma is especially valid in the healthcare sector.

Knowledge Sharing in Healthcare

Productive organizations have the ability to create an environment where specialized knowledge, skills, and abilities of all employees are leveraged to achieve advancements in service industry. However, healthcare organizations cannot be considered as a good example of such organizations. A healthcare organization is a collection of professional specialists who contribute to the delivery of patient care, but also often act competitively inside the organization, without being willing to transfer knowledge because of associated status and power within the organization and the society.

Taking also into account that people in general are not likely to share their knowledge unless they think it is valuable and important, it becomes clear why doctors and physicians are not willing to share and transfer their knowledge. In addition, due to minimal interdisciplinary training, the transfer of tacit knowledge which occurs through apprenticeship style work patterns—for example, internships where junior doctors work alongside a senior clinician in surgery or intensive care—remains problematic (Beveren, 2003).

Effective knowledge management requires a “knowledge sharing” culture to be successful. Especially in healthcare, it is crucial that doctors and physicians understand the benefits of knowledge sharing on a number of levels: benefits to the organization, benefits to patients, and benefits to them personally. The more you can clearly demonstrate these benefits, the more people are likely to be open to change. Doctors and physicians need to be recognized and rewarded in a formal way (e.g., promotions, cash awards) to make knowledge sharing a reality in healthcare.

The Wisecare (Workflow Information Systems for European Nursing Care) project—an EC-funded initiative (1997-1999)—has promoted knowledge sharing using the Internet and online communities. Wisecare provided nurses with a vast amount of information and knowledge about clinical practice through both the Wisecare Web site and data collection tool. This information has been specifically selected to meet their clinical needs and meant nurses had access to relevant knowledge extremely quickly.

Lesson learned systems can also be an effective knowledge sharing approach to be used in healthcare (Yassin & Antia, 2003).

Knowledge Application in Healthcare

Knowledge application refers to taking the shared knowledge and internalizing it within one's perspective and worldviews. For the healthcare organizations the reality is that technology can only fulfill some of their needs. And how well it fulfills them depends critically on managing the knowledge behind them—content management, assigning knowledge roles, and so forth. Tom Davenport (2002), a prominent author on knowledge management, is often quoted as offering the following rule of thumb: your investment in technology in terms of both cost and effort should stay under one-third of the total knowledge management effort—otherwise you are going wrong somewhere.

Knowledge-enabling technologies which can effectively be applied to healthcare organizations are:

- Groupware
- Intranet
- Collaborative tools (e.g., discussion boards, videoconferencing)
- Portals
- Taxonomies

Abidi (2001) presented the Healthcare Enterprise Memory (HEM) with the functionality to acquire, share, and operationalize the various modalities of healthcare knowledge. Davenport (2002) outlined how Partners Health Care System in Boston implemented an enormously successful expert-intervention KM solution. Case studies from the UK's National Health Service (NHS) and the Department of Health illustrated the drive towards modernization and more effective collaborative working among public-sector healthcare systems (Ark Group, 2002).

Knowledge Creation in Healthcare

In general, knowledge creation may take the form of new products or services, increased innovation, and improved customer relationships. In the healthcare setting, knowledge creation can take place in terms of improved organizational processes and systems in hospitals, advances in medical methods and therapies, better patient relationship management practices, and improved ways of working within the healthcare organization. Given the various constraints and barriers occur in the healthcare sector, it takes longer for a new idea to be implemented in the healthcare setting versus that in the business sector.

A few examples of knowledge creation technologies that can be used in healthcare are:

- Data Mining: Tools that analyze data in very large databases, and look for trends and patterns that can be used to improve organizational processes.
- Information Visualization: Computer-supported interactive visual representations of

abstract data to help improve understanding.

CONCLUSION

Knowledge is a critical tool for health, and knowledge management is the capacity to translate research results (knowledge) into policies and practices that can improve the quality of life and lengthen survival. Managing knowledge in a healthcare organization is like trying to knit with thousands of strands of knotted wool; data is held in a number of locations, managed by a variety of people, and stored in every imaginable format. Perhaps in no other sector does knowledge management have such a high promise.

Delivering healthcare to patients is a very complex endeavor that is highly dependent on information. Healthcare organizations rely on information about the science of care, individual patients, care provided, results of care, as well as its performance to provide, coordinate, and integrate services. The traditional single physician-patient relationship is increasingly being replaced by one in which the patient is managed by a team of health care professionals each specializing in one aspect of care. Hence, the ability to access and use the electronic healthcare record (EHCR) of the patient is fundamental. In addition, the transformation of healthcare data into a strategic decision-support resource is fundamental too.

KM can be approached in numerous ways to serve particular needs and conditions. Successful KM practices typically need to be supported by complementary efforts in different domains. IT-related support activities and infrastructures are very important. They serve vital functions, are complex, costly, and often take time to design and implement. In the case of healthcare, building the infrastructure for a KM practice requires extensive effort due to the peculiarities of the health sector (e.g., legal and ethical issues, complex procedures for provision of healthcare, doctors' behavior, etc.).

Coming back to the original question—How can we make knowledge management work in healthcare?—and by examining the knowledge management process, we can see that there are positive and negative points as to whether KM will truly work in the healthcare sector. Some people in healthcare think that KM is a passing fad like Total Quality Management, Business Process Reengineering, and other administration-backed initiatives. It is unfortunate to think in this light, as knowledge sharing should be encouraged so that lessons can be learned. KM solutions can facilitate the transfer of patient medical information, access to new treatment protocols as they emerge, knowledge exchange among experts, and so on.

Future research needs to be devoted to measuring the success of KM in healthcare organizations, showing quantitative benefits, and producing a "Return on Investment" index. Measurement is the least-developed aspect of KM because of the inherent difficulty to measure something that cannot be seen, such as knowledge (Bose, 2004). However, this is a very crucial issue since the future usage of KM is heavily dependent on both the quality of the metrics and whether output generated by this metric management would provide tangible value addition to the healthcare organizations. Integration of KM with e-health is also another direction for further research.

REFERENCES

Antrobus, S. (1997). Developing the nurse as a knowledge worker in health—learning the artistry of practice. *Journal of Advanced Nursing, 25*(4), 823-829.

Ark Group. (2002). Inside knowledge. *Knowledge Management, 6*(4).

Beveren, J. (2003). Does health care for knowledge management? *Journal of Knowledge Management, 7*(1), 90-95.

Booth, A. (2001). Managing knowledge for clinical excellence: Ten building blocks. *Journal of Clinical Excellence, 3*(4), 25-32.

Booth, A., & Walton, G. (2000). *Managing knowledge in health services.* Library Association Publishing.

Bose, R. (2003). Knowledge management-enabled healthcare management systems: capabilities, infrastructure and decision support. *Expert Systems with Applications, 24*, 59-71.

Bose, R. (2004). Knowledge management metrics. *Industrial Management & Data Systems, 104*(6), 457-468.

Brailer, D. (1999). Management of knowledge in the modern health care delivery system. *Joint Commission Journal on Quality Improvement, 25*(1), 1-7.

Chae, Y., Kim, H., Tark, K., Park, H., & Ho, S. (2003). Analysis of healthcare quality indicators using data mining and decision support systems. *Expert Systems with Applications, 24*, 167-172.

Clancey, B.C., & Shortliffe, E.H. (1984). *Medical artificial intelligence: The first decade.* Boston: Addison-Wesley.

Coiera, E. (1996). Artificial intelligence in medicine: The challenges ahead. *Journal of the American Medical Association, 6*, 363-366.

Coiera, E., Baud, R., Console, L., & Cruz, J. (1994). *The role of knowledge based systems in clinical practice.* Holland: IOS Press.

Davenport, T. (2002). Making knowledge work productive and effective. *Knowledge Management, 6*(1).

Davenport, T., & Beck, J. (2002). The strategy and structure of firms in the attention economy. *Ivey Business Journal, 66*(4), 48-54.

De Burca, S. (2000). The learning healthcare organization. *International Journal for Quality in Healthcare, 12*(6), 456-458.

Deming, W. (1986). *Out of the crisis.* Cambridge, MA: MIT Press.

Fennessy, G. (2001). Knowledge management in evidence based healthcare: Issues raised when specialist information services searched for the evidence. *Health Informatics Journal, 7*(1), 1-5.

Folland, S., Goodman, A., & Stano, M. (1997). *The economics of health and health care.* Englewood Cliffs, NJ: Prentice-Hall.

Frenster, J. (1989). *Expert systems and open systems in medical artificial intelligence.* Physicians' Educational Series.

Heathfield, H., & Louw, G. (1999). New challenges for clinical informatics: Knowledge management tools. *Health Informatics Journal, 5*(2), 67-73.

Juran, J. (1988). *Juran's quality control handbook* (4th ed.). New York: McGraw-Hill.

Metaxiotis, K., Samouilidis, J.-E., & Psarras, J. (2000). Expert systems in medicine: Academic illusion or real power? *Journal of Informatics in Primary Care,* (February), 3-8.

Mimnagh, C. (2002). Towards capturing implicit knowledge: A practical application of intranet development. *Proceedings of the Conference in Advances in Clinical Knowledge Management 5,* London.

Pedersen, M., & Larsen, M. (2001). Distributed knowledge management based on product state models—the case of decision support in healthcare administration. *Decision Support Systems, 31,* 139-158.

Ryu, S., Hee Hp, S., & Han, I. (2003). Knowledge sharing behavior of physicians in hospitals. *Expert Systems with Applications, 25*, 113-122.

Schwartz, D., Divitini, M., & Brasethvik, T. (2000). Knowledge management in the Internet age. In D. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based knowledge management and organizational memory* (pp. 1-23). Hershey, PA: Idea Group Publishing.

Shortliffe, E. (2000). *Medical informatics*. New York: Springer-Verlag.

Shortliffe, E.H. (1976). *Computer-based medical consultations: MYCIN*. Elsevier.

Torralba-Rodriguez, F., Fernandez-Breis, J., Garcia, R., Ruiz-Sanchez, J., Martinez-Bejar, R., & Gomez-Rubi, J. (2003). An ontological framework for representing and exploiting medical knowledge. *Expert Systems with Applications, 25*, 211-230.

Valencia-Garcia, R., Ruiz-Sanchez, J., Vivancos-Vicente, P., Fernandez-Breis, J., & Martinez-Bejar, R. (2004). An incremental approach for discovering medical knowledge from texts. *Expert Systems with Applications, 26*(3), 291-299.

Wickramasinghe, N., & Ginzberg, M. (2001). Integrating knowledge workers and the organization: The role of IT. *International Journal of Healthcare Quality Assurance, 14*(6), 245-253.

Wyatt, J. (2001). *Clinical knowledge and practice in the information age: A handbook for health professionals.* Royal Society of Medicine Press.

Yassin, K., & Antia, B. (2003). Quality assurance of the knowledge exchange process: A factor in the success of child health programs in developing countries. *International Journal of Health Care Quality Assurance, 16*(1), 9-20.

Yu-N, C., & Abidi, S. (1999). Evaluating the efficacy of knowledge management towards healthcare enterprise modeling. *Proceedings of the International Joint Conference on Artificial Intelligence.*

ENDNOTE

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Chapter 4.45
How to Handle Knowledge Management in Healthcare:
A Description of a Model to Deal with the Current and Ideal Situation

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ABSTRACT

There are many arguments why healthcare organizations need knowledge management. In The Netherlands, there are some things going on, like a new defrayment and remuneration system for the hospitals, the increasing aging population, the focus on quality, efficiency and effectiveness and the existence of more, very specialized disciplines, that there is a need for knowledge management. This chapter describes a model that can be used to chart the current situation regarding knowledge management. The model is based upon the primary and supported processes, a division in types of knowledge and a knowledge cycle. The use of the model is demonstrated by a case description. Conclusions which are drawn from the recap of the case description showing that the model can be useful but some things must be taking into account, such as the size of a case and its boundaries.

INTRODUCTION

There are many arguments why healthcare organizations (HCO's) need knowledge management. The argument for HCO's to develop knowledge management lies in:

- the hospital, or any other HCO, is a knowledge intensive organization;

- there is a big demand for optimizing the support and primary processes;
- the demand for efficiency and effectiveness due to shortages on the job market;
- the requirement of the patient for better quality care and related provision of information;
- the introduction of Diagnosis Treatment Combinations (DTCs) in The Netherlands which makes the learning capacity and competitiveness of the hospital an important factor.

HCO's make use of multiple knowledge areas, such as those of medicine and policy making (Lucardie, Ribbens & Singeling, 1998). These multiple knowledge areas and the existence alongside one another of a large number of interdependent disciplines each with their own professional autonomy makes a healthcare organization a knowledge intensive organization. Furthermore, there is a tendency toward more superspecialism. Especially medical doctors specialize towards small but very specialized areas, and as a result they have very unique knowledge. And this very unique knowledge has to be secured, disseminated and utilized.

In The Netherlands, through an increasingly aging population, the demand for care grows. At the moment the care sector has to cope with a shortage of staff. Improving the present capacity is mainly an issue of the last couple of years. Particularly due to the existence alongside one another of interdependent disciplines, the shortage in one professional group can also be felt directly by other professional groups. The shortage of (good) personnel is a challenge to knowledge management. The available knowledge must be secured and disseminated.

In The Netherlands the focus has in particular been on improving the quality, efficiency and effectiveness of care. Certainly in the last decade the Dutch government has paid a lot of attention to quality in the care sector. In particular, it has attempted to ensure the quality of care through legislation (Van Dijen, 1999). Much of this legislation relates to quality control and improving the position of the client/patient. With respect to the latter position, the Dutch Consumer Association (Consumentenbond) carried out a large-scale survey in 2002 into the quality of hospital care based expressly on patient opinion (Consumer Association, 2002). The conclusions and recommendations of the Consumer Association report offer starting points for using knowledge management in (hospital) care. In particular the provision of information for the patient about the period after discharge, or after care, is often found to fall short. Improvements can also be made in the information transfer between the various professional groups.

The introduction of a new defrayment and remuneration system in the Dutch hospitals stresses the need to develop, disseminate and utilize knowledge. After all, due to the introduction of market forces into the Dutch healthcare system an institution is more dependent on its own knowledge and skills to stay a step ahead of (or at least level with) the competition. The current system is a system of job-based budgeting of hospitals and the lump sum funding of medical specialists. This system will be replaced by a new defrayment and remuneration system for hospitals and medical specialists. It is a system based on the Diagnosis and Treatment Combinations (DTCs).

Added Value of KM

When using knowledge management a number of objectives can be pursued (Konter, 2002). In our view the most important objectives that also show the added value of knowledge management are:

1. to make (better) informed decisions
2. uniform action through the entire organization
3. learning organization which continually improves one and two above

4. as a result achievement of:
   (a) common vision of policy and objectives
   (b) quality improvement
   (c) efficiency increase
   (d) cost saving
   (e) greater competitiveness
5. patient empowerment

Everyone makes decisions, from medical specialist to staff manager. By becoming aware of the available knowledge (knowledge management), one is in a better position to make informed decisions. This can involve using decision support systems as well as many other types of solution (see section "Knowledge Activities"). By making informed decisions, one can also increase the quality of patient care (Friedman, Gatti, Elstein, Franz, Murphy & Wolf, 2001).

It can bring an efficiency increase when everyone in the organization acts uniformly, i.e., everyone has access to protocols, guidelines and procedures and also follows them. Uniform action also implies a shared view of the organizations policy and objectives.

If protocols, guidelines and procedures have been drawn up in accordance with the latest (medical) state of the art, this leads to an improvement in patient care. In various publications (Everdingen, 1993; O. Y., 1999) it has been demonstrated that using protocols, guidelines and procedures reduces the inter- and intra-care provider variance and the number of errors in care provision.

When staff is given the opportunity to follow a continuous learning process, the organization as a whole has a greater learning capacity and competitiveness. The introduction of a new defrayment and remuneration system in the Dutch hospitals stresses the need to develop, disseminate and utilize knowledge. The success of a self-learning organization depends very much on the culture and behavior of the staff. Change management will therefore be an important aspect in the implementation and the continuous process of knowledge management (see also "Knowledge Activities").

Another important aspect of the learning capacity of an organization concerns the ability to learn from one another's mistakes. Good incident and accident records are important here, as well as a culture in which incidents and accidents are actually reported (van Everdingen, 1993). The number of reports says something about the quality of the prevention policy. However paradoxical that sounds, the more reports, the better the quality.

By sharing knowledge about diseases with (future) patients, for example through certified websites and databanks, a degree of self-care is encouraged. This means that with good patient information one can achieve a lower care consumption, but also when a patient reaches the consulting room, he is better informed and can ask more specific questions.

It can be argued that knowledge management, in addition to making informed decisions, will result in an improvement due to a uniform procedure, an increased learning capacity, a reduction in costs due to greater efficiency and improved communication with the patient, as well as an improvement in the overall quality of the care provided. The various objectives are interrelated and interdependent. Quality standards can, for example, be built into the decision support systems, enabling the system to take quality standards into account when giving advice to the user. The system can also take into account legislation and regulations, which contributes to an improved quality. By acting uniformly in accordance with prescribed procedures, the quality is also improved. Another point that improves quality is that everyone can have the information they want and so can make informed decisions.

KM and Quality Improvement Projects

Describing the added value of KM, we have described the ideal situation. Many HCOs do one of the mentioned activities and call it a quality improvement project. KM and quality management often have the same purpose, namely to improve the processes and outcome involved. However, the added value of active knowledge management is to see all these activities/processes in cohesion with each other while quality management tends to look at individual processes/activities.

An ideal situation can only be approached by getting insight in the current situation. To do this, we have described below a model with which the current situation can be mapped and the (knowledge management) activities are presented in cohesion with each other.

METHODS

Before we deal with the model, first we make clear our way of thinking about knowledge management. We feel obliged to do this for a better understanding of the structure and way of reasoning used in the model.

Definition of Knowledge Management

When talking about knowledge management, many aspects are covered. Still, well-functioning knowledge organizations can be characterized by:

- the coherent promotion of common knowledge;
- the screening/filtering of only the knowledge that is necessary (less is more);
- the stretching of knowledge, communication and capturing.

With knowledge management it is like looking through a magnifying glass at information management. For example, a structured look is taken of how the current and ideal provision of information, for example of the professional groups and patients, is organized.

We define knowledge management as the management of the knowledge cycle. The knowledge cycle consists of developing, disseminating and utilizing knowledge (Oldenkamp, 2001, 2002; Brailer, 1999). Development consists of both the gathering and creating of knowledge. Disseminate means structuring, making explicit, distributing and explaining. Utilize refers to finding and (re-)deploying knowledge.

Several other authors have introduced similar cycles or "knowledge value chains" (Van der Spek & Spijkervet, 1996; Weggeman, 1997). We have opted for the definition as described above because of its simplicity and because in our view the cycle and its management includes all aspects referred to by the other authors. On the basis of the "develop, disseminate and utilize" knowledge cycle, the section titled "Case" discusses this.

Knowledge

Knowledge management, as we have said, is the management of a cyclical process centered on knowledge. But what do we understand by knowledge? It can be defined as the capacity to act competently. In acting, we necessarily make use of information. Further information puts us in a position to act more competently (Oldenkamp, 2001)

We can distinguish different kinds of knowledge. A common, and much used, division is one into procedural, declarative, social and contextual knowledge (Oldenkamp, 2001; Boers & Kruithof, 1998; Boersma & Stegwee, 1996). We find the following terminology more suitable:

- know what (declarative) – factual knowledge. This knowledge often forms the basis for the "know how" type of knowledge;
- know how (procedural) – knowledge of procedures. To deal with routine matters,

established procedures are often available, which capture factual and background knowledge;
- know who (social) – who knows what or meta-knowledge. You do not have a monopoly on wisdom, so you need to call upon others with the specific knowledge you need;
- know why (contextual) – background knowledge. This knowledge is required when new procedural knowledge is drawn up and when lines of reasoning have to be explained.

The "know what" and "know how" types of knowledge are also seen as the two most important types of knowledge for management and control of the organization (Boersma & Stegwee, 1996).

We have chosen the above division because in our opinion it fits in with the terminology and the experience of the professional groups in the healthcare sector. For example, doctors and nurses use mainly factual knowledge, but also use background knowledge and experience. By calling in colleagues, they are calling upon who-knows-what knowledge or meta-knowledge and everyone in his or her work comes up against certain guidelines, procedures, etc. The medical specialist follows a particular procedure for an operation, the nurses follow procedure when dressing wounds and a receptionist follows procedure when identifying the patient.

The use of a division into types of knowledge has often been found useful in structuring the knowledge present (Oldenkamp, 2001).

A Model for the Care Sector

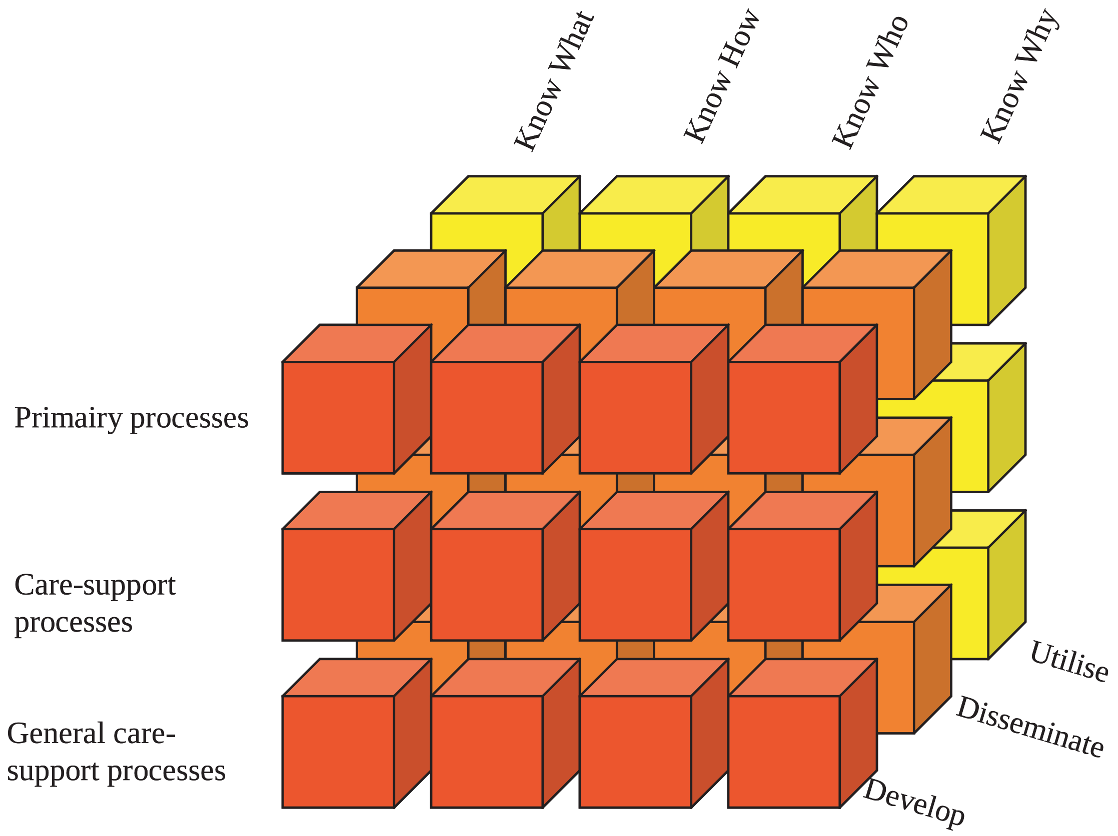
In the care sector a distinction is often made between primary and support processes. The primary processes are geared to (para)medical and nursing care. Support processes are geared to the direct support of the primary processes and the deployment of people and resources.

Table 1 sets out the processes in more detail. The support processes are broken down into care-support and general support processes. The aim is not for completeness here as different care institutions can have slightly different classifica-

Table 1. Breakdown of processes

Main groups	Sub-groups
Primary processes	1. Central registration 2. Outpatient consultation 3. Patient admission 4. Nursing and care 5. Outpatient treatment 6. Clinical treatment
Care-support processes	1. Medication 2. Diagnostic procedures[1] 3. Other care support
General support processes	1. Staff provision 2. Finance 3. Provision of information 4. Management 5. Facilities 6. Education

Figure 1. Model for the care sector



tions or names for the processes. The main lines do, however, correspond.

In combination with the knowledge cycle and the breakdown into types of knowledge, a framework is drawn up. For each process, for each type of knowledge and for each phase of the knowledge cycle, it is indicated which activities are being used in the current situation. Figure 1 shows the model. It shows the ideal situation because all parts are being filled.

The model can be filled in with even more detail, depending on the organization's requirement. The setup of the model is three-dimensional so that it can be looked at from three points of view of the knowledge processes. For example, what kind of process is used knowledge being used in, what sort of knowledge are we talking about and which phase of the knowledge cycle is the knowledge pointing at. In this manner a three-dimensional reproduction of the current situation can be acquired. In "Cases" we make clear how we can do this.

Knowledge Activities

In this section, brief examples of possible activities for applying knowledge management in an organization are given. These examples will be outlined to make clear what kind of activities are ranged under knowledge management. The framework of "A Model for the Care Sector" can be filled in with these activities, allowing one to see at a stroke where the activities are concentrated and to see them in cohesion with each other.

Per phase of the knowledge cycle, a few activities are listed, accompanied by a brief description. For each activity, the type of knowledge is indicated in brackets.

Develop

Developing knowledge involves gathering or creating knowledge. An example of gathering knowledge is recruiting new staff.2 New staff often have an unprejudiced view of existing — and often habitual — procedures and as a result they bring a measure of renewal, in addition to the knowledge and skill in a particular specialist area that they have made their own (know what, know why).

The buying of books3 can also be seen as gathering knowledge. For example, the (medical) library purchases specialist literature or the organization buys handbooks for interns/trainee specialist registrars and specialists to support them in their work (know what, know why).

By giving staff the opportunity to subscribe to specialist journals or other media — and to have these costs reimbursed — the development of knowledge is stimulated (know what, know why).

The development (or the creation) of knowledge is also carried out, for example, by continuing vocational training or via external training, courses, congresses or seminars. It is possible to work on knowledge development through continuing vocational training in the traditional lecturer-student form, as well as via online-training courses.4 Online-training courses have the advantage that they can be followed independently of time and place (know what, know why).

Registration systems are a separate example. Filling the registration systems with data so that the data can be subsequently analyzed, can be seen as the development of knowledge. Only when this is done, can we talk of disseminating and then utilizing the knowledge stored in the record systems.

Disseminate

Thanks to the facilities that ICT offers, copying and distributing knowledge takes hardly any time at all. However, the possible (ICT) solutions are very diverse. A well-known example is the knowledge bank, of which a protocol system5 is an example. This is the type of knowledge bank that is often found nowadays in hospitals. More and more hospitals also make their guidelines for treatment available for patients, though in understandable language6 (know how, know what, know why). This knowledge is made available through information pillars in the hospital or via websites containing a variety of information on treatment. Hospitals themselves also often refer to reliable sources on the Internet (know how, know what, know why).

In discussing the development phase, the registration system was already mentioned as a system for developing knowledge in the first instance. A specific example is a system for registering incidents and accidents. Making these records as complete and accurate as possible gives the organization an opportunity to learn from mistakes and so to increase the knowledge in certain areas as a result of which a quality jump and efficiency gain is achieved.7 Another example of a registration system for learning from mistakes is a system faults.

For disseminating knowledge, patient discussions or clinical lessons are an excellent form. By organizing regular meetings on certain clinical pictures or unique patients, knowledge can be disseminated (know what, know why).

Marketplaces, communities, discussion groups and forums are places, often on the Internet, where staff can exchange knowledge with one another (know what, know why). This is certainly not necessarily an internal or institutional matter, as they are more often aimed at groups such as heart patients or users of a particular software package. These places can moreover be regarded as a system for knowledge development.

Utilize

The investment of time, money and energy in the previous two phases is paid back in the last phase, i.e., knowledge utilization. By better utilizing the available knowledge, comparable work can be carried out (qualitatively) better, faster or perhaps cheaper. However, the success of this phase largely depends on the behavior of the staff and the culture of sharing knowledge. Does the staff think that they can learn something from others and do they also want to? This does of course happen in the first two phases of the knowledge cycle, for before the knowledge can be utilized, it is first necessary to develop and disseminate it.

A decision support system (DSS) is a well-known example of knowledge utilization. With the help of decision support systems, informed decisions can be made. Decision support systems are mainly important where many variables have to be weighed up against one another to arrive at a decision.8 This mainly occurs in the diagnostic process of the specialist (know what).

Other examples of a decision support system are an physician order entry system (POES) for achieving better decisions and savings on medication.9 In particular, general practitioners in The Netherlands make increasing use of POESs that are often already incorporated in their GP information systems.

Another example of utilizing knowledge is making use of literature. The modern physician is expected to base his decisions on the best and most recent evidence from the medical science literature (Rijssenbeek, 2001; Offringa, 2001). However, as Offringa (2001) notes, 40,000 medical science journals are published annually with more than one million articles. This means for an internist that he would have to read between 17 and 22 articles per day to keep up with the publication rate. For a general practitioner, this number is even higher. Medical information is easily available without restriction via MEDLINE. The Cochrane Collaboration is an organization that has taken upon itself “preparing, maintaining and promoting the accessibility of systematic reviews of the effects of healthcare interventions” (www.cochrane.nl). There are Cochrane Centers all over the world. By using the Cochrane Library, a doctor is able to obtain up-to-date information on the state of research regarding the efficacy of medical treatment (know what, know why).

In guidelines for medical practice, knowledge is stored or obtained through vocational training or external training or literature. By using a guideline this particular knowledge is utilized (know how).

Setting up a competence matrix can also facilitate the utilization of knowledge. With the help of such a competence matrix (who-knows-what), one can search for specific knowledge that is already present with a colleague (know who).

CASE

In this section the model will be put into practice by a case description and recap. This case will show our three-dimensional approach of the model.

Description

Mrs. W. is send by the midwife to the gynecologist because of an incomplete breech presentation of her baby. Mrs. W. is in her 34th week of pregnancy. With the help of echography, the gynecologist looks at precisely how the baby is presenting and also carries out an external examination. He discusses with Mrs. W. and her partner exactly what is happening — the baby is lying with its buttocks in the birth canal and with its head and legs upward — and what the policy will be for the coming weeks. This is in accordance with the guidelines drawn up for this specific condition by the scientific association (www.nvog.nl). Mrs. W. must come back the following week. The gynecologist expects that the baby can still turn itself.

The next week, Mrs. W. and her husband come back to see the gynecologist. An extensive echograph is scheduled and in addition to checking the presentation, a number of length measurements are taken of the baby and the pelvic passage. A co-assistant will accompany them. He tells them that if pelvic narrowing is suspected, there is an increased risk of fetal mortality/morbidity in case of vaginal birth. However, there is no question of this. The baby is also of normal length. Mrs. W's abdomen does not, however, offer the baby much room. The gynecologist decides to wait another week so that the baby can still turn itself, but considers that chance small. He also wants to wait as long as possible for any external turning. This is a guideline the gynecologists have implemented in their practice. There is a significant chance when external turning will be done, the delivery of the baby can start. When this is happening, the baby has to be mature/developed enough.

In the 36th week of her pregnancy, Mrs. W. comes back again. Again the gynecologist looks with the help of echography at how the baby is lying. The baby is still lying in an incomplete breech presentation. The doctor discusses the options with the couple. He does not want to turn the baby externally because of the limited room in the abdomen, the placenta that is under the navel and Mrs. W's very contractile abdomen. The two options for the delivery, which cannot be left for long, are a breech delivery and a planned caesarean section. He refers the couple to the website of the scientific association for some background information in order to make their choice. In the waiting room is a big notice on the wall drawing attention to the website as being reliable information.

Once home, Mrs. W. and her husband study the information on the website and discuss the risks, advantages and disadvantages of one option or the other. They decide on a c-section.

When they notify the gynecologist of this decision, he agrees with their choice. He tells them that he recently took part in a clinical lesson of a nurse from the gynecology/obstetrics ward where the results of a randomized "multi-centre trial" have been presented in which for more than 2,000 women with a fetus in breech presentations and with a pregnancy term of 37 weeks, a policy aimed at a vaginal delivery was compared with one aimed at a planned c-section. Perinatal mortality, neonatal mortality and serious neonatal morbidity were significantly lower in the group with a policy aimed at a planned c-section. Between the two groups, there was no significant difference in maternal mortality and serious maternal morbidity in the short term (www.nvog.nl). The gynecologist did not tell the couple this at the previous meeting so as not to influence their choice. As they leave, he gives them a brochure containing information on the how and what for a c-section.

The c-section is planned for two weeks later, in the 39th week of the pregnancy. However, a week after her last appointment with the gynecologist, Mrs. W. starts spontaneous contractions and a healthy baby boy is born after a c-section, without complications for either mother or son.

Recap

The recap is divided into three parts according to the model described earlier. The case will be analyzed by looking at the processes in which it takes place, what kind of knowledge is being used and to which phase of the knowledge cycle the case refers.

The knowledge activities are taking place in the primary and care-support processes. The patient has an outpatient consultation several times (primary process), whereby diagnostic procedures (care-support process), e.g., an echograph, are carried out. It is possible to break down the primary and care-support process to be more detailed in what specific part of the process the case is taking place. For instance, the knowledge is being transferred from the gynecologist to the patient while performing the consultation. Writing it down in the patient record is disseminating the information. Performing the consultation and writing down the information (i.e., knowledge to decide what kind of guideline to use) are subprocesses of outpatient consultation.

We can also point out the diagnostic procedure, e.g., an echograph, at a sub-level, namely radio-diagnostics. We can even go one level deeper, for example, by performing an echograph. During performance, the gynecologist gives the co-assistant, who has to learn this profession, information about what he is doing and why: he disseminates his knowledge.

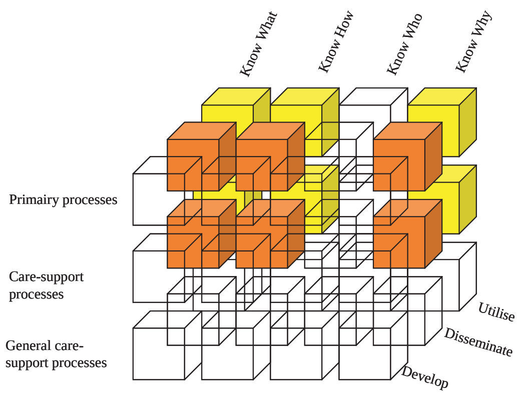
The case points itself especially at two phases (disseminate and utilize) of the knowledge cycle. The clinical lesson of the nurse, which the gynecologist took part in, and the website where the patient was referring to for reliable background information are knowledge activities which fall under the disseminating phase. The gynecologist, when explaining the "what" and "why" as he was doing an extensive echograph, disseminates his knowledge to the co-assistant. By using the guidelines for incomplete breech presentation and external turning, the gynecologist utilizes the knowledge, which is stored in these guidelines.

The case uses three kinds of knowledge: know what, know how and know why. The information on the web site contains factual and background knowledge. When the gynecologist quotes a remarkable survey, the patient and her husband are given more background knowledge. During his performance of the extensive echograph, he gives the co-assistant factual knowledge. The brochure contains know how, i.e., procedural knowledge.

Figure 2 shows the results of charting the case in the 3D model described where all the different activities are presented in cohesion with each other.

The case is an example of several objectives that can be pursued by using knowledge management, namely uniform treatment (all gynecologists follow the same guidelines), making informed decisions (clinical lesson and the choice the couple had to make) and patient empowerment (informing the patient by referring to a reliable web site and brochures).

Figure 2. Results of the case



CONCLUSIONS

In this chapter a model is presented that can be used to chart the current situation regarding knowledge management. A fully filled model represents the ideal situation, whereby all activities are in cohesion with each other. In the beginning of the chapter, we described the ideal situation. How the model can be used to chart the current situation is then described.

By applying the model to our case in section 3 the following conclusions can be drawn:

- The model appears to be suitable for positioning the case in terms of process types, cycle and types of knowledge involved. The question is, however, whether this picture is also obtained when a whole organization is examined. It is therefore recommended to use a more detailed breakdown of the primary and support processes so that more distinction is made within the processes;
- During the recap of the case, all the different activities were brought together in cohesion. This resulted in a useful overview, in addition to the separated descriptions of the activities one by one;
- Also, during the recap of the case, it was difficult to draw a boundary — what is the scope of a process and what is not. In practice this boundary will be difficult to indicate as a hospital is not independent and the processes extend outside the walls of the hospital. The process approach is a good starting point;
- The distinction between the types of processes gives a clear picture of where in the organization the knowledge processes are affected. The question is, however, whether the distinctions can be maintained in daily practice, as the processes tend to be so strongly intertwined. Take, for example, the diagnostic process which forms a considerable part of the out/in-patient treatment of the patient;
- To fill in the model, a person who knows much about knowledge management is needed.

When dealing with KM-projects, it is recommended to start with the processes where "quick wins" are to be expected. This will motivate the people involved to adapt to and work with the necessary change for a better KM process. It is expected that the outcome of active knowledge management, when the results become clearly noticeable, will have a positive effect on staff motivation and staff/patient satisfaction.

To conclude, knowledge management can certainly contribute to optimizing primary and support processes. The case in this chapter has shown that the objectives to be achieved with knowledge management are no utopian dream. By pursuing these objectives, one is not only working on the efficiency and learning capacity of the organization, but also on improving the quality of care which are, and should be, supplemental to each other.

REFERENCES

General

Consumentenbond [Consumer Association, Hospital Comparison Group]. (2002). Ziekenhuisvergelijkingssysteem.

Everdingen, J. J. E. van (red.). (1993). *Smetten op de witte jas* [Stains on the white coat].

Lagendijk, P. J. B, Schuring, R. W., & Spil, T. A. M. (2001). *Elektronisch Voorschrijf Systeem, van kwaal tot medicijn* [Electronic Prescription Service, from complaint to medicine].

Raad voor de Volksgezondheid en Zorg. (2002). E-health in zicht [National Health Care Council, E-health in sight].

Van Dijen, M.E.M. (1999, September). *Advies-groep Gezondheidszorg, Kwaliteitsmanage-ment, alternatieven voor de gezondheidszorg* [Health Care advisory group, Quality management, alternatives for health care], Ernst & Young Consulting.

General Knowledge Management

Boers, A., & Kruithof, E. (1998). *Procesbenadering* [Process approach], reeks IT Professional & Onderneming, Kluwer Bedrijfsinformatie.

Boersma, S. K. Th., & Stegwee, R. A. (1996). *Exploring the issues in knowledge management*. Information Resources Management Association International Conference.

Brailer, D. J. (1999, January). Management of knowledge in the modern health care delivery system. *Journal on Quality Improvement, 1*(25), 6-19.

Konter, M. D. (2002, September). *Kennismanagement bij ziekenhuizen (een onderzoek naar de behoefte aan en toegevoegde waarde van kennismanagement bij ziekenhuizen*) [Knowledge management in hospitals (a survey into the need for added value in knowledge management in hospitals)], afstudeerscriptie/master's thesis, University of Twente.

Lucardie, L., Ribbens, H., & Singeling, H. (1998). Transformatie van kennisintensieve naar kennisgebaseerde organisaties: het ziekenhuis als voorbeeld [Transformation from knowledge-intensive to knowledge-based organisations: The hospital as an example]. *Informatie & zorg: kwartaaluitgave VMBI,* 103-108.

Oldenkamp, J. H. (2001). *Succesvol overdragen van kennis* [Succesful knowledge transfer], Utrecht: Lemma.

Oldenkamp, J. H. (2002). *Professioneel leren* [Professional learning], Utrecht: Lemma.

O. Y. (1999, September). Kennismanagement in de zorg [knowledge management in health care], *Informatie & zorg: kwartaaluitgave VMBI, 3*, 97-102.

Rijssenbeek, A. (2001). *Kennismanagement in de zorg* [Knowledge management in the care sector]. MIC-congres 2001, Noordwijk.

Van der Spek, R., & Spijkervet, A. L. (1996). *Kennismanagement: intelligent omgaan met kennis* [Knowledge management handling knowledge intelligent]. Utrecht, Kenniscentrum CIBIT.

Weggema, M.C.D.P. (1997). *Kennismanagement: inrichting en besturing van kennisintensieve organisaties* [Knowledge management: set-up and control of knowledge-intensive organisations]. Schiedam: Scriptum.

Applications: Protocols and Guidelines

Richtlijn 07 Stuitligging, *Nederlandse Vereniging voor Obstetrie en Gynaecologie* [Guideline 07 Breach presentation, Dutch Association for Obstetrics and Gynaecology]. Retrieved December 30, 2002 from the World Wide Web: www.nvog.nl.

www.rdgg.nl (n.d.). Retrieved November 30, 2002.

Applications: Decision Support Systems

Friedman, C., Gatti, G., Elstein, A., Franz, T., Murphy, G. & Wolf, F. (2001). *Are clinicians* *correct when they believe they are correct? Implications for medical decision support.* Medinfo 2001, Amsterdam.

Offringa, M. (2001). *Workshop: Gebruik van snel toegankelijke, voorbewerkte informatie bij klinische beslissingen in het Evidence Based Medicine tijdperk* [Use of rapidly accessible, pre-processed information in clinical decisions in the Evidence Based Medicine age], MIC-congres 2001, Noordwijk.

www.cochrane.nl (n.d.). Retrieved November 10, 2002 from the World Wide Web.

ENDNOTES

1 Diagnostic procedures also include diagraphs and procedures in the clinical chemistry laboratory (clinical chemistry and hematology, parasitology and microbiology).

2 This can be done on an individual basis, but by mergers and take-overs new knowledge is also gathered in the form of new staff.

3 This does not necessarily immediately lead to the spreading and utilisation of knowledge. The acquired material must be brought to the attention of staff where there may be a potential need.

4 From the report "E-health in zicht" (E-health in sight) (Raad voor de Volksgezohdheid en Zorg, 2002) it appears that 84% of Dutch doctors would like to receive continuing vocational training via the Internet.

5 Guidelines are also often included in a protocol system.

6 A good example of this is the treatment of breast cancer in the Reinier de Graaf Groep (in Dutch) where various paths can be followed, depending on the treatment that is necessary for this diagnosis (www.rdgg.nl).

7 In The Netherlands the care institutions have MIP (Melding Incidenten Procedure - incident reporting procedure)-/FONA (Fouten, Ongevallen en Near Accidents — errors, accidents and near accidents) committees. Accidents and errors (for example, falls or medication errors) are reported via a form and dealt with by the committee or, in the most serious case, by the management. It does, however, appear that via the reporting committees an insufficient idea is obtained of the number and nature of the incidents. The number of reports does in fact say something about the quality of the prevention policy in institutions. It sounds paradoxical, but the more reports that are made, the better the quality (Everdingen, 1993). This does of course depend on the reporting culture in an institution.

8 Investigation shows that people can weigh up a maximum of seven related variables to come to the right conclusion. Often the assessment is influenced by things such as tiredness, mood, prejudice, etc. And knowledge and experience of other experts is not available.

9 According to a recent publication, the use of POESs is not what was expected (Lagendijk, Schuring & Spil, 2001). There is no appreciable saving among general practitioners because they already prescribe economically and sensibly and are not the greatest generators of medication costs. Being able to make better justified decisions for therapy is however considered an advantage.

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Chapter 4.46
Issues in Clinical Knowledge Management:
Revisiting Healthcare Management

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ABSTRACT

The objective of this chapter is to examine some of the key issues surrounding the incorporation of the Knowledge Management (KM) paradigm in healthcare. We discuss whether it would it be beneficial for healthcare organizations to adopt the KM paradigm so as to facilitate effective decision-making in the context of healthcare delivery. Alternative healthcare management concepts with respect to their ability in providing a solution to the above-mentioned issue are reviewed. This chapter concludes that the KM paradigm can transform the healthcare sector.

INTRODUCTION

In today's information age, data has become a major asset for healthcare institutions. Recent innovations in Information Technology (IT) have transformed the way that healthcare organizations function. Applications of concepts such as Data Warehousing and Data Mining have exponentially increased the amount of information to which a healthcare organization has access, thus creating the problem of "information explosion". This problem has been further accentuated by the advent of new disciplines such as Bioinformatics and Genetic Engineering, both of which hold very promising solutions which may significantly change the face of the entire healthcare process from diagnosis to delivery (Dwivedi, Bali, James, Naguib, & Johnston, 2002b).

Until the early 1980s, IT solutions for healthcare used to focus on such concepts as data warehousing. The emphasis was on storage of data in an electronic medium, the prime objective of which was to allow exploitation of this data at a later point in time. As such, most of the IT applications in healthcare were built to provide support for retrospective information retrieval needs and, in some cases, to analyze the decisions undertaken. This has changed healthcare institutions' perspectives towards the concept of utility of clinical data. Clinical data that was traditionally used in a supportive capacity for historical purposes has today become an opportunity that allows healthcare stakeholders to tackle problems before they arise.

Healthcare Management Concepts

Healthcare managers are being forced to examine costs associated with healthcare and are under increasing pressure to discover approaches that would help carry out activities better, faster and cheaper (Davis & Klein, 2000; Latamore, 1999). Workflow and associated Internet technologies are being seen as an instrument to cut administrative expenses. Specifically designed IT implementations such as workflow tools are being used to automate the electronic paper flow in a managed care operation, thereby cutting administrative expenses (Latamore, 1999).

One of the most challenging issues in healthcare relates to the transformation of raw clinical data into contextually relevant information. Advances in IT and telecommunications have made it possible for healthcare institutions to face the challenge of transforming large amounts of medical data into relevant clinical information (Dwivedi, Bali, James, & Naguib, 2001b). This can be achieved by integrating information using workflow, context management and collaboration tools, giving healthcare a mechanism for effectively transferring the acquired knowledge, as and when required (Dwivedi, Bali, James, & Naguib, 2002a).

Kennedy (1995, p. 85) quotes Keever (a healthcare management executive) who notes that "Healthcare is the most disjointed industry…in terms of information exchange... Every hospital, doctor, insurer and independent lab has its own set of information, and … no one does a very good job of sharing it." From a management perspective, these new challenges have forced healthcare stakeholders to look at different healthcare management concepts that could alleviate the problem of information explosion. The following are some of the new paradigms and concepts that have caught the attention of healthcare stakeholders.

EVIDENCE BASED MEDICINE (EBM)

EBM is defined as the "conscientious, explicit and judicious use of current best evidence in making decisions about the care of individual patients" (Cowling, Newman, & Leigh, 1999, p. 149). A typical EBM process starts with an identification of knowledge-gaps in current healthcare treatment processes, followed by a search for the best evidence. This is then succeeded by a process to aid in the selection of appropriate electronic data/information sources and IT applications that focus on clinical competencies in the context of the best evidence generated.

The next step is to carry out a critical appraisal of the best evidence identified by carrying out checks for accuracy and diagnostic validity of the procedure/treatment identified by the best evidence generated. The costs and benefits of alternative procedures (i.e., the current best evidence procedure/treatment being recommended) are then considered. The last step is its application to patients' healthcare which calls for integration of the best evidence with the General Practitioners' (GP) clinical expertise so as to provide best treatment and care (Cowling et al., 1999).

MODEL OF INTEGRATED PATIENT PATHWAYS (MIPP/IPP)

Schmid and Conen (2000) have argued that the model of integrated patient pathways (MIPP/IPP) is a more comprehensive concept for healthcare institutions. As the acronym suggests, IPPs aim to enable better support for healthcare institutions by focusing on the creation of clinical guidelines for commonly accepted diagnostic and therapeutic procedures at a defined level of quality. This would lead to cost-efficient treatment. It could be argued that IPP calls for in-house development of standardized clinical treatment procedures for some pre-defined diagnoses and treatments.

Schmid & Conen (2000) elaborate that IPP aims to ensure that patients receive the right treatment which is based upon best practice guidelines that have sufficient evidence to warrant the label of "best practice" and which have been proven to be clinically adequate. They argue that when a hospital tries to implement IPP, it will automatically go through a circular chain process that calls for identifying sources of best practice, converting them to worldwide implementation practices and then, based upon their performance, converting them to benchmarks. Deliberation on current health reform is centered on two competing objectives: expanding access and containing costs. The challenge is to find an acceptable balance between providing increased access to healthcare services while at the same time conserving healthcare resources.

Pryga and Dyer (1992) have noted that, in the USA, hospitals receive a fixed amount per patient for each Medicare patient admission. As such, they have an objective of providing essential medical services whilst physicians are remunerated on the basis of the clinical service provided. The situation emerges where the physician and healthcare managers can have conflicting goals; such a dilemma is bound to affect formulation of best care practices particularly for preventive care.

CLINICAL GOVERNANCE (CG)

Clinical governance (CG) was first introduced in the UK by way of a National Health Service (NHS) white paper (Firth-Cozens, 1999) and calls for an integrated approach to quality, team development, clinical audit skills, risk management skills, and information systems. A typical CG process can be delineated into a sequential process that calls for (a) the means to disseminate knowledge about relevant evidence from research, (b) best treatments rather than focusing just on recognition of poor treatments, (c) better appreciation of what IT led solutions can do for clinical governance, and (d) knowing what data/information is available so as to provide baselines for best care and treatments.

Melvin, Wright, Harrison, Robinson, Connelly, and Williams (1999) have remarked that the NHS has witnessed the incorporation and development of many approaches that support and promote effective healthcare, but in practice, none of them have been successful. Research by Zairi and Whymark (1999) submits that the problem lies in the lack of proper systems to support the measurement of organizational effectiveness (i.e., clinical) in a healthcare delivery context.

According to Sewell (1997), one of the biggest challenges in having concise summaries of the most effective clinical practices is establishing what is meant by "quality in healthcare" (i.e., a measurement standard for clinical effectiveness). Sewell (1997) elaborates that measurement standards in clinical practice will change from each context and that this is attributed to the linkage between measurement standards and values and the expectations of the individual healthcare stakeholders (which, in turn, originate from the shared values and expectations to which all the healthcare stakeholders subscribe).

Melvin, et al. (1999) have noted that, in the UK, the NHS has started to support the concept of clinical governance by identifying individual best effective clinical practices. This process provides concise summaries of the most effective clinical practices in all key clinical areas. Summaries that are successfully substantiated are then disseminated throughout the NHS. Sewell (1997) has noted that the USA, Canada, Australia and New Zealand have adopted a formal accreditation system for the healthcare sector based upon the ISO 9000 approach.

COMMUNITY HEALTH INFORMATION NETWORKS (CHIN)

Modern day healthcare organizations have realized that in the future their survival would depend upon their ability to give the caregiver access to such information that would enable the caregiver to deliver personalized clinical diagnosis and treatment in real-time in very specific clinical contexts, a process termed Information Therapy (Dwivedi et al., 2002a). This vision has been translated into concepts such as Integrated Delivery System (IDS) and Community Health Information Networks (CHIN) (Lang, 1997; Mercer, 2001; Morrissey, 2000).

IDS refers to a Healthcare Information System (HIS), a business model based on computing technologies such as Object Orientation (OO) "to share key data, with partners and providers, that will allow faster and more accurate decision making … to deliver care to a broader population with fewer requirements for expensive and scarce resources" (Lang, 1997, p.18).

CHINs are integrated healthcare institutions based upon a combination of different technology platforms connected to enable support for data sharing amongst different healthcare providers (Mercer, 2001). Both IDS and CHIN are very similar in nature and both refer to an integrated network for allowing the delivery of personalized healthcare. CHINs were founded on the premise that patient information should be shared by competitors (Morrissey, 2000). The main aim of CHIN was to enable hospitals and other healthcare stakeholders to electronically exchange patient encounter summaries and medical records between emergency departments and related departments.

Another factor responsible for emphasis on CHIN was the perception in the healthcare industry that, for small-scale players to survive as individual entities, it was essential for them to form some sort of technological alliances (Huston & Huston, 2000). The original technological objective of CHIN was to enhance data-sharing capabilities amongst different healthcare stakeholders. The original technological infrastructure supported the creation of "point to point" connections. This did not succeed primarily due to limitations in technology coupled with the high amount of financial resources required to establish the "point to point" technological infrastructure (Morrissey, 2000).

The objective behind the incorporation of the CHIN concept is that it allows users to collect data which could be used to formulate "best practice protocols for effective treatment at a low-cost", that is, clinical best evidence practices for both healthcare diagnosis and delivery (Kennedy, 1995). It was anticipated that the advent of CHINs in conjunction with Internet technologies would empower healthcare stakeholders to provide healthcare to patients in real time whilst being in geographically distinct locations (Kennedy, 1995).

KM TAXONOMIES

KM has become an important focus area for organizations (Earl & Scott, 1999). It has been argued that KM evolved from the applications of expert systems and artificial intelligence (Liebowitz & Beckman, 1998; Sieloff, 1999). Almost all of the definitions of KM state that it is a multi-disciplinary paradigm (Gupta, Iyer & Aronson, 2000) that has further accentuated the controversy regarding the origins of KM. One of the main factors behind widespread interest in KM is its role as a possible source of competitive advantage (Havens & Knapp, 1999; Nonaka, 1991). A number of leading management researchers have affirmed that the Hungarian chemist, economist and philosopher Michael Polanyi was among the earliest theorists who popularized the concept of characterizing knowledge as "tacit or explicit" which is now recognized as the accepted knowledge categorization approach (Gupta et al., 2000; Hansen, Nohria & Tierney, 1999; Zack, 1999).

The cornerstone of any KM project is to transform tacit knowledge to explicit knowledge so as to allow its effective dissemination (Gupta et al., 2000). This can be best met by developing a KM framework. Authors such as Blackler (1995) have reiterated that the concept of knowledge is complex and, in an organizational context, its relevance to organization theory has not yet been sufficiently understood and documented. This is one of the fundamental reasons why KM does not have a widely accepted framework that can enable healthcare institutions in creating KM systems and a culture conducive to KM practices.

KM is underpinned by information technology paradigms such as Workflow, Intelligent Agents and Data Mining. According to Manchester (1999), a common point about software technologies such as (1) information retrieval, (2) document management and (3) workflow processing is that they blend well with the Internet and related technologies (i.e., technologies which focus on dissemination of information). Deveau (2000, p. 14) submits that: "KM is about mapping processes and exploiting the knowledge database. It's taking people's minds and applying technology." Deveau (2000) also noted that information technology puts the organization in a position to state the currently available information in the organizational knowledge base. At this point, the role of IT ends and the role of KM commences.

As KM deals with the tacit and contextual aspects of information, it allows an organization to know what is important for it in particular circumstances, in the process maximizing the value of that information and creating competitive advantages and wealth.

APPLICABILITY OF THE KM PARADIGM IN HEALTHCARE

A KM solution would allow healthcare institutions to give clinical data context, so as to allow knowledge derivation for more effective clinical diagnoses. In the future, healthcare systems would see increased interest in knowledge recycling of the collaborative learning process acquired from previous healthcare industry practices. This chapter puts forward the notion that this sector has been exclusively focused on IT to meet the challenges described above and reiterates that this challenge cannot be met by an IT led solution.

KM initiatives should be incorporated within the technological revolution that is speeding across healthcare industry. There has to be balance between organizational and technological aspects of the healthcare process, that is, one cannot exist without the other (Dwivedi et al., 2001a). This chapter emphasizes the importance of clinicians taking a holistic view of their organization. Clinicians therefore need to have an understanding of IT in a healthcare context and a shared vision of the organization. Clinicians and healthcare administrators thus need to acquire both organizational and technological insights if they are to have a holistic view of their organization.

The KM paradigm can enable the healthcare sector to successfully overcome the information and knowledge explosion, made possible by adopting a KM framework that is specially customized for healthcare institutions in light of their ICT implementation level. Adoption of KM is essential for healthcare institutions as it would enable them to identify, preserve and disseminate "best context" healthcare practices to different healthcare stakeholders.

PREFATORY ANALYSIS OF ALTERNATIVE HEALTHCARE CONCEPTS

The failure of some healthcare management concepts propelled a new stream of thought that advocated the incorporation of the KM paradigm in healthcare (Health Canada, 1999; Mercer, 2001). KM could allow healthcare organizations to truly take advantage of the driving forces behind the creation of the CHIN concept. However, very few organizations have adopted a comprehensive healthcare KM system. The main reason attributed is the failure of healthcare stakeholders in properly creating a conducive organizational culture. Based on a literature review above, a preliminary conceptual analysis of alternative healthcare management concepts is presented in Table 1. As can be seen from the table, healthcare stakeholders are searching for alternative paradigms that support collaboration in order to synergistically learn from others' experiences, training and knowledge within specific organizational cultures. Healthcare institutions have realized that existing concepts such as EBM and CG do not enable healthcare stakeholders to achieve this challenge as they do not holistically support effective integration of IT within specific organizational cultures and processes. Contemporary concepts such as EBM, CHIN, ICHDS and IPP focus on IT at the expense of having too little emphasis on people. This is further aggravated by the presence of dysfunctional organizational processes in the majority of healthcare institutions.

CONCLUSION

For any healthcare organization to succeed, it needs to excel in a number of key processes (i.e., patient diagnosis, care treatment, etc.) that are necessary for it to achieve its mission. If the

Table 1. Prefatory analysis of alternative healthcare concepts

Concept	Support for People	Support for Process	Support for Technology	Limitations
CG	Present	Insufficient	Present	Policy initiative
EBM	Insufficient	Insufficient	Present	Tacit Processes?
CHIN	Insufficient	Absent	Present	Limited Trials
IHCDS	Insufficient	Insufficient	Present	Technology focus
IPP	Insufficient	Present	Present	Tacit Knowledge?
KM	Present	Present	Present	Not validated

processes are repetitive, automation is possible via the use of IT. Modern IT applications in healthcare are not sufficient in meeting the information needs of current healthcare institutions as they lack the ability to deliver precise, accurate and contextual information to the desired caregiver at the desired time.

This chapter has presented an analysis of alternative healthcare management concepts with respect to their ability in providing a solution to the issue of information management. Furthermore, this chapter has examined the feasibility of the KM paradigm in solving the problem of information explosion in healthcare and has found validation for the proposition that the current focus on technological solutions will aggravate the problem of explosion in clinical information systems for healthcare institutions.

The chapter has also presented the key requirements for creating a KM framework, which can act as a template in enabling healthcare institutions in their attempts to initiate KM projects. This chapter concludes that any potential solution has to come from a domain that synergistically combines people, organizational processes and technology, thereby enabling healthcare stakeholders to have a holistic view of the entire healthcare continuum. This chapter further concludes that KM is the only paradigm that combines the above-mentioned perspectives (i.e., people, organizational processes, and technology) into healthcare and as such, KM is the next indispensable step for integrated healthcare management.

REFERENCES

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Cowling, A., Newman, K., & Leigh, S. (1999). Developing a competency framework to support training in evidence-based healthcare. *International Journal of Health Care Quality Assurance, 12*(4), 149-159.

Davis, M., & Klein, J. (2000). Net holds breakthrough solutions. *Modern Healthcare,* Supplement, Eye on Info. Feb 7, 2000, 14-15.

Deveau, D. (2000). Minds plus matter: Knowledge is business power. *Computing Canada, 26*(8), 14 -15.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2001a). Telehealth systems, Considering knowledge management and ICT issues. *Proceedgins of the IEEE-EMBC 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*, [CD-ROM], Istanbul, Turkey.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2001b). Workflow management systems, The healthcare technology of the future? *Proceedings of the IEEE EMBC-2001 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS),* [CD-ROM], Istanbul, Turkey.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2002a). The efficacy of using object oriented technologies to build collaborative applications in healthcare and medical information systems. *Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) 2002,* Winnipeg, Canada (Vol. 2, pp. 1188-1193).

Dwivedi, A., Bali, R.K., James, A.E., Naguib, R.N.G., & Johnston, D. (2002b). Merger of knowledge management and information technology in healthcare: Opportunities and challenges. *Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) 2002,* Winnipeg, Canada (Vol. 2, pp.1194-1199).

Earl, M., & Scott, I. (1999). What is a chief knowledge officer? *Sloan Management Review, 40*(2), 29-38.

Firth-Cozens, J. (1999). Clinical governance development needs in health service staff. *Clinical Performance and Quality Health Care, 7*(4), 155-160.

Gupta, B., Iyer, L.S., & Aronson, J.E. (2000). Knowledge management: Practices and challenges. *Industrial Management & Data Systems, 100*(1), 17-21.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Havens, C., & Knapp, E. (1999). Easing into knowledge management. *Strategy & Leadership, 27*(2), 4-9.

Health Canada (1998). *Vision and strategy for knowledge management and IM/IT for Health Canada* [online]. Retrieved March 20, 2002, from http://www.hc-sc.gc.ca/iacb-dgiac/km-gs/english/vsmenu_e.htm

Huston, T.L., & Huston, J.L. (2000). Is telemedicine a practical reality? Association for Computing Machinery, *Communications of the ACM, 43*(6), 91-95.

Kennedy, M. (1995). Integration fever. *Computerworld, 29*(14), 81-83.

Lang, R.D. (1997). The promise of object technology. *Journal of Healthcare Resource Management, 15*(10), 18-21.

Latamore, G.B. (1999). Workflow tools cut costs for high quality care. *Health Management Technology, 20*(4), 32-33.

Liebowitz, J., & Beckman, T. (1998). *Knowledge organizations: What every manager should know.* USA: St. Lucie Press.

Manchester, P. (1999). Technologies form vital component, INFRASTRUCTURE, The IT infrastructure will capture, store and distribute the information that might be turned into knowledge. *Financial Times*, London, Nov 10, 1999, 8.

Melvin, K., Wright, J., Harrison, S.R., Robinson, M., Connelly, J., & Williams, D.R. (1999). Effective practice in the NHS and the contribution from public health, a qualitative study. *British Journal of Clinical Governance, 4*(3), 88-97.

Mercer, K. (2001). Examining the impact of health information networks on health system integration in Canada. *Leadership in Health Services, 14*(3), 1-30.

Morrissey, J. (2000). The evolution of a CHIN. *Modern Healthcare,* Supplement, Eye on Info, May 29, 2000, 42-43.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review, 69*(6), 96-104.

Pryga, E., & Dyer, C. (1992). The AHA's national health reform strategy: An overview. *Trustee, 45*(5), 10.

Schmid, K., & Conen, D. (2000). Integrated patient pathways, "mipp"—A tool for quality improvement and cost management in health care. Pilot study on the pathway "Acute Myocardial Infarction". *International Journal of Health Care Quality Assurance, 13*(2), 87-92.

Sewell, N. (1997). Continuous quality improvement in acute health care, creating a holistic and integrated approach. *International Journal of Health Care Quality Assurance, 10*(1), 20-26.

Sieloff, C. (1999). If only HP knew what HP knows: The roots of knowledge management at Hewlett-Packard. *Journal of Knowledge management, 3*(1), 47-53.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

Zairi, M., & Whymark, J. (1999). Best practice organisational effectiveness in NHS Trusts Allington NHS Trust case study. *Journal of Management in Medicine, 13*(5), 298-307.

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Chapter 4.47
Knowledge Management for Healthcare:
Using Information and Communication Technologies for Decision Making

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EXECUTIVE SUMMARY

This case study is based on data collected from a prominent UK-based healthcare software house (Company X Ltd). The organization specializes in information and communication technologies (ICT) solution development, implementations, support services (including system and application support and telephone hotline support), and training and consultancy services. The organization prides itself on the fact that, by providing unique customized ICT solutions based on the Internet and database technologies, it is able to ensure that its healthcare-based clients (hospitals and allied organizations) have strategic advantages. The case study describes the outcome of a three-year research project, the chief outcomes of which were the development of a knowledge management (KM) conceptual model for use in the healthcare solutions sector as well as detailed advice and recommendations for the organization.

BACKGROUND OF THE CASE STUDY

This case study presents an extensive discussion on the cultural, organizational, and technical implications of introducing the knowledge management (KM) paradigm in the healthcare sector. Company X Ltd ("Company X") is a UK-based healthcare information and communication technologies (ICT) solutions provider. The organization was concerned about the possibility of a sharp decline in its share of the UK healthcare-ICT solution provider market. Company X was interested in identifying the emerging trends in the highly competitive UK-healthcare ICT solution provider market. The market is composed of such organizations as the National Health Service (NHS) Trusts (government-funded hospitals and healthcare centers) which were becoming more skeptical and demanding, both in terms of service and price for new and innovative ICT products.

To accomplish the goal of identifying the emerging trends in this highly competitive market, Company X initiated a research collaboration with the Biomedical Computing Research group (BIOCORE) based at Coventry University, UK. One of the primary objectives of the research was to investigate the efficacy of the KM paradigm for Company X in order to redesign itself to meet the changing healthcare ICT needs.

ORGANIZATIONAL BACKGROUND

Company X is a software house based approximately 40 miles west of central London. Employing 45 persons as well as a number of external associates, the company specializes in ICT solution development, ICT implementations, support services (including system and application support, telephone hotline support), training, and ICT consultancy services, all primarily for the healthcare sector.

Most of the business solutions provided by Company X are based on the Microsoft Windows platform and on Web browser technologies. The company has extensive experience in integrating Web browser technologies with information databases. The company prides itself on the fact that by providing unique customized Web-based ICT solutions and database technologies, it is able to ensure that its clients have strategic and operational advantages.

Provision of such high-quality customized ICT solutions necessitates Company X to work in close collaboration with its clients. As a result, the company has considerable contacts with a wide cross section of the community (such as social services, NHS Trusts, GP practices, councils, care agencies, and charities).

Company X was started approximately 12 years ago by a managerial team that had close ties with the SQLBase development team at ORACLE. The Company X managerial team was responsible for introducing SQLBase into the UK. The company is almost entirely owned by its employees, and all research and development at Company X is remunerated from income generated from its consultancy services.

The original Company X business plan was to focus on the development of client-server solutions using Microsoft Windows, SQL, and information databases. Company X is also a synergy partner of Centura Software (formerly Gupta), an ORACLE reseller, an Informix business partner, and offers the services of Microsoft-certified trainers. Company X is also a Microsoft healthcare solutions partner. Company X also has an excellent relationship with a local telemarketing company that uses Company X to host its strategic telemarketing database for Europe, the Middle East, and Africa. Company X has proprietary rights over several solutions, the most prominent of which are a set of toolkits used for the rapid implementation and maintenance of customized solutions running on Internet-based technologies.

The organization provides professional services in the following areas:

1. ICT Consultancy and Application Development: The company has specialist skills in creating solutions relating to executive information solutions, management information systems, and office automation systems.
2. Business Expertise: Company X has considerable expertise in the use of ICT for creating solutions to assist its clients in achieving their business objectives. The company has created ICT solutions for a wide range of industry sectors including healthcare, banking, distribution, finance, insurance, manufacturing, oil, and gas.
3. Application Consultants: Company X has acted as application consultants on a wide range of business issues across diverse industry sectors and has extensive experience in building client-server ICT solutions using component and object-oriented techniques. The unique synergistic use of these two technologies has allowed the firm to develop a reputation for building fast and efficient ICT solutions that are also cost effective. Its solutions allow it to save both time and money for its clients as the software code can be effectively reused. This also allows its clients to reduce their maintenance costs.
4. MIS and EIS Consultants: The company also offers services in building management information systems and executive information solutions. The unique selling proposition (USP) of Company X's MIS and EIS solutions is that they include a graphical user interface which provides clients with significant information, allowing them to have more control over strategic business activities.
5. Technical and end-user training: The company offers bespoke end-user training for all of its solutions. It offers specialized training courses that cover the key aspects of various application development languages and client-server solutions.
6. Project Management: Company X also acts as a project management consultant; in this capacity, its main role involves the coordination of all procedures and operations within the software application development life cycle of each project so as to ensure that other software projects are completed on time and within budget.

The organization has a diverse client base (over 300 clients) that consists of a cross section of industry and public sectors. The company also acts as an adviser and trainer to some of the largest software houses in the UK.

SETTING THE STAGE

The Company X Toolkit

As mentioned previously, Company X offers a set of integrated toolkits which have been customized for healthcare institutions (HIs). Currently, the toolkit has been implemented at over 24 National Health Service (NHS) Trusts throughout the UK. The toolkit consists of four main modules:

1. Admin: offers users the ability to control access to databases. It allows authorized administrators to ensure the integrity of the databases. It supports simultaneous management and control of information over several different vendor databases such as Microsoft SQL Server and Oracle SQL Base.
2. Upload: supports the rapid development of applications that allow users to automate electronic feeds between different databases. It automatically generates integrity rules whilst establishing connections between different databases.

3. QuickBuild: allows users to maintain information (records) that is being held in databases.
4. Report Organizer: is a tool that supports information search and retrieval and supports presentation of the same on word processing applications.

As the toolkit has been built using component technology, it is possible to rapidly build customized applications from these modules. This leads to low maintenance costs and saves additional costs for making add-on applications. The use of eXtensible Markup Language and eXtensible Stylesheet Language as primary standards in the development of the toolkit ensures that other software applications have the ability to interact with existing data in the toolkit, thereby ensuring true heterogeneity. As the HTTP interface is an integral part of the toolkit, all applications built with it are accessible via Web browsers.

In recent years, the healthcare ICT solution providers' market in the UK has undergone a rapid transformation, allowing the company to exploit new opportunities in the market. The company has noted that, in recent years, the existing exclusive suppliers to NHS Trusts had become outdated with regard to the quality of services offered to them as compared with the quality of services offered to clients in the commercial sector by other solution providers. This gave the company an opportunity to demonstrate its RAD (rapid application development) techniques to Trusts, allowing it to efficiently develop solutions for the NHS based on components developed for the commercial sector.

Company X has noted that the existing exclusive suppliers to NHS Trusts had also become outdated with regard to after-sales service, which it was offering. The company overcame this by ensuring that it always worked in partnership with Trusts, allowing it to demonstrate its widespread after-sales experience, lessons learned from ICT projects in other industry sectors (i.e., banking, distribution, etc.).

Examples of Relevant Healthcare IT Experience in NHS Trusts

Examples of relevant ICT experience in healthcare organizations include the XYZ Oncology Information System Project, a consortium of 24 NHS Trusts and a regional cancer registry. At the end of a lengthy vendor evaluation process, Company X was selected to be the sole supplier for the entire oncology project. The evaluation board felt that Company X's key attributes were the fact that its solution eliminated programming code, was accessible via a Web browser, and ran on a Windows platform.

Another project involved the ABC Group of Hospitals. The Group was part of the XYZ Oncology Information System Project consortium. After reviewing the results of the oncology solution, the ABC Group decided that they wanted to use Company X's EPR toolkit to implement a Clinical Knowledge Solution (CKS). The CKS was a suite of operational solutions, which shared a common set of information such as patient demographics, but which maintained its own patient-related information. The first applications supplied by Company X were in general surgery, theater management, and endoscopy. Company X and the ABC Group are currently examining ways of implementing a Trust-wide CKS.

Typical of many solution providers, Company X had undergone several organizational changes. In the past year or so, the organization had acquired another healthcare ICT solution provider (which created clinical systems for NHS Trusts). This had led to a rebranding of its healthcare business. The company has entered the financial services sector by creating an alliance with another solution provider in order to cater to business opportunities in the banking sector, particularly in asset management systems and securities trading systems.

At the time of writing, Company X was in discussions with a US-based solution provider that was investigating organizations in the UK healthcare-ICT market in order to form a joint venture, the precise details of which were still at a preliminary stage. Company X was hoping to learn from the proposed American partner's expertise as it employed over 2,000 people, supplies clinical, practice management, and home health solutions to over 100 US-based hospitals and practices, and processes transactions for over 500 physicians.

PREVAILING ROLE OF ICT IN DECISION MAKING

Within Company X, an evaluation of how knowledge was being created, stored, and retrieved was carried out. It was felt that the intranet was being used only as a storage area for company documents and more importantly, it was not serving as an enabler in context of knowledge creation and transfer.

Case Description

The participants in the research program who were specialists in healthcare management were given a brief which required them to formulate a strategy, the adoption of which would enable Company X to be a leading player in the UK healthcare-ICT solution provider market. These participants formulated a strategy for Company X. This strategy was presented in the form of two reports. The first report was a preliminary report, which presented an analysis of the challenges facing UK healthcare-ICT solution providers. In the second report, high-level details for an alternate product (i.e., creation of a software which would allow HIs to create customized KM solutions) which would complement Company X's existing main product offering (i.e., a set of integrated toolkits for healthcare-ICT solution provider market) were presented. The main thrust of the second report was that it was important for Company X's future to start creating clinical knowledge management (CKM) solutions for the healthcare sector.

Report No. 1: An Analysis of the Challenges Facing UK Healthcare-ICT Solution Providers

The research project commenced with an analysis of the global healthcare industry, the findings of which were presented in the form of a preliminary report to Company X's senior management. The salient points of the findings were as follows:

(1) There is information overload for healthcare stakeholders — the average physician spends about 25% of his or her time managing information and has to learn two million clinical specifics (The Knowledge Management Centre, 2000). This is further compounded by the fact that biomedical literature is doubling every 19 years. In the UK, each physician receives about 15 kg of clinical guidelines per annum (Wyatt, 2000). The above indicators illustrate how difficult it is for HIs and healthcare stakeholders (HSs) to successfully meet the healthcare information needs that are growing at an exponential rate.

The impact of the above, particularly from a societal perspective, is enormous. Up to 98,000 patients die every year as a result of preventable medical errors (Duff, 2002). The financial cost of these preventable medical errors cost from US $37.6 billion to $50 billion and, in numerical terms, account for more deaths than from car accidents, breast cancer, or AIDS (Duff, 2002). A study has pointed out adverse drug reactions result in more than 770,000 injuries and deaths each year (Taylor, Manzo, & Sinnett, 2002).

Another study reported in the Harvard Business Review noted that, as early as 1995, there were indications that "more than 5% of patients had adverse reactions to drugs while under medical care; 43% of those inpatient reactions were serious, life threatening, or fatal" (Davenport & Glaser, 2002, p. 107). Advances in biomedical sciences have unalterably transformed the healthcare sector. Modern-day healthcare stakeholders (physicians, nurses, etc.) require information about "10,000 known diseases, 3,000 drugs, 1,100 lab tests, 300 radiology procedures … 2,000 individual risk factors … with 1,000 new drugs and biotechnology medicines in development" (Pavia, 2001, pp.12-13). An indicator of the enormity of the exponential increase in biomedical knowledge is witnessed by the growth in the National Library of Medicine's Medline database (4,500 journals in 30 languages, dating from 1996) of published literature in health-related sciences. In 2002, Medline contained 11.7 million citations and, on average, about 400,000 new entries were being added per year (Masys, 2002).

Observations evidence the impact of these exponential advances on individual stakeholders (Masys, 2002). Even if a typical modern-day healthcare stakeholder were to read two articles a day, it would take him or her 550 years to get updated with the new literature added every year (ignoring the existing literature level of 11.7 million). If we assume that about 1% of the new literature added every year is of relevance to a healthcare stakeholder, it would take a stakeholder five years (reading an average of two articles a day) to be updated with the healthcare advances of one year. It would appear that contemporary healthcare stakeholders are always behind the current state of knowledge (Masys, 2002).

(2) In today's information age, data have become a major asset for healthcare institutions. Recent innovations in information and communication technologies (ICTs) have transformed the way that healthcare organizations function. Applications of concepts such as data warehousing and data mining have exponentially increased the amount of information that a healthcare organization has access to, thus creating the problem of "information explosion." This problem has been further accentuated by the advent of new disciplines such as bioinformatics and genetic engineering, both of which hold very promising solutions which may significantly change the face of the entire healthcare process from diagnosis to delivery (Dwivedi, Bali, James, Naguib, & Johnston, 2002b).

(3) Healthcare managers are being forced to examine costs associated with healthcare and are under increasing pressure to discover approaches that would help carry out activities better, faster, and cheaper (Davis & Klein, 2000; Latamore, 1999). Work flow and associated Internet technologies are being seen as an instrument to cut administrative expenses. Specifically designed ICT implementations, such as work flow tools, are being used to automate the electronic paper flow in a managed care operation, thereby cutting administrative expenses (Latamore, 1999).

(4) One of the most challenging issues in healthcare relates to the transformation of raw clinical data into contextually relevant information. Kennedy (1995, p. 85) has quoted Keever (a healthcare management executive) who notes that "Healthcare is the most disjointed industry … in terms of information exchange.... Every hospital, doctor, insurer and independent lab has its own set of information, and … no one does a very good job of sharing it."

(5) Advances in IT and telecommunications have made it possible for healthcare institutions to face the challenge of transforming large amounts of medical data into relevant clinical information (Dwivedi, Bali, James, & Naguib, 2001b). This can be achieved by integrating information using work flow, context management, and collaboration tools, giving healthcare a mechanism for effectively transferring the acquired knowledge, as and when required (Dwivedi, Bali, James, & Naguib, 2002a).

(6) Until the early 1980s, ICT solutions for healthcare used to focus on such concepts as data warehousing. The emphasis was on storage of data in an electronic medium, the prime objective of which was to allow exploitation of this data at a later point in time. As such, most of the ICT applications in healthcare were built to provide support for retrospective information retrieval needs and, in some cases, to analyze the decisions undertaken. This has changed healthcare institutions' perspectives toward the concept of utility of clinical data. Clinical data that was traditionally used in a supportive capacity for historical purposes has today become an opportunity that allows healthcare stakeholders to tackle problems before they arise.

(7) The contemporary focus is only on how best to disseminate the information, which could be fatal for the future of the healthcare applications (i.e., current use is static). Rather than creating or disseminating contextual knowledge, healthcare applications are being used to disseminate data and information. Future healthcare industry applications would have to support the transfer of information with context (i.e., such schemes would have to become dynamic in nature).

Such a scenario is likely to lead to a situation where healthcare institutions would be flooded with large amounts of clinical data. The introduction of the KM paradigm would enable these institutions to face the challenge of transforming large amounts of medical data into relevant clinical information. Future healthcare systems would have to shift their emphasis to deal with the intangibles of knowledge, institutions, and culture.

Healthcare institutions require a framework that would help to assess how best to identify and create knowledge from internal and external organizational experiences and how best to disseminate it on an organization-wide basis in a manner that ensures that the acquired knowledge is available for preventive and operative medical diagnosis and treatment when required. This would call for the contextual recycling of knowledge which has been acquired from the adoption of healthcare industry trials. KM can assist the healthcare industry to become viable by giving healthcare information context, so that other healthcare providers can use the healthcare industry to extract knowledge and not information. The healthcare industry is focused on the technology aspect of healthcare and that the key to success of the healthcare sector in the 21st century is an effective integration of technology with the human-based clinical decision-making process. It is therefore important for Company X to develop a conceptual healthcare management framework that encompasses technological, organizational, and managerial perspectives for the healthcare industry.

(8) The first report ended by stating that, from a management perspective, these new challenges have created the need for a CKM (Clinical Knowledge Management) system that can assist healthcare stakeholders in alleviating the problem of information explosion in the healthcare industry. The

> primary obstacle to the report's recommended integration of the KM paradigm in healthcare was the lack of any established framework or model which had its roots in either clinical or healthcare environments.

KM does not have any commonly accepted or de facto definition. However, KM has become an important focus area for organizations (Earl & Scott, 1999). It has been argued that KM evolved from the applications of expert systems and artificial intelligence (Liebowitz & Beckman, 1998; Sieloff, 1999). Almost all the definitions of KM state that it is a multidisciplinary paradigm (Gupta, Iyer, & Aronson, 2000) which has further accentuated the controversy regarding the origins of KM. It has been argued that the main aim behind any strategy of KM is to ensure that knowledge workers have access to the right knowledge, to the right place, at the right time (Dove, 1999).

One of the main factors behind widespread interest in KM is its role as a possible source of competitive advantage (Nonaka, 1991; Havens & Knapp, 1999). A number of leading management researchers have affirmed that the Hungarian chemist, economist, and philosopher Michael Polanyi was among the earliest theorists who popularized the concept of characterizing knowledge as "tacit or explicit" which is now recognized as the de facto knowledge categorization approach (Gupta et al., 2000; Hansen, Nohria, & Tierney, 1999; Zack, 1999).

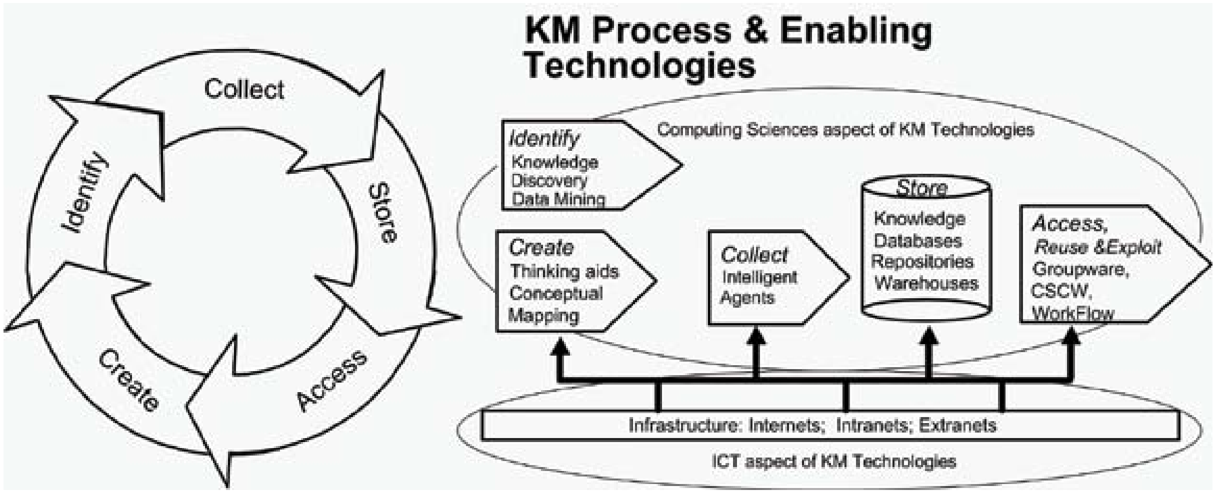
Explicit knowledge typically takes the form of company documents and is easily available, whilst tacit knowledge is subjective and cognitive. One of the characteristics of explicit knowledge is that it can be easily documented and is generally located in the form of written manuals, reports, and/or found in electronic databases (Dwivedi, Bali, James, & Naguib, 2001a). As such, it is easily accessible and in many cases available on an organization's intranet. The cornerstone of any KM project is to transform tacit knowledge to explicit knowledge so as to allow its effective dissemination (Gupta et al., 2000). This can be best met by developing a KM framework. Authors such as Blackler (1995) have reiterated that the concept of knowledge is complex and, in an organizational context, its relevance to organization theory has not yet been sufficiently understood and documented. This is one of the fundamental reasons why KM does not have a widely accepted framework that can enable HIs in creating KM systems and a culture conducive to KM practices.

Figure 1 illustrates how the KM process revolves around a cycle. As illustrated, KM is underpinned by information technology paradigms such as computer-supported cooperative work (CSCW), work flow, intelligent agents, and data mining. According to Manchester (1999), a common point about software technologies such as (1) information retrieval, (2) document management, and (3) work flow processing is that they blend well with the Internet and related technologies (i.e., technologies that focus on dissemination of information).

Deveau (2000, p. 14) submits that "KM is about mapping processes and exploiting the knowledge database. It's taking people's minds and applying technology." Deveau (2000) also noted that information technology puts the organization in a position to state the currently available information in the organizational knowledge base. At this point, the role of ICT ends and the role of KM commences. As KM deals with the tacit and contextual aspects of information, it allows an organization to know what is important for it in particular circumstances, in the process maximizing the value of that information and creating competitive advantages and wealth.

A KM solution would allow healthcare institutions to give clinical data context, so as to allow knowledge derivation for more effective clinical diagnoses. In the future, healthcare systems would see increased interest in knowledge recycling of the collaborative learning process acquired from previous healthcare industry practices. The report

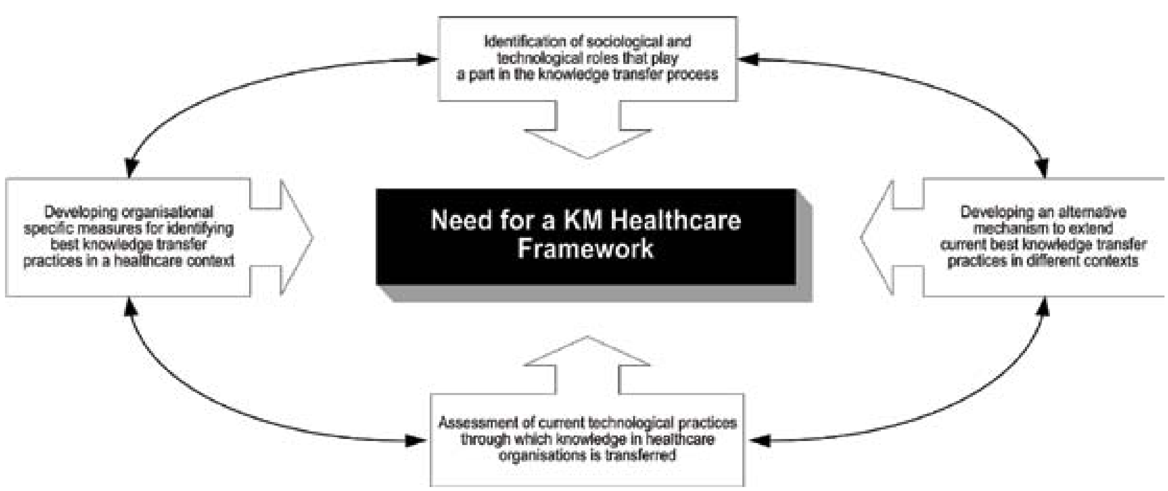
Figure 1. The KM cycle (Dwivedi et al., 2002b) (modified from Skyrme, 1999)



put forward the notion that the healthcare sector has been exclusively focused on ICT to meet the challenges described above and reiterates that this challenge cannot be met by an ICT-led solution.

KM initiatives should be incorporated within the technological revolution that is speeding across healthcare industry. There has to be balance between organizational and technological aspects of the healthcare process, that is, one cannot exist without the other (Dwivedi et al., 2001a). The report emphasized the importance of clinicians taking a holistic view of their organization. Clinicians therefore need to have an understanding of ICT in a healthcare context and a shared vision

Figure 2. Requirements for a KM framework



of the organization. Clinicians and healthcare administrators thus need to acquire both organizational and technological insights if they are to have a holistic view of their organization.

The KM paradigm can enable the healthcare sector to successfully overcome the information and knowledge explosion, made possible by adopting a KM framework that is specially customized for HIs in light of their ICT implementation level. Adoption of KM is essential for HIs as it would enable them to identify, preserve, and disseminate "best context" healthcare practices to different HSs.

The report additionally identified four elements (Figure 2) that would be integral to any such KM framework for the healthcare industry. It is emphasized that when an attempt is made to formalize knowledge in an institutional framework, the multidisciplinary nature of healthcare knowledge in an organizational context emerges.

Report No. 2: Creation of a Template for Clinical Knowledge Management (CKM) Solutions for the Healthcare Sector

Based on empirical data from the healthcare sector, Company X was presented with a four-layer KM framework, the Organization Current Knowledge Design (OCKD) model, which could serve as a generic toolkit for HIs who are interested in developing an understanding on how to develop a KM strategy (see Figures 3 and 4). As one goes on peeling one layer, another layer emerges, cumulating finally on the organizational core competencies.

The first step (layer 1 in Figure 3) in formulating a KM strategy involves the identification of the core competencies of an HI. This can be carried out in a number of ways (i.e., using the traditional five forces model by Porter [1985]).

Figure 3. Four-layer OCKD KM framework

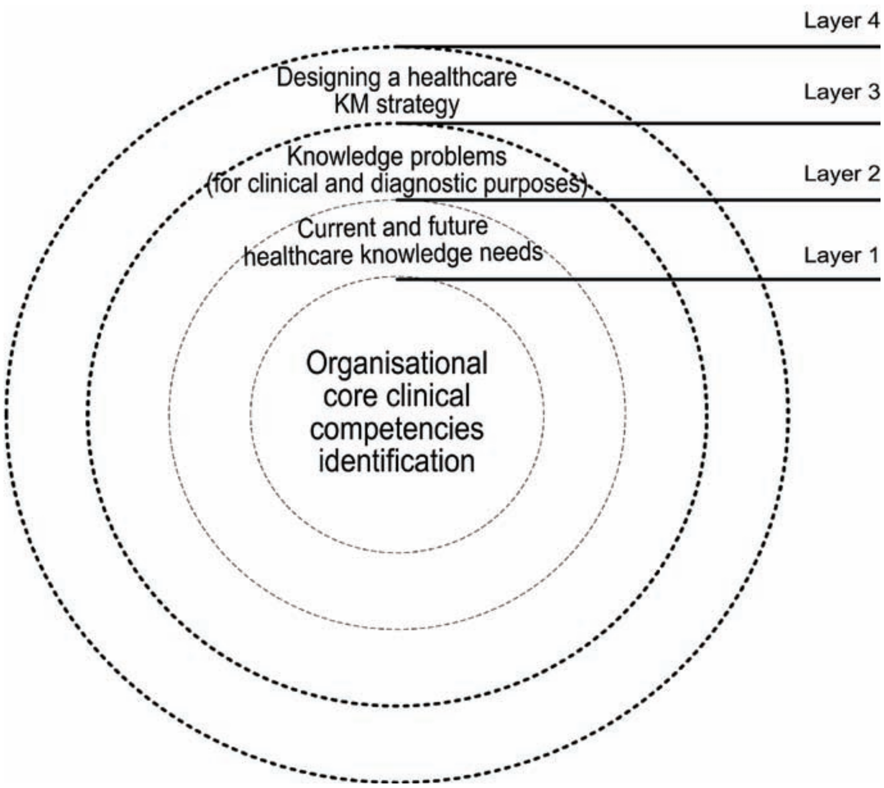
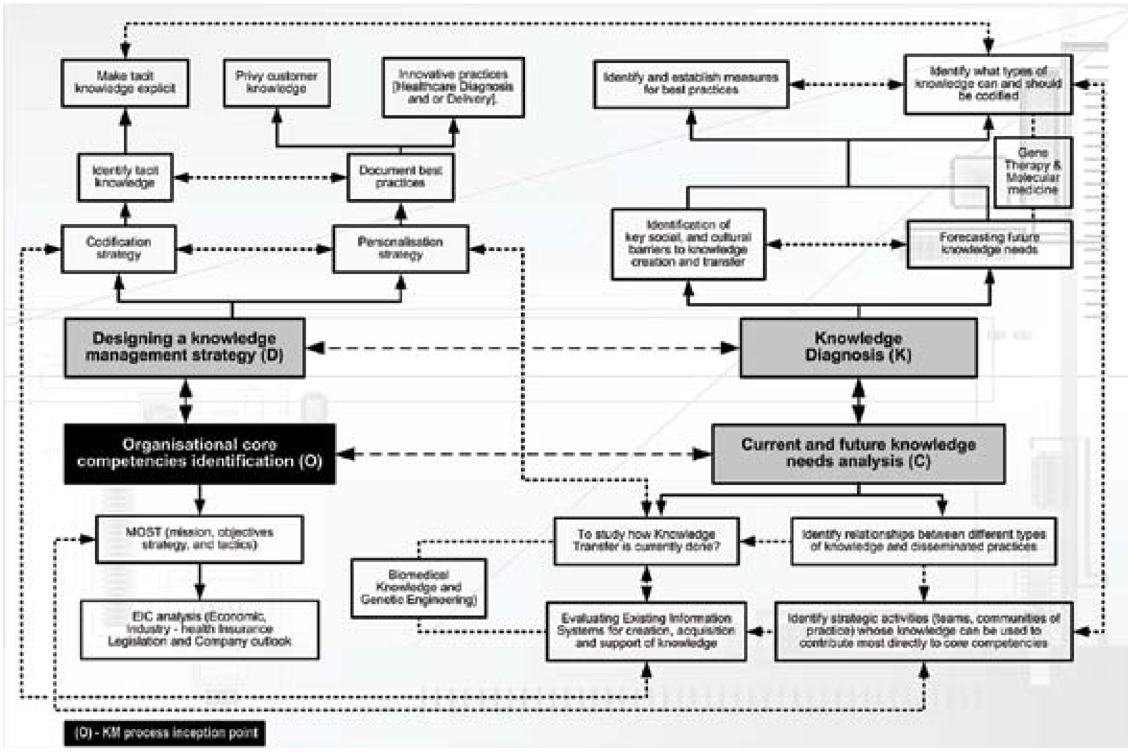


Figure 4. Elaborated OCKD framework for Company X



This process will enable an HI to be clear about its MOST (mission, objectives, strategy, and tactics). It would also allow it to notice how its MOST is aligned with its organizational core competencies, the EIC analysis (economic, industry, and company outlook). The next step would be a study to identify the HI's current and future knowledge needs (layer 2 in Figure 3). This would call for an analysis of the current technological infrastructure (i.e., support for m-health applications) that is in place for supporting knowledge transfer. After this process, an HI will need to assess how much knowledge should and can be codified (see layer 3 in Figures 3 and 4). This stage will result in the decision to adopt a KM strategy with emphasis on either personalization or codification. Irrespective of the strategy adopted, HIs would have to be clear on what constitutes best clinical innovative practices. This, to some extent, will help in capturing the tacit knowledge of clinical specialists. At the top layer (layer 4 in Figure 3), an HI has a KM strategy. Each HI can either adopt a KM strategy, which has emphases either on the tacit knowledge that resides in its resources or on a KM strategy that emphasizes the organizational processes: the codification strategy. This leads to the identification of relationships that exist between different types of knowledge (tacit or explicit) being transferred and to dissemination practices. It then results in a spiral transfer between the processes marked with the broken arrow signs (Figure 4).

CURRENT CHALLENGES FACING THE ORGANIZATION

Impact of New ICT in Decision Making

Senior management at Company X noted that the existing ICT (i.e., the intranet) was not enabling users to create new knowledge and/or exploit existing knowledge. It was decided to create a new IT infrastructure, one which would be seen as an enabler and which would comprise of various tools. At the same time, it was decided to restructure existing pay and reward schemes (i.e., remuneration), so as to reward information/knowledge sharers (both at an individual and group level). It was also decided to bring about a change in the leadership style and organizational culture, so as to enable members of staff to develop a strong feeling of cultural affinity toward each other.

As a first step, Company X carried out a network-wide installation of Lotus Notes. At the same time, it offered financial and nonfinancial incentives to those teams and individuals who adopted Lotus Notes to capture and share best practices. This scheme was complemented by senior management communication initiatives that emphasized integration of the new IT infrastructure in a new organizational culture—one that emphasized knowledge sharing.

As a result of the above initiatives, the following developments took place:

1. Middle- and lower-level managers have started to enable and promote learning. As a consequence, communities of practice whose focus is on creation and transfer of best practices have evolved.
2. Another interesting observation was in the use of ICT (after the installation of Lotus Notes and creation of a KM-conducive organizational culture) — ICT was perceived to be responsible for creation and transfer of information and knowledge in a bottom-up fashion. This was in sheer contrast to the top-down approach for creation and transfer of information and knowledge which has resulted from the use of the intranet as the key ICT (i.e., intranet, which was in existence before the installation of Lotus Notes and creation of a KM-conducive organizational culture).
3. The adoption of Lotus Notes resulted in the creation of a common process classification scheme (i.e., an organizational thesaurus) which uses a common language and terminology that allows users to find presentations, data and language models, schemas, best practices, and so forth.
4. Adoption of Lotus Notes was seen to create synergy between different departments of Company X. This success promoted senior managers at Company X to consider adopting the KM paradigm and in this context — they were interested in the OCKD model (Figure 4). This is discussed further in Section 5.2.
5. Senior managers at Company X believed that the next step would call for the creation of a customized expert system whose user interface would be as friendly and appealing as possible. They did add that such a system would allow Company X to eliciting the best available knowledge, but it would be quite a while before it would become a reality. They did add that they were working toward their long-term goal of creating a customized expert system, which would complement their initiatives (i.e., Lotus Notes and the communities of practice).

Adoption of the OCKD Framework at Company X

The participants in the research program for Company X presented the OCKD framework to Company X. The accompanying report argued that it was important that Company X starts to create CKM solutions for the healthcare sector. It continued that, as a first step for building an enterprise-wide (i.e., entire hospital) CKM system, Company X should make separate CKM suites for the following key healthcare ICT systems:

1. Radiology Information Systems (RIS)
2. Patient Administration System (PAS)

3. Laboratory Information Systems (LIS)
4. Clinical Patient Record (CPR)
5. Pharmacy Systems (PS)
6. Nursing Systems (NS)

The report stressed that the above-mentioned CKM suites, once implemented individually, should automatically be able to interface with each other, thus making the vision of an enterprise-wide CKM system a reality for the healthcare industry. No UK-based healthcare ICT solution provider has come up with such a product, and in light of its findings in its preliminary report, creation of a product like an enterprise-wide CKM system would ensure that Company X becomes the undisputed market leader in the UK market.

The OCKD framework was very well received within Company X. However, senior management noted that there remained several barriers to the possible acceptance of the OCKD model:

- A key constraint would be getting the top management of NHS Trusts to support any new projects and that Trusts and hospital administrators had first to recommend KM products. This would require NHS Trusts and hospital administrators to be convinced of the utility of the KM paradigm. This would call for substantiation of the results obtained from KM trials, preferably in health-related scenarios.
- NHS Trusts are now particularly more skeptical and demanding, both in terms of service and price, and more so for new innovative ICT products. They felt that the KM concept would take a few years to develop into a mature product.
- The UK solution provider market is driven by the centralized buying procedure of the NHS, that is, the NHS Purchasing and Supply Agency, which is currently very cost sensitive. The need for a new KM system has to be recommended by the Agency.
- There is no measurement tool that could quantify the impact of the OCKD model on the processes of an organization.
- They also noted that there could be legal liabilities for the sellers of the model in case the stated best practices are not properly validated in a healthcare context.
- An additional key constraint was finance. Building an enterprise-wide CKM would require additional funds.
- Detailed supporting technical documentation for each CKM application had to be developed. This would take both time and money.

CONCLUDING COMMENTS

Company X is currently working with several NHS Trusts in an attempt to develop jointly an enterprise-wide CKM product. It remains convinced on the feasibility of the KM paradigm solving the problem of information explosion in healthcare. The company is also in agreement with the fact that the current focus on technological solutions will aggravate the problem of explosion in clinical information systems for healthcare institutions. It remains convinced that any potential solution has to come from a domain that synergistically combines people, organizational processes, and technology, thereby enabling HSs to have a holistic view of the entire healthcare continuum and that an enterprise-wide CKM product, based on the OCKD framework, is the first step in this transformation.

REFERENCES

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Davenport, T.H., & Glaser, J. (2002). Just-in-time-delivery comes to knowledge management. *Harvard Business Review, 80*(7), 107-111.

Davis, M., & Klein, J. (2000, February 7). Net holds breakthrough solutions. *Modern Healthcare, 14*.

Deveau, D. (2000). Minds plus matter: Knowledge is business power. *Computing Canada, 26*(8), 14-15.

Dove, R. (1999). Knowledge management, response ability, and the agile enterprise. *Journal of Knowledge Management, 3*(1), 18-35.

Duff, S. (2002). It's easier to tell the truth. *Modern Healthcare, 32*(23), 12-13.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2001a). Telehealth systems: Considering knowledge management and ICT Iissues. *Proceedings of the IEEE-EMBC 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*, Istanbul, Turkey.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2001b). Workflow management systems: The healthcare technology of the future? *Proceedings of the IEEE EMBC-2001 23rd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBS)*, Istanbul, Turkey.

Dwivedi, A., Bali, R.K., James, A.E., & Naguib, R.N.G. (2002a). The efficacy of using object oriented technologies to build collaborative applications in healthcare and medical information systems. *Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) 2002*, 2, 1188-1193.

Dwivedi, A., Bali, R.K., James, A.E., Naguib, R.N.G., & Johnston, D. (2002b). Merger of knowledge management and information technology in healthcare: Opportunities and challenges. *Proceedings of the IEEE Canadian Conference on Electrical and Computer Engineering (CCECE) 2002*, 2, 1194-1199.

Gupta, B., Iyer, L.S., & Aronson, J.E. (2000). Knowledge management: Practices and challenges. *Industrial Management & Data Systems, 100*(1), 17-21.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Havens, C., & Knapp, E. (1999). Easing into knowledge management. *Strategy & Leadership, 27*(2), 4-9.

Kennedy, M. (1995). Integration fever. *Computerworld, 29*(14), 81-83.

The Knowledge Management Centre. About the Knowledge Management Centre. Retrieved November 12, 2000, from www.ucl.ac.uk/kmc/kmc2/AboutKMC/index.html

Latamore, G.B. (1999). Workflow tools cut costs for high quality care. *Health Management Technology, 20*(4), 32-33.

Liebowitz, J., & Beckman, T. (1998). *Knowledge organizations: What every manager should know*. St. Lucie Press.

Manchester, P. (1999, November 10). Technologies form vital component: INFRASTRUCTURE: The IT infrastructure will capture, store and distribute the information that might be turned into knowledge. *Financial Times* (London), p. 8.

Nonaka, I. (1991). The knowledge-creating company. Harvard Business Review, 69(6), 96-104.

Pavia, L. (2001). The era of knowledge in health care. *Health Care Strategic Management, 19*(2), 12-13.

Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: The Free Press.

Sieloff, C. (1999). If only HP knew what HP knows: The roots of knowledge management at Hewlett-Packard. *Journal of Knowledge Management, 3*(1), 47-53.

Taylor, R., Manzo, J., & Sinnett, M. (2002). Quantifying value for physician order-entry systems: A balance of cost and quality. *Healthcare Financial Management, 56*(7), 44-48.

Wyatt, J.C. (2000). 7. Intranets. *Journal-Royal Society of Medicine, 93*(10), 530-534.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 4.48
The Challenge of Privacy and Security and the Implementation of Health Knowledge Management Systems

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ABSTRACT

Health information privacy is one of the most important and contentious areas in the development of Health Knowledge Systems. This chapter provides an overview of some of the daily privacy and security issues currently faced by health services, as health knowledge system developments risk outpacing medico-legal and professional structures. The focus is a mixture of philosophy and pragmatics with regard to the key "privacy" and "security" issues that challenge stakeholders as they try to implement and maintain an increasing array of electronic health knowledge management systems. The chapter utilises a number of evolving simple visual and mnemonic models or concepts based on observations, reflections and understanding of the literature.

INTRODUCTION

The focus of this chapter is largely shaped by the common themes and thoughts expressed, and dilemmas experienced, within the environment in which the Author works. However many of these local opinions are shaped by more universal forces, media, and experiences, and common themes, concepts and challenges can be found internationally, both within health, and other complex systems that handle personal information (Anderson, 1996; Coiera & Clarke, 2003; Tang, 2000). Health Knowledge Management systems are assisted by processes that provide complete, accurate, and timely information. Issues of security and privacy have the capacity to facilitate or inhibit this process. However, there are a myriad of perspectives with regard to the meaning, significance, and interrelation of the terms privacy, security, and health knowledge system, which shall be discussed throughout the chapter.

A Health Knowledge system should aim to integrate and optimise stakeholders' "capacity to act" (Sveiby, 2001) or "capacity to C.A.R.E." (that is, the capacity to deliver in a coordinated fashion the integral Clinical, Administrative, Research and Educational functions of healthcare). The Electronic Patient Record term typically aims to describe the technology or software that stores the record of care or provides a degree of decision support. However, the term "Health Knowledge Management System" aims to better capture or identify the overall system changes required to implement decision support systems, such as changes in underlying processes and the development of a culture that values, respects and protects the acquisition, distribution, production and utilisation of available knowledge in order to achieve better outcomes for patients (Standards Australia, 2001; Wyatt, 2001).

A Health Knowledge Management System should facilitate closing the communication gaps on an ongoing basis, between all the key stakeholders involved in optimising care, GPs, Allied health services (including hospitals), and the often forgotten Patients and their Supports, who all need and should benefit from an improved "capacity to C.A.R.E." The system should also aim to be fast, intuitive, robust, stable, and trustworthy (Orr, 2000).

PRIVACY AND SECURITY

Internationally there is a growing array of privacy and security codes, laws, and standards with many shared core themes (Office of the Privacy Commissioner, 2002; Standards Australia and Standards New Zealand, 2001). However, creating a shared understanding of the essential nature of "Privacy" continues to afford particular challenges, as many of its associated elements are contextual, percep-

Table 1. Health knowledge systems—Closing the C.A.R.E. G.A.P.S. F.I.R.S.T.

C.A.R.E.	**C**linical **A**dministration **R**esearch **E**ducation
G.A.P.S.	**G**eneral Practitioner (primary and community care) **A**llied Health Services (including secondary and tertiary care) **P**atients **S**upports
F.I.R.S.T.	**F**ast **I**ntuitive **R**obust **S**table **T**rustworthy

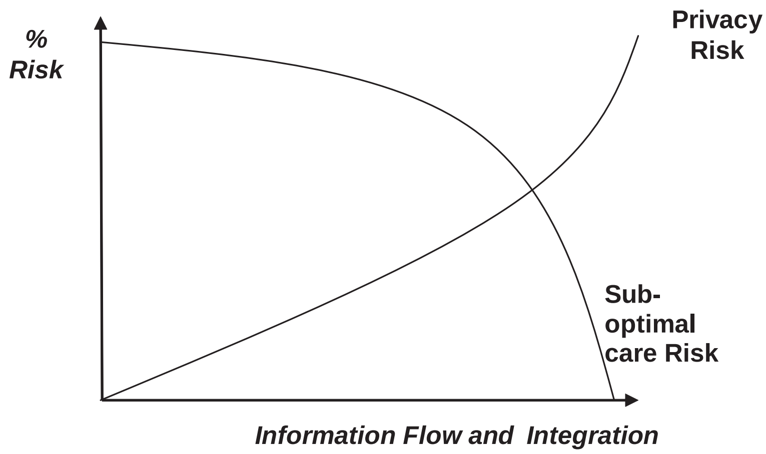
tual and personal. Clarke (2004) and Anderson (2004) provide comprehensive resources exploring the dimensions and complexities of privacy, security, and related concepts.

There is the potential for conflict, as well as the need for balance between the hierarchy of needs (Maslow, 1943) or wants of an individual or a particular group, versus the needs, and wants and capabilities of the wider community or system. The original Latin origin of the word "Privacy" aims to convey a sense of something "set apart", owned by oneself rather than the state or public (Online Etymology Dictionary, 2001). Therefore we could view private information as something we feel ownership of or particularly connected to, information that should be "set apart" and out of the public domain, or at least over which we should have particular control and an understanding of the competence and motivation of those who may use it.

However with regard to our health (and accordingly our health information) we are rarely truly "set apart" from the public or our communities. Our health, our health management, and our behaviour are continually impacted on by the complex biopsychosocial (Engel, 1977) system in which we live. The need or desire to be "set apart" or have control can lead to conflict or at least opportunity costs with the needs of other aspects of the finely balanced system within which we function. Each stakeholder group may attribute different weights to different factors and believe the balance should lie to one side or the other.

The Latin origin of the word "Security" conveys the sense of something safe or without care (Online Etymology Dictionary, 2001). Security with respect to Information Systems typically focuses on the preservation of confidentiality integrity, and availability. Confidentially refers to the need to limit access only to those authorised to have access, integrity refers to ensuring the completeness and accuracy of information and associated system processes while availability refers to the need to ensure that information and associated system processes are accessible to authorised users when required (Standards Australia/New Zealand, 2001).

Figure 1. Privacy versus sub-optimal care risk: Possible clinician view



Perceptions of privacy and sub-optimal care risk according to degree of information flow can be depicted by way of a schematic (Figure 1).

As a background to a discussion on the challenges of privacy impact assessment and informed consent or "e-consent" systems, it is worth trying to stimulate a shared conceptual understanding, of some of the perceptions of what the impacts or risks and benefits of a health knowledge management system might be. As a beginning, we might consider Figure 1, which illustrates how a clinician might perceive the relative decrease in sub-optimal care risk and increase in privacy risk as health information increasingly flows and is shared and integrated.

Privacy risk is defined as the perceived risk of an adverse outcome or sub-optimal care related to a privacy infringement. Sub-optimal care risk is defined as the perceived risk of non-optimal care related to information flow restriction or disintegration.

The focus of electronic health knowledge management system value analysis is often on preventing death or adverse events. However there is a whole range of care that, although it does not result in a reported adverse event or death, could be described as non- or sub-optimal. A health outcomes curve (Figure 2) may have optimal care at one end with everything else considered increasingly sub-optimal as it moves through various degrees of poorly co-ordinated and inefficient care, towards adverse events, permanent disability and death at the other end. This poorly co-ordinated or inefficient care may for example include duplication of assessment or investigation or the use of expensive or multiple interventions, without evidence of greater benefit over a cheaper or single intervention or simply failing to stop or review an intervention.

Therefore the hypothetical clinician's opinion (Figure 1) may be shaped by the perspective that, on balance, the greatest risk our communities face is a whole range of sub-optimal care, that at least in part is attributable to the poor flow and integration of health information. Based on this hypothesis, better integrated health information leads to better integrated healthcare, the desired outcome from an effective health knowledge management system would be to shift the norm of the health outcomes curve towards the optimal end of the curve minimising the degree of sub-optimal care.

However while not disputing the desire to minimise sub-optimal care, a patient may perceive the relative risks differently (Figure 3). It is currently, and likely to remain, difficult to

Figure 2. Health outcomes curve: Death to-optimal care

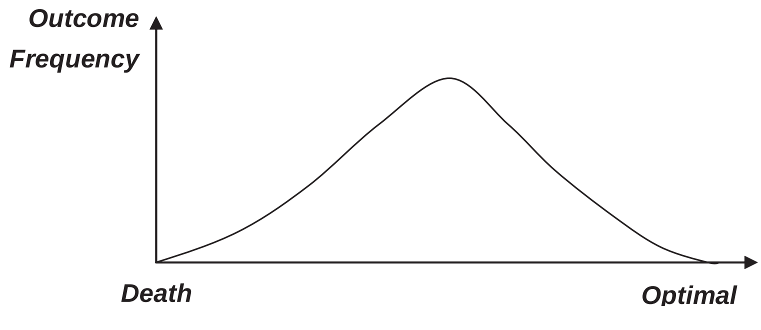
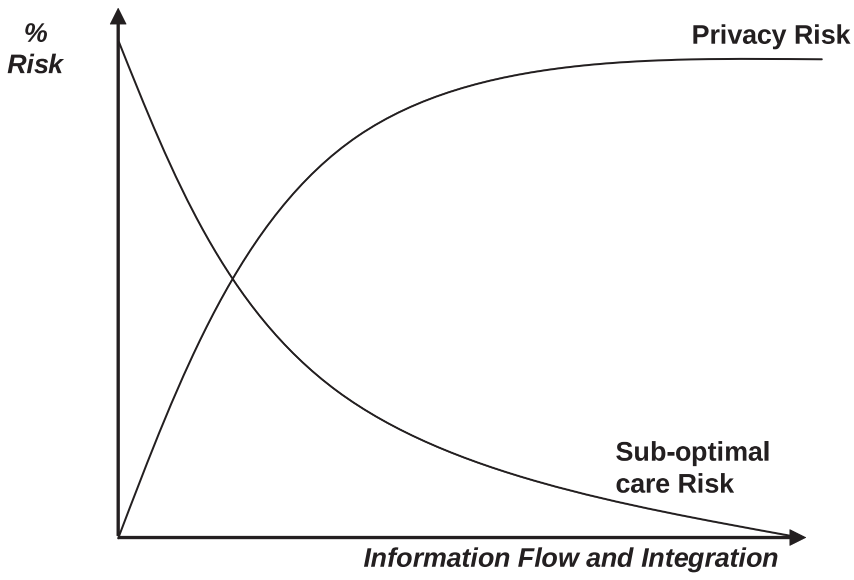


Figure 3. Privacy versus suboptimal care risk: Possible patient/consumer view



provide "evidence" based data on relative privacy versus sub-optimal care risks to an individual or indeed populations, as there will be strong perceptual differences as to what the scope of that evidence should be and how it should be weighed. However we could assume the relative risk graphs are unlikely to be reflected by straight lines. The relative risks are likely to be influenced by individual perception, respective roles, the nature of the data, and to change over time. The frequency, imminence, likelihood, and magnitude of risk would also need to be considered, as would the ability to identify, evaluate, manage, and review risk.

In the absence of definitive data, and with the recognition that the perceived risk arising from a privacy infringement has such a personal perceptual component, it is important to highlight some of the views and perceptions with regard to this matter.

It could be argued, that severe physical disability or death is unlikely except in the case of a privacy infringement leading to severe psychological distress resulting in attempted or completed suicide. However there are a number of counter arguments to this. These suggest that what we do now even with good intention could have future potentially unforeseen but not unforeseeable adverse impacts. These suggest that there is not only the potential for sub-optimal care, but also for active discrimination if not persecution and political or regime sanctioned killings.

Perceived risk of a privacy infringement may lead to a patient withholding information, or delaying presentation to health services. This may result in delayed investigation and treatment and potentially sub-optimal care including avoidable morbidity and death. This morbidity may extend to others particularly in the case of infectious diseases, not least partners and unborn children in the case of sexually transmitted diseases.

Current data integration, data mining, risk prediction, and genetic profiling developments have the potential for great benefit for our communities. However there is also the risk that without appropriate regulation, certain segments of the populations could be identified at high health risk and become unemployable, uninsurable and unable to obtain credit, a mortgage or appropriate affordable healthcare (Kennedy, 2004).

Insurers and employers are generally not innately bad. They are businesses charged with making a profit (or minimising loss) by their shareholders, and can be expected to use every legal means and loophole possible to identify and manage their risk particularly if it gives them an advantage over a competitor.

However it can be argued that the potential unfettered ability of insurance companies and health management organisations to be progressively able to segment or cut up the market, and discard those least profitable should be a concern for every community.

Unique Health Identification Numbers

Unique health identification numbers can facilitate the process of data integration across multiple electronic systems, and lead to better-integrated care. It can also be argued that within the context of a large integrated electronic system they may decrease privacy or security risk by minimising the amount of non secure activity around bringing a disintegrated paper record together, such as multiple phone calls to other services inquiring as to the availability of records, and the subsequent transfer of paper records.

However, it can be argued that if there is an infringement of an integrated unique identifier based electronic system, there is the opportunity for thousands of records to be accessed, with unique identifiers facilitating access to a wide range of comprehensive health information. An infringement could in theory be the result of a hacker gaining unauthorised access to the health network. However, of likely greater risk is a health service staff member, acting out of curiosity, malice or pecuniary gain, or having simply been misled or talked into it by someone posing as a patient or clinician on the telephone. This latter method of infringement has been highlighted by Anderson (1996). The risk of staff access, facilitating a range of crimes including murder has also entered the popular fictional literature (Gerritsen, 2001), also shaping community perceptions.

It could also be argued that significant parts of humanity's past and present has been dominated by war, invasion, totalitarian regimes, and state sanctioned terror, and even those of us currently living in relatively benign environments are naïve to believe that such horrors will not feature in our future. Such invading or totalitarian regimes have and would use every means possible to control and terrorise the population, including health data. The provision therefore of a national unique health identification number could facilitate this process, including the singling out of specific subgroups for discrimination, persecution or killing (Black, 2001).

There are also general privacy infringement concerns, including health information systems, being cross referenced, or matched with other government systems including social services, benefits and police, and the use of data for unauthorised research or commercial purposes.

Are patient privacy concerns sometimes just a smokescreen for clinician privacy concerns? Are clinicians sometimes just trying to minimize the transparency of a whole range of issues from limitations of their skill and efficiency to fraudulent practice? It is understandable why many clinicians would find these questions challenging if not insulting. However in terms of exploring the challenges that might impact on the effective implementation of health knowledge management systems, they are perspectives that cannot be ignored, and following is a brief limited discussion of some of the potential underlying issues.

Evidence Based Medicine (EBM) or the concept that treatment choices should be based on, or backed by, the best evidence available, has unfortunately in many situations, become perceived as an excuse for "evidence bound" medicine. That is the establishment of rigid regimes, or marked limitation of treatment choices that stifle innovation or new developments and do not recognise individual patient variation. This has particularly become associated with the term "managed care". Managed care is a concept that in its pure form has some worth, as it promotes the idea of effective clinical care pathways and efficient targeted integrated use of resources. However the form of "managed care" espoused by profit focused health organisations, and insurance companies is perceived as having little to do with effectively managing care in the patients interests, but everything to do with managing costs and subsequently maximising profits.

Accordingly clinicians may be rightly concerned with respect to whether, Health Information Management Systems that propose to support "evidence based medicine" and "quality management" are not just Trojan Horses, implemented with purely financial goals that will lead to a state of "evidence bound medicine" (Orr, 2000).

It can be argued that in a fee-for-service environment concerns for patient privacy may be a smokescreen to prevent monitoring of over-servicing and over-investigation and subsequent over-claiming. Unfortunately this argument might have some credence, but hopefully it applies to only a small minority of clinicians.

The clinician population, just like the patient population, will have a spectrum of views and needs and behaviours with regard to their own personal privacy. The view that those who are doing nothing wrong have nothing to worry about may have some validity, but it does not dismiss the fact that some of those who have done nothing wrong will worry, or certainly will not enjoy or embrace their employing, funding or regulatory body's ability to closely monitor or control their behaviour.

Clinicians may rightly question a health information management system's capacity for "evidence building medicine", the potential to support research and effectively improve clinical processes from their perspective and to augment their clinical skill and professionalism.

Coiera and Clark (2003) have comprehensively described some of the parameters, complexities, and potential solutions for the concept of "e-consent" with regard to the handling of electronic patient information. It may be useful to focus on some of the perceived potential limitations or challenges of the concept (or more specifically the concept of so called "informed consent") in practice, when it interacts with the complex system of health and clinical care information flows and utilisation. As a context to this discussion, a series of perspectives, and metaphors about how the current health system (and particularly clinical practice) functions is presented.

Informed consent implies some form of formal risk benefit analysis; or at least that a patient is freely consenting to a particular action having been appropriately informed of the potential risks and benefits of such an action. In relation to an electronic Health Information System, informed consent can be used to imply that a patient, based on perceived privacy risk, should have the right to suppress certain information, or to prevent certain caregivers from viewing specific information. Additionally, to protect privacy, it can be argued the caregiver should be given no indication that information has been suppressed or is deliberately being withheld from their view. One argument that can be used for this is that patients have always withheld information from caregivers, and caregivers have always been willing to make incomplete notes on patient's request.

A caregiver utilises a Health Knowledge System with a view to making more effective or optimal decisions about a patient's care. A clinician may recognise that, just like a paper record, the electronic record may not always be complete accurate and timely. However is it acceptable for an employer to provide systems that can deliberately deceive or mislead a clinician by suppressing information, while giving no indication that information is being withheld?

Biopsychosocial Healthcare (Engel, 1977) should be related to Biopsychosocial Pattern Recognition. Healthcare that seeks to address a patient's illness or disease, not just as biological pathology, but within a psychosocial context, needs to have an understanding of that context. From an information system perspective, assistance with pathology recognition and general treatment advice may be helpful, for example if a patient presents with certain symptoms and signs, the clinician is provided with list of potential diagnoses and general investigation and management advice.

However, for optimal biopsychosocial healthcare, it is important to know an individual's specific risk profile and psychosocial circumstances, their coping mechanisms and supports and how they may have progressed and responded in the past, with the aim of facilitating individualised chronic care and task management. Pattern recognition and appropriate interventions are often related to subtle changes for that specific patient. Longitudinal history and knowing not just how a patient is presenting now but how they have presented and responded over time is one of the major benefits of a longstanding relationship between a patient and a trusted clinician.

In an environment where patient and clinician relationships may be increasingly fragmentary, with multiple short term interventions by multiple caregivers, a health knowledge system should seek to act as an organisational glue and organisational memory, holding together and integrating both the shared collective and longitudinal knowledge of a patient and appropriately co-ordinated responses.

A Health Knowledge System should aim to bring together as soon as possible the required "pieces" that will increase the "capacity to act" (Sveiby, 2001), or capacity to C.A.R.E. (that is the capacity to deliver in a coordinated fashion the integral clinical, administrative, research and educational functions of healthcare). Like a jigsaw, the more pieces already in place, the quicker it is to start seeing the overall picture and what pieces (areas) best to solve next. Indeed, in terms of biopsychosocial pattern recognition, a clinician may sometimes think they are working on putting together the pieces to build one picture, but get more pieces and realise they are actually working on another.

Media reviews of adverse events or deaths using a "retrospectascope" often see simple clarity where none was evident to clinicians involved at the time. Using the "retrospectascope" often one can see all the pieces of the jigsaw at a single place and point in time when in reality the pieces will have emerged from multiple sources over time. In reality, a clinician often needs to solve the jigsaw, as if riding around it in a roller coaster through a dark tunnel with only glimpses from different perspectives of not only the index problem, but multiple problems for multiple patients they may be being asked to solve at the same time.

A machine or computerised jigsaw, with increasing levels of intelligence, could bring pieces together for you, sort and frame pieces into groups and provide decision support telling you a piece is missing or a piece cannot go here as it does not fit with another (e.g., preventing medication errors). If you switch on the privacy mode of this "intelligent" jigsaw should it place mittens on you, slowing the problem solving process or say "sorry you cannot see that piece" or even withhold pieces without even telling you? There will undoubtedly be situations where the withholding of specific information from specific caregivers can be justified. However the concept of informed consent should at least seek to convey an understanding of not just the perceived privacy risks and benefits of information flowing or not flowing, but also the clinical risks and benefits.

However there are different perceptions or perspectives of what those risks and benefits are, and these can differ for each disorder, patient, caregiver, and can vary over time. For example information typically considered sensitive includes that related to infectious and sexually transmitted diseases, alcohol, and drug and mental health history and obstetric and gynaecological history (particularly in relation to induced abortion).

However some patients may consider, for example a family or personal history of carcinoma as, or more, sensitive while one clinician suggested he would be more worried about an insurance company (via their GP) checking his lipids. We also need to consider the time and resource implications of information flow "informed consent" processes and how realistic it is at the time of information collection to make decisions on all information collected in terms of its current and future information flows; for example, that information item A can go to Doctor A but not Doctor B or Nurse C, but item C can only be viewed by Doctor D. In the common situation of resource limitation and prioritisation it can be argued there may be a pragmatic need for "implied consent", with the patient having to actively indicate they want a particularly piece of information limited in its flow.

Similarly it can be argued that it is misleading to even attempt to utilise the concept of informed consent to imply that a health service can truly offer a patient the option of control over their information flows. There may be clinical, statutory, regulatory or financial requirements that require a clinician or health service to pass certain information or partial information to other bodies. A clinician or health service can do their best to make a patient aware of the nature and purpose of the information they are collecting and how it may be utilised, but it is misleading to imply that the patient has total, un-coerced control over that information, for which they can freely offer or withdraw consent.

Accordingly a patient may be advised that if they do not agree to their information being stored or shared in a particular way, the clinician or health service may not be in a position to offer them a service. The Foundation for Information Policy Research (Anderson, 2004) has criticised the draft UK NHS patient information sharing charter (NHS 2002) for including a statement of this nature that makes specific reference to the potential refusal of treatment, if a patient's decision to restrict information sharing, is considered to make them untreatable or their treatment dangerous.

Challenges to Privacy and Security Processes

Healthcare, and indeed human physiology and disease progression are increasingly recognised for their complexity and non-linear dynamics, where there are limitations for reductionistic views and solutions that do not or can not recognise or adapt to that complexity (Plsek & Greenhalgh, 2001; Goldberger, 1996). This section will not attempt an exploration of the theory or to utilise the formal language of non-linear dynamics, but again, through the use of metaphor and perspectives, aims to convey some of that complexity, particularly as it relates to privacy and security and the implementation of electronic health knowledge management systems.

Knowledge Neurones and the Therapeutic Knowledge Alliance

From a distance and at a fixed point in time clinical information may appear to be exchanged in a simple linear chain like fashion. For example, organisation or person A communicates with organisation or person B who communicates with organisation or person C, and all may be expected to exchange the same information in a standardised format.

Therefore conceptually, one might hope to control the flow of information by mapping these connections and asking a patient who trusted connections they consent or agree to have in their own particular chain and under what conditions information should flow along it. However in reality there are often a series of intermingling web-like connections, both within and between multiple organisations and their constituent individuals that are continually being realigned, reshaped and restructured over time. Additionally, as opposed to information being passed in a single standardised format, there are often different variants or segments of the information passed between each connection.

Knowledge Neurones

In addition to electronic health information systems storing text-based records clinicians utilise a multitude of other channels to transfer and manage health information. These include paper records, phones, personal digital assistants, pagers, voicemail, fax, e-mail, and not least conversation or personal and group interaction. Therefore, rather than being considered a simple link in a linear knowledge chain, a clinician can be considered as being at the centre of a multi-pronged spherical neurone like structure, with each prong representing a different channel through which they may connect with others, to push, pull, and produce knowledge.

Electronic health knowledge management systems may assist the clinician in the continuous process of integrating these multiple channels and adding or discerning intelligence. The clinician may strengthen or utilise more channels perceived to add value and ignore or weaken channels perceived to add less value. "Value" may be a function of perceived ability to integrate and add intelligence, and can vary by individual, context, and time.

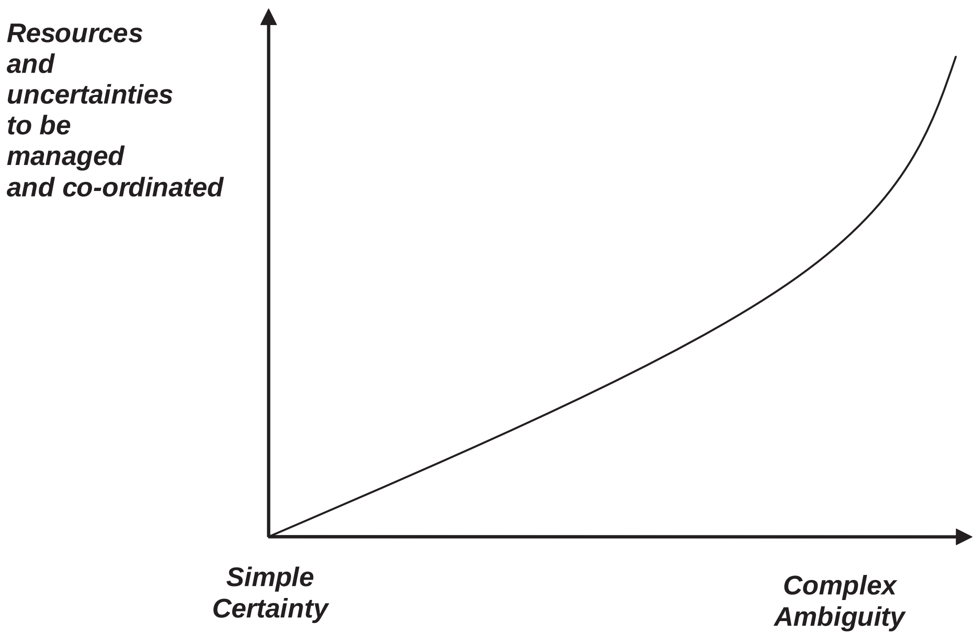
Historically the "therapeutic alliance" concept has had an evolving meaning, but carries the sense of clinician and patient working together (Goldstein, 1999). Similarly, the earlier definition of a health knowledge management system attempted to convey the sense of GPs, allied health services, and patients and their supports all working together. We could consider each of these groups as forming their own knowledge neurones and conceptualise a "therapeutic knowledge alliance" comprising of a web of these interweaving knowledge neurones, all supporting each other and working together to make a healthy difference.

Healthcare may involve a spectrum of clinical presentations or scenarios that have to be managed, which can be described as simple certainty to complex ambiguity (Figure 4). The range from simple to complex relates to the number of caregivers and interventions that may have to be coordinated in a patient's care in relation to their condition or multiple conditions. Certainty to ambiguity relates to the degree of perceived accuracy or certainty with regard to the diagnosis or diagnoses and the potential effectiveness of interventions or treatments.

Traditionally, as clinicians have moved from simple certainty to complex ambiguity, they have utilised an increasing array of resources within their therapeutic knowledge alliance. This typically includes their multidisciplinary team colleagues directly involved in the patient's care in the form of ward rounds or case conferences, but can also involve de-identified case presentations, to non-involved peers or senior colleagues for support and advice on how to best manage this complexity and ambiguity.

The quest for increasingly highly structured data runs the risk of adopting a cloak of scientific certainty that loses the art of dealing with this often-prevalent complex ambiguity in clinical practice. A specialist may have more factual knowledge or skill in a particular clinical area

Figure 4. Resources and uncertainty to be managed with increasing complexity and ambiguity



than a generalist or someone in training, but it is often their ability to recognise, adapt and cope with what they do not know, or what is not initially clear that provides their particular value. A patient's presentation may not fit neatly into a specific textbook or diagnostic category, but a specialist may say to a referrer: "I have a sense this patient may be suffering from condition A or maybe B; however, I do not know the exact answer either, but let's monitor and manage the situation this way." Similarly, the value in sharing a case with colleagues is often not so much that they provide an immediate diagnosis or recommend you dramatically change the management, but more that they provide support and contain anxiety that you have not missed anything obvious, and that you are taking a course that would best manage a range of possibilities that may become evident over time (Smith, 1996).

Intuition and learning from experience to cope with complex ambiguity is an aspect of the art of medicine that could arguably be just sophisticated learned pattern recognition and risk management that is and will be increasingly codifiable in electronic form. Indeed, a central aim of an electronic health knowledge management system should be to enhance and develop the capability of the health system and the individuals within it, to adapt and cope with varying degrees of complexity and ambiguity. However, at present there is a need to recognise the relative limitations of structured electronic data and guidelines, for dealing with complex ambiguous clinical scenarios, and to recognise the current reality of how clinicians cope with that complex ambiguity (Figure 5).

The above section and Figure 5 refer to the increasing relative utility of the wider therapeutic knowledge alliance versus structured data and

Figure 5. Therapeutic knowledge alliance versus structured data and guidelines

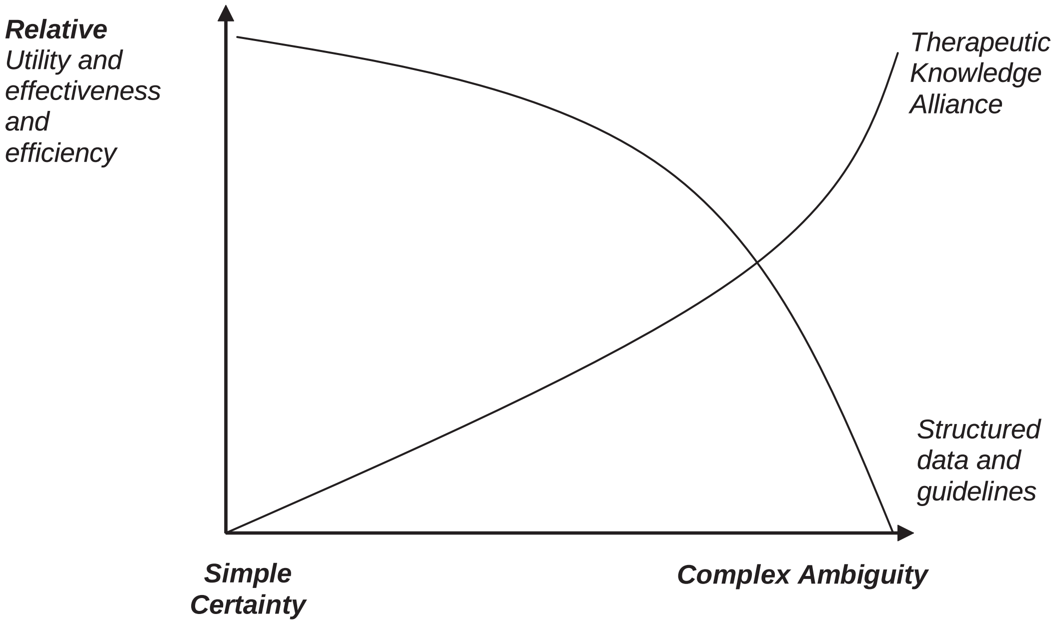
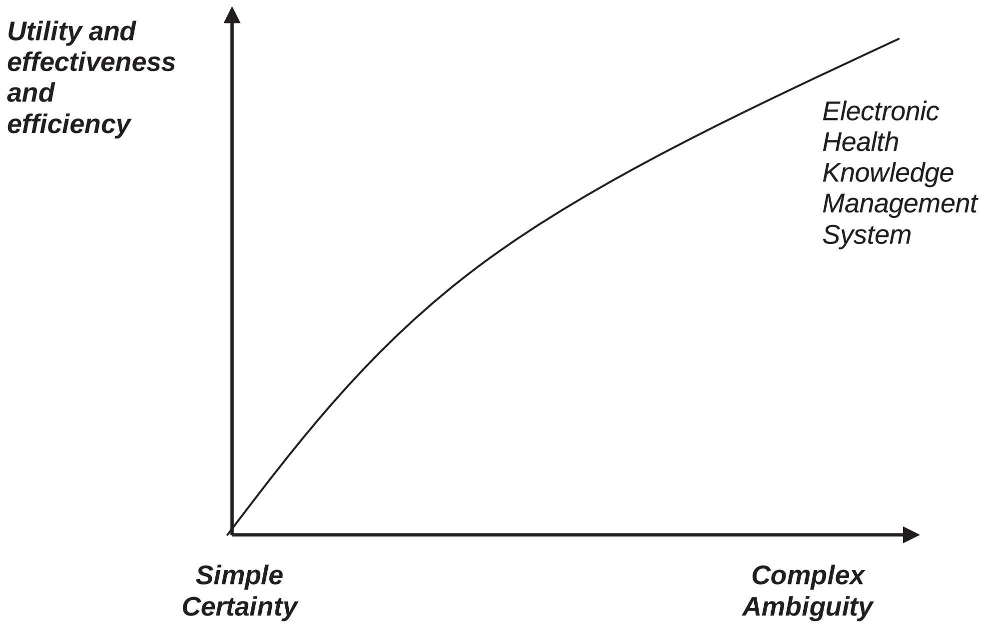


Figure 6. Utility of an electronic health knowledge management system in clinical scenarios of increasing complexity and ambiguity



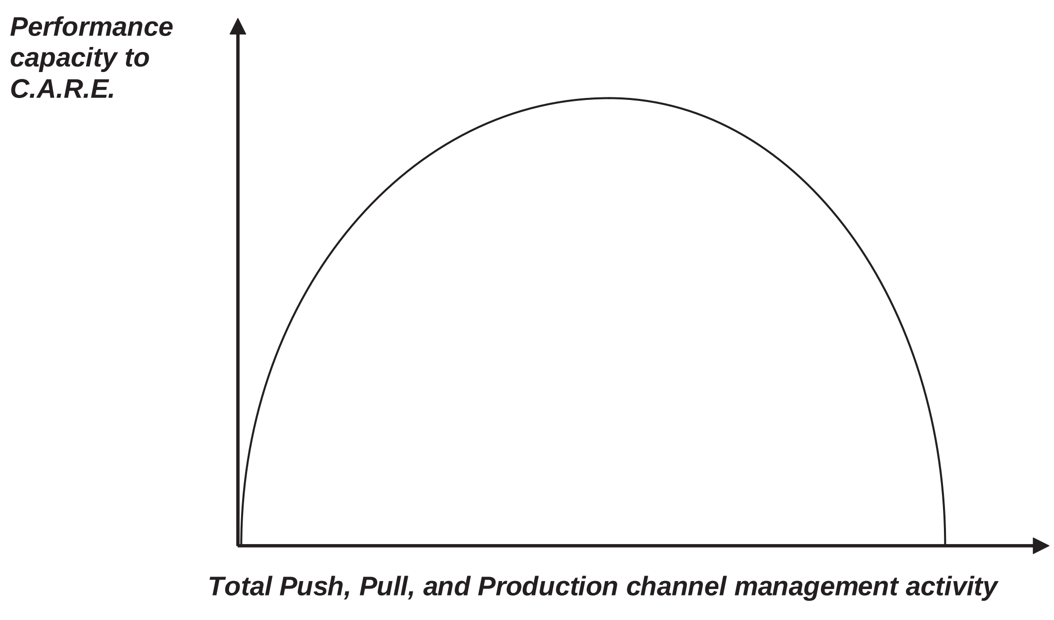
guidelines when dealing with increasing levels of complex ambiguity. However, this of course does not infer no utility. An electronic health knowledge management system, particularly one focused on care coordination management, could be of increasing utility, effectiveness, and efficiency in helping manage complex ambiguous health scenarios (Figure 6).

Channel Management and the Therapeutic Knowledge Alliance

Many Information System developments may just add additional channels to manage, diluting limited resource and consuming more time and may not be of immediate perceived benefit. The clinician may have to utilise multiple poorly integrated channels, with the concern that increasing levels of non-productive channel management activity may lead to decreased performance across the range of clinical, administrative, research, and educational activities. Privacy and security interventions should aim to optimise performance and minimise the level of associated channel management activities that may lead to decreased performance (Figure 7).

Senior clinicians' failure to use electronic information systems to the same degree as their junior colleagues is often attributed to their reluctance or fear of change or technology, when the reality may be they have established channel management methods that are more productive and efficient in terms of their limited time. The clinician, rather than seeking or entering data on a computer, may perceive the most efficient use of their time may be to seek information from a trusted colleague who can integrate, and quickly add intelligence or make sense of the data, or may communicate with a trusted individual verbally to carry out some recommended course of action. A telephone or face-to-face interaction may be perceived as a more effective way to clarify ambiguity and convey knowledge not easily structured

Figure 7. Performance versus channel management activity



or codified, and come to a shared understanding on the course forward.

Elevator, Corridor and Coffee Table Conversations

There have been longstanding concerns with regard to clinicians discussing patient information in public places, where they can be overheard (Vigod, Bell & Bohnen, 2003). A lack of respect or appreciation of patient confidentiality may be one facet of this behaviour. However within the concept of the therapeutic knowledge alliance we also need to consider some of the other drivers. These include the increasing mobility and fragmentation of the workforce and use of mobile communications and the decrease in segregated or dedicated space for clinicians. The clinician may be answering an urgent cell phone or pager call, or these locations may be one of the few contexts in which they perceive they can access a colleague or group of colleagues in a timely fashion to discuss or seek advice or support on a patient's care.

In terms of advising a patient on the risks and benefits of limiting their health information flow, there are limitations as to how much we can identify what will be the high value information, result, channel or knowledge neurone within the caregiver's therapeutic knowledge alliance that may facilitate the patient's healthcare at a future stage. Rather than denying or trying to close down the therapeutic knowledge alliance, we should increasingly recognise the centrality of patients and their supports within it, in terms of building trust and recognising and managing the complexity and ambiguity of their healthcare.

The Shift from Passive Decision Support to Active Autonomous Intervention

Many health systems worldwide are currently implementing electronic health knowledge management systems introducing various levels of electronic passive to active decision support. Oncken (1999) has described the concept of levels of initiative as applied to people. Similarly to the Oncken concept, we can expect to see the development of increasing levels of initiative and autonomous intervention by the computer or machine:

1. Online patient data and online textbooks which user has to actively seek out;
2. Computer generated prompts asking whether you would like to go and look at more information on a particular subject, for example, in the form of a hypertext link;
3. General suggestions automatically provided as information, or guidelines, for example, general drug or evidence based medicine disease management information;
4. Specific optional recommendations automatically provided. These may outline a specific course of action, but can be over ridden by various levels of clinician justification with clinician still effectively making decision;
5. Mandatory recommendations automatically provided. These, for example, may relate to preventing life threatening drug interactions, or allergic reactions. Here the system or machine can be viewed as moving from realm of decision support into realm of decision making, (if only under mandate of an overarching organisational protocol);
6. The machine, only if specifically told or requested, will utilise data to make a decision, which the machine rather than the clinician then acts on;
7. The machine, automatically utilises data to make a decision, which it then acts on, but advises clinician on all actions immediately;
8. The machine, automatically utilises data to make a decision, which it then acts on,

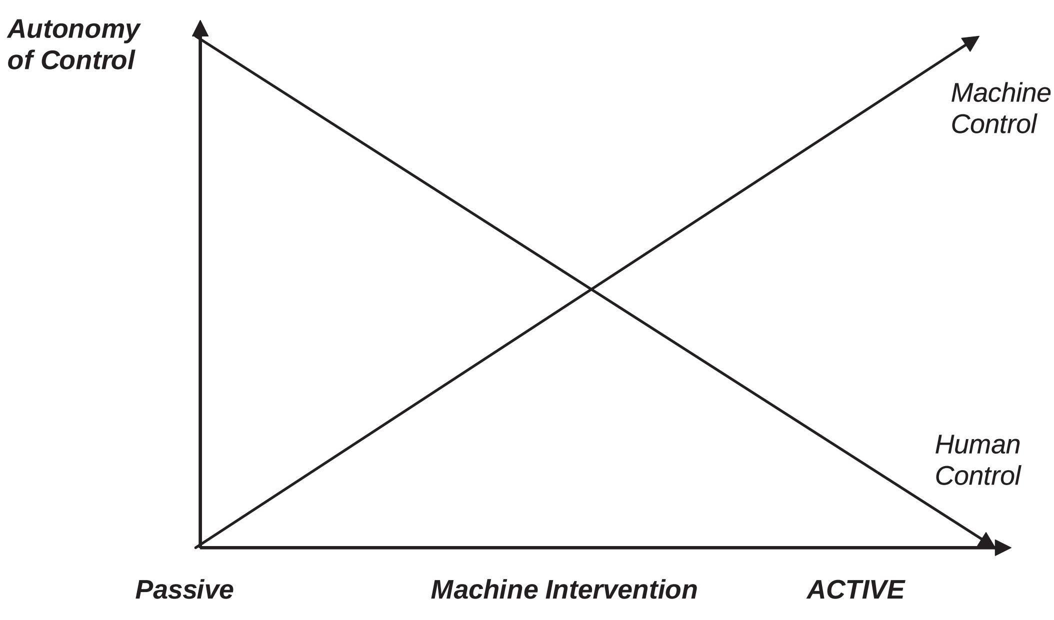
but clinician only advised immediately if exceeds certain parameters;

9. The machine automatically utilises data to make a decision which it then acts on, and reports to clinician at certain agreed periods; and
10. The machine automatically utilises data to make a decision, which it then acts on, with no active feedback to clinician.

Moving along this spectrum, there is a progressive increase in machine control and decrease in immediate human control (Figure 8). The clinical user is given increasing levels of active advice and overview by the machine, in terms of patient data and specificity of medical evidence and treatment recommendations, while the machine gets decreasing levels of active immediate advice and overview of its use of patient data by the individual clinician user. In general relatively few Health Knowledge Systems have reached level 3, but there is the capacity for this to change rapidly with significant privacy and security implications. For example, what are the privacy and security implications of a "booking system" that could draw data from several sources and act on its own to decide on suitability or eligibility, and then instigate certain forms of care?

Pragmatically this increase in the machine's capacity to act will be limited by the difficulties in coding for the complexities of the health environment. However, as the machine becomes less dependent on immediate human overview, there will be an increasing need to consider the risks and benefits in respect of privacy and security. The lack of overview, and integrity of the data and processes by which decisions are made, will be a significant issue. However possibly of greater moment, will be how we perceive, value, or balance the impartiality versus heartlessness of a

Figure 8. Machine versus human control



machine accessing our health information and making decisions based on protocols.

Internationally, there is a growing awareness of the need for information system developments to undergo a Privacy Impact Assessment, underpinned by a state sanctioned privacy code (Slane, 2002). For example the New Zealand Privacy Impact assessment recommendations and underlying code sets out a number of principles in relation to unique identifiers, the purpose, source, and manner of collection, storage, security, access, and correction, and limits on storage, use, and disclosure of personal information.

Internationally similar principles or rules are common to a myriad of legal, professional, and research codes and acts that relate to the collection, storage, and utilisation of health information.

Assessing the impact, or future consequences of current actions, presents a particular challenge for health knowledge systems. The risk-benefit equation, used to assess how certain information is handled may change over time and we have to question how far forward we can see, or how far forward we are expected to see.

PRIVACY AND SECURITY OBJECTIVES

Privacy and security developments may be focused on addressing a number of key objectives or concerns including medico-legal or patient trust or confidence concerns, within the context of a belief that better integrated information will lead to better integrated care for our communities. However what is perceived best by or for an individual may be in conflict with what is perceived as best for the community.

Each clinician and health service, depending on their location may be conceptually subject to a multitude of privacy and security codes and laws, for which in reality at the clinical coal face there is only limited compliance due to various combinations of lack of knowledge, attention, priority, will, ability, or perception of unacceptable costs and burden. There may be broad agreement that patient privacy should be protected, but a range of views as to what that pragmatically can or should mean in practice and how much any law or code may achieve this. For example, Marwick (2003) outlines similar views and responses as having greeted the introduction in the USA of the privacy rule of the Health Insurance Portability and Accountability Act.

However health organisations need to increasingly strive to create a culture that respects and protects health information, and seek to demonstrate and reinforce that culture through a number of basic or initial communication, human resource or technical steps. These include creating with, and communicating to, their communities clear open policies around the nature and purpose of health information flows and utilisation.

These include the risks and benefits of information flowing or not flowing and respective privacy versus sub-optimal care risks .In pragmatic terms this may take the form of conversations, leaflets, posters or web-sites.

Human resource processes may include training and development and professionalisation of all healthcare workers in terms of their attitude to health information and clear disciplinary procedures for malicious use. Anderson (1996) has highlighted the importance of training and procedures for the high-risk area of providing patient information on the telephone. Davis, Domm, Konikoff and Miller (1999) have suggested the need for specific medical education on the ethical and legal aspects of the use of computerised patient records.

Technical processes may include ensuring that an electronic information system has at least an audit trail that allows who has viewed or accessed a particular piece of health data to be monitored, providing some degree of psychological reassurance to patients and psychological deterrence against malicious use.

While having highlighted some of the concerns around restriction of information flows, particularly if the clinician is not advised of the suppression there is of course a place for restricted access for sensitive information. This may include allocating graded access levels to certain categories of information and graded access levels for providers or users, with the user only able to access information for which they have an appropriate level of clearance. The system may also include a "break glass" or override facility for emergencies, which allows access to restricted information, but triggers a formal audit or justification process. Denley & Smith (1999) discuss the use of access controls as proposed by Anderson (1996).

However for all these processes we can predict an inverse relationship between complexity and utility (and subsequent uptake or compliance). When planning privacy or security developments, we should strive to make it easier to do the right thing. This can include making login processes as fast and intuitive as possible, so as to decrease the behavioural drivers for clinicians to leave themselves logged in, or the sharing of personal or generic logins or passwords. With unlimited resource or the passage of time and decreasing costs, this may mean installing the latest proximity login or biometric authentication device that can log a clinician in or out as they move towards or away from a information access point, with instantaneous fingerprint or retinal scan verification. However initial steps may involve configuring systems so they minimise the login time, and developing fast, intuitive, and clearly understood administration systems for the issuing (and terminating) of logins or passwords so that new or locum clinicians can immediately access systems without having to utilise generic logins or "borrowing" other clinicians logins.

Our vision may be to make a healthy difference by facilitating the development of Health Knowledge Systems that help us provide safe and effective integrated care, within a culture that respects and protects both the value and privacy of health information. However recognising the difficulties of implementing an information system within the complex health environment (Heeks, Salazar & Mundy 1999), each step or building block towards attaining that vision , including privacy and security developments, needs to be SAFE: Scalable (while retaining usability and implementability), Affordable (in terms of resource time and risk); Flexible (enough

Table 2. SAFE-diffusibility factors

SAFE-Diffusibility factors	
Scalable	Retaining implementability / usability (Fast, Intuitive, Robust, Stable, Trustworthy)
Affordable	Resource/Time/Risk
Flexible	Individual/Local/National needs
Equitable	Perceived Equity/Relative Advantage

to meet individual, local and national needs) and Equitable (in that potential stakeholders perceive a relative advantage for them in terms of adopting the change or development) (Table 2).

FUTURE TRENDS

As we look to the future we can expect to see both increasing perceived benefits and privacy and security concerns with respect to data mining and risk profiling particularly genetic and geographic profiling, and increasing attention to the related actions of insurance, financial, and health organisations and government. We can expect to see greater use of technology in the provision of healthcare and broadening of the therapeutic knowledge alliance, both at the triage stage via call centres and so on to the chronic care management stage with the increasing use of texting, email and web broadcast reminders, as well as web based patient self evaluation and shared or self management.

With an increasingly elderly population, and corresponding ageing and diminishing healthcare provider population, we can also expect to see more healthcare workers working from home. While minimising the importance of travel distance to work and retaining the ability to for example support their own children or elderly parents at home, healthcare teleworkers will have an increasing technology based capacity to provide triage functions, telemonitoring of essential functions, parameters or progress, or telepresence while patients for example take medication or monitor their blood glucose level.

There will be ongoing debate around the issue of anonymity and the correlation and matching of data across databases. While there may be a current public focus on privacy or confidentiality issues, as health services become more dependent on electronic systems, we can expect a greater media, public, and clinician appreciation for the integrity and availability aspects of information system security. This would be true particularly if there were a major system availability failure causing at best major inconvenience or disruption; or if a data integrity error were to lead to a significant adverse event or sub-optimal care.

There is a need for ongoing iterative research into the identification and minimisation of privacy and security risk and the effective implementation of a local and national culture that respects, protects, and values health information. There is also an ongoing need for research into the public's views on health information privacy and security, and the priortisation of limited health resource. In the UK the NHS has published some work in this area (NHS Information Authority, 2002) but the methodology and results reporting have been criticised as unbalanced and misleading (Anderson, 2004).

There has been an underlying argument or assumption throughout this chapter that electronic health knowledge management systems providing better integrated information will lead to better integrated care and outcomes for our communities. However it has to be recognised that this is another area that requires ongoing research and development as there are still significant limitations and challenges to the evidence base of widespread successful implementations of electronic systems that make a cost effective positive impact on patient care and outcomes (Heeks et al, 1999; Littlejohns, Wyatt & Garvican, 2003; Ash, Berg & Coiera, 2004; Ash, Gorman, Seshdri & Hersh, 2004).

Unique identifiers will continue to be a cause for concern, and resistance in some countries, however whether through incremental stealth or necessity in combination with increased implementability, we can expect to see their wider use. Also we can expect the increasing use of unique clinician identifiers, which although facilitating the development of electronic ordering and task management systems may also be perceived negatively as a method to monitor, micromanage and restrain the clinical workforce. We can also envisage the increasing use of both patient and clinician unique identifiers linked to global positioning systems or tracking technologies, which although having potential benefits for both patient and clinician safety and resource management could also be perceived similarly negatively.

While we may initially see increasing integration between General Practitioners or primary care and allied healthcare or hospital services, over time we should expect increasing integration of patients and their supports into the health knowledge management system. These developments will increasingly highlight data availability and integrity, including who should have the right to access or view versus who should have the right to make entries or change data.

We may also see a movement from electronic decision support to decision making to autonomous active intervention, which will have significant implications for privacy and security.

We will also increasingly have to recognise that within our communities there will be a spectrum of different needs and ability to participate in and benefit from these technological developments together with an increasing knowledge gap between those that have and those that do not have the required technology to access the therapeutic knowledge alliance.

Should a health service spend limited resource on creating and maintaining complex email or web based assessment or self management channels that the most deprived or in need are least able to access? These complex systems may clearly be of benefit, but are potentially of greatest benefit to those already most able to advocate for themselves and access the resource. Subsequently we will need to continuously revisit the question of, what are the needs of our community and how can we best met those needs with limited resource? Should the more complex, resource intensive systems be provided on a user pays or targeted basis? Should a health service focus largely on the channels most accessible to most people, or the channels most appropriate for those sub groups with the greatest levels of deprivation and identified need? When considering the Therapeutic Knowledge Alliance, as a whole and not just electronic channels, the wider security issues of "integrity" and "availability" still need to be considered. Getting clinicians out into deprived communities, making "available" an "interpersonal" rather than "electronic" channel in the therapeutic knowledge alliance may be the most effective way to ensure data "integrity" and identify and address unmet needs.

CONCLUSIONS

Health information privacy and security is an area of at times, strongly held and diverse perspectives. The focus of this chapter has not been on supporting or refuting a single view, but introducing a range of perspectives (even if they challenge my innate clinician bias) and argue for balance and shared understanding. Privacy risk is not a single simple definable entity, but instead complex and multidimensional with quantitative and qualitative perceptual aspects, dynamically changing over time as various factors along the knowledge chain interact, change and possibly compete. Clinicians and patients and the wider community of healthcare stakeholders may vary markedly in their perceptions of privacy risk, particularly when compared to the sub-optimal care risk that may arise from the non flow of health information.

Knowledge management and data mining techniques, provide an opportunity to utilise large clinical data repositories to identify trends and patterns and "risk". This ability to identify risk can be perceived as a double edged sword. It can be used positively to promote or support further research and lead to changes in clinical processes and effective targeting of efficacious and cost efficient interventions; or could be used negatively to discriminate with potential perceived consequences ranging from increased insurance premiums, to refusal of insurance and health cover, mortgages or employment and the creation of an uninsurable, unemployable "under-class", to fears with regards to persecution from totalitarian regimes.

Sporadic incidents or reports of illegal "hacking", or privacy infringement of individual patient records by healthcare workers out of carelessness, malice or pecuniary gain will remain of concern. However as a community looking to the future, we should be possibly more concerned for potential frequent legal and systematic uses of health information that lead to discrimination by insurers, employers or indeed government agencies.

Before designing "privacy" solutions it is important to be clear on privacy risks and priorities (whether medico-legal concerns, deterring malicious access or use, or the increase in patient trust) and how any solution will contribute to or deter from providing better integrated information for better integrated care. Technical processes, such as firewalls, restricted access and audit trails, can provide important physical and psychological deterrents to malicious use and psychological reassurance to patients. However significant risk is likely to lie beyond the protection of our technological armour and within the behaviour of end users.

Pragmatic "privacy" solutions focused on end user behaviour can include making login processes as fast and intuitive as possible, (decreasing behavioural drivers to leave self- logged in or to share logins), privacy training and clear censure processes for malicious use.

There is a need for shared zones or models of acceptance within our communities, with regard to privacy risk, sub-optimal care risk and information flow. In building a shared zone of acceptance, we need to appreciate the complex ambiguity of many aspects of healthcare, and the non linear nature of the therapeutic knowledge alliance, and the need to integrate patients and their supports within that alliance. Recognising the difficulties of implementing change within the complex health system, we need to adopt an incremental iterative S.A.F.E. (Table 2) stepping stone ,or building block approach ,reflecting on and learning from each intervention, and progressively adapting to our changing context or understanding of that context.

Within an environment of limited resource, we need to recognise the diminishing returns or additional benefit we may receive for each unit of expenditure, and how individually worthy needs may have to be balanced against each other for an optimal outcome for our communities. Electronic developments may certainly assist with data confidentiality, integrity and availability, but education and the "professionalisation" of all health knowledge system users, (clinical, non-clinical staff, patients and supports), is possibly more important.

Clinicians and health services will increasingly need to "respect, value and protect" health information if they are to maintain patient confidence, and the comprehensiveness and integrity and validity of information volunteered by patients for entry into electronic systems. However potentially of greater risk is not clinicians or health services' use of patient data or an electronic health knowledge management system , to carry out their integral clinical, administrative, research and educational roles, but how much that data is respected, valued and protected within wider society. If the fears of discrimination and creation of an uninsurable, unemployable underclass come to pass it will be the result of individual and collective actions of all us. The simple individual action of for example accepting cheaper insurance or health premiums as we are in a highly identifiable low risk group, without at least recognising that our gain is someone's loss; the collective action of governments failing to legislate to protect against discrimination, and to provide a safety net for those most vulnerable.

Assessing or predicting the impact or future consequences of current actions will remain an ongoing challenge for health knowledge management system developments. We may certainly carry out Privacy Impact Assessments and risk benefit analysis, based on our current knowledge and context. However, as a global community, it is likely that the challenges of grasping the double-headed sword of electronic health knowledge management systems have only just begun.

REFERENCES

Anderson, R. (1996). Clinical system security: Interim guidelines. *British Medical Journal 312,* 109-111.

Ash, J.A., Berg, M., & Coiera E. (2004). Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *JAMIA. 11*:104-112. First published online as doi: 10.1197/jamia.M1471.

Ash, J.A., Gorman, P.N., Seshadri, V., & Hersh, W.R. (2004). Computerized physician order entry in U.S. hospitals: Results of a 2002 survey. *JAMIA, 11,* 95-99. First published online as doi:10.1197/jamia.M1427.

Berger, R.G., & Kichak, J.P. (2004). Viewpoint paper: Computerized physician order entry: Helpful or harmful? *JAMIA 2004, 11,* 100-103. Pre-Print published November 21, 2003; doi:10.1197/jamia.M1411.

Black, E. (2001). *IBM and the Holocaust: The strategic alliance between Nazi Germany and America's most powerful corporation.* New York: Crown Publishers.

Coiera, E. & Clarke, R. (2003) "e-Consent": The design and implementation of consumer consent mechanisms in an electronic environment. *JAMIA, 11*(2), 129-140. Pre-Print published March 1, 2004; doi:10.1197/jamia.M1480.

Davis, L., Domm, J.A., Konikoff, M.R., & Miller, R.A. (1999). Attitudes of first year medical students toward the confidentiality of computerised patient records. *JAMIA, 6*(1).

Denley, I., & Weston Smith, S. (1999). Privacy in clinical information systems in secondary care. *British Medical Journal, 318*, 1328-1331.

Engel, G.L. (1977). The need for a new medical model: A challenge for biomedicine. *Science, 196* (4286).

Etymology Dictionary (2001). Retrieved March 2004 from http://www.etymonline.com

Gerritsen, T. (2001). *The surgeon*. London: Bantam Books.

Goldberger, A.L. (1996). Non-linear dynamics for clinicians: Chaos Ttheory, fractals, and complexity at the bedside. *The Lancet, 347*(9011).

Goldstein, W. (1999). Dynamically based psychotherapy: A contemporary overview. *Psychiatric Times, XVI*(7).

Heeks, R., Mundy, D., & Salazar, A. (1999). *Why health care information systems succeed or fail. Information systems for public sector management.* Working Paper Series, paper no. 9. Institute for Development Policy and Management, Manchester, UK.

Kennedy, H. (2004). Stop taking uncivil liberties with DNA. *New Scientist*, 2439.

Littlejohns, P., Wyatt, J.C., & Garvican, L. (2003). Evaluating computerised health information systems: Hard lessons still to be learnt. *British Medical Journal, 326*, 860-863.

Maslow, A.H. (1943). A theory of human motivation. *Psychological Review, 50*, 370-396.

NHS Confidentiality Consultation (2003). FIPR (Foundation for Information Policy Research). Retrieved March 2004 from http://www.cl.cam.ac.uk/users/rja14/

NHS Information Authority (2002) *Draft: National patient information sharing charter.*

Retrieved March 2004 from http://www.nhsia.nhs.uk/confidentiality

NHS Information Authority (2002). *Share with care! People's views on consent and confidentiality of patient information.*

Oncken III, W. (1999). Having initiative, executive excellence. *Provo, 16*(9), 19.

Orr, M. (2000). *Implementation of health information systems: Background literature review.* MBA research dissertation, Southern Cross University.

Plesk, P.E., & Greenhalgh, T. (2001). The challenge of complexity in health care. *British Medical Journal, 323*, 625-628.

Roger Clarke's Web site (n.d.). Online http://www.anu.edu.au/people/Roger.Clarke/

Ross Anderson's Web site (2004). Online http://www.cl.cam.ac.uk/users/rja14/

Slane, B.H. (2002). In *Forward to Privacy impact assessment handbook.* Wellington, New Zealand: Office of the Privacy Commissioner.

Smith, R. (1996). What clinical information do doctors need? *British Medical Journal, 313,* 1062-1068.

Standards Australia (2001). *Knowledge management: A framework for succeeding in the knowledge era.* HB275.

Standards Australia/Standards New Zealand (2001). *Information technology – Code of practice for information security management,* AS/NZS ISO/IEC 17799:2001.

Sveiby, K-E. (2001). *Knowledge management – Lessons from the pioneers.* Online http://www.sveiby.com/KM-lessons.doc

Tang, P.C. (2000). An AMIA perspective on proposed regulation of privacy of health information. *JAMIA, 7*(2).

Wyatt, J. (2001). Top tips on knowledge management. *Clinical Governance Bulletin, 2*(3).

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Chapter 4.49
Knowledge Management Systems for Emergency Preparedness:
The Claremont University Consortium Experience

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ABSTRACT

This article is about the design and implementation of an information system, using Wiki technology to improve the emergency preparedness efforts of the Claremont University Consortium. For some organizations, as in this case, responding to a crisis situation is done within a consortium environment. Managing knowledge across the various entities involved in such efforts is critical. This includes having the right set of information that is timely and relevant and that is governed by an effective communication process. This study suggests that Wiki technology might be useful to support knowledge management in the context of emergency preparedness within organizations. However, issues such as training in the use of a system(s), a knowledge-sharing culture among entities involved in emergency preparedness, and a fit between task and technology/system must be there in order to support emergency preparedness activities that are given such structures.

INTRODUCTION

Research about emergency management information systems has accelerated since the September 11, 2001 events (Campbell, Van DeWalle, Turoff & Deek, 2004). However, researchers do not use a common terminology to describe emergency management information systems. Jennex (2004, 2005), for instance, calls these systems emergency information systems (EIS). Campbell et al. (2004) use the term emergency response systems. Turoff (2002) uses the term emergency response management information systems (ERMIS) and extends this idea to the notion of a dynamic emergency response management information system (DERMIS) (Turoff, Chumer, Van De Walle & Yao, 2004). Nevertheless, the majority of the researchers in this area seem to agree that, despite different naming conventions, emergency management information systems should be designed to support emergency preparedness and to guide effective response during an actual crisis situation. In addition, although researchers explicitly do not link the idea of emergency management information systems to knowledge management, the influence of the latter on emergency management systems is evident in the literature.

This article presents a case study about the implementation of a Web-based knowledge management system to support the Claremont University Consortium (CUC) and the Claremont Colleges, in general, in emergency preparedness. The academic nature of this study centers on how an information system (specifically, a knowledge management system) can improve emergency preparedness within a consortium environment. The practical nature of the research concerns how CUC was made more ready to respond to and recover from emergencies that it might experience.

This study suggests that Wiki technology might be useful to support knowledge management in the context of emergency preparedness within organizations. However, issues such as training in the use of a system(s), a knowledge-sharing culture between entities involved in emergency preparedness, and a fit between task and technology/system must be there in order to support emergency preparedness activities given such structures.

Turoff, et al. (2004) take a design stance in discussing emergency management systems. We suggest that design of any emergency management system can be tied to knowledge management principles. In addition, our findings suggest that, in addition to design, issues such as training with technology fit between tasks and technology and the existence of a knowledge-sharing culture are crucial when an organization intends to implement a knowledge management system to support emergency preparedness efforts.

The article proceeds as follows. Section two provides a snapshot of literature relevant to our study. Section three presents the methodology used, with emphasis on the case setting and the problem domain therein. Section four discusses how Wiki technology was used as an instantiation of a knowledge management system to overcome some of the emergency preparedness issues within the Claremont Colleges. Section five presents an evaluation of the system, which is presented in the form of qualitative data. The article ends with a discussion of how our findings might impact knowledge management theory and practice in the context of emergency preparedness.

RELEVANT LITERATURE

A knowledge management system in this study refers to any Information Technology (IT) based system that is “developed to support and enhance the organizational knowledge processes of knowledge creation, storage, retrieval, transfer and application” (Alavi & Leidner, 2001, p. 114). Gupta and Sharma (2004) divide knowledge management systems into several major categories, as follows: groupware, including e-mail, e-logs, and wikis; decision support systems; expert systems; document management systems; semantic networks; relational and object oriented databases; simulation tools; and artificial intelligence.

Jennex (2004) defines an EIS as any system that is used "by organizations to assist in responding to a crisis or disaster situation" (p. 2148). He further adds that an EIS should be designed to (1) support communication during emergency response, (2) enable data gathering and analysis, and (3) assist emergency responders in making decisions.

Lee and Bui (2000) document vital observations about the use of EIS during the massive earthquake that hit the city of Kobe, Japan, several years ago. Key lessons for emergency management systems designers that are based on Lee and Bui's (2000) work are as follows:

- Relevant information should be included in the emergency response system prior to the actual disaster situation. This is to ensure that emergency responders have sufficient information to guide decision-making processes when responding to an emergency. The authors imply that the task of gathering relevant information to support emergency response should be incorporated as part of the emergency preparedness strategic initiative.
- Information from prior experiences should become part of the emergency management system. The system somehow should be able to capture both tacit and explicit knowledge about how prior crisis situations were handled. Lessons learned can be used to guide future action. The authors in this regard imply that the design of any emergency preparedness system should support some form of organizational memory component.

In addition to designing relevant systems features to support emergency planning and response, researchers suggest that successful implementation of any emergency management system is contingent on how well people are trained to use such systems (Lee & Bui, 2000; Patton & Flin, 1999; Turoff, 1972). Turoff, et al. (2004) state that emergency management systems that normally are not used will not be used when an actual emergency situation occurs.

In summary, researchers indicate that emergency management information systems should support the following features inherent in any knowledge management system: (1) enable individuals and groups to create, share, disseminate, and store knowledge (Turoff, 1972; Turoff et al., 2004); (2) offer the ability to document experiences and lessons that have been learned to form the overall organizational memory for dealing with crisis situations (Lee & Bui, 2000); (3) support asynchronous and collaborative work (Campbell et al., 2004); (4) provide emergency response-related information that is relevant, accurate, and presented in a timely manner (Jennex, 2004; Turoff, 1972; Turoff et al., 2004); and (5) enhance the overall communication process among people involved in emergency preparedness and response by inserting more structure into the manner in which information is organized and documented (Turoff, 1972; Turoff et al., 2004).

METHODOLOGY

This article uses canonical action research to conduct this study (Davidson & Martinsons, 2002; Lindgren, Henfridsson & Shultze, 2004; Susman & Evered, 1978). Both qualitative and quantitative data were collected and analyzed throughout the research process.

One of the authors worked for CUC for three years as the Emergency Management Assistant. The research process in canonical action research starts with the involvement of the researcher with an identified organization. This is followed by the problem diagnosis by the researcher to determine issues and challenges faced by the organization.

The diagnosis leads to action planning; that is, a formal proposal is made to the client/organization in terms of a proposed solution/system. Upon approval by the client, the proposed solution is implemented. Action or intervention then occurs. Evaluation and reflection of the solution/system that is implemented then is conducted.

The Case Setting

The Claremont University Consortium (CUC) provides services to the seven members of the Claremont Colleges1 by operating programs and central facilities on their behalf. Each college maintains its own emergency preparedness plan. Every plan calls for the activation of a college-level emergency operations center (EOC) in the event of an emergency. The Multi Agency Coordination Center (MACC) exists to coordinate responses among the seven colleges and CUC. MACC's action plan is guided by the Claremont Colleges Emergency Preparedness Plan. This plan defines an emergency as preparing for and responding to any situation "associated with, but not limited to, disasters such as earthquakes, life threatening incidents, terrorist attacks, bio-terrorism threats and other incidents of a similar capacity" (p. 1).

MACC is a group that becomes active whenever emergencies occur at any of the colleges and at CUC that could impact any one or more of the consortium members. It is intended to (1) coordinate among the colleges and external agencies, (2) prioritize and fill requests for assistance from central resources, and (3) assist the colleges in returning to normalcy as soon as possible.

The Problem

Prior to embarking on the systems design and implementation initiatives, interviews were conducted with nine representatives from five colleges and CUC who were involved in emergency preparedness. Through these interviews, it was found that the top three issues pertaining to emergency preparedness at CUC (and within the Claremont Colleges at large) are (1) communication between college level EOCs and the MACC, both before and during an emergency can be improved; (2) coordination between CUC and college-level EOCs, in terms of activities and overall efforts in preparing for an emergency, can be enhanced; and (3) emergency related information/knowledge could be shared seamlessly. This includes access to information about drills; policy documentation; emergency notification protocols; access to college level emergency plans; and status and availability of emergency resources such as debris removal equipment, housing, and medical expertise. The following statements offer several examples:

Communication issues across the colleges in terms of who knows what, when they know it is vital, but I don't think that we are there yet. For example, in a recent incident, I was informed after five hours only. So communication is an issue. My struggle with that was, if we are indeed mobilized, we need to know and be contacted earlier. The communication of when there is an incident, when a contact is made, this is a concern for all of us.

Communication between colleges can be improved. We need a load of practice in this area to ensure better informational flow. Mutual aid agreement, sharing of resources to handle localized incidents needs to be shared and communicated. Training, and this would include training conducted in a jointly organized fashion. Use of technology during drills that are simulated can help the above.

We rely on written plans and rely on documentation when we need information. This can take time and cost. When we need to update some document *we need to make sure that everyone has updated their respective documents. Again, time and cost is involved. The documents that we have are easy to read, but knowing exactly what to do when something happens, remains a challenge.*

We at this college do have some of the information available online, on the Web [pdfs] which is used by the building managers. These are secured and restricted to those involved in emergency preparedness. Again, the information may not be easy to retrieve, even in Web format. We need more quick links, shortcuts, and need to know what is new when it comes to emergency preparedness.

Extended Problem Diagnosis

In stage two of the problem diagnosis, interviews were conducted with an additional 25 CUC personnel involved in emergency preparedness. The objective was to focus on the knowledge management issues in the context of emergency preparedness within the Claremont Colleges. A 15-question questionnaire was developed in order to ascertain the critical success factors for implementing a knowledge management system for CUC. These questions were based on the KMS Success Model (Jennex & Olfman, 2005). The KMS Success Model is based on three main constructs: System Quality, Knowledge/Information Quality, and Service Quality (Jennex & Olfman, 2005). The respondents were asked to rank the extent to which they either agreed or disagreed with the statements on a five-point Likert scale. Table 1 lists the statements and how these map to the KMS Success Model constructs. Table 1 also provides a summary of the data analyzed using SPSS.2

The average scores for the statements ranged from 3.12 to 4.56. The high average scores for most of the statements that relate to the key success factors of implementing a Web-based knowledge management system suggest the following:

- The system should provide key features of managing emergency related knowledge, such as being able to provide timely and relevant information.
- The system should provide links to both internal and external sources of knowledge about emergency preparedness.
- The top management within CUC must support the system implementation.
- The system must support committees involved in emergency preparedness to make strategic decisions.

The first three statements relate to post-implementation resource issues. The average scores for these statements (from 3.12 to 3.16) are relatively lower than the other statements. The majority of the respondents feel that CUC may not have the necessary resources to develop, update, and maintain a knowledge management system to support emergency preparedness. This is due to the fact that involvement in emergency preparedness activities, for the majority of the staff, is not part of their main job function. In addition, CUC has a limited budget for emergency preparedness activities.

PROPOSED SYSTEM

The potential use of Wiki technology as an instantiation of a knowledge management system to support emergency preparedness within the Claremont Colleges was discussed with the CEO and key IT personnel. Three criteria guided the selection of a suitable Web-based knowledge management system to support CUC's emergency preparedness efforts.

- Cost. During the initial discussion with the CEO, she made it clear that for the time being, any system developed to support CUC's emergency-related activities had to rely on

Table 1. Linking the KMS success model to emergency preparedness at the Claremont Colleges

	Concept (From the KMS Success Model)	**Constructs (From the KMS Success Model)**	**Min**	**Max**	**Mean**	**Std. Deviation**
CUC has the necessary resources to develop a KMS to support emergency planning/preparedness	System Quality	Technological resources	1.00	5.00	3.16	1.07
CUC has the necessary resources to update a KMS to support emergency planning/preparedness	System Quality	Technological resources	1.00	5.00	3.16	1.03
CUC has the necessary resources to maintain a KMS to support emergency planning/preparedness	System Quality	Technological resources	1.00	5.00	3.12	1.01
More information about emergency preparedness at CUC can be converted to Web format	System Quality	KMS form	2.00	5.00	4.04	0.79
Knowledge about emergency preparedness from individuals can be made available online	System Quality	Level of KMS	2.00	5.00	4.12	0.83
Knowledge about emergency preparedness from relevant groups can be made available online	System Quality	Level of KMS	2.00	5.00	4.24	0.72
Information about emergency preparedness could be automated, shared and retrieved from a single Web interface	Knowledge/ Information Quality	Richness	2.00	5.00	4.16	0 .90
A KMS for emergency preparedness should simplify searching and retrieving of information	Knowledge/ Information Quality	Richness	2.00	5.00	4.24	0.72
A KMS can enhance the strategic planning process for teams involved in emergency preparedness	Knowledge/ Information Quality	Knowledge Strategy/ Process	3.00	5.00	4.32	0.69

Table 1. continued

	Concept (From the KMS Success Model)	Constructs (From the KMS Success Model)	Min	Max	Mean	Std. Deviation
A KMS should provide timely information for staff involved in emergency preparedness to support emergency planning	Knowledge/ Information Quality	Richness	3.00	5.00	4.32	0.69
A KMS should provide accurate/ up-to-date information for staff involved in emergency preparedness to support emergency planning	Knowledge/ Information Quality	Richness	3.00	5.00	4.40	0.58
A KMS should provide relevant information for staff involved in emergency preparedness to support emergency planning	Knowledge/ Information Quality	Richness	3.00	5.00	4.36	0.57
A KMS to support emergency planning should provide linkages to external and internal information sources	Knowledge/ Information Quality	Linkages	3.00	5.00	4.56	0.58
Top management support is needed in implementation of a KMS to support emergency preparedness	Service Quality	Management Support	3.00	5.00	4.40	0.71
I welcome the idea of being trained in using a KMS to support emergency preparedness activities at CUC	Service Quality	Management Support	1.00	5.00	4.28	1.02

open source solutions. This is due to the fact that CUC does not have a sufficient budget to implement any commercially available knowledge management system.

- Our Experience. We were allowed to develop any system with which we were familiar, so long as it was in the best interest of the organization in the context of its emergency preparedness initiatives.
- Issues Faced. The system that is developed has to address the key emergency preparedness issues/concerns faced by the Claremont Colleges, as described earlier.

These criteria then were used to examine the list of options available to CUC. Gupta and Sharma's (2004) categorization of knowledge management systems was used to examine if a particular category met the three system selection criteria discussed previously. It was decided to implement an instantiation of a knowledge management system using Wiki technology, given budgetary and resource constraints, with regard to emergency preparedness faced by CUC. The technology also was selected because of our familiarity with using Wikis for teaching and learning (Raman & Ryan, 2004).

Why Wikis?

Wiki is a Hawaiian word that refers to being quick. Leuf and Cunningham (2001) define a Wiki as "a freely expandable collection of interlinked Web pages, a hypertext system for storing and modifying information—a database where each page is easily editable by any user with a forms-capable Web browser client" (p. 14).

Leuf and Cunningham (2001) suggest that Wiki technology can support knowledge management initiatives for organizations. The authors state that three collaborative models are available over the network today: e-mail exchanges, shared folders/file access, and interactive content update and access. They suggest that use of e-mail systems solely may not enable effective management of knowledge for an organization, based on the following reasons: (1) e-mail postings cannot be edited easily; (2) a central archiving system might be necessary to support effective documentation of information, which implies that using some form of database that hosts various postings directly might be a more effective manner of managing information flow for the organization; and (3) e-mail systems necessarily may not support shared access to a particular information base.

The second model to support collaborative work and knowledge sharing is the shared access system (Leuf & Cunningham, 2001). The main difference between a shared file system and an e-mail system is that the former enables users to access a common information base. In this regard, different users could be allowed to edit/update, "based on varying degrees of freedom" a particular information base (Leuf & Cunningham, 2001, p. 6). Nevertheless, this system is still similar to an e-mail system in that discussions and knowledge sharing is contingent upon threaded postings or, in a worst case, governed as a regular e-mail system (Leuf & Cunningham, 2001).

Wiki technology is an example of the interactive server model that offers users a newer avenue to share knowledge and to participate in online collaborative work (Leuf & Cunningham, 2001). The main components of an interactive server model are the database, the Web server, and user access to a common front end. The authors suggest that the main benefits of using collaborative server models include, among others: (1) allowing more effective organization of information by individuals and groups and (2) enabling ad hoc groups to collaborate on specific projects.

Wagner (2004) examines the use of different knowledge management systems that can be categorized based on two dimensions: (1) how knowledge is distributed in organizations and (2) the nature of the task involved. He asserts that in an organizational context, the source of knowledge is either centralized or distributed. The nature of the task is either ad hoc or repetitive. Based on these two dimensions, he proposes a particular form of knowledge management system to support a particular organizational need to manage knowledge. Table 2 summarizes the "knowledge management system fit based on knowledge distribution and task repetitiveness" in an organizational context (Wagner, 2004, p. 267).

Wagner's (2004) framework suggests that an organization's need for a knowledge management system is contingent upon the nature of the task involved and where knowledge resides in the organization. Use of FAQs, for instance, is suitable when knowledge is centralized and when

Table 2. Knowledge management system tasks and sources of knowledge[3]

Knowledge management system type	Knowledge source	Task
Conversational technologies	Distributed	Ad hoc
FAQ	Centralized	Repetitive
Search engine	Distributed	Repetitive
Portals	Distributed-Centralized	Ad hoc-Repetitive

tasks are repetitive in nature. Conversational knowledge management systems, in contrast, are more suitable when the source of knowledge is distributed. Wagner's classification of knowledge management systems implies that conversational technologies might be relevant to support emergency preparedness activities at CUC, because emergency preparedness at CUC involves tasks that are ad hoc and dependent upon knowledge that is distributed across the different EOCs and among the MACC members. Wiki technology can support numerous knowledge management requirements for organizations, including filtering knowledge from noise, ensuring knowledge quality, providing search functions, tracing the source of knowledge, building/enhancing knowledge continuously, and supporting the need for dynamically changing information content in a given system (Wagner, 2004). The system selection criteria, our prior experience with Wikis, and support from relevant literature led us to choose Wiki technology.

TikiWiki: Emergency Management System for the Claremont Colleges

The first step during the intervention stage of the project was to install and test a prototype Wiki clone. In December 2004, TikiWiki version 1.7.4 was installed on a test server. TikiWiki is only one instance of Wiki technology. TikiWiki bundles the requirements for a Web server (Apache), a database server (mySQL), and the front-end Web pages (written using Python).

Components of the TikiWiki that were viewed as relevant to the requirements specified by the users then were selected for activation. Only two features have been enabled in the current prototype of the system: the TikiWiki module and linking features. The module feature (administered by the system administrator) was used to create particular groupings of quick links to information about emergency preparedness. For the purpose of the prototype, the following modules were created:

- CUC Links: Provides links to key information sources about emergency preparedness for CUC. This module is based on CUC EOC's organizational structure. It has links to the information requirements for each of the EOC members, based on her or his respective job functions. The planning and intelligence coordinator, for instance, has access to weather information, notification protocols, phone trees, hazardous material information, lessons learned from tabletop sessions, and online maps of the Claremont Colleges.

- MACC Information: A quick link and reference to emergency resources and supplies available thorough CUC's Central Services/Physical Plant. The MACC module now is extended to include other key elements relevant to the MACC.
- Calendar of Events: Information about meetings, meeting summaries, drills, training events, and other related activities. The objective of this module is to assist all EOCs and the MACC in coordinating their respective activities.
- Knowledge Base: This module has links to local weather conditions, transcripts from tabletop (drill) sessions, and links to federal and local emergency response agencies.
- Maps: Online maps for the Claremont Colleges and CUC.
- Linking: Permits users to create multiple links within the system, which can be done through the use of the back link function. For example, through a back link, the CUC overview page is linked to the system's home page. TikiWiki also permits users to create links to external sources.

The focus of systems design and implementation in Stage 2 was to improve the communication issues related to emergency planning at CUC. When a crisis of a particular magnitude occurs within the Claremont Colleges, the MACC is activated. The MACC consists of members from CUC and a representative from all the Claremont Colleges. The MACC members provide input to the MACC Chair and Operations Co-coordinator, based on information received from the respective college EOCs. Based on the current protocol, the information flow between MACC and the colleges is facilitated through the use of telephones and information that is documented on a 6 x 8 foot white board located inside the MACC room.

The CUC was aware that during a crisis, the flow of information between the MACC and the college EOCs, was subject to noise and inaccuracy. The CUC also was aware, based on participation in drills, that the MACC does not have sufficient information about actual crisis situations within the respective colleges. This makes response efforts rather difficult during certain incidents. In order to overcome the communicational issues, an additional module in the system called the MACC Situation Board was developed. This module consists of the following four main elements:

- Situation: This section enables the MACC representatives to document real-time information about a particular situation at their respective colleges.
- Action: This section is used to document specific actions that a college/CUC has taken to address a particular emergency situation.
- Need: Links to another page that consolidates the emergency resources (i.e., debris removal equipment, temporary housing, search-and-rescue teams, food, and first-aid supplies) needed by all colleges and CUC in order to respond to an emergency. The MACC Chair and Operations Coordinator were given access to the consolidated resource needs page, which can be used to guide the decision on resource allocation between CUC and the colleges. The consolidated information about resources needed is expected to improve the communication between MACC and the respective college EOCs.
- Sharing: Links to another page that consolidates all information about resources that each college and CUC is willing to share to support a particular emergency response initiative. The type/category, quantity, and status of emergency related resources within the Claremont Colleges will be made known

to all MACC members through the system in the near future.

The purpose of this module is twofold. First, as mentioned, it is designed to facilitate documentation of resources required by respective colleges during an emergency. Through this module, member institutions can record a particular type of resource that they need and are willing to share with other colleges when a particular emergency situation occurs. This information, unlike before, is now available via the Web, easily accessible to every EOC and MACC member. Second, the information can be used by the MACC Operations Coordinator to facilitate resource allocation among the colleges when an emergency occurs.

EVALUATION

Effectiveness of the system was evaluated through a series of one-on-one interviews with the MACC members who had participated in two separate training sessions in February 2005, where the system was used. Thirteen individuals were interviewed. The instrument used to facilitate the process had 10 open-ended questions that were divided into two categories: (1) general feedback/overall impression of the system and (2) extent of goal achievement, or the ability of the system to facilitate the knowledge management requirements within the context of emergency preparedness.

FINDINGS

The following subsections list several of the respondents' answers to the open-ended questions. The responses are organized according to the two categories mentioned earlier. Given the action-oriented nature of this study, we acknowledge the potential bias of our involvement in the project and the findings, particularly with reference to the use of Wiki technology.

Category 1: General Feedback/Impression

Overall, the respondents were pleased with the system. The feedback was largely positive. The majority of the respondents felt that the system was simple to use. One of them said the following:

My immediate reaction was very good. I thought that the ease of use of the system was there and that the visual layout was very clear. That's not how I often feel when I am exposed to new systems. It was logical too. Visually it made sense to me. I don't always react very positively to new systems. My immediate reaction was very positive. In prior cases, I have had the experience of feeling "Oh My God," what do we have here? This was not the case this time.

However, not everyone was totally comfortable using the system. One respondent mentioned the following:

It is a key step but it is a little daunting in some ways. One must be a computer savvy person to really play with the system. I look at it from an end user standpoint, particularly how it can be used better. But it sure seems like we are moving in the right direction especially after the last drill at the MACC when there was chaos in there—that was really wild. This is a good start, but there are issues that we need to address.

Another respondent suggested that the system could improve the overall communication process. Specifically, she said:

It seemed like it would be a very useful tool and could eliminate many of the previous problems with communication. I was excited to hear there would *be a standard protocol for us to transfer information from our campus EOCs to the MACC.*

Assisting Emergency Preparedness Efforts

On balance, the majority of the respondents felt that the system could assist CUC and the colleges in emergency preparedness efforts. However, this is contingent upon continuous training, access control, and willingness of emergency planners to update the system with relevant information. The following statements offer evidence:

I do think that the system can assist emergency preparedness. Specifically, the system can provide better and quicker access to information. However, before this works, people need to populate the system and be diligent in updating the information base in the system. I am not sure about controlled access through with the Wiki technology. Anyone can update or delete the information. People can go in and mess around even though we can assume that they would not.

The system provides for an additional method of communication between all entities involved in emergency preparedness. The system facilitates a more effective written communication process. This can reduce any misunderstanding between the emergency responders. After all, visual aids are better to process and faster to comprehend, as well. By providing a place where various human and material resources can be listed prior to being needed, enables more common space and a means of documenting what happens during a response.

Aspect of Emergency Preparedness Supported

The general consensus from the respondents was that the system might support the following aspects within emergency preparedness: (1) coordinating planning efforts; (2) offering a better mechanism to document processes; (3) assisting in communication efforts; and (4) sharing emergency related information. The following statements offer evidence:

I am tempted to say that the system helps emergency planning, but I don't think the system supports planning solely. If used well, the system can save us all a lot of time in terms of communication. It provides us with an overview of what is happening across the colleges when an emergency occurs, through the MACC Situation Board Module. The campus status for every college is right there. This is why I say that it will help us in all future emergency planning efforts.

I think the system supports both information storing and the emergency response communication process. In terms of communication, the information that is available readily to the users can help them communicate more effectively. The right word might be information that is immediately viewable or accessible can support the communication process. Also, the system provides a quick way of getting information. The system surely helps to capture knowledge as well. As I mentioned, you have everyone from the respective colleges who report to MACC there, and they post their knowledge and information into the system. This seems like a very organized way of capturing information.

Category 2: Goal Achievement

Improving Communications

The majority of the users felt that the system can enhance emergency-related communication both before and during an actual emergency. One respondent even suggested that the system might benefit recovery communication with external agencies such as FEMA. However, before this happens, issues such as training, willingness to share information, and trust among one another must be resolved. The following statements offer examples:

The system can improve the overall communication process. This is due to the fact that all the schools have access to the system, and all the schools should be posting information relevant to emergency response. And one can access the system from anywhere. It does not matter which part of the world you are from, you can get to it, as it is Web-based.

The system helps us to communicate better even after an emergency has ended, as the information will be at everyone's fingertips, which could later be served as data for any report or justification in an inquiry, such as FEMA and other agencies that may need that information.

The system can facilitate communication during an emergency. However, before this works, we need to make sure that people are willing to trust each other. For example, under the resources-to-share and resources-needed pages, people need to be aware that just resources available as they have been posted pre-crisis may not necessarily be available when an actual crisis occurs.

Emergency Preparedness Knowledge Capture

The users also generally felt that the system can facilitate some aspects of knowledge management. Specifically, benefits such as being able to archive information, capture knowledge and information about emergency preparedness, and offer a more structured way to manage information were noted. The following statements offer evidence:

I think that it will help us create an archive of every drill, actual emergency, and also any other related activities that we conduct. This tells me that the system might serve as a useful knowledge book or "book of knowledge," so to speak. People must be willing to contribute to this book, though.

The system can help us capture information/knowledge about emergency planning and response. The scribe could copy and paste information into any Microsoft program such as Excel or Microsoft Word for later usage.

The system allows us to better manage emergency related information, because now we have a written record of everything that is done and by whom. This is useful for future references, too. The system also provides a common platform/space, structuring of information.

Knowledge-Sharing

The users were also optimistic about the ability of the system to facilitate knowledge and information sharing among individuals and entities involved in emergency preparedness. However, this is contingent upon the willingness of people to share information and trust the source of information/knowledge that resides in the system. Some of the responses to this issue are as follows:

Frankly, I don't think all the members from the various colleges have a knowledge-sharing culture. Based on my experience here, my guess is that people need to share more information about emergency planning with each other. It seems easier to share with some relative to others. I guess we are comfortable with speaking directly with people and may not be willing to share information in an open platform. This needs to change though. People must be willing to share information with each other.

As mentioned, easy access to the system and a fairly direct way to input ideas will allow people to share knowledge about emergency preparedness *with each other. It will allow them to populate the database or to fill in the blanks. But people must be willing to do this.*

The system has useful refreshing abilities and allows users to share information and knowledge with each other instantaneously. It provides timely information and, therefore, can help better communication between the EOCs and the MACC.

General Concerns

Several issues must be addressed before the value of the system to support emergency preparedness within CUC and the Claremont Colleges is maximized. The respondents mentioned the following general concerns:

I think for the system to work, training is key. People at MACC need to be trained to use the system. But, as you know, the people that report to MACC either don't show up for training sessions or keep changing. Then, there is this issue of the information sharing culture that I spoke to you about. This must change for the system to be used effectively. People should put personality differences aside and be willing to share and communicate with each other. The technology itself seems powerful and is a great idea. It can handle different and very dynamic sets of information when an actual crisis occurs. But at the heart of all of this is the willingness to be trained and share information. For this to happen, emergency preparedness must become part of peoples' job function. With the exception of a few people on MACC, for the majority of us, emergency preparedness is not of a primary concern. We prepare only when we think about drills; otherwise, it seems to be lost in our daily primary functions.

I would be concerned if we don't have Internet connectivity. I think we need a paper-based system as a backup. This is really my only concern. And I saw during our drill, some people are not too Web savvy. There might be issues with training; people who are not familiar with a Web-based system need to be trained. Also the colleges keep sending new people to the MACC. If we have new people who don't know how to use the system or have not been trained to do so, this could cause some problems as well. In the event of an emergency there might not be any IT staff to support the use of the system. This again could become an issue. Ongoing training for staff involved in emergency preparedness is necessary.

I think the challenge is keeping everyone constantly abreast of the system. I think the idea of playing with the system every month when the MACC meets is welcomed. Your relearning time or startup time will become longer if this is not done. We need to make sure that people know where to fill information and not do this inaccurately. Also, people should not edit other people's information.

I think people need to be trained continuously. In addition, it only makes sense if the EOCs for all colleges use this system, too; after all they need to provide MACC representatives with the information needed.

If it is used properly, updated, and maintained, then this will work. However, this is subject to some budget being approved for a system-resource or admin staff that helps in this task. Also, we need to make sure that people do not mess up due to poor access control.

DISCUSSION AND LESSONS LEARNED

Feedback from the evaluation phase suggests that the system that has been implemented can impact emergency preparedness activities for CUC and the Claremont Colleges in two ways: (1) improve communication and (2) assist in emergency preparedness knowledge/information sharing.

Communication

Key staff members involved in emergency preparedness now realize that, through the project, the Web-based system can assist the overall emergency preparedness communication process as follows:

- Provide a centralized information base about emergency situations, campus action, resource status, and MACC action, which are now accessible to all relevant groups and individuals involved in emergency planning.
- Minimize the overflow of information within MACC and thereby reduce the possibility of communication chaos.
- Empower staff members involved in emergency preparedness to update information as and when it is received, without the need for relying on the MACC scribe to do so.
- Provide a structured way to document emergency-related information, which can support external communication and recovery efforts (e.g., claiming reimbursement from FEMA and other federal agencies). Wiki technology has a function called history, which documents exactly what was entered into the Wiki, by whom, and when.

Knowledge Sharing

Anyone can contribute to a Wiki page in a given Wiki community (Leuf & Cunnigham, 2001). Wiki technology thrives on the principle of being open (Wagner, 2004). Emergency preparedness and response within the Claremont Colleges involves both knowledge and experience from a diverse set of individuals. Within CUC alone, there are staff members that have been trained in particular emergency preparedness areas. Examples are people who are trained in search and rescue, earthquake evacuation procedures, hazardous material handling, CPR, and first aid response.

Critical Success Factors

Our findings suggest that the positive outcomes of the system can materialize fully only if the following factors are taken into consideration by the CUC's top management involved in emergency preparedness:

- People involved in emergency preparedness are willing to share information with one another. The MACC Situation Board module, for instance, can support the Operations Coordinator to plan for and allocate resources during an actual crisis, only if the resource-available template is filled a priori by the respective college EOCs. As one respondent mentioned, "I am not sure if people will be willing to share information with one another, particularly about the status of their resources."
- The technology is designed to support a knowledge-sharing culture. However, we are uncertain if this culture exists among every EOC and individuals involved in emergency preparedness in this case.
- The system must play a vital role in every emergency response drill and training session. Unless the system is used during drills and such events, it will not be used during an actual emergency.
- The technology must support and not hinder the existing emergency response protocol. In this context the CEO indicated the following concern, "Everyone [with reference to the EOCs] can act prematurely and go talk directly to one another without going thorough the central body (MACC) to coordinate efforts. The system should support existing protocols that we have. People should be trained to use it to ensure that the technology supports MACC's role. This can be done."

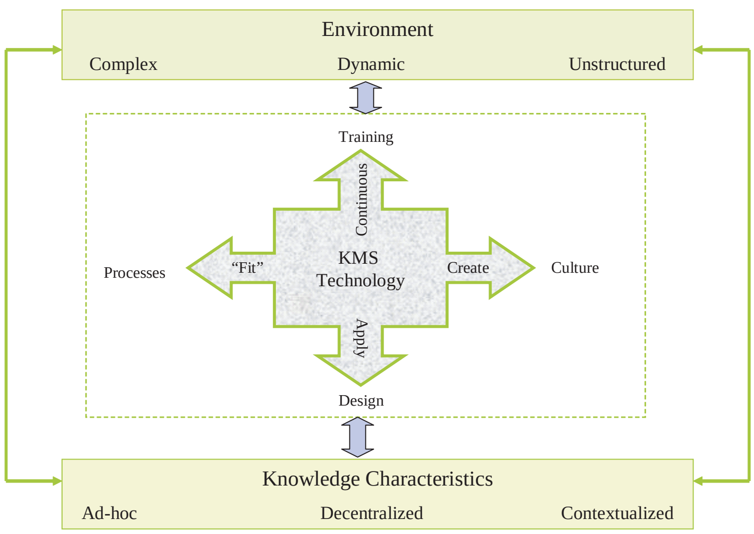
THEORETICAL IMPLICATIONS

Figure 1 illustrates how the project findings might further inform theory about emergency management information systems. This study suggests that the environment faced by emergency responders is complex, dynamic, and unstructured (Burnell, Priest & Durrett, 2004; Kostman, 2004; Van Kirk, 2004). The majority of literature about emergency management information systems does not state clearly that systems designed to support emergency preparedness are associated with knowledge management. This study suggests that the environment faced by emergency responders forces them to deal with the following characteristics of knowledge:

- Ad Hoc: Knowledge within emergency responders at the Claremont Colleges is largely tacit and utilized as and when an emergency occurs. Individuals and groups involved in emergency preparedness may not necessarily think about responding to a particular situation beforehand. This implies that the knowledge that they need to respond to an emergency is ad hoc in that it is required as and when a crisis occurs.
- Decentralized: The knowledge repository to respond to a particular crisis in a consortium environment is predominantly decentralized. In the case of the Claremont Colleges, this knowledge resides within eight EOCs and the MACC.
- Contextualized: Emergency preparedness requires responders to deal with knowledge that is highly contextualized. Every crisis is unique and requires a different set of ideas and response initiatives (Burnell et al., 2004).

Given these characteristics, the findings of this study suggest that any system designed to support emergency preparedness should be linked closely to ideas inherent within the domain of knowledge management. A particular technology selected to support emergency preparedness should cater to

Figure 1. Theoretical framework



knowledge that might be decentralized, ad hoc, and highly contextualized.

We suggest that Wiki technology might be a simple yet cost-effective option for organizations that intend to use or design any information system to manage information and knowledge related to emergency preparedness. Wiki technology is appropriate for knowledge that is dynamic and decentralized (Wagner, 2004). Nevertheless, technology alone is not sufficient to foster effective emergency preparedness initiatives. The system should be designed to cater to the requirements of emergency responders and must be used in every drill and emergency training activities (Turoff et al., 2004). Figure 1 suggests that, in addition to effective design and training considerations, the following two additional factors are required when thinking about emergency information management systems:

- A fit between the knowledge management system and the existing emergency preparedness policies must be sought. Stated differently, the technology should support and not hinder emergency response initiatives.
- There is a need to foster a knowledge-sharing culture among various entities involved in a given emergency preparedness organizational structure. In the case of CUC, this refers to the willingness of different EOCs to share information and knowledge with one another.

CONCLUSION

An organization's emergency preparedness activities might involve collaborative efforts among various entities. A vital activity is responding to an actual crisis situation that hits one or more of the member organizations or entities. For some organizations, as in this case, responding to a crisis situation is done within a consortium environment. Managing knowledge across the various entities involved in such efforts is critical. This includes having the right set of information that is timely, relevant, and governed by an effective communication process. Given such organizational structures and a need to manage knowledge in these environments, IT, which manifests itself in the form of knowledge management systems, might play a crucial role. However, before this occurs, the following issues must be considered: (1) sufficient training in the use of a system(s) must take place; (2) a knowledge-sharing culture among entities involved in emergency preparedness should exist; and (3) a fit between task and technology/system must be guaranteed.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issue. *MIS Quarterly, 25*(1), 107–136.

Burnell, L., Priest, J., & Durrett, J. (2004). Developing and maintaining knowledge management system for dynamic, complex domains. In J. Gupta, & S. Sharma (Eds.), *Creating knowledge based organizations* (pp. 203–229). London: IGP.

Campbell, C.L., Van De Walle, B.V., Turoff, M., & Deek, F.P. (2004). A research design for asynchronous negotiation of software requirements for an emergency response information system. *Proceedings of the Americas Conference on Information Systems,* New York.

Claremont University Consortium. (2006). *The Claremont Colleges emergency preparedness plan.* Retrieved February 20, 2006, from http://www.cuc.claremont.edu/emergency/emergplan.pdf

Davidson, R., & Martinsons, M. (2002). Empowerment or enslavement? A case of process-based organizational change in Hong Kong. *Information Technology and People, 15*(1), 42–59.

Gupta, J.D., & Sharma, S.K. (2004). *Creating knowledge based organizations:* Hershey, PA: Idea Group.

Jennex, M. (2004). Emergency response systems: Lessons from utilities and Y2K. *Proceedings of the Americas Conference on Information Systems,* New York.

Jennex, M.E. (2005). Emergency response systems: The utility Y2K experience. *Journal of Information Technology Theory and Application, 6*(3), 85–102.

Jennex, M., & Olfman, L. (2005). Assessing knowledge management success. *International Journal of Knowledge Management, 1*(2), 33–49.

Kostman, J.T. (2004). 20 rules for effective communication in a crisis. *Disaster Recovery Journal, 17*(2), 20.

Lee, J., & Bui, T. (2000). A template-based methodology for disaster management information systems. *Proceedings of the Hawaii International Conference on Systems Science*, Hawaii.

Leuf, B., & Cunningham, W. (2001). *The WIKI way: Quick collaboration of the Web.* Boston: Addison-Wesley.

Lindgren, R., Henfridsson, O., & Shultze, U. (2004). Design principles for competence management systems: A synthesis of an action research study. *MIS Quarterly, 28*(3), 435–472.

Patton, D., & Flin, R. (1999). Disaster stress: An emergency management perspective. *Disaster Prevention and Management, 8*(4), 261–267.

Raman, M., & Ryan, T. (2004). Designing online discussion support systems for academic setting—"the Wiki way." *Proceedings of the Americas Conferences on Information Systems,* New York.

Susman, G., & Evered, R. (1978). An assessment of the scientific merits of action research. *Administrative Science Quarterly, 23*, 583–603.

Turoff, M. (1972). Delphi conferencing: Computer based conferencing with anonymity. *Journal of Technological Forecasting and Social Change*, *3*(2), 159–204.

Turoff, M. (2002). Past and future emergency response emergency response information systems. *Communications of the ACM, 45*(4), 38–43.

Turoff, M., Chumer, M., Van De Walle, B., & Yao, X. (2004). The design of a dynamic emergency response management information systems (DERMIS). *Journal of Information Technology Theory and Application, 5*(4), 1–35.

Van Kirk, M. (2004). Collaboration in BCP skill development. *Disaster Recovery Journal, 17*(2), 40.

Wagner, C. (2004). WIKI: A technology for conversational knowledge management and group collaboration. *Communications of the Association for Information Systems, 13*, 265–289.

ENDNOTES

1. There are seven colleges within the Claremont Colleges: Claremont Graduate University, Harvey Mudd College, Scripps College, Pomona College, Keck Graduate Institute, Pitzer College, and Claremont McKenna College (http://www.claremont.edu).
2. N=25.
3. Adapted from Wagner (2004), Figure 1, p. 267.

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Chapter 4.50
Knowledge Management and Hurricane Katrina Response

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ABSTRACT

This article explores the use of knowledge management with emergency information systems. Two knowledge management systems that were utilized during the Hurricane Katrina response are described and analyzed. The systems specified were developed by federal agencies as well as grass root efforts without the support or mandate of government programs. These programs, although developed independently, were able to share data and interact in life-saving capacities, transcending traditional geopolitical boundaries. We conclude that emergency information systems are enhanced by incorporating knowledge management tools and concepts.

INTRODUCTION

Emergency response in the United States of America (US) is evolving from something that was handled locally to something that is standardized under federal control. The US implemented the National Incident Management System (NIMS) in 2004 to accomplish this. NIMS established standardized incident management protocols and procedures that all responders are to use to conduct and coordinate response actions (Townsend, 2006).

It was expected that on August 27, 2005, when President George W. Bush declared a state of emergency for three coastal states days before the August 29, 2005, landfall of Hurricane Katrina, this approach would be sufficient to handle necessary emergency response. However, Mississippi, Alabama, and Louisiana would be the site of the worst natural disaster in US history, stretching government resources far beyond their abilities to respond to the instantaneous and growing number of casualties. Running out of shelter and supplies for the growing number of victims, the government became logistically overwhelmed and underequipped. Private citizens and companies (all nongovernment offices) responded immediately. Multiple independent yet collaborative-by-design knowledge management systems (KMS) were developed and implemented for immediate use to help victims find housing and medical supplies and to post requests for immediate evacuation as well as help to find those separated in the storm. Via the Internet, people as far north as Michigan were able to help find housing in the state of Washington for people in southern New Orleans. This article proceeds to describe how theses systems were developed, implemented, and used. We will describe the situation that led to the need for these systems, how these systems were created, the resources required for each, within which category of knowledge management system each falls, the use of the systems by the end users, and finally the end result of these systems.

This article discusses two of these systems developed to respond to Hurricane Katrina. The purpose of this discussion is to illustrate the use of knowledge management (KM) and KMS in emergency response. The article will discuss how KM was implemented and how effective the resulting systems were.

BACKGROUND

Before discussing these systems, it is important that we establish what we mean by KM and KMS as well as provide a framework for how KM fits into disaster and/or emergency response.

Knowledge

Davenport and Prusak (1998) define knowledge as an evolving mix of framed experiences, values, contextual information, and expert insight, which provides a framework for evaluating and incorporating new experiences and information. Knowledge often becomes embedded in documents or repositories and in organizational routines, processes, practices, and norms. Knowledge is also about meaning in the sense that it is context-specific (Huber, Davenport, & King, 1998). Jennex (2006) extends the concepts of context to also include associated culture that provides frameworks for understanding and using knowledge. A simpler definition of knowledge is that it is the how and why of something. It is the insight into why something happens that creates knowledge. To be useful, though, this knowledge needs to be framed in context and culture, the information and data that explain how the knowledge was generated, what it means, and how it should be used.

Knowledge Management

Jennex (2005) defines KM as the practice of selectively applying knowledge from previous experiences of decision making to current and future decision-making activities with the express purpose of improving the organization's effectiveness. KM is an action discipline; knowledge needs to be used and applied in order for KM to have an impact. Inherent in KM is communication between knowledge creators and/or possessors and knowledge users. A KMS is the system developed to aid knowledge users in identifying, sharing, retrieving, and using knowledge that they need. The following section further defines a KMS.

Knowledge Management Systems

Alavi and Leidner (2001) defined a KMS as "IT (Information Technology)-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application" (p. 114). They observed that not all KM initiatives will implement an IT solution, but they support IT as an enabler of KM. Maier (2002) expanded on the IT concept for a KMS by calling it an ICT (Information and Communication Technology) system that supported the functions of knowledge creation, construction, identification, capturing, acquisition, selection, valuation, organization, linking, structuring, formalization, visualization, distribution, retention, maintenance, refinement, evolution, accessing, search, and application. Stein and Zwass (1995) defined an Organizational Memory Information System (OMS) as the processes and IT components necessary to capture, store, and apply knowledge created in the past on decisions currently being made. Jennex and Olfman (2002) expanded this definition by incorporating the OMS into the KMS and adding strategy and service components to the KMS. We expand the boundaries of a KMS by taking a Churchman (1979) view of a system. Churchman (1979) defines a system as "a set of parts coordinated to accomplish a set of goals" (p. 29) and that there are five basic considerations for determining the meaning of a system:

- System objectives, including performance measures
- System environment
- System resources
- System components, their activities, goals, and measures of performance
- System management

Churchman (1979) also noted that systems are always part of a larger system and that the environment surrounding the system is outside the system's control but influences how the system performs. The final view of a KMS is a system that includes IT/ICT components, repositories, users, processes that use and/or generate knowledge, knowledge, knowledge use culture, and the KM initiative with its associated goals and measures.

Key to the KMS is a strategy that determines what knowledge is captured; how well the KMS performs the mnemonic functions of search, retrieve, manipulate, extract, and visualize; and knowledge repositories. There are three types of knowledge repositories: paper documents, computer-based documents/databases, and self memories:

- Paper documents incorporate all hard copy documents and are organizationwide and groupwide references that reside in central repositories such as a corporate library. Examples include reports, procedures, pictures, videotapes, audiocassettes, and technical standards. An important part of this knowledge is in the chronological histories of changes and revisions to these paper documents as they reflect the evolution of the organization's culture and decision-making processes. However, most organizations do not keep a separate history of changes but do keep versions of these documents.
- Computer-based documents/databases include all computer-based information that is maintained at the work-group level or beyond. These may be made available through downloads to individual workstations or may reside in central databases or file systems. Additionally, computer documents include the processes and protocols built into the information systems. These are reflected in the interface between the system and the user, by who has access to the data, and by the formats of structured system inputs and outputs. New aspects of this type of repository are digital images and audio recordings. These forms of knowledge provide rich detail but require expanded storage and transmission capacities.

- Self-memory includes all paper and computer documents that are maintained by an individual as well as the individual's memories and experiences. Typical artifacts include files, notebooks, written and unwritten recollections, and other archives. These typically do not have an official basis or format. Self-memory is determined by what is important to each person and reflects his or her experience with the organization.

Repositories can overlap each other; for example, the computer repository stores the specific knowledge, but the context and culture needed to use the knowledge is captured in paper procedure documents used to guide the knowledge use and in the mind of the knowledge user as a result of training on how to use the knowledge. Other examples include paper documents being indexed or copied into computer databases or files, self-memory using paper and computer-based documents/databases, and computer databases or files being printed and filed. Typically, it is desired to capture as much knowledge as possible in computer- and paper-based memories so that the knowledge is less transient. It would be expected that organizations that are highly automated and/or computerized would be expected to have a greater dependence on computer-based repositories, while less automated organizations may rely more on paper-based or self-memory-based repositories.

A recent development in KMS technology is the use of the wiki. A wiki is a Web site or similar online resource that allows users to add and edit content collectively and/or collaboratively (Parlament of Victoria, 2005; Wikipedia, 2006). The wiki originated in 1994/1995 (Cunningham, 2005) but only recently has become popular as a content management system (Mattison, 2003). Very recent research has found that wikis are useful for KM, since they provide content management combined with knowledge exchange/communication and collaboration capabilities. Vazey and Richards (2006) found improved decision making and knowledge acquisition, while Raman, Ryan, and Olfman (2006) applied a wiki as a tool for improving emergency response.

Knowledge Management Systems and Emergency Response

Jennex (2004) identified an expanded model of an Emergency Information System (EIS). This model considers an EIS more than the basic components of database, data analysis, normative models, and interface outlined by Bellardo, Karwan, and Wallace (1984), adding trained users, methods to communicate between users and between users and data sources, protocols to facilitate communication, and processes and procedures used to guide the response to and improve decision making during the emergency. The goals of the EIS are to facilitate clear communications, improve the efficiency and effectiveness of decision making, and manage data to prevent or at least mitigate information overload. EIS designers use technology and work-flow analysis to improve EIS performance in achieving these goals. Turoff, Chumer, Van de Walle, and Yao (2004) expanded the expanded EIS model by introducing the concept of a dynamic EIS and identifying design requirements that expanded EIS capabilities in group communication and data/information/knowledge management. The result is that the focus of an EIS is on communication and facilitating decision making; both are also key attributes of a KMS.

Additionally, in recent years, disaster managers have realized the potential of KMS for faster and more organized response to natural disasters. The large number of groups that respond to a disaster needs access to a wide range of real-time information, which requires coordination. Groups have proposed and created KMSs that allow for more efficient use of data and faster response. One example that has been proposed is the Information Management System for Hurricane disasters (IMASH) (Iakovou & Douligeris, 2001). IMASH is an information management system based on an object-oriented database design and is able to provide data for response to hurricanes. IMASH was designed with the premise that the World Wide Web is the medium of choice for presenting textual and graphical information to a distributed community of users. This design is much more effective in the fast-changing environment of a natural disaster than the historical use of static tools that, out of necessity, have been the tools used in disaster response. Kitamato (2005) describes the design of an information management system, Digital Typhoon, designed to provide a hub of information on the Internet during a typhoon disaster. Digital Typhoon provides access to information from official sources (news, satellite imagery) as well as a forum for individuals to provide information (local, personal). It effectively became a hub of information but created questions about organization, filtering, and editing. Systems used for Hurricane Katrina response realized the benefits and difficulties of these systems. Like IMASH, the systems described next use the Internet to distribute data to a community of users, and like Digital Typhoon, the knowledge management systems described for Hurricane Katrina response became hubs of information that required data management to reduce repetition and allow for editing.

In summary, there is a fusion of EIS with KM and KMS. This is because decision makers, when under stress, need systems that do more than just provide data; they need systems that can quickly find and display knowledge relevant to the situation in a format that facilitates the decision maker in making decisions. It is expected that EIS evolution will continue to utilize KM concepts and approaches as experience in responding to disasters is showing that these systems are more effective than traditional EIS. Examples of how KM aids emergency response includes using knowledge of past disasters to design communication and data/information capture protocols and templates; capturing emergency response knowledge in procedures and protocols; incorporating lessons learned into response team training, interface and display design, and the generation of heuristics guiding decision making; and using knowledge to guide the creation of experience knowledge bases that responders can use to generate emergency response actions. The rest of this article illustrates how KM can help disaster response by looking at two systems used in response to Hurricane Katrina.

PEOPLEFINDER

Problem Emerges and Information Overload Occurs

During the first days after Hurricane Katrina hit the Gulf Coast, the Gulf Coast News Web site (http://www.gulfcoastnews.com) set up a Web page for people to talk about their hurricane stories. Obviously geared for stories about how New Orleans spent a few days without power, the site quickly became an online repository for people to look for victims and to post requests for help. Posts on the Web site ranged from asking for directions out of town to people from other states asking if someone could check on or save their family members at flooded addresses. This trend grew, and quickly 23 Web sites had people posting that they survived as well as people looking for information on victims that had not been found. Anyone looking for loved ones had to check each Web site, since at that time there was no central repository for information. There also was no way to leave contact information, should their search queries be matched. As Table 1 indicates, many Web sites hit upon the same idea at the same time to host servers on which survivors could post their status. Although this was a terrific response from mostly civilian Internet companies, it created

Table 1. Web sites and the number of survivor records each held (PeopleFinderTech, 2005)

Web Site	Number of Entries
http://www.msnbc.msn.com/id/9159961/	143,000
http://www.familylinks.icrc.org/katrina/people	135,222
http://wx.gulfcoastnews.com/katrina/status.aspx	42,477
http://www.publicpeoplelocator.com/	37,259
http://www.katrina-survivor.com/	9,071
http://www.lnha.org/katrina/default.asp	4,500
http://connect.castpost.com/fulllist.php	2,871
http://www.findkatrina.com	2,474
http://www.katrinasurvivor.net	2,400
http://theinfozone.net	1,300
http://www.cnn.com/SPECIALS/2005/hurricanes	1,120
http://www.wecaretexas.com/	200,000
http://www.scribedesigns.com/tulane/	1,933

confusion on about which sites on which to post and search; this created the need for a site like PeopleFinder (PeopleFinderTech, 2005).

Proposed Knowledge Management Solution

David Geihufe of the Social Software Foundation had been working on an open source Customer Relationship Management (CRM) system called CiviCRM (Geilhufe, 2005). During the intelligence phase (Kersten, Mikolajuk, & Yeh, 1999), David envisioned using his CRM system to create a Web-based, data-driven Decision Support System (DSS) (Power & Kaparthi, 2002) form of KMS that would be a central repository for victims and the people looking for them. The Web site would accept data in an open standard from other Web sites as well as allow people to post information directly to the server. Not having the resources necessary to use this system, David received corporate support from the Salesforce Foundation. Within 24 hours, the Salesforce servers were accepting PFIF (PeopleFinder Interchange Format). Twenty-four hours after that, 60,000 records had been inputted by global volunteers to the PeopleFinder knowledge management system. Some inputs were parsed (scraped) from sites such as Craigslist and Gulf Coast News. Ultimately, more than 620,000 records were searchable, and more than 500,000 searches were processed. Tables 2 and 3 show the database schema.

The note table is necessary, as it is a lesson learned from the September 11, 2001, World Trade Center attacks (Lal et al., 2005). Entries may be updated multiple times, and syncing data between servers can become very difficult. The note table solves this problem by keeping a log of who has made what change and what changes were made. The timestamp on each file can be used as a quantitative metric on which entry is the most recent.

Integrity of data, a key component of a successful DBMS (Database Management System), while syncing between multiple servers, was nontrivial. Multiple approaches were considered, and the decision was made to keep all data sets as read-only throughout the entire transaction

Table 2. The note schema (Lal, Plax, & Yee, 2005); Note_record_id is the primary key

NOTE Table	
string	**note_record_id**
string	person_record_id
string	linked_person_id
date	entry_date
string	author_name
string	author_email
string	author_phone
bool	found
string	email_of_found_person
string	phone_of_found_person
string	last_known_location
text	text

Table 3. The person schema (Lal et al., 2005); Person_record_id is the primary key

PERSON table	
string	**person_record_id**
date	entry_date
string	author_name
string	author_email
string	author_phone
string	source_name
string	source_date
string	source_url
string	first_name
string	last_name
string	home_city
string	home_state
string	home_neighborhood
string	home_street
int	home_zip
string	photo_url
text	other

Figure 1. Data flow diagram (based on Lal et al., 2005)

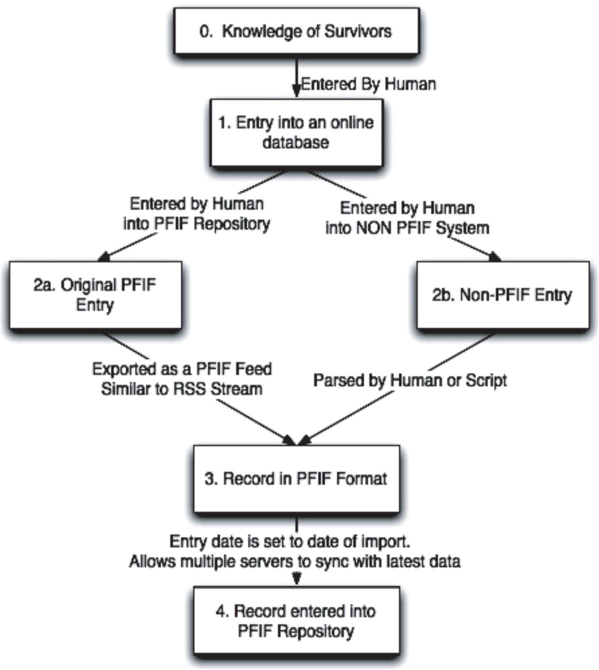

Table 4. Decision table for assessing how to proceed with new Web sites discovered

Potential Conditions	Actions to be Performed		
	Manual entry	Task a parser for later development	Task a parser for immediate development
If (postings) <25	X		
If (postings) <25 but anticipate growth	X	X	
If (postings) > 25		X	
If (postings) > 100			X

process, except for the field entry_date, which would indicate when that entry had been posted to the server (Lal et al., 2005).

Figure 1 shows the data flow diagram depicting how the data transverses the system. Table 4 details the decision table, providing a rule set for when to manually enter the data into the PFIF repository and when to request to have a parser written.

Leaderless Development

A wiki was used to coordinate tasks and development for the PeopleFinder system. Anyone wanting to make changes to the wiki had to register on it. Similar to public bulletin board Web sites, registration was automated and required no formal approval (Aronsson, 2002). When a developer found bugs or noticed new features that needed to be added to the system, he or she could post a task that needed to be completed. One of the other developers could assign themselves to the task to complete it, give status on its development, and clear the task upon completion. Sites to be scraped were handled like this as well. Sites that had information to share could be listed on the wiki, and people either could manually transfer the information record by record or coders could write parsers to grab the information and repost it into the Salesforce server in PFIF. The determination on whether to manually parse the site or to write a parser for it was determined by the number of entries on the site, the number of entries expected on the site, and whether or not the author of the original site had made safeguards to prevent scripts from parsing the site (PeopleFinderTech, 2005).

With any Web site that can be modified by the general public, vandalism is an immediate and valid concern. For example, there was nothing to keep political protestors from registering and defacing the Web site with a political message that had nothing to do with the purpose of the Web site. Fortunately, editors on the Web site kept vandalism suppressed by monitoring the Recent Changes page (Tanaka, 2005).

PeopleFinder Analysis

PeopleFinder went from an idea to operationally functioning within a 72-hour window. Due to the nature of the Web site, few users would be inclined to leave feedback in order to make the site more helpful. Therefore, features may have been incorrectly prioritized based on what the developers thought would be helpful rather than on what the user base needed. Future concerns about this type of project most likely will include privacy rights. When someone wants their online entry removed from the database, perhaps to avoid any risk of identity theft, there is currently no feature that allows them to be removed. In fact, the data network is set up to maintain the entries at all cost. It is also difficult to have an easy-to-use Web site that allows distraught people to find their family and friends while making sure that those with criminal intentions are filtered out. Regardless of the security downfalls, PeopleFinder was a success as soon as the first person was able to quickly ascertain the status of a loved one.

KM use in PeopleFinder is reflected in its construction. The system itself reflects the capture of lessons learned and is itself a repository of knowledge. Knowledge capture and use also are reflected in the capture of notes and the history of notes for each person. KMS features implemented in the system include knowledge repositories and the implementation of good mnemonic functions (search, retrieve, visualize). As stated, it was not expected that feedback would be left by users; this needs to be compensated by researchers who need to collect some system satisfaction data so that future systems can learn from mistakes in this system.

SHELTERFINDER

FEMA estimated that more than 500,000 people were left homeless and another 500,000 jobless (California Political Desk, 2005) by Hurricane Katrina. With that many people residing in such a close proximity to each other, finding a new place to live even for a limited amount of time can be nearly impossible. Employment in other cities could be located online through already existing job databases; however, there was no way to find somewhere to live for free during the victims' rebuilding from devastation. At the same time, hundreds of thousands of people across the nation offered their homes to let Katrina victims have somewhere to stay until they could find permanent housing. The problem was how to coordinate information so that people who were in the affected areas could find housing across the nation. Like PeopleFinder, multiple Web sites began to pop up to offer housing, but there was no organized metasearch that allowed users to check one centralized location.

Collecting Shelter Data for Hosting

ShelterFinder (2005) was set to solve the same problem as PeopleFinder. Continuing with open standards for the systems data formats, ShelterFinder maintained a means for a single server to stream new data feeds to multiple servers while simultaneously being ready to respond to requests for data from other servers. Rather than PFIF that was designed for victims, ShelterFinder used standard formats such as CSV (Comma Separated Values) and XML (Extensible Markup Language) (Walsh, 2003). These formats allowed an independent team of developers to write database search systems and another independent team to build the GIS front end for more efficient use of the database system. Like PeopleFinder, a wiki was used for distributed management of the project. ShelterFinder would become a Web-based, data-driven DSS (Power & Kaparthi, 2002) form of knowledge management system.

ShelterFinder Development

ShelterFinder, in addition to being a distributed development group, had three constant managing members for promoting collaboration, managing the direction, and developing the system. Despite the fantastic strides made in such a short period of time, in reflection, the team discussed that there are some key aspects of their implementation strategy that could have been executed differently in order to bring more attention to the system and users. While PeopleFinder was a more evolutionary approach to software development, ShelterFinder attempted to maintain a quality of service by not releasing code until it had been tested thoroughly by the users and implemented by the lead developer. Keeping the system off-line until specific milestones were met kept ShelterFinder unavailable during potentially critical periods of time. A different software development methodology could have helped to garner more resources and to get more users while attention was still focused on the amazing open-source efforts that were emerging.

ShelterFinder Analysis

ShelterFinder gained huge acceptance due to two major components. First, it was a combined search engine that hosted records for more homes or shelters than most housing search engines. Letting the victims choose a specific city, even if it was on the opposite side of the United States, allowed victims to try to find temporary housing near family or in areas where they might be able to get jobs. This helped families find shelter near helpful social resources while decreasing the stress that the increased number of people could inadvertently cause on the resources of an area. When large amounts of people have been displaced, any opportunity to place them in different geographic areas helps the relief effort.

Second, the GUI was uniquely easy to use and made finding homes or shelters near specific addresses incredibly easy and intuitive. The GUI was a result of the recent introduction of Google Maps (http://maps.google.com). Using the built-in Google Maps XML parsing engine provided a graphical front-end that allowed users to see where homes were available in America as well as an intuitive graphical representation on the map of how many spaces were free at each shelter, based on icon color. At a community level, Google Maps has developed a means for conventional GIS developers to become Web-based GIS developers and to create Web-based applications quickly and cheaply.

KM use in ShelterFinder also is reflected in its construction. The system itself reflects the capture of lessons learned and is itself a repository of knowledge. However, this system is actually a reflection of a failure to capture and use knowledge. The system should have been designed to capture and use knowledge of survivor preferences and housing and service characteristics in order to obtain better fits of survivors to available housing other than fits based on location. Allowing searchers to pick locations that they thought best is convenient but not ideal, as reflected in reported dissatisfaction with survivors in a number of communities that took in and housed survivors. A key issue was the widespread dispersion of current or former criminals to locations at which residents did not know what they were getting. Knowledge use could have mitigated these issues. KMS features implemented in the system included knowledge repositories, although they were weak repositories based on location knowledge, and the implementation of good mnemonic functions (search, retrieve, visualize).

LEADERLESS DEVELOPMENT APPROACHES

The alternative software development approach taken by ShelterFinder shows that leaderless development systems can explore the same variety of software development approaches as well as share the same need for system requirements as their traditionally managed counterparts. The nontraditional leaderless system does have the hindrance of not necessarily being able to replace the traditional roles that a managed software development project would identify at the start of the project. In a leaderless system, this role is replaced by a group of personnel that claims and executes the publicly obtainable tasks that typically would be reserved for a specific role. This type of open task claiming allows willing members of the development team to attempt and execute tasks that normally they would not be aware of if the task weren't normally assigned to the traditional role they would play. When a task is overburdened and risks are holding back the other parts of the project, team members that normally wouldn't characterize themselves within a specialty can claim tasks that they are capable of accomplishing.

CRITICAL MASS REQUIREMENT

Distributed, by definition, requires the capability to be stretched across large redundant numbers. Leaderless development worked especially well for the PeopleFinder project, given the varying expertise available to the project by the massive number of constantly changing contributors. PeopleFinder was fortunate to have some early members that specifically spent their time advertising PeopleFinder, which, in turn, helped attract more development personnel, feeding the leaderless system. ShelterFinder, relying on a lesser quantity of members to oversee these tasks, was overwhelmed partially with the amount of work and the pressing timeline and was unable to advertise the site in the same way as PeopleFinder. This identifies a weakness in the leaderless system that if sufficient numbers of personnel are lacking, necessary functions can go without execution. Without other team personnel that is able to identify underperforming tasks within the project, the lacking tasks will continue until noticeable system degradation occurs, if noticed at all. For example, without team members persistently advertising the system's capability, users won't know about the site, and the site won't be used to its maximum capacity. Nonmarketing groups, perhaps isolated from usage statistics, might not know that the site isn't being used or that factors might be keeping the site from being used. In a rapid application development with a critical timeline such as disaster response, this can be a fatal system flaw.

CONCLUSION

Even as recently as the Sumatra-Andaman earthquake of 2004, disaster management response required printed maps and specially trained disaster management personnel to coordinate the deployment of resources. Military groups, such as the US Army's Civil Affairs branch and NGOs such as the American Red Cross, have specially trained personnel to sort through the overwhelming amount of information that arrives and to interact directly with victims. The incoming information arrives in a variety of formats, inconsistent for the operations center but usually in a consistent format from each source. This type of work usually requires specialized operations centers and a specialty staff to manage the data, and requires significant time to sort through the paper records submitted from the disaster area. Everyday citizens that would like to contribute are unable to, not only because they are not inside the physical operations center but also because there was no way for responders to reach out to the community to look for resources. Knowledge management systems, such as IMASH and the Digital Typhoon, have been researched and developed to help coordinate response to disasters. However, only by assessing how these types of systems actually worked in a disaster can improvements be made and resources like these used most efficiently in the future.

The technologies discussed here are changing the traditional approach to disaster response. Conventional, expensive, and isolated operations centers are morphing into a series of scalable, cheap, distributed, and highly networked information portals that can be used wherever a computer and Internet access are available. The more wireless options that become available to people in disaster-struck areas, from WiMax to satellite, the more options this new breed of distributed systems will have for helping people in real time wherever tragedies strike.

The social approach of these two projects is fairly unconventional in comparison to both commercial America as well as traditional disaster response. Leaderless cells performing specific actions are historically more comparable to terrorist networks than they are to humanitarian operations. The concept of groups self-determining their order of operations is countertraditional management approaches. However, the unsuccessful initial Hurricane Katrina response by the government (CNN, 2005) has shown that a rigid management can become overwhelmed when emergencies are too geographically widespread or when too many people have been affected. Distributed teams that can utilize knowledge management systems and can dynamically call upon the continually growing user base of the Internet for expert resources and manpower have a better chance to respond to the myriad of future emergencies.

Finally, the use of KM and KMS functions is shown to improve the speed and quality of response actions. This is expected, and it is our conclusion that future EIS should incorporate KM considerations.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107–136.

Aronsson, L. (2002). Operation of a large scale, general purpose wiki Website. In *Proceedings of the 6th International ICCC/IFIP Conference on Electronic Publishing*. Berlin, Verlag für Wissenschaft und Forschung (pp. 27–37).

Bellardo, S., Karwan, K.R., & Wallace, W.A. (1984). Managing the response to disasters using microcomputers. *Interfaces, 14*(2), 29–39.

California Political Desk. (2005). Kennedy, colleagues urge the administration to rebuild gulf coast in a way that is fair to workers. *American Chronicle*. Retrieved October 29, 2005, from http://www.americanchronicle.com/articles/viewArticle.asp?articleID=3229

Churchman, C.W. (1979). *The systems approach* (revised and updated). New York: Dell Publishing.

CNN. (2005). People making decisions hesitated: More officials' jobs may fall to Katrina response criticism. *Cnn.com*. Retrieved October 31, 2005, from http://www.cnn.com/2005/US/09/13/katrina.response/index.html

Cunningham, W. (2005). *Wiki history*. Retrieved October 29, 2005, from http://c2.com/cgi/wiki?WikiHistory

Davenport, T.H., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Geilhufe, D. (2005). *CRM project one pager—Confluence*. Retrieved October 29, 2005, from http://objectledge.org/confluence/display/CRM/CRM+Project+One+Pager

Huber, G.P., Davenport, T.H., & King, D. (1998). Some perspectives on organizational memory [unpublished working paper for the task force on organizational memory]. In *Proceedings of the 31st Annual Hawaii International Conference on System Sciences*, Kona, Hawaii.

Iakovou, E., & Douligeris, C. (2001). An information management system for the emergency management of hurricane disasters. *International Journal of Risk Assessment and Management, 2*(3/4), 243–262.

Jennex, M.E. (2004). Emergency response systems: The utility Y2K experience. *Journal of IT Theory and Application, 6*(3), 85–102.

Jennex, M.E. (2005). What is knowledge management? *International Journal of Knowledge Management, 1*(4), i–iv.

Jennex, M.E. (2006). Culture, context, and knowledge management. *International Journal of Knowledge Management*, *2*(2), i–iv.

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. In *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*, Kona, Hawaii.

Kersten, G.E., Mikolajuk, Z., & Yeh, A. (Eds.). (1999). *Decision support systems for sustainable development in developing countries*. Boston: Kluwer Academic.

Kitamato, A. (2005). Digital typhoon: Near real-time aggregation, recombination and delivery of typhoon-related information. In *Proceeding of the 4th International Symposium on Digital Earth*, Toyko, Japan. Retrieved October 26, 2005, from http://www.cse.iitb.ac.in/~neela/MTP/Stage1-Report.pdf

Lal, K., Plax, J., & Yee, K. (2005). *People finder interchange format 1.1*. Retrieved October 29, 2005, from http://zesty.ca/pfif/1.1

Maier, R. (2002). *Knowledge management systems: Information and communication technologies for knowledge management*. Berlin: Springer-Verlag.

Mattison, D. (2003). Quickwiki, swiki, twiki, zwiki and the plone wars—Wiki as PIM and collaborative content tool. *Searcher: The Magazine for Database Professionals*, *11*(4), 32.

Parlament of Victoria. (2005). *Victorian electronic democracy—Final report*. Retrieved October 29, 2005, from http://www.parliament.vic.gov.au/sarc/E-Democracy/Final_Report/Glossary.htm

PeopleFinderTech. (2005). Retrieved October 29, 2005, from http://www.katrinahelp.info/wiki/index.php/PeopleFinderTech

Power, D.J., & Kaparthi, S. (2002). Building Web-based decision support systems. *Studies in Informatics and Control*, *11*(4), 291–302. Retrieved October 29, 2005, from http://www.ici.ro/ici/revista/sic2002_4/art1.pdf

Raman, M., Ryan, T., & Olfman, L. (2006). Knowledge management systems for emergency preparedness: The Claremont University consortium experience. *The International Journal of Knowledge Management, 2*(3), 33–50.

ShelterFinder. (2005). Retrieved October 29, 2005, from http://katrinahelp.info/wiki/index.php/ShelterFinder.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85–117.

Tanaka, B. (2005). The oddmuse wiki engine. *Linux Journal.* Retrieved October 29, 2005, from http://www.linuxjournal.com/article/7583

Townsend, F.F. (2006). *The federal response to Hurricane Katrina, lessons learned*. Washington, DC: Department of Homeland Security.

Turoff, M., Chumer, M., Van de Walle, B., & Yao, X. (2004). The design of a dynamic emergency response management information system (DERMIS). *The Journal of Information Technology Theory and Application (JITTA), 5*(4), 1–35.

Vazey, M., & Richards, D. (2006). A case-classification-conclusion 3Cs approach o knowledge acquisition: Applying a classification logic wiki to the problem solving process. *The International Journal of Knowledge Management, 2*(1), 72–88.

Walsh, N. (2003). *A technical introduction to XML*. Retrieved October 29, 2005 from http://www.dsi.unive.it/~xml/docs/introduction.pdf

Wikipedia. (2006). *Wiki*. Retrieved March 30, 2006, from http://en.wikipedia.org/wiki/Wiki

Chapter 4.51
Organic Knowledge Management for Web-Based Customer Service

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ABSTRACT

This chapter introduces practical issues of information navigation and organizational knowledge management involved in delivering customer service via the Internet. An adaptive, organic approach is presented that addresses these issues. This approach relies on both a system architecture that embodies effective knowledge processes, and a knowledge base that is supplemented with meta-information acquired automatically through various data mining and artificial intelligence techniques. An application implementing this approach, RightNow eService Center, and the algorithms supporting it are described. Case studies of the use of eService Center by commercial, governmental and other types of organizations are presented and discussed. It is suggested that the organic approach is effective in a variety of information-providing settings beyond conventional customer service.

INTRODUCTION

The phrase "organizational data mining" in the title of this book suggests the importance of tapping all sources of information within an organization. The bare term "data mining" is most often applied to the extraction of patterns and relationships from databases or other structured data stores, enabling the productive use of information otherwise buried in overwhelming quantities of raw data. More recently, methods have been developed to extract information from relatively unstructured text documents, or, at least, to render that information more available via techniques of information retrieval, categorization and extraction. But in spite of such progress, one major source of organizational knowledge often remains inadequately managed.

It is widely recognized that much of the knowledge of any organization resides in its people. A major difficulty in tapping this key resource is that much of this knowledge is not "explicit" but rather "tacit." For our present purposes, we call explicit the sort of knowledge that could be captured relatively easily in a document, such as a memorandum, a manual or a white paper. In contrast, tacit knowledge is generally not committed to any permanent, structured form, because it tends to be strongly dependent on context or other variables that cannot be described easily. Because of its difficult nature, as well as its importance, the concept of tacit knowledge has received much attention in the recent literature (e.g., Nonaka & Takeuchi, 1995; Stenmark, 2000; Richards & Busch, 2000), though its roots go back at least to Polanyi (1966). It has become clear that the obstacles to capturing such knowledge are not merely technical, but psychological, sociological and even philosophical. No simple solution can be anticipated to this inherently difficult problem. Nevertheless, one can hope to identify certain features of the problem that are likely to be important in designing systems to deal with it.

In the following, we shall present our view of some key aspects of human-centered knowledge acquisition and dissemination. We do this within the context of a specific software application, RightNow eService Center (RNeSC), which was originally developed and is primarily used for Web-based customer service. This is not the limited domain it might at first appear, for the basic paradigm of knowledge exchange between producers (e.g., customer service representatives, university staff or government agencies) and consumers (e.g., customers, students or citizens) can be applied very generally. To cover this broad spectrum using a common terminology, we shall refer to the producers as "experts" and the consumers as "novices" or "end-users," while the general term "users" will encompass both groups.

Focusing on the knowledge management aspects of our application, the fundamental goal is to facilitate information finding by end-users and information providing by experts. We recognize that the information transfer, though asymmetric, occurs in both directions. Indeed, one of our main points is that for end-users to learn effectively, the experts must also learn about the end-users and their information needs. Furthermore, we note that the same basic paradigm can also apply to the situation where experts and end-users are the same population. (Our software is actually used in that way within a number of organizations, including our own.)

Data mining is key to the function of RNeSC in more than the metaphorical sense of eliciting knowledge from experts or the conventional sense of extracting information to generate various reports on the system status, history and use. Beyond these, the continuous analysis of text exchanges and the mining of user interaction logs represent embedded data mining functions that are crucial to the performance of RNeSC. Their main purpose is to extract what could be considered tacit knowledge of both experts and end-users about the relationships among knowledge items in the knowledge base. This metaknowledge would be both tedious and overly demanding for users to provide directly, but greatly improves the operation of the system in terms of user experience, as we shall describe.

Our aim in this chapter is to present our approaches to knowledge acquisition and access, and show how they are implemented in the RNeSC application. We outline various statistical and artificial intelligence techniques that are used in the process. Based on extensive usage information provided by companies and educational and governmental institutions that have used RNeSC, we describe some practical aspects of deploying and using the application. Finally, we discuss future trends and draw several conclusions.

KNOWLEDGE MANAGEMENT FOR CUSTOMER SERVICE

Knowledge Management Issues

We begin with a few general observations relating to the tasks of collecting or acquiring knowledge from people and providing it to others. We make no attempt to survey the vast literature on knowledge management, but simply note that a great deal of effort has gone into analyzing the nature of knowledge in its various forms and, in particular, the feasibility of capturing it for re-use or training. As mentioned, much discussion has centered around the distinction between explicit and tacit knowledge (Nonaka & Takeuchi, 1995; Stenmark, 2000; Sternberg, 1999). Though not clearly separable, these two types of knowledge are equally significant. Because tacit knowledge is often unique to an organization, it is considered a major source of competitive advantage, distinguishing that organization from others. Furthermore, tacit knowledge presents special management problems as personnel changes. For some authors (Polanyi, 1966; Cook & Brown, 1999), tacit knowledge is by definition that which cannot be expressed, while others (Nonaka & Takeuchi, 1995; Stenmark, 2000; Richards & Busch, 2000) consider "externalization" of tacit knowledge to be possible in appropriate settings. We believe the latter view is more appropriate to the domain of generalized customer service.

The process of conveying knowledge — both explicit and tacit — from expert to novice can be divided into stages, each associated with certain artifacts. This division is not unique. One traditional approach, exemplified by the creation of product documentation, models the process in two stages: (1) the expert writes the documentation, and (2) the novice reads it. While straightforward and familiar, this approach places a heavy burden on the expert to anticipate all the knowledge that could be required and present it in a way that can serve all those who might need it. An equally heavy burden is placed on the novice who must extract from the resulting large body of knowledge just that part corresponding to his or her need. Naturally, it often happens that what the novice needs is not fully provided, or the context is different enough that the novice fails to find the separate "nuggets" that, combined, would meet the need.

For example, it is difficult, if not impossible, to write a service manual for some piece of equipment that covers all repair situations. Yet an experienced repairperson can usually figure out what is needed on a particular job. If that specific repair procedure is described, elements of tacit knowledge are implicitly captured. In most organizations, as described in Brown and Duguid (1991), such stories are circulated informally within a community of practice. If they can be recorded and made more widely available, as was done with the well-known Eureka system at Xerox, the resulting knowledge base can be of extraordinary value to the organization (Powers, 1999; Fischer & Ostwald, 2001).

A second traditional approach is simple dialogue between expert and novice, in which the expert can both assist in the expression of the novice's needs and convey the knowledge in the most effective way for the particular novice. Such a model is the ideal of the conventional help desk. It typically results in the greatest benefit to the novice, but, depending on the setting, it may be highly burdensome and expensive to have an expert always available for each novice.

The model of the knowledge transfer process embodied in the architecture of RNeSC comprises elements of both the traditional approaches described above. Our interactive approach starts with the novice's specific information need. This is not necessarily clearly formulated, so we provide various means for the novice to satisfy the need via a self-service knowledge base. If that effort is unsuccessful, the novice must express the need in the form of a text message, which is sent to an expert. The expert then responds, drawing on accumulated experience, including appropriate elements of tacit knowledge. The response is, thus, much more limited in scope and tailored to the immediate need. In this setting, tacit knowledge, which might not have found its way into a manual, is activated; the expert realizes intuitively what will work best in the case at hand. This leads to what we consider an important aspect of any approach that aims to capture such knowledge: it is easiest to do so at the point of application, that is, in the consideration of a particular situation that calls for such knowledge. In a final stage of the process, the expert can choose to add the newly articulated knowledge to the knowledge base, thus enhancing self-service capability on the part of other novices.

Knowledge management in our model contrasts with that in the traditional model in several key regards. First, knowledge creation by the expert occurs not in a relative vacuum but in a specific, situated context. This facilitates application and capture of tacit knowledge, which is stored in the knowledge base along with the context. The knowledge transfer is not limited to transmission via a static artifact, such as a manual, but either by direct, personal response of expert to novice or via the novice's ability to locate the knowledge on his own. Since the latter is preferred, it is important to provide tools that assist the novice in navigating the knowledge base. Finally, utilization of the knowledge tends to be more effective under our model because of increased relevance to the particular situation of the novice.

Note that we have so far taken the expert to be omniscient. In most real cases, the expert also might need to refer to the knowledge base in the course of responding to a novice, especially if the expert is really an expert-in-training.

The Customer Service Domain

Customer service represents a quintessential knowledge management problem. Answers, i.e., information or knowledge, must be identified, transcribed or acquired by or from experts (e.g., customer service representatives) and then provided to novices (end-users) in response to their questions. Because of the economic importance of customer satisfaction, significant resources may be devoted to this function. In recent years, many companies and other entities have found it necessary to maintain a presence on the World Wide Web, and customer service is naturally one of the functions that can be provided by this means. However, the journey has not always been easy or successful.

Historically, the first step toward Web-based service was that of simply listing contact phone numbers and e-mail addresses on a Web page; end-user inquiries were then handled through these more traditional channels. This approach has the advantage of using existing infrastructure, but is typically very expensive per transaction, especially as there is now a general expectation of rapid response, even 24 hours a day. The majority of organizations are still at this level.

A second generation of Web-based service provides a set of answers to frequently asked questions (FAQs) on a support Web page. The composition of such a FAQ list is based on the accumulated experience of customer service representatives (CSRs). If well written and organized, this can significantly reduce the number of repeated inquiries received by CSRs, reducing their overload and increasing their productivity. However, unless the common inquiries are quite stable over time, this method requires a significant maintenance effort to keep the FAQ list organized and up to date. In many cases, depending on the organization, change can be relatively great on a weekly or monthly time scale. This change can also be unpredictable. Although it may be easy to see that introduction of a new product will lead to inquiries related to that product, it is not so easy to foretell what external events, such as a new law or regulation, or new products offered by competing companies, will cause a shift in end-user information needs. A further problem with this type of service is that as the number of FAQs grows larger, it becomes increasingly difficult for users to find answers to their questions.

A third level of Web-based service involves the provision of search capability over a set of indexed documents that constitute the online knowledge base. With such a system, answer-containing documents can be added independently of each other, and the structure is essentially the invisible one provided by the search facility. Related documents are, by definition, those returned together in response to a specific search query. Depending on the design of the search engine, it may or may not provide additional features, such as natural language input or matching to related words such as word-form variants (drive, driver, driving, etc.) or synonyms (car, automobile, etc.). These well-known search engine problems have led some companies to deploy conversational question-answering systems, or "chatbots." Unfortunately, at their current stage of development, such systems require extensive knowledge engineering in the form of identifying input question patterns that should be recognized and the links to the corresponding answers. Beyond pre-scripted patterns, the performance degrades rapidly. Furthermore, this type of system either does not support overviews and browsing of the knowledge base, or again requires knowledge engineering to create and maintain a taxonomy and relate it to the collection of knowledge base documents.

At present, there is a wide range of levels of customer service available on the Internet. Some organizations have managed a good fit between what they need and what they provide. But many are still struggling with expensive, cumbersome systems that do not serve them well. In some cases, organizations simply don't have a good understanding of what state-of-the-art customer service can or should be. But probably most often it is a lack of resources — both human and financial — that limits the quality of service. For this reason, a constant aim in the development of RNeSC was to minimize the effort necessary to establish and maintain the system. This entailed an architectural design in accordance with the above and other considerations, as well as integration of data mining and artificial intelligence techniques to reduce the burden on users.

AN ORGANIC KNOWLEDGE BASE

The Organic Approach

To find a way to meet the sometimes conflicting needs of experts and end-users, we believe that attention must first be focused on the core of the system where knowledge is stored, namely the knowledge base. In the type of system we envision, this is a publicly available (via the World Wide Web), dynamic collection of documents that we shall refer to as Answers. We assume here that it is created and maintained by the experts (e.g., CSRs). In actuality, there may be distinct managers who perform various important functions, but whose role is outside the scope of this paper.

The knowledge base must first of all contain the knowledge sought by end-users. How does one know what this is? Within our organic approach, the reply is simple: Let the end-users identify what is needed by the questions they ask. This implies that the knowledge base does not exist in isolation; it must be closely coupled to channels through which end-users ask questions.

As a concrete example, take the case of a computer services help desk that receives several complaints about problems with a new software version. Though one might expect certain problems to arise with such upgrades, it would be extremely difficult to attempt to forestall complaints by preparing a comprehensive troubleshooting guide. In contrast, it is relatively easy for a technician to answer a specific question in a given context and easier for the end-user to understand that answer than the full troubleshooting procedure. If the Answer is published in the knowledge base, incoming questions on the topic may be reduced either because only that single case led to problems, or because other users could resolve their problems also by following the approximate answer. If not, new support requests will come in, and then either the first answer could be modified or expanded, or a new answer added. This adaptive "just-in-time" approach is very efficient in terms of experts' effort.

Thus, along with the knowledge base itself, end-users must have direct access to experts when they don't find the information they need in the knowledge base. It is their needs that drive knowledge creation, while the experts' effort is conserved. A similar concept of experts backing up a knowledge base in a system for organizational memory, an application close in spirit to customer service, has been described and studied by Ackerman (1998).

According to the organic growth scenario, the knowledge base is initially seeded with a fairly small set of Answers to known or anticipated FAQs. After that, Answers are added as needed to respond to new incoming questions frequent enough to merit creation of a public Answer. (Of course, Answers to predictable concerns can also be added even before questions arise.) Depending on the organization, the threshold could range from one to perhaps hundreds.

This approach has a number of advantages for experts:

- Tacit as well as explicit knowledge can be brought to bear on the specific questions.
- Answers can be based on existing private responses (made before reaching the threshold).
- No time and effort are spent creating unneeded Answers.

Furthermore, experts have a natural motivation to upgrade private responses to publicly available Answers: A single Answer can eliminate the need for many private responses. As in any knowledge management endeavor, it is also important for the organization to create a culture in which such contributions are recognized or rewarded in one way or another.

End-users also benefit. Unlike a traditional call center or contact center, this approach develops an authoritative, self-service knowledge base, accessible 24 hours a day, in which an end-user can generally locate information faster than she can compose, say, an e-mail describing her question or problem. This is especially true if the initial problem description is unclear and a series of back-and-forth communications would be necessary for clarification. End-users with novel or inherently personal questions can still receive service through the traditional channels, now improved because of the reduced load on the experts.

Critical to success of this approach is the ease with which end-users can actually navigate the knowledge base to find information. Frustration leads not only to negative attitudes towards the organization but, if anything, increases the burden on experts. In contrast, a positive experience for the end-user enhances trust and loyalty, key assets for noncommercial as well as business entities. Ensuring such a positive interaction requires attention to the psychology as well as the statistics of searching. To support each end-user's quest, the interface to the knowledge base must be as intelligent as possible and be adaptable to the range of search skills that different users may have. This entails use of natural language and artificial intelligence (AI) methods. Appropriately integrated, these techniques can also be applied to improving performance of the system from the experts' point of view.

Feedback from end-users to experts, in addition to that implicit in the asking of questions, should be such as to facilitate various forms of optimization, as well as provide understanding of end-user behavior that may be significant to the organization. This can be accomplished by mining records of user interactions with the knowledge base.

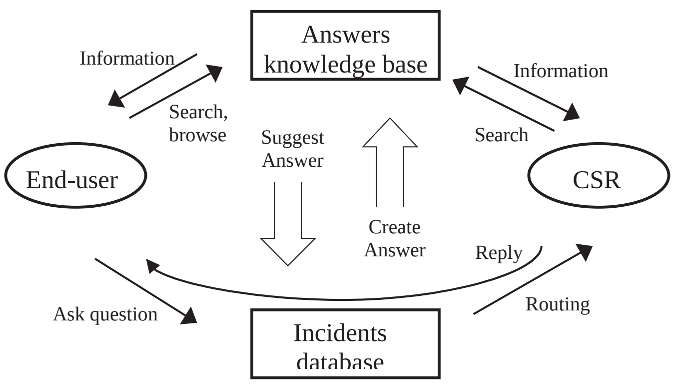
In the following, we detail how this organic approach is embodied in RNeSC. After briefly introducing the overall system, we focus on those aspects related to the knowledge base, since this is where most of the AI and data mining techniques come into play. We describe the use of the system in practice, as well as the algorithmic techniques employed and their multiple roles.

System Architecture

RNeSC is an integrated application that combines e-mail management, Web self-service, live collaborative chat, and knowledge management. The core of the application, from our present perspective, is the publicly accessible Answer knowledge base and the tools by which it is created, maintained and accessed. In addition, there is a database of customer-service Incidents, i.e., messages from end-users, which are fully tracked from initial creation—via e-mail, Web form or live chat—through resolution and archiving. Figure 1 illustrates these key components and how they are involved in end-user and CSR (or other expert) knowledge-related transactions.

As indicated in the previous section and in Figure 1, the architecture of RNeSC provides a strong interaction between question and answer

Figure 1. Principal Knowledge-Related Transactions in RNeSC (End-users search the Answer knowledge base for information; if they cannot find what they need, they submit a question, which is stored and tracked in an Incidents database, and replied to by a CSR. CSRs also use the knowledge base, and add to it by creating new Answers, typically suggested by frequently asked questions. Answers to questions can be suggested from the knowledge base either to assist CSRs in forming replies or as auto-replies to end-users. See text for a fuller description.)



channels. As CSRs respond to the questions submitted by end-users, they naturally become aware of trends and commonalities among them. At any time, a private CSR reply can be proposed as a potential public knowledge base item, or a new Answer can be composed on the basis of previous replies or predicted information needs. Depending on organizational practices, the item might be reviewed or edited by collaborators or managers before being made a publicly available Answer.

In typical operation, the main knowledge flow (in terms of volume) is from the knowledge base to end-users who are successful in their searching. But even if they are unsuccessful, or if they make no attempt at self-service, the contents of their question may suggest that one or more relevant Answers actually exist. In that case, Answers can be suggested automatically, based on search technology described later. These Suggested Answers can either be routed directly to the end-user as an auto-reply or to the CSR engaged in formulating a personal reply. Naturally, CSRs also make direct use of the knowledge base for their own information, especially novice CSRs.

In this paper we leave aside the multiple administrative functions of RNeSC, though these are vital to its overall ease of use (especially from a CSR's point of view). Some of these use AI techniques also employed in the central knowledge management functions. For example, one of the criteria that can be used in routing incoming questions to individual CSRs is an emotive index that estimates the degree to which the tone of a message is angry, neutral or happy. This determination uses the same natural language processing algorithms described later, in combination with wordlists and grammar rules. As RNeSC is available in about 15 languages and dialects, implementing this feature takes a significant effort. Also not indicated in Figure 1 is a module that generates a wide variety of reports to aid in evaluating transaction statistics, CSR performance and Web-site usage. These are developed through both batch and incremental analysis of system interaction records. Finally, except to mention a notification function that allows a user to be informed of any changes in a selected Answer, we won't detail here the many customization options that users can set.

Using the Knowledge Base

It is widely appreciated that knowledge comprises not only facts, but relationships among these, as well as perspective on their importance, relevance, etc. A knowledge base organized to incorporate or reflect such metaknowledge provides a much better match to user habits and expectations and is consequently easier to use. In RNeSC this metaknowledge is acquired through several techniques. In addition to intelligent searching, these include adaptive clustering and classification of text documents (the knowledge base Answers), and collaborative filtering techniques that mine usage patterns to extract implicit user feedback on importance, timeliness and relatedness of knowledge base items. We will describe these techniques as they might come into play while a user navigates a knowledge base.

An illustration of a simple end-user view of a knowledge base is shown in Figure 2. This page is reached after first selecting the "Answers" link on the support home page, before any search has been made. The Answers shown are listed in order of historical usefulness — called solved count — which measures how helpful an answer is likely to be based on the experience of previous users. If the knowledge base is not too large and the end-user is looking for information that is commonly sought, there is a fair probability that the appropriate Answer will be listed in the first set. If the solved count of answers happens to follow a Zipf distribution, then even with 500 items in the knowledge base, there is nearly a 50 percent chance that the appropriate Answer will be within the top 10.

The solved count is obtained from a combination of explicit and implicit user feedback. If enabled, each Answer page carries evaluation buttons (e.g., labeled 0 percent, 25 percent, 50 percent, 75 percent and 100 percent) that the user can select to indicate the degree to which his or her question was answered; these contribute proportionately to the solved count. Since relatively few users make the effort to provide explicit feedback, we also derive an implicit evaluation from the user's actions. Simply choosing to view a particular Answer is taken as a partial vote for its usefulness. If the Answer is the last one viewed, it is assumed that it provided the information sought, and the vote is given a higher weight (though still less than an explicitly approved Answer).

An Answer that appeared promising from its title might prove insufficient. If so, to the extent the title represented the content, an Answer with similar or related content might help the user. Each Answer page can be provided with links to a variable number of the most closely related Answers. The relatedness ranking, like the solved count, has explicit and implicit components. The explicit relatedness is derived from text similarity, currently based on the vector model common in information retrieval (see, e.g., Manning & Schutze, 1999, p. 296), with stopword removal and conflation of words having the same stem. To obtain an implicit relatedness score, the application maintains a link matrix, the corresponding element of which is incremented each time an end-user navigates from one Answer to another, presumably related one. The increment is larger if the second Answer is the final one viewed or is given a high explicit rating.

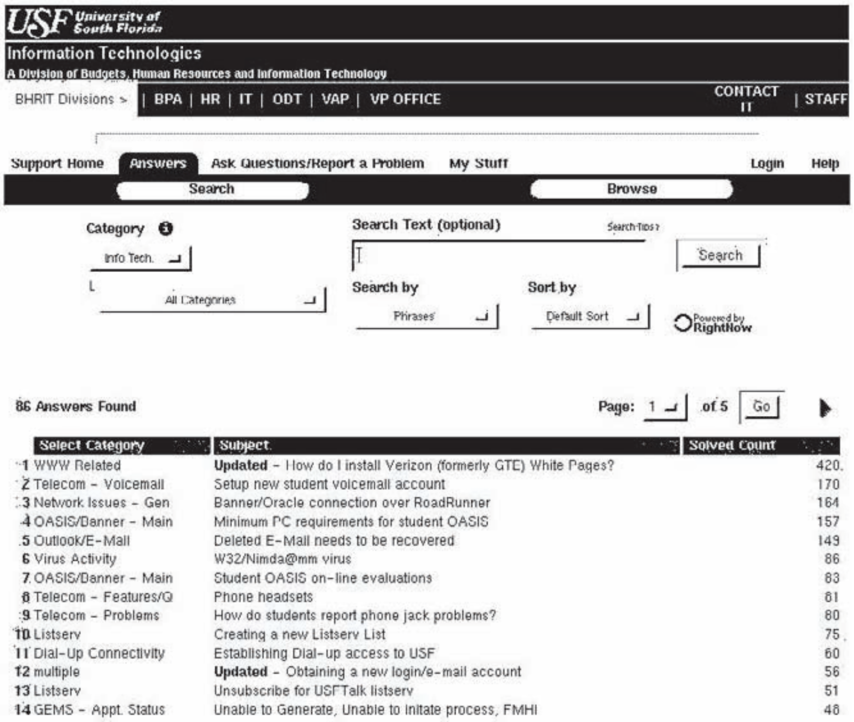
The methods just mentioned for capturing user perceptions of usefulness and relatedness are inspired by both collaborative filtering (Levy & Weld, 2000) and swarm intelligence (Dorigo, Di Caro & Gambardella, 1999) approaches. In our application, rather than software agents traversing a network as in the usual form of swarm intelligence, it is human users whose paths leave a trace as a pheromone-like record. The resulting link matrix certainly contains noise in the sense that not every item-to-item transition is made by users only on the basis of perceived relatedness. Nonetheless, averaged over many users who each tend to be searching for information related to a specific need, we have found that the strong links indicate useful relationships. By means of the accumulated links, the application learns which other items in the knowledge base are most closely related to a given one.

The algorithm as described so far would be appropriate for a static knowledge base but not for a changing one. Just as an insect pheromone trail evaporates with time, so we perform an aging process by which both solved count and link values are periodically reduced in strength when not reinforced. This aging keeps the knowledge base responsive by enforcing the primacy of recent usage patterns. By this means the most useful Answers float to the top of the list and appear on the very first page. For a more complete discussion of these collaborative and swarm intelligence methods, see Warner, Richter, Durbin and Banerjee (2001).

Both the solved count and the link matrix represent a form of knowledge acquired from users about items in the knowledge base. From a knowledge management point of view, the role of this metaknowledge is to aid in the principal knowledge transfer by making it easier for end-users to find the Answers they need.

To find Answers to less frequently asked questions, end-users may need to perform a search of the knowledge base. Intelligent search is a prerequisite for easy access to information. In RNeSC, queries entered into the search box (Figure 2) can be processed according to a variety of search modes, including natural language input and similar phrase searching (which carries out spelling correction and synonym expansion). Searches can also be restricted to predefined

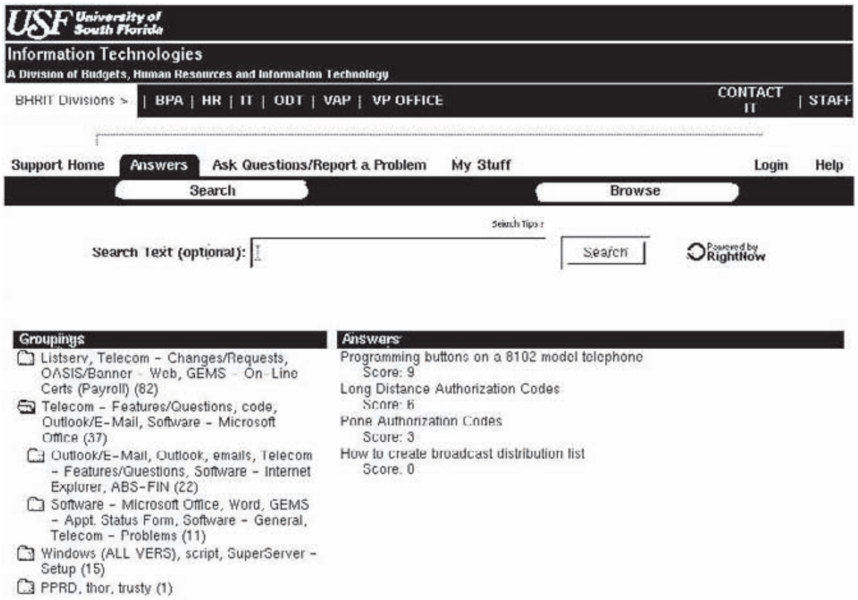
Figure 2. Portion of the Web Browser Display from the Support Page of the University of South Florida Information Technology Division [The page is configured to list by default the historically most useful Answers (i.e., highest solved count). Users may search in various modes by entering search text, and they may contact a CSR via the "Ask a Question" tab.]



products and categories, if such taxonomies have been established. The results of a search can be displayed in order of relevance or solved count.

End-users may or may not come to a support Web site with specific questions, but, in either case, they may find it convenient to browse the knowledge base from a more distant perspective, gaining an overview of the available information. Our system offers a browse mode of access in which categories of documents are displayed as folders, labeled with the key terms most descriptive of their contents (Figure 3). Clicking on a folder opens it to display documents and subfolders corresponding to more specific categories. The automatically determined labels on the folders give a summary of the contents. Because the user can navigate by selecting subfolders and individual documents without needing to type search terms, the browse mode is especially helpful when the user is unfamiliar with the terminology used in the Answers, and, hence, might have difficulty formulating a productive search query. If desired, it is also possible to search within a browse category. In a sense, the ease of browsing is related

Figure 3. Web Browser Display from the Support Page of the University of South Florida Information Technology Division [This page displays a hierarchical set of folders and subfolders, where a given folder (like a typical computer file system) may contain both subfolders and Answer documents.]



to the tacit knowledge of a user about the subject area. Most people are able to recognize what they're looking for much more easily than they can articulate it.

The browse function is made possible by a hierarchical categorization of the text items in the knowledge base. For this we employ a modification of the fast, hierarchical clustering algorithm BIRCH (Zhang, Ramakrishnan, & Livny, 1996), the result of which is used to learn RIPPER-style classification rules (Cohen, 1995). The final topic hierarchy is determined by classifying all knowledge base items according to the learned rules. Because of the inherent multiplicity and subjectivity of similarity relationships, we allow single items to be classified in multiple places where they fit well. This makes using the browse interface much more convenient, as the user can locate an item along various paths and does not have to guess what rigid classification might control the listing. New Answers are, on creation, simply inserted into the hierarchy according to the classification rules. After a predetermined amount of change in the knowledge base, due to modification or addition, a reclustering is performed so that the browse hierarchy reflects the current state of the contents, rather than a fixed hierarchy.

The features on the basis of which the clustering is performed are obtained from the document texts by shallow parsing. The natural language processing starts with part of speech tagging via a transformation-based tagger (Brill, 1994). Rules are the used to identify noun phrases, which receive the highest weight as features, though other selected words are also used. In addition, customer-supplied keywords and product or category names provide highly weighted features. The weights of feature words are additionally adjusted on the basis of the frequency with which users have searched for them, as reflected in a table maintained with the knowledge base. The clustering procedure is actually carried out several times with different sets of parameters, and the best clustering, according to a composite figure of merit, is chosen.

To assist CSRs in composing responses, as well as to optionally supply automated responses to end-users submitting questions, RNeSC can be configured to automatically suggest Answers. This is done by first processing the text of the question as if it were a search query. Simply taking the top-ranked Answers returned can result in spurious matches. Hence, they are filtered by checking whether they would appear in the same cluster as would the question text, now treated as an Answer for categorization. If this feature is used by a CSR, the suggested Answers are directly pasted into a reply form, where they can be edited by the human expert.

As with the solved count and the link matrix, the clustering represents automatically generated metaknowledge that serves to aid knowledge acquisition by end-users. To evaluate scientifically the utility of such aid would require extensive human testing, which we have not carried out. However, both our own observations and, more importantly, the experience of RNeSC users, as described in the next section, indicate that the benefits can be significant.

USER EXPERIENCE WITH RNESC

The system we describe has been used, through several versions, by a wide variety of commercial, educational, and governmental organizations. Drawing from their accumulated experience, we present both aggregate statistics and case studies illustrating the dramatic reduction of time and effort for knowledge-base creation and maintenance, and the increase in satisfaction of knowledge base users. This holds across the spectrum of organizations and applications, including those outside the area of conventional customer service.

Different organizations use the system in a variety of ways. The Rotherham England Metropolitan Borough Council uses it as a community clearinghouse where answers are provided to all kinds of questions about which one might contact a city office. As of this writing, it contains 476 answers to questions ranging from regularly recurring ones, such as “Can I report a pothole in the road?,” to more timely ones, such as “Do you have any information regarding the Queen’s Golden Jubilee?” Statements by the council make it clear that they view this information service for citizens, part of an e-government initiative, as very analogous to a business’ support for customers. Although the majority of the 16,000 daily hits on the site are from the UK, there are also high numbers from the U.S., Taiwan, Germany, France, Sweden and Denmark, some of which, it is hoped, may represent people looking to invest in the UK and attracted by Rotherham’s assets.

Within our own company (RightNow Technologies), independent instances of RNeSC are used for external customer support and for internal company information. More interesting is its use as a resource for developers, who answer each other’s questions — a case of experts and end-users being the same population. It also provides a defect posting and tracking system shared by the development and quality assurance departments. The resulting history of bug fixes, with each incident often carrying contributions from several developers and testers, is a heavily used company resource. In terms of knowledge management theory (see, e.g., Brown & Duguid, 2000), each bug history document constitutes a “boundary object,” collaboratively produced by two groups within the organization, serving to facilitate communication between them.

Due to the high degree of automation of RNeSC, the ease of installation is such that it has been accomplished in as little as a few days, or even one day. Once set up, the knowledge base can grow rapidly. For example, the United States Social Security Administration started with 284 items in their initial knowledge base, and over 200 new items based on user-submitted questions were added within two weeks. After two years, the number has stabilized at about 600, though the composition continues to change. Due to the public availability of the knowledge base, the number of telephone calls has dropped by 50 percent, from 50,000 to 25,000 daily. Similar experiences are common.1

The ability of a Web self-service system to handle dynamic fluctuations in usage can be very important. As one example, an announcement of a rate hike by the U.S. Postal Service led to a short-term increase in visitors to the support site of Pitney-Bowes, which provides mailing services, of nearly 1,000 percent over that for the previous rate hike. Attempting to handle such volume via telephone or e-mail would have resulted in huge backlogs.

One quantitative measure of end-user success in finding information is the self-service index, is defined as the percentage of end-users who are able to find Answers online, rather than sending a message to a CSR. Table 1 is excerpted from a Doculabs study (Watson, Donnelly & Shehab, 2001) in which it was found that the self-service

Table 1. Self-Service Index for Various Types of Organizations Using RNeSC [The self-service index is the fraction of end-users that find needed information in the Answer knowledge base, rather than initiating contact (escalating) with a support person via e-mail or online chat.]

Industry	Visits	Escalations	Self-Service Index
General Equipment	342,728	4,144	98.79%
Manufacturing	22,784	489	97.85%
Education	8,400	317	96.23%
Entertainment/Media	113,047	4,622	95.91%
Financial Services	40,574	1,972	95.14%
Contract Manufacturers	77,838	4,203	94.60%
Utility/Energy	19,035	1,122	94.11%
ISP/Hosting	147,671	8,771	94.06%
IT Solution Providers	53,804	3,277	93.91%
Computer Software	449,402	27,412	93.90%
Dot Coms	267,346	20,309	92.40%
Medical Products/Resources	17,892	1,451	91.89%
Professional Services	24,862	2,142	91.38%
Insurance	40,921	3,537	91.36%
Automotive	3,801	373	90.19%
Retail/Catalog	44,145	6,150	86.07%
Consumer Products	1,044,199	162,219	84.46%
Computer Hardware	101,209	15,759	84.43%
Government	108,955	17,347	84.08%
Travel/Hospitality	27,099	4,610	82.99%
Association/Nonprofit	14,620	2,772	81.04%
Telecommunications	809,320	202,158	75.02%
Overall Total	**3,779,652**	**495,156**	**86.90%**

index for organizations using RNeSC ranged from 75 to almost 99 percent, averaging 85 to 90 percent. The lower values for some categories of organization, such as telecommunications or travel services companies, may be due to a greater number of end-user-specific questions in these areas. Nonetheless, given typical costs of $30 per telephone transaction, $10 per e-mail exchange and $1 per Web interaction, such high self-service rates can lead to dramatic savings. According to anecdotal reports from users, the benefits described are largely attributable to the features of RNeSC described in this paper.

DISCUSSION AND FUTURE TRENDS

We believe that the performance of the RNeSC application in a range of settings is evidence that the underlying principles have a sound practical basis. Nevertheless, there is certainly room to do better. Some improvements are incremental, such as making the clustering algorithm more adaptive to knowledge bases that may differ significantly in the nature and length of the documents they contain, and in the granularity of the product and category divisions they use, if any. More difficult is the issue of descriptive labels for the clusters; the area of multidocument summarization is one of active current research (see, e.g., Mani & Maybury, 1999).

More qualitative enhancements can be obtained from applying AI techniques to a greater number of functions. Advanced machine learning techniques can potentially be employed wherever rules are used, including incident routing, text categorization and natural language processing. In the latter area, sophisticated question-answering systems will probably soon reach the point of being commercially viable, at least within restricted subjects. A fluent conversational interface to a knowledge base would fulfill many developers' dreams. Until that is available, the art is to provide some approximation with capabilities that outweigh the disappointments.

Another trend is toward greater personalization of user interfaces. Care must be exercised to ensure such customization facilitates rather than constrains. The extent to which significant personalization is feasible for frequent and for one-time users remains to be investigated.

Along other lines, the pursuit of applications in different sectors of knowledge management could suggest a new mix of features. RNeSC is already quite flexible and user-configurable and could evolve in many different directions. We believe that many of its advantages as a customer-service application could be realized in related areas as well.

CONCLUSION

We have presented an organic approach to knowledge creation and delivery that emphasizes rapid response for dynamic information environments. The user-driven architecture helps mobilize tacit knowledge and dramatically reduces the time and expense of creating a knowledge base. Facilitated and cooperative creation of knowledge base documents takes place as an extension of the normal activities of experts. Continuous mining of implicit end-user recognition of the importance and relationships of information items enables the system to adapt quickly, while remaining easy to use through automated re-organization. As embodied in the Web-based customer service application Right Now Service Center, the system uses a number of AI techniques to facilitate construction, maintenance and navigation of a knowledge base of answers to frequently asked questions. These techniques include collaborative filtering, swarm intelligence, natural language processing, text clustering and classification rule learning. Many of these individual techniques have been similarly employed in other commercial applications, but we know of no other system that combines all of them. Customers using RNeSC report dramatic decreases in support costs and increases in customer satisfaction due to the ease of use provided by the "self-learning" features of the knowledge base.

We have argued that the principles and methods of our approach are also applicable in other settings, for example, government agencies reaching out to concerned citizens. In fact, organizations and associated constituencies with information needs are ubiquitous in modern society. Ubiquitous also is the need for software tools to assist them. "Since it is the value added by people — context, experience and interpretation — that transforms data and information into knowledge, it is the ability to capture and manage those human additions that make information technologies particularly suited to dealing with knowledge" (Davenport & Prusak, p. 129).

REFERENCES

Ackerman, M. S. (1998). Augmenting organizational memory: A field study of Answer Garden. *ACM Transactions on Information Systems, 16*(3), 203-224.

Brill, E. (1994). Some advances in transformation-based part of speech tagging. *Proceedings of the Twelfth National Conference on Artificial Intelligence* (pp. 722-727). Menlo Park, CA: AAAI Press.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities-of-practice: Toward a unified view of working, learning, and innovation. *Organization Science, 2*, 40-57.

Brown, J. S., & Duguid, P. (2000). *The social life of information.* Boston: Harvard Business School Press.

Cohen, W. H. (1995). *Fast effective rule induction. Machine Learning: Proceedings of the Twelfth International Conference* (pp. 115-123). Lake Tahoe, CA: Morgan Kaufmann.

Cook, D., & Brown, J. S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 10,* 381-400.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge.* Boston: Harvard Business School Press.

Dorigo, M., Di Caro, G., & Gambardella, L. M. (1999). Ant algorithms for discrete optimization. *Artificial Life, 5*(2), 137-172.

Fischer, G., & Ostwald, J. (2001). Knowledge management: Problems, promises, realities, and challenges. *IEEE Intelligent Systems, 16*, 60-72.

Levy, A. Y., & Weld, D. S. (2000). Intelligent Internet systems. *Artificial Intelligence, 118*, 1-14.

Mani, I., & Maybury, M. T. (Eds.). (1999). *Advances in automatic text summarization.* Cambridge, MA: MIT Press.

Manning, C. D., & Schutze, H. (1999). *Foundations of natural language processing.* Cambridge, MA: MIT Press.

Nonaka, I., & Takeuchi, H. (1995). *The Knowledge creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

Polanyi, M. (1966). *The tacit dimension.* London: Routeledge & Kegan Paul.

Powers, V. J. (1999). Xerox creates a knowledge-sharing culture through grassroots efforts. *Knowledge Management in Practice*, (18), 1-4. American Productivity & Quality Center.

Richards, D., & Busch, P. (2000). Measuring, formalising, and modeling tacit knowledge. *Proceedings of the ICSC Symposium on Intelligent Systems and Applications.* Millet, Alberta, Canada: NAISO Academic Press.

Stenmark, D. (2000). Leveraging tacit organizational knowledge. *Journal of Management Information Systems, 17*, 9-24.

Sternberg, R. J. (1999). What do we know about tacit knowledge? Making the tacit become explicit. In R. J. Sternberg &J. A. Horvath (Eds.), *Tacit knowledge in professional practice* (pp. 231-236). Mahwah, NJ: Lawrence Erlbaum Associates.

Warner, D., Richter J. N., Durbin, S. D., & Banerjee, B. (2001). Mining user session data to facilitate user interaction with a customer service knowledge base in RightNow Web. *Proceedings of the Seventh ACM SIGKDD International Conference on Knowledge Discovery and Data Mining* (pp. 467-72). New York: Association for Computing Machinery.

Watson, J., Donnelly, G., & Shehab, J. (2001). *The self-service index report: Why Web-based self-service is the ROI sweet-spot of CRM*. Retrieved on March 25, 2003, from http://www.doculabs.com

Zhang, T., Ramakrishnan, R., & Livny, M. (1996). BIRCH: An efficient data clustering method for very large databases. *Proceedings of the 1996 ACM SIGMOD International Conference on Management of Data* (pp. 103-114). New York: Association for Computing Machinery.

ENDNOTE

[1] See more case studies at http://www.rightnow.com/resource/casestudies.php.

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Chapter 4.52
Opportunities for Data Mining and Customer Knowledge Management for Shopping Centers

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ABSTRACT

Shopping centers are an important part of the UK economy and have been the subject of considerable research. Relying on complex interdependencies between shoppers, retailers and owners, shopping centers are ideal for knowledge management study. Nevertheless, although retailers have been in the forefront of data mining, little has been written on customer knowledge management for shopping centers. In this chapter, the authors aim to demonstrate the possibilities and draw attention to the possible implications of improving customer satisfaction. Aspects of customer knowledge management for shopping centers are considered using analogies drawn from an exploratory questionnaire survey. The objectives of a customer knowledge management system could include increasing rental incomes and bringing new life back into shopping centers and towns.

INTRODUCTION

Shopping centers are an interesting topic for knowledge management — relying on interdependency between owner, retailers and shoppers. Why are shopping centers important? Firstly, planned shopping centers comprise a substantial part of the UK economy, employing over three-quarters of a million people and playing a 'key role in the investments of pension funds' (Davies et al., 1993; OXIRM, 1999). Shopping centers are therefore important not just to customers, but also employees and indeed to many others because of the investments of their pensions. Secondly, retail and shopping centers form the heart of UK towns and create a focus for the community. Shoppers tend to follow the provision of attractive shopping areas. Improving shopper satisfaction can lead to changes in population, expenditure, residence patterns and bring new life to run-down areas (Dennis et al., forthcoming 2002b). The findings of the research could be applicable to traditional high streets and towns as they are to purpose-built shopping malls — if there is in place some form of central administration such as Town Center Managers. This chapter considers the possibilities for shopping centers to make their offer more attractive using techniques of data mining and customer knowledge management.

DATA MINING AND CUSTOMER KNOWLEDGE MANAGEMENT IN THE RETAIL CONTEXT

Data mining has been defined as:

"The process of exploration and analysis, by automatic or semi-automatic means, of large quantities of data in order to discover meaningful patterns and rules." (Berry and Linoff, 1997)

Berry and Linoff (2000) list six data mining activities: (1) classification; (2) estimation; (3) prediction; (4) affinity grouping or association rules; (5) clustering; and (6) description and visualization. Retail studies have included many other techniques (e.g., sequence-based analysis; fuzzy logic; neural networks; fractal-based algorithms (Rao, 2000; Rensselaer Polytechnic Institute, 1999). Nevertheless, Berry and Linoff's six categories serve our purposes here.

Data mining has many uses, but the aspect of most concern here is what is usually known as 'Customer Relationship Management' (CRM). Good CRM means: (1) presenting a single image of the organisation; (2) understanding who customers are and their likes and dislikes; (3) anticipating customer needs and addressing them proactively; and (4) recognizing when customers are dissatisfied and taking corrective action (Berry and Linoff, 2000).

Some UK retailers recognize the potential of data mining in discovering customer knowledge. For example, Halfords and Sainsbury's uses Brann Viper software, Tesco and John Lewis Dunn Humby (Computer Weekly, 16 January and 29 May 1997). Most, though, jealously guard their customer knowledge capital. The authors argue that dissemination of this knowledge to a shopping center owner could result in meeting shopper requirements better.

Since the mid-1980s, there has been an increasing recognition that "knowledge is a fundamental factor behind an enterprise's success" (Wiij, 1994) — a statement that applies in the retail industry as in others. This chapter will consider shopping center customer knowledge management from Wiij's (1998) third, broadest focus: "all knowledge activities affecting success … using knowledge assets to realize their value." The specific concern is with customer knowledge management — the management and exploitation of customer knowledge. There are two aspects of this knowledge: (1) knowledge about customers; and (2) knowledge possessed by customers (Rowley, 2001). The empirical study reported here concerns the first aspect, but we will conclude with a recommendation for further research on the second.

Richards et al. (1998) argued that the marketing success of an enterprise is founded on "a continuous dialogue with users, leading to a real understanding … the more mundane the category [shopping centers?], the more dependent on knowledge." In the early 1980s, data warehousing transformed operational data into knowledge for decision-making. As retail IT systems company NCR put it: "For retailers the key … is to establish data warehouses to improve and manage customer relationships" (Teresko, 1999).

Data mining can use programming methods to identify patterns among data objects — for example between products in a shopping basket. The well-known early example is the 'diapers-beer' link on Friday evenings spotted by Wal-Mart in the U.S. By placing the two side by side, more fathers took home extra beer when they went to buy the diapers after work. Woolworths (UK) have installed a system costing UK£2 million, claimed to have boosted sales in women's toiletries alone by more than UK£5 million per year (Bird, 1996). The authors contend that incorporating data mining and customer database aspects within a framework of knowledge management can help increase knowledge value.

The main focus of this chapter concerns the opportunities for data mining and customer knowledge management for shopping centers. Data mining normally refers to large quantities of data, so our survey of 287 respondents must be near the smaller end of the scope. Nevertheless, the dataset has been useful in illustrating the utility of aspects of data mining and customer knowledge management that may be suitable for larger-scale use. Further, the exercise has demonstrated that a full data warehouse is not essential. Rather, effective data mining techniques can be applied to a smaller sample drawn from a large database. Another aspect for discussion (not the main focus of this chapter, though) concerns the possibilities of extending customer knowledge management to the sharing of information between shopping center managers and potentially competing retailers. The case for such sharing is not clear-cut. Howard (1995) pointed out that shopping center landlord/tenant relationships are characterized by bargaining and outright conflict. Most UK shopping centers are not customer-orientated (according to Howard). This statement may be arguable, but we concur to the extent that more customer knowledge could help shopping centers to make their offers more attractive. Howard is on safer ground in pointing out that more marketing success could be achieved by a utilizing a partnership approach for collecting, sharing and using information. Howard (1997) cited a store manager at the successful Lakeside (UK) center as claiming that CSC (the owner of Lakeside) is different and has a more open relationship between retailers and center management. The information-sharing approach (Howard implied) has contributed substantially to CSC's success.

Some retailers, notably the UK market leaders Tesco (supermarkets) and Boots (drugstores), have exploited customer knowledge by means of loyalty schemes. Such schemes have been successful for retailers but are unlikely to pay for themselves by increased loyalty (Field, 1997). Rather, the benefits arise from their function of facilitating the flow of information and rewards between suppliers and consumers (Worthington, 1999), i.e., as part of a customer knowledge management system. Some UK towns and shopping centers have experimented with loyalty schemes, but as far as the authors are aware, the potential knowledge benefits have not been fully explored. In the Cobham (small town in Surrey, UK) and Lakeside (regional out-of-town shopping center in Essex, UK) schemes, data from customer receipts had to be entered by hand. For the town or center management, the method provided access to customer transaction information, without needing the explicit agreement of individual retailers to data sharing. There is, of course, a privacy issue concerning the use of customer data in this way. The shopping centers may well have taken the view that the transaction data belonged to the individual shoppers — who gave written consent for the data use when they requested the loyalty card. Certain large retailer tenant(s), though, are understood to have considered that they owned the data concerning their shoppers' transactions, and to have objected to the use of that data by the shopping center landlord's loyalty scheme. Some schemes including Lakeside and Cobham have been dropped under the burden of paperwork or lack of support from retailers (Hallsworth, 2000). Lakeside replaced the loyalty card with an 'affinity' credit card — the administrative load was transferred to banks, but customer data were lost to Lakeside. Nevertheless, the authors contend that loyalty schemes can be successful. The essential aspect is to design them from the start for customer knowledge management.

In the interests of providing a preliminary illustration, this chapter reports exploratory mall interview surveys at UK shopping centers. In a full-scale application, data mining for customer knowledge management would be applied to a customer database, but such a dataset was not available to the researchers. As an alternative, data mining techniques such as cluster analysis and predictive modeling have been applied to the findings of a questionnaire survey. The standard SPSS program has been used for the analysis, being less expensive and more applicable to this scale of project than would be a custom data warehouse. The authors have explored the differences in behaviour between shoppers and drawn attention to differences between exemplar segments as to which attributes are critical in shopping center choice.

EXPLORATORY STUDY

The results are from a survey of 287 respondents at six shopping centers varying in size from small in-town sub-regional to large regional out-of-town. A 'regional' center is defined as having a gross retail area of greater than 50,000 m2 and a 'sub-regional' one 20,000-50,000 m2 (based on Guy, 1994a, b; Marjenen, 1993; Reynolds, 1993). The objective was to determine which specific attributes of shopping centers were most associated with spending for various subgroups of shoppers. If it can be demonstrated that customer knowledge management can enhance the attractiveness of shopping centers and lead to increased store sales, there will be an incentive for retailers to 'buy in' to the idea of sharing customer data.

The study evaluated shoppers' comparative ratings of two shopping centers, one of them being the center where the interview took place. The alternative center was the one where they shopped most (or next most after the interview center) for non-food shopping. The questionnaire instrument was based on the 'attributes of image' elements employed by McGoldrick and Thompson (1992a; b), together with additional constructs derived from analyses of preliminary unstructured interviews. Respondents stated their perceptions of the 'importance' of each of 38 attributes, including those identified by Guy (1994a; b) as figuring in consumers' choices of shopping destination, for example, 'quality of stores,' 'cleanliness' and 'availability of rest rooms,' following a similar procedure to that used by Hackett and Foxall (1994). Each attribute was also 'rated' for both the center studied and the alternative center. Respondents estimated perceived travel distance and time to both centers, and supplied details such as age, location of residence and occupation of the main earner in the household. Examination of the characteristics of the sample indicated the distribution of socio-economic groups, age and sex reasonably representative of that anticipated at UK shopping centers. The number classified in the higher socio-economic groups of managerial, administrative, professional, supervisory or clerical (ABC1 on the UK JICTAR scale) was 59%. This compared, for example, with a figure of 63% for the Lakeside (UK) out-of-town regional center (owner's proprietary survey of 2,000 respondents over two years) and 55% for the Treaty Centre, in-town, sub-regional (Hounslow, UK — from the center 'Education pack' citing 'street surveys'). The proportion in the younger age groups 16 to 44 years was 65% in our sample compared with 73% at Lakeside and 67% at the Treaty Centre. Our sample was 69% females compared with 60% at Lakeside and 59% at the Treaty Centre.

Further questions concerned typical perceived monthly spending at each of the two centers. As McGoldrick and Thompson (1992b) pointed out, much of the variation in shoppers' expenditure relates to factors such as income or socio-economic groups, rather than travel distance or attributes of the shopping center. Following this approach, the main dependent variable was the 'individual relative spend.' A value of 100 indicated all expenditure at the center studied and none at the alternative center. A value of 50 indicated half of the expenditure at each center. The same approach was used to scale perceived travel distance and time producing the variables 'individual relative travel distance' and 'time.'

The view of 'attractiveness' taken by the authors is that any product (such as a shopping center) "can be seen as a bundle of expected costs and rewards" which East (1997, page 131) found was 'upheld by research.' East drew support from Westbrook's (1980) finding that an overall measure of retail satisfaction correlated well with a simple addition of the satisfactions. In the authors' procedure, the measures of satisfaction and dissatisfaction have been taken from the respondents' ratings of the shopping center compared to their main alternative center (on five-point semantic differential-type scales). These satisfactions for the individual attributes were weighted, firstly by the 'importance' of the attribute to the respondent (also on a five-point scale) and secondly by the degree of association with the stated relative spending. Once weighted, satisfactions were added, giving an overall 'attractiveness' measured value. The next stage was to combine the attractiveness measurements with the relative travel time or distance variables, to derive (statistically significant) models of individuals' relative spending. More detailed derivations of the attributes and models have been reported elsewhere (Dennis et al., 1999; 2000a).

Attribute evaluations have been considered as interval rather than ordinal data (following the approach of Oppewal and Timmermans, 1999). Ordinary least squares regression analysis has been used to investigate associations between shopping center attributes and shoppers' spending at the center studied compared to a competing center. For example, 'cleanliness' was the attribute most associated with the spending of female shoppers, $R2 = 0.075$. Individual regressions were performed for each variable; multiple regression was less appropriate on account of multicollinearity (Dennis et al., 1999). Attribute ratings have been summed and combined with travel distance to allow comparisons between the subgroups of the fit of each model. R2 values were between 0.09 and 0.40 — i.e. 'modest.'

In the analysis of the results, we have firstly used conventional demographics to group shoppers, eliciting the most significant shopping center attributes separately, for example, for females and males. A further stage concerned the identification of attributes for various motivation clusters. Retail data mining schemes have aimed to identify subgroups that share similar shopping motivations. Researchers (Boedeker, 1995; Boedeker and Marjenen, 1993; Jarrett, 1996) have identified shopping center motivation clusters. Targeted marketing mixes satisfy these more appropriately, increasing satisfaction, sales and profits. These researchers identified two subgroups (among others) that could be described as 'shopping' and 'service' motivations. It is hypothesized that members of these two groups can be identified as individuals for marketing communications purposes. Those primarily motivated to shop by attributes such as quality of the stores and selection of merchandise can be contrasted with those more interested in service and experience aspects such as the availability of good rest rooms and cleanliness. Accordingly, our study has also included a cluster analysis approach aimed at identifying the attributes critical for shoppers motivated by the importance of 'shops' vs. 'service.'

RESULTS

Table 1 lists the 'top six' attributes associated with individual relative spending for the subgroups. This table is designed to be read horizontally with comparative groups (e.g., females vs. males) side by side. The R2 columns indicate the coefficients of determination of the specific attributes from linear regression with relative spending. Thus, these R2 values are used here as a parameter to indicate the strength of the association between the attributes for the particular groups and shopper spending. Below the 'females vs. males' comparison follows a comparison of higher vs. lower socio-economic groups. 'ABC1' refers to the (UK, JICTAR) classifications of managerial, administrative, professional, supervisory and clerical. 'C2DE' categories include manual workers, senior citizens and unwaged. Comparisons of higher vs. lower income and age then travel by auto vs. public transport follow. The final comparison is of the shopper clusters that we have termed 'service importance' vs. 'shops importance' motivation.

Conventional Demographics

Females vs. males: The attributes significant for females were clearly different to those for males, with 'cleanliness' top for females, significantly different with respect to the association with spending compared to males. Only one of the 'top six' attributes for females ('nice place to spend time') was significant for males. Conversely, three out of the 'top six' attributes were significantly more associated with spending for males than for females ('lighting', 'sheltered access' and 'no undesirable characters'). Space limitations preclude a full discussion, but for females, two separate factors have been elicited (maximum likelihood extraction and varimax rotation — Kinnear and Gray, 1997). We have named these factors shopping (including, for example 'selection of merchandise') and experience (exemplified by 'friendly atmosphere'). On the other hand, for males the concerns were with the center ('lighting' and 'sheltered access' — the factor analysis did not produce separate factors for males). The interviewers reported that many males were in the center mainly to accompany females. Our interpretation of these results is that females, who were enjoying the trip, were naturally concerned with 'shopping' and 'experience.' Conversely, males who were simply 'there' were more evaluative of the 'center.'

Upper vs. lower socio-economic groups: For managerial, administrative, professional, supervisory and clerical (ABC1s), 'lighting' and 'access by road' were significantly more associated. For manual workers, senior citizens and unwaged (groups C2DE), 'good for children' and 'quality of the stores' were among the most significant. The differences are to some extent understandable in light of our observation that upmarket shoppers are more likely to travel by auto, whereas those from the lower socio-economic groups are more likely to bring children on shopping trips.

Higher vs. lower income groups: 'Lively or exciting' and 'Covered shopping' were significantly more associated for the lower income respondents. The authors speculate that lower income (and lower socio-economic group) shoppers might tend to live nearby, patronizing as alternatives small, unexciting local centers. Therefore, they might tend to appreciate the benefits of lively covered shopping centers more than do the more upmarket customers who may take these benefits for granted.

Older vs. younger shoppers: 'Eating and drinking' was in the 'top six' for the older shoppers who

Table 1. The "top six" significant attributes for each segment, ranked in order of the coefficient of determination, R2, associated with individual relative spending

	R^2		R^2
***FEMALES* (199 respondents: UK£68 per month)**		***MALES* (88 respondents: UK£58 per month)**	
Cleanliness *	**0.075**	General layout	0.104
Nice place to spend time	0.063	Nice place to spend time	0.086
Availability good rest rooms	0.056	**Lighting ***	**0.085**
Friendly atmosphere	0.053	**Sheltered access ***	**0.081**
Selection of merchandise	0.051	Helpfulness of staff	0.069
Eating and drinking	0.048	**No undesirable characters ***	**0.067**
***ABC1* (168: UK£73)**		***C2DE* (113: UK£53)**	
Nice place to spend time	0.156	Nice place to spend time	0.049
Lighting *	0.118	Cleanliness	0.044
Access by road *	**0.113**	Good for children	0.043
Friendly atmosphere	0.101	Quality of stores	0.038
General layout	0.101	General layout	0.037
Cleanliness	0.092	Availability good rest rooms	0.036
***INCOME UK£20000 +* (101: UK£89)**		***INCOME UP TO UK£20000* (81: UK£59)**	
Nice place to spend time	0.077	**Lively or exciting ***	**0.110**
General layout	0.069	General layout	0.095
Cleanliness	0.062	**Covered shopping ***	**0.093**
Availability good rest rooms	0.046	Cleanliness	0.088
Selection of merchandise	0.045	Selection of merchandise	0.084
Quality of the stores	0.043	Nice place to spend time	0.074
***AGE UP TO 44 YEARS* (186: UK£65)**		***AGE 45 YEARS +* (100: UK£65)**	
General layout	0.070	Nice place to spend time	0.074
Availability good rest rooms	0.069	Cleanliness	0.058
Selection of merchandise	0.039	General layout	0.053
Nice place to spend time	0.038	Availability good rest rooms	0.046
Lighting	0.035	Friendly atmosphere	0.042
Value for money	0.034	Eating and drinking	0.042
***TRAVEL BY AUTO* (149: UK£81)**		***PUBLIC TRANSPORT* (57: UK£60)**	
Nice place to spend time	0.079	Selection of merchandise	0.155
Covered shopping	0.072	Quality of the stores	0.131
General layout	0.069	**Shoppers nice people ***	**0.110**
Selection of merchandise	0.044	**Availability of seats ***	**0.080**
Choice of major stores	0.039	**Big shopping center ***	**0.080**
Eating and drinking	0.038	**Value for money ***	**0.076**
***SERVICE IMPORTANCE* (74: UK£82)**		***SHOPS IMPORTANCE* (213: UK£59)**	
General layout	0.104	Nice place to spend time	0.080
Relative travel distance	0.099	**Shoppers nice people ***	**0.067**
Cleanliness	0.078	**Quality of the stores ***	**0.065**
Availability good rest rooms	0.069	Friendly atmosphere	0.057
Nice place to spend time	0.059	**Lively or exciting ***	**0.056**
Good for children	0.057	Selection of merchandise	0.052

All listed attributes were significantly associated with individual relative spending at p = 0.05.
The number of respondents and the average monthly spending for each subgroup is indicated in parentheses.
** Segments significantly different at p = 0.05 with respect to the association with spending of these attributes (combination of Monte Carlo and t-test, Dennis et al., 1999b).*

we expect might shop at a slower pace than younger ones and take more refreshment breaks.

Shoppers travelling by auto vs. public transport: 'General layout,' 'choice of major stores' and 'eating and drinking' were in the 'top six' for shoppers travelling by auto, but not significant for public transport. Four of the 'top six' were significantly more associated for 'public transport': 'Shoppers nice people,' 'availability of seats,' 'big shopping center' and 'value for money.' The authors consider that most of these attribute differences are related to differences in spending power. For example, shoppers travelling by public transport are more likely to appreciate (free) seats, compared to the more affluent auto travelers who choose to relax in a restaurant, bar or café.

Cluster Analysis: Shoppers Motivated by the 'Importance' of 'Shops' vs. 'Service'

An alternative to the conventional demographics approach was the search for clusters of buyers who shared needs or wants for particular benefits. A cluster analysis (SPSS 'K-means,' minimizing the squared distances of each value from its cluster center, (Kinnear and Gray, 1997) based on 'importance' scores has identified distinct subgroups of shoppers classified by 'importance motivation.' The main attributes that distinguished the clusters (with the average 'importance' scores on the 1 to 5 scale, where 1 was 'no relevance' and 5 was 'extremely important') are listed in Table 2. These segments were described as 'shops importance

Table 2(a): Shops importance motivation cluster

	Final cluster center 'Importance' scores
Variety of the stores	3.49
Quality of the stores *	**3.41**
Covered shopping	3.30
Access by public transport **	**3.14**

Table 2(b): Service importance motivation cluster

	Final cluster center 'Importance' scores
Parking facilities **	**4.47**
Access by auto **	**4.29**
Cleanliness **	**4.22**
Availability of good rest rooms **	**4.01**
Value for money **	**3.99**
Helpfulness of the staff **	**3.96**

*Differences between clusters 'Importance' scores significant at: * $p = 0.05$ ** $p = 0.001$. 'Importance' scores are on the 1 to 5 scale, where 1 is 'no relevance' and 5 is 'extremely important.' Only attributes above the scale mid-point (3.00) are listed, and each attribute is listed once only, in the cluster where most dominant.*

motivation' (abbreviated to 'shops'), Table 2 (a), and 'service importance motivation' ('service'), Table 2 (b). The two 'importance motivation' clusters were strikingly different in attributes significantly related to relative spending (the final section of Table 1). As hypothesized, 'quality of the stores' and 'selection of merchandise' were both in the 'top six' for the 'shops' group, with 'quality of the stores' being significantly more associated with spending for the 'shops' group than for 'service.' For the 'service' shoppers, 'availability of good rest rooms' and 'cleanliness' were among the most significant. Not so expected, 'other shoppers nice people' and 'lively or exciting' were significantly more associated with spending for 'shops' than 'service' shoppers. One possible interpretation might be that consumers motivated by 'shops' are evaluating not just the tangible merchandise but also the shopping experience. Our term 'shops' encompasses not just the physical environment of the shops but also the wider systemic shopping environment.

Compared to 'shops,' the 'service' shoppers were slightly higher socio-economic group (63% ABC1s vs. 59%), income (60% UK£20000 per year + vs. 53%) and age (42% 45 + vs. 33%) than the 'shops' group. They predominantly traveled by car (90% vs. 52% — see Figure 1).

MODELS OF RELATIVE SPENDING

The regression models for the various groups are reported in Table 3. These are introduced in the same order as in the reporting of the critical attributes for these groups in the 'Results' section above and in Table 1. The models describe the relationships observed between relative spending for the groups vs. the attractiveness of the centers and the distance shoppers travel. The first column is the group for which the model applies (the numbers of respondents in each group were indicated in Table 1). The second column is the constant from the regression equation, representing the amount of relative spend not associated with the variations in attractiveness and distance. The third and fourth columns are the regression coefficients for attractiveness and distance respectively. The fifth column is the coefficient of determination, R2 of the regression equation, and the sixth the degree

Figure 1. Characteristics of the "service" and "shops" clusters

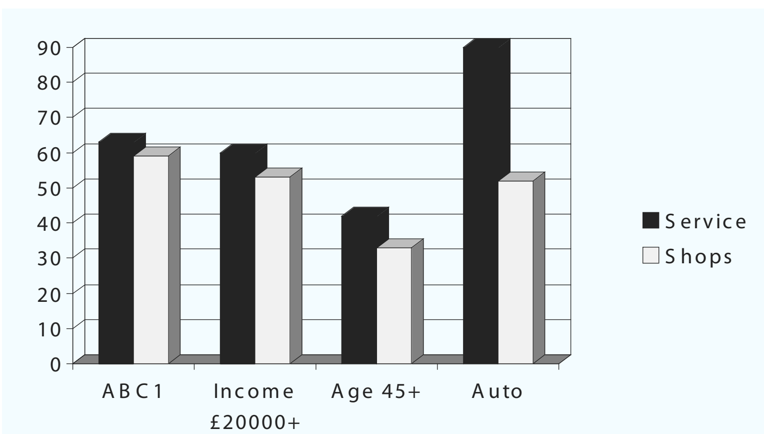


Table 3. Models for shopper segments

	Constant	Attractiveness Coefficient	Distance Coefficient.	R^2	Significance p	Model number
Females	**28.3**	**0.63**	**-0.24**	**0.19**	**<0.0001**	**1**
Males	**21.1**	**0.49**	**0**	**0.09**	**<0.01**	**2**
ABC1	**19.0**	**0.72**	**-0.19**	**0.20**	**<0.01**	**3**
C2DE	**34.4**	**0.50**	**-0.24**	**0.13**	**<0.01**	**4**
Income UK£20000+	**28.6**	**0.62**	**-0.24**	**0.17**	**<0.01**	**5**
Income up to UK£19000	**27.0**	**0.58**	**-0.19**	**0.18**	**<0.05**	**6**
Age up to 44	**29.3**	**0.58**	**-0.23**	**0.16**	**<0.0001**	**7**
Age 45 +	**18.0**	**0.61**	**0**	**0.14**	**0.0001**	**8**
Auto	**32.8**	**0.53**	**-0.20**	**0.15**	**<0.01**	**9**
Public transport	**31.8**	**0.58**	**-0.22**	**0.19**	**<0.05**	**10**
'Shops motivation'	**19.4**	**0.70**	**-0.21**	**0.17**	**0.0001**	**11**
'Service motivation'	**39.6**	**0.54**	**-0.28**	**0.22**	**<0.01**	**12**
All respondents	**26.0**	**0.62**	**-0.20**	**0.16**	**0.0001**	**13**

of significance (p-value). These two columns indicate modest correlations. All of the models would be normally be described as 'significant.' All except model numbers 6 (lower income) and 10 (travel by public transport) would actually be considered 'highly significant.' The final column is simply the identification number allocated to each model to facilitate discussion.

For example, for the 'shops' group:

(11) Spending = 19.4 + 0.70 X Attractiveness - 0.21 X Distance

Whereas for the 'service' shoppers:

(12) Spending = 39.6 + 0.54 X Attractiveness - 0.28 X Distance

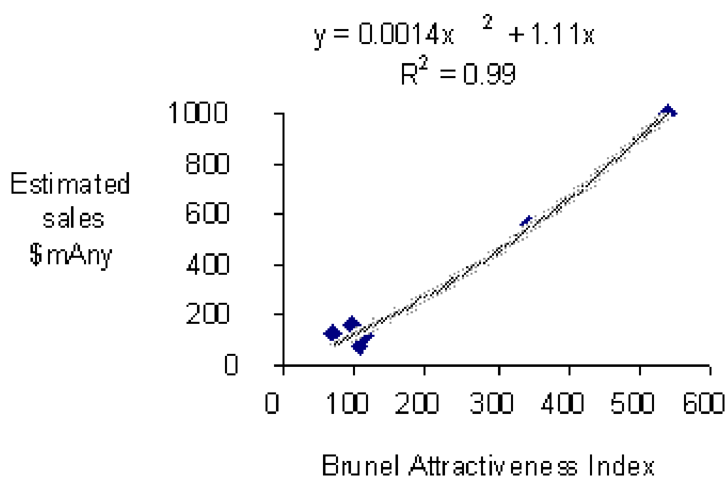
These models mean that we can be confident (at normal test levels) that an increase in the attractiveness of a center would result in an increase in spending at that center. For example, for the 'shops' group (11), the increase in spending for a given improvement in attractiveness would be greater than for the 'service' group (12). By going back to the weighting that each attribute carried in the attractiveness model, it is possible to predict by how much spending would be likely to increase for any given improvement in any attribute. The models also mean that spend was inversely related to the distance that shoppers traveled to the center.

In the 'Exploratory study' section earlier, the procedure for calculating respondents' weighted satisfactions was outlined. The satisfactions for all attributes were summed to give each respondent's total satisfaction score for the center studied. The average of the respondents' satisfaction scores represented a measured attractiveness score for each center, the 'Brunel Attractiveness Index.' This index has been described more fully elsewhere (Dennis et al., 2002a forthcoming, 2002b). Stated briefly, the Brunel Attractiveness Index is an empirically derived measure of shoppers' evaluations of the attractiveness of shopping centers.

The utility of the models has been investigated by examining the relationship between the empirically measured attractiveness and the estimated sales turnover. Figure 2 illustrates the relationship between our measured attractiveness, the Brunel Attractiveness Index and the estimated sales turnover for the six centers. The sales value scale has been changed by an arithmetical factor in order to disguise commercially sensitive data. The sales turnover values are necessarily estimates based on the questionnaire responses plus footfall data of unknown reliability supplied by the center managements. The estimates, though, were made before the models were designed — and were not used in the development of the index. From an inspection of Figure 2, it would appear that the modeling procedure has been effective in measuring attractiveness in a manner relevant to sales turnover.

The models are useful in estimating changes in spending that could result from improving aspects of a shopping center. For the high spending 'service' shoppers (model 12 in Table 3), a 25% improvement in the ratings for cleanliness and rest rooms could be associated with an increase in spending for those shoppers of 10%, equivalent to an increase in the total center sales turnover of over 3%. One measure of the validity of the subgroups is the improvement in 'fit' of the models. 'Service' vs. 'shops' had the best fit, with R2 increased to an average of 0.195 for the two subgroups. Apart from 'income' (average R2 0.175), the models from the other pairs of groups did not improve the fit above the overall level of 0.16. 'Service' vs. 'shops' discriminated well between high and low customer spend, with the 'service' segment's average stated monthly spend UK£82, compared with the overall average of UK£65.

Figure 2. Estimated sales of shopping centers vs. the Brunel Attractiveness Index — Polynomial plot forced through the origin



DISCUSSION AND CONCLUSIONS

Information from a customer database can be used to identify needs of different groups of customers. This knowledge can help shopping centers to improve marketing communications and customer satisfaction. Cluster analysis has identified a group of customers that shopping centers and retailers will want to target: high-spending 'service' shoppers. How can they be identified, given the high costs of a data warehouse? Firstly, this experimental study has demonstrated that a full data-mining system is not essential. Analysis, identification of target segments and assessment of cost-effectiveness can be carried out on a small sample, with only simple processing needed on a complete database. As in this experiment, the SPSS program can be used — saving the costs of custom software. For future, larger-scale projects, though, the authors recommend the use of a multi-agent system. Such systems can handle text alongside quantitative data and furnish individual shoppers with a 'personal agent.' This represents customized marketing segmentation — a software 'personal shopper' for every participating consumer. So far in this chapter, we have considered the knowledge about customers aspect of customer knowledge management. The personal agent system could address the knowledge possessed by customers aspect. It could be argued that such a system might not work in the UK cultural context. For the customers, though, this would be a small step from the well-established loyalty card. The customer might only be aware of the difference when presenting a 'smart card' to obtain benefits or information. Customers having a personal agent could receive communications specifically targeted to their needs and wants. There are a number of ways that this could be achieved, but one of the simplest would be for customers to present their card for reading at an information kiosk in order to receive personalized vouchers and information sheets.

In the 'models of relative spending' section above, it was pointed out that a (probably achievable) improvement of 25% in the ratings for 'cleanliness' and 'rest rooms' could be associated with an increase in spending by the service shoppers of 10%. The 10% increase for this group would add 3% to the total center sales turnover. A regional shopping center would gain tens of millions of dollars sales, with retailers seeing a seven-figure increase in gross profits. In the medium term, rental incomes follow sales: shopping center owners could expect US$2 million in increased rents.

Customer knowledge management systems could be based on data sourced from loyalty schemes. Worthington (1999) reviewed the typology of local loyalty cards in the UK. Integrated chips (e.g., Nottingham), and magnetic stripe payment (Hereford; Lakeside) or non-payment (Chester; Meadowhall) are applicable and cost-effective for cities and regional shopping centers. The main distinguishing feature of the higher-spending 'service' shopper cluster was the preponderance of auto as the means of travel — 90% of the group (illustrated in Figure 1). Therefore, for smaller centers, a scheme could be based on parking. For in-town centers that charge for parking, our solution is the 'parking lot membership scheme.' Shoppers would buy a 'carnet' of tickets at a discount and fill in a detailed 'lifestyle' questionnaire including the information needed for the database. Parking lot schemes are already in use in Australia (Worthington and Hallsworth, 1999). For centers that offer free parking, the suggestion is to recruit shoppers at a kiosk in the parking lot, offering incentives such as a prize drawing.

The results presented in this chapter have demonstrated what can be achieved using some of the typical data mining activities applied to a simple dataset of survey data. In terms of Berry and Linoff's six activities, we have (1) 'classified' using, for example, standard socio-economic groupings, evaluating critical attributes for those segments; have (2) 'estimated' potential increases in sales arising from changes to these critical attributes using (3) 'predictive' modeling. We did not use (4) 'association rules' in the usual basket analysis context. Rather our 'affinity grouping' was achieved using (5) 'cluster' analysis — the most effective classification technique of our modeling exercise. Finally, we contend that our analysis and modeling process has assisted the (6) 'description and visualization' of shopper behavior.

In terms of Berry and Linoff's four components of CRM, we have outlined an effective procedure for measuring the (1) 'image' of a shopping center. Evaluating the image of the different customer groups has led us to (2) a greater 'understanding of who the customers are and their likes and dislikes.' Although the methodology does not (3) 'anticipate' customer needs, the survey approach does at least allow needs and wants to be 'identified and addressed proactively.' Similarly, using survey data in the database has identified a number of instances of (4) 'customer dissatisfaction,' leading to recommendations for 'corrective action.' CRM is normally implemented by a system of personalized communications (e.g., welcome letter, satisfaction questionnaire, special offers and so on). The details are beyond the scope of this chapter, but an applicable strategy should be facilitated by the installation of a simple data mining and customer knowledge management system. Shopping center managers could obtain a similar level of data to ours from (for example) a membership questionnaire, and could use a similar analysis process to that described here. Such activities would have to comply with data protection principles, but in the UK at least, many shoppers are willing to part with personal and transaction information in exchange for benefits — the principle behind the success of the Tesco and Boots loyalty cards.

Adding real sales transaction information would enrich the possibilities (although this raises the possibility of conflict with retailers over ownership of the data). Shoppers might be grouped according to spending on fashion/designer styles rather than bargains? A knowledge management network between retailers and the center would be a further stage — allowing wider access to graphs, patterns and associations in the data. There is a parallel in systems that multiple grocery retailers operate with suppliers. It is understood that supermarkets such as Tesco allow suppliers direct, real-time access to individual store sales and stock data via the Internet. In this model, a retailer and (potentially competing) suppliers share data in a knowledge network managed by the retailer. Bearing in mind the relationships of conflict rather than cooperation (mentioned in the earlier part of this chapter) that, according to Howard (1997), dominate shopping center landlord/tenant relationships, cooperation in a knowledge management network might seem unlikely. Nevertheless, Howard did identify one UK shopping center owner (CSC) that was the exception. On the basis of the limited empirical results reported here, little further analysis of this issue is possible, but we contend that further research into retailer/shopping center networks could be worthwhile for the more enlightened centers and retailers.

Dennis et al. (2002a forthcoming, 2000b) have argued that the most successful shopping centers are those where 'active marketing' and 'pro-active management' feature. Bennett and Gabriel (1999) contended that market orientation is central to the rapid introduction of knowledge management in UK companies, pre-supposing and spreading customer information. Change-friendly enterprises are more likely to have extensive knowledge management systems than others are. The authors predict that a rapid uptake of knowledge management is likely for the most successful, marketing-orientated shopping centers. There are substantial benefits to be gained from the customer knowledge database.

Finally, the authors accept that there have been many limitations in this small exploratory study. A true data mining system would be expected to work on a much larger dataset. The benefits predicted from a customer knowledge management system are purely speculative at this stage. Therefore, a more extensive pilot and research program is recommended. This could take the form of (1) a further questionnaire survey with more respondents and shopping centers, (2) a pilot scheme based on exchange of customer information for parking discount benefits (at a paid-for parking lot), and (3) a pilot 'personal agent' trial based on a smart card. This trial could run on shopper data at a single shopping center gathered by, for example, a parking lot membership scheme as outlined above. If this pilot were to achieve no more success than confirming the effects of cleanliness and rest rooms found in our exploratory survey (which was carried out at nominal cost), the center could expect a medium-term increase in rental income alone of US$2m. In our view, there is a clear case for the cost-effectiveness of further research in this area.

REFERENCES

Bennett, R., & Gabriel, H. (1999). Organizational factors and knowledge management within large marketing departments: An empirical study. *Journal of Knowledge Management, 3*(3), 212-225.

Berry, M. J. A., & Linoff, G. S. (1997). *Data mining techniques for marketing, sales and customer support.* Chichester: John Wiley & Sons.

Berry, M. J. A., & Linoff, G. S. (2000). *Mastering data mining.* Chichester: John Wiley & Sons.

Boedeker, M. (1995). New type and traditional shoppers: A comparison of two major consumer groups. *International Journal of Retail and Distribution Management, 23*(3), 17-26.

Boedeker, M., & Marjanen, H. (1993). *Choice orientation types and their shopping trips: An empirical study of shopping trips to the city center vs. to an edge-of-town retail park.* Seventh International Conference on Research in the Distributive Trades, University of Stirling, Institute for Retail Studies.

Bird, J. (1996). Data in knowledge out. *Management Today,* September, 70-72.

Davies. R., Howard, E., & Reynolds, J. (1993). *The shopping centre industry 1993: Thirty years of growth.* Oxford: Oxford Institute of Retail Management/British Council of Shopping Centres.

Dennis, C. E., Marsland, D., & Cockett, W. A. (1999). *Why do people shop where they do? Recent Advances in Retailing and Services Science, 6th International Conference. Organizer: The European Institute of Retailing and Services Studies,* Eindhoven, The Netherlands. Location: Puerto Rico, July 7-10.

Dennis, C. E., Marsland, D., & Cockett, W. A. (2000a). Objects of desire: Attraction and distance in shopping centre choice. *International Journal of New Product Development and Innovation Management, 2*(2), 43-60.

Dennis, C. E., Marsland, D., & Cockett, W. A. (2000b, July 13-14). Can a shopping centre be a brand? *Proceedings of the 11th International EARCD Conference on Retail Innovation,* (CD-ROM) ESADE, Barcelona.

Dennis, C. E., Murphy, J., Marsland, D., Cockett, W., & Patel, T. (2002a). Measuring image: Shopping centre case studies. *International Review of Retail, Distribution and Consumer Research, 12*(4).

Dennis, C. E., Marsland, D., & Cockett, W. (2002b). Central place practice: Shopping centre attractiveness measures, hinterland boundaries and the UK retail hierarchy. *Journal of Retailing and Consumer Services, 9*(4), 185-199.

East, R. (1997). *Consumer behaviour.* Englewood Cliffs, NJ: Prentice Hall.

Field, C. (1997). Data goes to market. *Computer Weekly,* (January 16), 44-45.

Guy, C. M. (1994a). *The retail development process: Location, property and planning.* London: Routledge.

Guy, C. M. (1994b). Whatever happened to regional shopping centres? *Geography, 79*(4) 293-312.

Hackett, P. M. W., & Foxall, G. R. (1994). A factor analytic study of consumers' location specific values: A traditional high street and a modern shopping mall. *Journal of Marketing Management, 10*, 163-178.

Hallsworth, A. (2000). Britain's loyalty cards — An unmanageable retail innovation? *International Journal of New Product Development and Innovation Management, 2*(2), 133-144.

Howard, E. (1995). *Partnerships in shopping centres.* Oxford: Oxford Institute of Retail Management.

Howard, E. (1997). The management of shopping centres: Conflict or collaboration? *The International Review of Retail, Distribution and Consumer Research, 7*(3), 261-286.

Jarratt, D. E. (1996). A shopper typology for retail strategy development. *The International Review of Retail Distribution and Consumer Research, 6*(2), 196-215.

Kinnear, P. R., & Gray, C. D. (1997). *SPSS for Windows.* Hove: Psychology.

McGoldrick, P. J., & Thompson, M. G. (1992a). The role of image in the attraction of the out-of-town centre. *The International Review of Retail, Distribution and Consumer Research, 2*(1), 81-98.

McGoldrick, P. J., & Thompson, M. G. (1992b). *Regional shopping centres: Out-of-town versus in-town.* Aldershot: Avebury.

Marjanen, H. (1993). *Store location analysis and the mystery of consumer spatial behaviour: Competition between downtown shopping areas and out-of-town shopping centres as a special case.* Turku (Finland), Turku School of Economics and Business Administration.

Oppewal, H., & Timmermans, H. (1999). Modeling consumer perception of public space in shopping centers. *Environment and Behaviour, 31*(1), 45.

OXIRM. (1999). *The shopping centre industry: Its importance to the UK economy.* Oxford: Oxford Institute of Retail Management/MCB.

Rao, B. P. (2000). Improving retail effectiveness through technology: A survey of analytical tools for physical and on-line retailers. *Technology in Society, 22,* 111-122.

Rensselaer Polytechnic Institute. (1999). Data mining. Retrieved from http://www.rpi.edu/~arunmk/dml.html.

Reynolds, J. (1993). The proliferation of the planned shopping centre. In D. F. Bromley & C. J. Thomas (Eds.), *Retail change contemporary issues*. London: UCL.

Richards, I., Foster, D., & Morgan, R. (1998). Brand knowledge management: growing brand equity. *Journal of Knowledge Management, 2*(1), 47-54.

Rowley, J. (2001). Eight questions for customer knowledge management in e-business. *Proceedings of the e-Business Workshop,* IBM/de Montfort University.

Teresko, J. (1999). Information rich, knowledge poor? *Industry Week, 248*(3), 19.

Westbrook, R. A. (1980). Intrapersonal affective influences upon consumer satisfaction. *Journal of Consumer Research, 7*(June), 49-54.

Wiij, K. M. (1994). *Knowledge management: The central management focus for intelligent-acting organisations.* Arlington, VA: Schema.

Wiij, K. M. (1998). Knowledge management: An introduction and perspective. *Journal of Knowledge Management, 1*(1), 6-14.

Worthington, S. (1999). A classic example of a misnomer: The loyalty card. *Journal of Targeting, Measurement and Analysis for Marketing, 8*(3), 222-234.

Worthington, S., & Hallsworth, A. (1999). Cards in context — The comparative development of local loyalty schemes. *International Journal of Retail and Distribution Management, 27*(10), 420-428.

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Chapter 4.53
Musical Metadata and Knowledge Management

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INTRODUCTION

Is music a form of knowledge? Probably not, even if music is undoubtedly an important part of our cultural heritage. Music is not a type of knowledge, at least in first approximation, because music has no consensual, shared meaning. One of the main reasons why music has no meaning, as opposed to text or even pictures, is that music is not referential: music is made of elements (notes, chords, sounds) which do not refer to any objects or concepts outside the musical world (Meyer, 1956). Being without meaning, music is not a type of knowledge.

However, our heavily digitized society continuously produces and exploits an increasing amount of knowledge about music. This knowledge, also called metadata, has taken a growing importance in the music industry and deserves a special treatment in this encyclopedia because of the specificities of music. On one hand, music is ubiquitous and pervasive: there are about 10 million music titles produced by the major music labels in the Western world. Adding the music produced in the non-Western world probably doubles this figure. The music industry is one of the prevalent industries in the Western world today. On the other hand, music is elusive, in that it is difficult to define exactly what music is (for instance, distinguishing music from ambient sounds is not always trivial). To make all this music easily accessible to listeners, it is important to describe music in ways that machines can understand. Music knowledge management is precisely about this issue: (1) building meaningful descriptions of music that are easy to maintain, and (2) exploiting these descriptions to build efficient music access systems that help users find music in large music collections.

BACKGROUND

The issue of building music description is the subject matter of the audio part of the Mpeg-7 standard (Nack & Lindsay, 1999). Mpeg-7 focuses only on the notion of metadata, as opposed to its predecessors (Mpeg-1, 2, and 4), and proposes schemes to represent arbitrary symbolic and numeric information about multimedia objects, such as music or movies. However, Mpeg-7 deals only with the syntax of these descriptions, and not with the way these descriptions are to be produced. Here is, for instance, an extract of an Mpeg-7 description of the music title "Blowin' in the Wind" by Bob Dylan. This extract declares the name of the artist, the name of the song, and its genre (here, "Folk," according to a genre classification indicated in the extract itself).

The first step toward music knowledge management is probably music identification. Robust audio fingerprinting techniques have been developed recently to identify music titles from the analysis of possibly distorted sources, such as radio broadcasts, or direct recordings from cell phone microphones (Cano, Batlle, Kalker, & Haitsma, 2002). Audio fingerprinting is not a knowledge management technique per se, but is a prerequisite to build music collections. This technique has received considerable attention in the last few years, and today very robust solutions have been designed and implemented in real-world systems, such as the MoodLogic Music Browser.

To give a concrete idea of typical music descriptions used in musical knowledge management systems, let us give here three examples and their related use.

Figure 1. An Mpeg-7 extract for describing information about a music title

```
<?xml version="1.0" encoding="UTF-8"?>
<Mpeg7
  xmlns="urn:mpeg:mpeg7:schema:2001"
  xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
  xmlns:mpeg7="urn:mpeg:mpeg7:schema:2001"
  xsi:schemaLocation="urn:mpeg:mpeg7:schema:2001 mpeg7-smp-2004.xsd">
  <Description xsi:type="CreationDescriptionType">
    <!-- ID3 Track number -->
    <CreationInformation id="track-01">
      <Creation>
        <!-- ID3 Song Title -->
        <Title type="songTitle">Blowin' in the wind</Title>
        <!-- ID3 Album Title -->
        <Title type="albumTitle">The Freewheelin'</Title>
        <!-- ID3 Artist -->
        <Creator>
          <Role href="urn:mpeg:mpeg7:RoleCS:2001:PERFORMER"/>
          <Agent xsi:type="PersonType">
            <Name>
              <FamilyName>Dylan</FamilyName>
              <GivenName>Bob</GivenName>
            </Name>
          </Agent>
        </Creator>
      <!-- ID3 Genre  -->
      <Classification>
        <Genre href=" urn:id3:cs:ID3genreCS:v1:80"><Name>Folk</Name></Genre>
      </Classification>
    </CreationInformation>
  </Description>
</Mpeg7>
```

Several companies produce and exploit so-called editorial musical metadata—for instance, AllMusicGuide (Datta, 2002) or MusicBrainz (http://www. musicbrainz. org). This information typically relates to songs and albums (e.g., track listings of albums), but also includes information on artists (biographies, periods of activities) and genres. A typical scenario of use is the display in a popular music player of an artist's biography and genre when a title is played. When a title is played, an identification mechanism produces the identity of the title and artist, and a query is made to AllMusicGuide to retrieve more information, for example, the biography of the artist or the photograph of the album the title comes from.

Another popular application of musical metadata is query-by-humming. Query-by-humming consists of letting users sing or hum a melody, and retrieves the songs whose melodies match the input (Birmingham et al., 2002). Technically, query-by-humming is one instance of music information retrieval systems. In terms of knowledge management, this application makes use of the analysis of melodies from the audio signal and the sung inputs, so they fall in the category of acoustic descriptors as described below.

Finally a popular view on music knowledge management is collaborative filtering, as used in music portals such as Amazon. Collaborative filtering makes intensive use of user profiles, and exploits similarity or patterns in large databases of profiles. Technically, collaborative filtering is one instance of so-called cultural descriptors, as we will see below.

The three examples are deliberately chosen to represent three types of information: editorial, cultural, and acoustic. These three types of information actually cover the whole range of techniques for music knowledge management. The next section reviews in more detail each of these types of information and highlights the main technical issues related to each of them.

THREE TYPES OF MUSICAL METADATA

Although there is a virtually infinite number of musical metadata that can be thought of concerning the description of music, we propose here to classify all of them in only three categories: editorial, cultural, and acoustic. This classification is based on the nature of the process that leads to the elaboration of the metadata.

Editorial Metadata

Editorial metadata refers to metadata obtained, literally, by the editor. Practically, this means that the information is provided manually, by authoritative experts. Examples of editorial metadata in music range from album information (e.g., the song "Yellow Submarine" by the Beatles appears on the Album "Revolver" issued in the UK) to administrative information such as the dates of recording, the composers or performers. Because editorial metadata covers a wide range of information, from adminstratrivia to historical facts, it is difficult to define precisely its scope other than by stating how it was produced.

Editorial metadata is not necessarily objective. For instance, the AllMusicGuide editorial metadata portal (Datta, 2002) provides information about artist biographies, which may be biased by cultural factors. In particular, genre information—seen as editorial metadata (i.e., entered by human experts)—is known to be particularly subjective.

Technically, the tasks of organizing editorial metadata raises specific challenges, such as:

- Providing a consensual view on subjective editorial information. For instance, agreeing on a taxonomy of musical genres.
- Coping with the evolving nature of music. New artists, new genres, new events occur all the time in music. The organization of an

editorial information system must be able to cope with these changes efficiently.
- Organizing the human effort into clear and distinct roles. For example, as editorial management and data enterers.

There is another distinction one can make concerning editorial metadata which concerns the nature of the human source: editorial metadata as produced in AllMusicGuide is prescriptive: the information is decided by one well-defined expert or pool of experts.

Editorial metadata can also be produced in a non-prescriptive manner, using a collaborative scheme—that is, by a community of users. In this case, both the nature of the information provided and the management techniques differ.

A typical example of this "collaborative editorial" information is the CDDB effort (www.cddb.com). CDDB is a database of "track listing" (i.e., the information, for each music album produced, of the songs contained in the album). Surprisingly, this track listing information is not systematically present in CD albums, and it is precisely the role of CDDB to fill this gap. The identification technique used is very simple and relies on a hashing code produced by the number of tracks and their exact durations. This signature uniquely identifies most of the albums. To the signature is associated the track listing information. Such editorial information is, however, not prescriptive, and is on the contrary produced by a collaborative effort. When a user fetches a track listing information for a given album, it is retrieved automatically from the CDDB database (provided the media player used has a license with CDDB). If the album is not recognized, then the user can input the information himself, and thus contribute to the database content.

Another example of such an approach is MoodLogic (www.moodlogic.com). The MoodLogic approach consists of building a database of song "profiles" from ratings of users. This database is used to classify and recommend music, and is integrated in various music management tools such as music browsers. When a song is added to a user's collection, a fingerprinting technique identifies the song and fetches the corresponding metadata in the MoodLogic database. If the song is not present in the database, the user is asked to rate the song. This approach has proven to be scalable, as the MoodLogic database now contains profiles for about one million titles. The nature of the information entered is quite different, however, than the information present in prescriptive systems such as AllMusicGuide: MoodLogic includes information such as genres, mood, perceived energy, and so forth.

It is important to stress again here that this information is considered in our context as editorial—more precisely as collaborative editorial—because of the way the information is provided. However, we will see that this kind of information can be used in a totally different context, in particular to produce acoustic metadata.

Cultural Metadata

Cultural information or knowledge is produced by the environment or culture. Contrarily to editorial information, cultural information is not prescribed or even explicitly entered in some information system. Cultural information results from an analysis of emerging patterns, categories, or associations from a source of documents.

A common method of obtaining cultural information is collaborative filtering (Cohen & Fan, 2000). In this case, the source of information is a collection of user profiles.

However, user profiles are a relatively poor source of information, and there are many other cultural information schemes applicable to music. The most used sources of information are Web search engines like Google, music radio programs, or purely textual sources such as books or encyclopedias. The main techniques used borrow from natural language processing and are mostly based on co-occurrence analysis: for a given item of interest (say an artist or a genre), co-occurrence techniques allow one to associate to this item other items which are "close," in the sense that they often appear close to each other. Co-occurrence can be based on closeness of items in a Web page or by neighboring relations in music playlists. The main difficulty in this approach is to derive a meaningful similarity relation from the co-occurrence information. Approaches such as Pachet, Westerman, and Laigre (2001) or Whitmann and Lawrence (2002) give details on the actual language processing techniques used and the evaluation of results. The typical information that can be obtained from these analysis are:

- Similarity distance between musical items such as artists or songs. Such similarities can be used in music management systems such as music browser, or music recommendation systems.
- Word associations between different word categories. For instance, a co-occurrence technique described in Whitmann and Lawrence (2002) indicates which most common terms are associated with a given artist. The same technique can also be used to infer genre information; by computing the co-occurrence between an artist name (say, "the Beatles") and different genre names (say "Pop," "Rock," "Jazz," etc.). In this case, the resulting information may also be called genre, as in the editorial case, but editorial genre and cultural genre will most of the time not coincide (see the section titled "Discussion").

Acoustic Metadata

The last category of music information is acoustic metadata. Acoustic here refers to the fact that this information is obtained by an analysis of the audio file, without any reference to a textual or prescribed information. It is intended to be purely objective information, pertaining to the "content" of the music.

A typical example of musical acoustic information is the tempo, that is, the number of beats per second. Beat and Tempo extraction have long been addressed in the community of audio signal processing, and current systems achieve excellent performances (Sheirer, 1998). Other, more complex rhythmic information can also be extracted, such as the metric structure (is it a ternary rhythm, like a waltz, or binary rhythm?) or the rhythm structure itself.

Besides rhythm, virtually all dimensions of music perception are subject to such extraction investigation: percussivity (is a sound percussive or pitched?), instrument recognition (Herrera, Peeters, & Dubnov, 2002), perceived energy (Zils & Pachet, 2003), or even mood (Liu, Lu, & Zhang, 2003). The results of these extractions are very disparate, and today no commercial application exploits these descriptors. But the robustness of these descriptors will likely greatly improve in the coming years, due to the increase of attention these subjects have attracted recently.

These preceding examples are unary descriptors: they consist of one particular value for a whole title and do not depend on other parameters such as the position in the music title. Non-unary descriptors are also very useful to describe music and manage large music collections. Melodic contour or pitch extraction can be used, for instance, for query-by-humming applications (Birmingham et al., 2001). At a yet higher level, music structure can be inferred from the analysis of repetitions in the audio signal (Peeters, La Burthe, & Rodet, 2002), leading to applications such as automatic music summaries.

The issue of representing in a standardized manner all these metadata is addressed by the audio part of the Mpeg-7 standard (Nack & Lindsay, 1999). However, Mpeg-7 focuses on the syntax of the representation of these descriptors, and it is quite obvious that the success of the standard heavily depends on the robustness of the corresponding extractors.

One major problem this endeavor has to deal with is that there is rarely any "music grounded facts," except for trivial information. Building a grounded facts database is therefore one of the main difficulties in acoustic descriptor design. Information obtained from collaborative editorial sources, such as MoodLogic, can paradoxically prove very valuable in this context.

Another issue is that although there is a lot of formal knowledge about music structure (tonal music in particular), this knowledge is rarely adapted to perceptive problems. For instance, taxonomies of genres or taxonomies of instruments are not directly usable for building ground truth databases, because they are not based on perceptive models: depending on the playing mode, context, and so forth, a clarinet can sound very close to a guitar and very different from another clarinet.

DISCUSSION

Because of the wide diversity of music knowledge types, there is a growing concern about the evaluation and comparison of these metadata. Indeed, the exploitation of large-scale music collections is possible only if these metadata are robust. But what does it mean exactly to be robust?

There are different types of evaluations in our context, some of which do not raise any particular problems. For instance, the evaluation of acoustic descriptors targeting consensual, well-defined music dimensions (such as tempo or instrument recognition on monophonic sources) do not usually raise any particular issues. The evaluation of acoustic similarities is more problematic, as the elaboration of a ground truth reference is itself a hard task (Aucouturier & Pachet, 2004).

However, the most complex evaluation task is probably the comparison of metadata across different categories. For instance, comparing acoustic similarity with cultural similarity is not a well-defined problem. Indeed, cultural metadata can be used to train machine-learning algorithms to produce acoustic metadata or similarities. In this case, the comparison is simple to do, but misleading, since the cultural similarities are known to be based not only on acoustic features. On the other hand, comparing two similarity measures obtained from different sources (e.g., Berenzweig, Ellis, Logan, & Whitman, 2003) produces results that are hard to interpret or exploit.

Another important consequence of this diversity of sources of metadata is that complex information dependency loops can be created which eventually produce meaningless musical knowledge, at least to non-informed users. The example of genre is, to this respect, emblematic, as genre can be produced by any of our three categories of approaches:

- Editorial genre is a genre prescribed by an expert, say, the manager of a label, or the team of AllMusicGuide. In this case, the Beatles can be described as "Pop-Sixties."
- Cultural genre is extracted from an analysis of textual information such as the Web. Depending on the source used, the Beatles can be described, culturally, as, say "Pop" (versus "Jazz" and "Classical).
- Finally, acoustic genre can be extracted too, using audio signal processing techniques (see, e.g., Tzanetakis, Essl, & Cook, 2001). It is important to note that acoustic genre will entirely depend on the learning database used for building the extractor. This database usually comes either from editorial or cultural information sources.

These intricate dependencies of information call for a better realization, by users, of the implications and meanings of the metadata they are provided with for managing their collections. Instead of trying to artificially compare or fit these different sources of knowledge about music, a simpler and more efficient strategy is probably to find simple ways to explain to users what each of them is doing.

FUTURE TRENDS

The representation of musical knowledge, as represented by metadata, is a blooming field. From the early experiments in beat tracking to the industries of metadata, many results have been obtained and problems solved. More are being addressed with promising results, such as the separation of sources in polyphonic recordings, which will bring new descriptions to music management systems.

Important directions concerning the future of music knowledge in this context are:

- The invention of new music access modes. So far, the main use of music metadata has been for implementing efficient music query systems. Metadata can also be used to create new music access modes, for instance integrating performance and music access. Preliminary works have been proposed, such as concatenative synthesis (musaicing) (Zils & Pachet, 2001), which exploits metadata to create new music and not only to listen to songs.
- More subjective measures of user interests. So far, work on evaluation has focused on objective measures. However, users accessing large-scale music collections are often animated by desires such as the quest for discovery or the pleasure of partially controlled browsing. Music access systems would clearly benefit from measures of interestingness combining possibly contradictory similarity relations together.

CONCLUSION

While music itself is not a form of knowledge, musical knowledge is needed to manage large-scale music collections. We have discussed a classification of musical metadata into three basic categories, based on the nature of the process leading to the creation of the metadata and their potential uses. These three categories may intersect, at least superficially, and it is important to understand the possibilities and limits of each of these categories to make full use of them. It is very likely that future applications of music content management will make increasing use of such metadata, and conversely will exert pressure for the creation of new music metadata types.

REFERENCES

Aucouturier, J.-J., & Pachet, F. (2004). Improving timbre similarity: How high is the sky? *Journal of Negative Results in Speech and Audio Sciences, 1*(1).

Berenzweig, A., Ellis, D., Logan, B., & Whitman, B. (2003, October 26-30). A large-scale evaluation of acoustic and subjective music similarity measures. *Proceedings of the 2003 International Symposium on Music Information Retrieval*, Baltimore, MD.

Birmingham, Dannenberg, Wakefield, Bartsch, Bykowski, Mazzoni, Meek, Mellody, & Rand. (2001). MUSART: Music retrieval via aural queries. *Proceedings of ISMIR 2001, the 2nd Annual International Symposium on Music Information Retrieval* (pp. 73-82). Bloomington, IN: Indiana University.

Cano, P. Batlle, E. Kalker, T., & Haitsma, J. (2002, December). A review of algorithms for audio fingerprinting. *Proceedings of the International Workshop on Multimedia Signal Processing*, U.S. Virgin Islands. Retrieved from http://www.iua.upf.es/mtg

Cohen, W., & Fan, W. (2000). Web-collaborative filtering: Recommending music by crawling the Web computer networks. *The International Journal of Computer and Telecommunications Networking, 33*(1-6).

Datta, D. (2002). Managing metadata. *Proceedings of the International Symposium on Music Information Retrieval 2002*, Paris.

Herrera, P., Peeters, G., & Dubnov, S. (2002). Automatic classification of musical instrument sounds. *Journal of New Music Research, 31*(3).

Liu, D., Lu, L., & Zhang, H.-J. (2003). Automatic mood detection form acoustic music data. *Proceedings of ISMIR 2003,* Washington.

Meyer, L. (1956). *Emotions and meaning in music.* Chicago: University of Chicago Press.

Nack, F., & Lindsay, A. (1999). Everything you wanted to know about Mpeg-7: Part 2. *IEEE Multimedia, 6*(4).

Pachet, F., Westerman, G., & Laigre, D. (2001). Musical data mining for electronic music distribution. *Proceedings of the 1st WedelMusic Conference.*

Peeters, G., La Burthe, A., & Rodet, X. (2002). Towards automatic music audio summary generation from signal analysis. *Proceedings of the International Conference on Music Information Retrieval (ISMIR02),* Ircam.

Scheirer, E. (1998). Tempo and beat analysis of acoustic musical signals. *JASA, 103*(1), 588-601.

Sheirer, E. (2002). About this business of metadata. *Proceedings of the International Symposium on Music Information Retrieval 2002*, Paris.

Tzanetakis, G., Essl, G., & Cook, P. (2001). Automatic musical genre classification of audio signals. *Proceedings of ISMIR 2001*, Bloomington, IN.

Whitman, B., & Lawrence, S. (2002, September 16-21). Inferring descriptions and similarity for music from community metadata. *Voices of Nature: Proceedings of the 2002 International Computer Music Conference* (pp. 591-598), Göteborg, Sweden.

Zils, A., & Pachet, F. (2003, September). extracting automatically the perceived intensity of music titles. *Proceedings of the 6th COST-G6 Conference on Digital Audio Effects (DAFX03),* Queen Mary University, London.

Zils, A., & Pachet, F. (2001, December). Musical mosaicing. *Proceedings of DAFX 01,* University of Limerick, Ireland.

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Chapter 4.54
Why Knowledge Management Fails:
Lessons from a Case Study

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EXECUTIVE SUMMARY

Knowledge is increasingly recognized as providing a foundation for creating core competencies and competitive advantages for organizations, thus effective knowledge management (KM) has become crucial and significant. Despite evolving perspectives and rigorous endeavors to embrace KM intentions in business agendas, it is found that organizations cannot capitalize on the expected benefits and leverage their performances. This is a case study of an organization in Hong Kong. It is a typical organization with a strong awareness and expectation of KM, yet its program failed within two years. Our findings show that KM activities carried out in the organization were fragmented and not supported by its members. Based on this failure case, four lessons learned are identified for use by management in future KM initiatives.

BACKGROUND

Founded in 1983, HS (the actual name of the company is disguised for confidentiality) is a Hong Kong-based enterprise with a production plant in mainland China. HS is primarily engaged in the production and export of handbags and leather premium products to the United States and European markets. The current CEO is the second generation of the founder. Like many companies in Hong Kong, HS centralizes all its strategic planning and decisions, as well as sales and marketing functions at its head office in Hong Kong while doing the production and assembly work across the border for low production cost. Appendix 1 is the organizational chart of HS. It is found that the head office has 10 staff including a CEO, a general manager, a sales manager, an operation manager, and six other administrative staff. The production plant in China has 450 staff including 40 managerial, supervisory, or administrative staff and 410 skilled workers. Over the years, HS has expanded its range of products and production capacities and resources in order to seize market opportunities and has enjoyed quite healthy growth in terms of sales turnover and profits.

SETTING THE STAGE

Business began declining with double-digit revenue losses in 1998. This was primarily attributed to the fierce competition in the markets and soaring production cost. For example, some competitors were offering drastic price cuts in order to obtain business contracts. Also, new product designs did not last long before being imitated by the competition. The CEO and the senior management team began planning the future of the company and to look for ways to improve the efficiency and productivity of its employees. Business continued to deteriorate, so that by 2001, in order to find out what had gone wrong, the CEO formed a strategic task force consisting of all managers in Hong Kong, several key managers responsible for the production plant in China, and himself to look into the matter. After two weeks of exploration (including observation and communicating with other staff in the company), the strategic task force concluded that knowledge within the organization was ineffectively managed; specifically, there was low knowledge diffusion from experienced staff to new staff, and high knowledge loss due to turnover. Driven by traditional management philosophy, the CEO and the strategic task force believed that they understood the organizational context better, and thus decided to undertake an in-depth investigation through internal effort instead of hiring an external consultant.

CASE DESCRIPTION

In June 2001, the strategic task force carried out investigation, observation, and interviews of employees in various departments. After three months, they identified the knowledge management (KM) issues summarized in Table 1.

From these findings, the strategic task force determined that open communication and discussion was necessary and effective to further examine the KM problems, and therefore called for a couple of meetings with managers and supervisors. In order to encourage open discussion, the meeting was conducted in an informal manner instead of the frequently used formal discussion (such as predefined order for reporting departmental issues). Furthermore, the room setting was changed with seats arranged in a circle to allow everyone to see each other and a flip chart was made available to jot down immediate thoughts. More importantly, everyone was encouraged to express his/her thoughts, opinions, and feedback from a personal perspective or collective stance (e.g., comments from subordinates).

The results of the meeting were encouraging as many participants expressed their opinions and comments eagerly. In particular, staff in the meeting agreed that KM was neither an extension of information management nor solely a technology application to capture, organize, and retrieve information or to evoke databases and data mining (Earl & Scott, 1999; Thomas, Kellogg, & Erickson, 2001). Instead, knowledge was embedded in people (e.g., skills and actions), tasks (e.g., production process), and the associated social context (e.g., organizational culture) that involved communication and learning among loosely structured networks and communities of people. Therefore, individuals/employees were crucial to the implementation of KM initiatives by utilizing their knowledge and skills to learn, share, combine, and internalize with other sources

Table 1. Diagnosis of KM problems in HS

Issues	Problems from a KM perspective
❖ Supervisors complained about the heavy workload as they were merely the experts/ advisors for their team members. ❖ Supervisors had little interest in what other supervisors were doing and practicing as they considered their tasks were the most important agenda. ❖ Employees demonstrated passivity and taken-for-granted passion while they were learning new skills, e.g., they implemented instructions without asking.	❖ Knowledge was not shared but solely kept by a small group of people. ❖ Learning initiatives among employees was low due to the silo effect of organizational structure.
❖ When skilled workers left HS, specific production techniques were swiftly acquired by other competitors who employed those ex-staff of HS.	❖ Knowledge was lost to competitors.
❖ Supervisors did not have unified standard to extract best practices from experiences. ❖ Employees encountered difficulties in identifying success stories or effective production techniques for respective clients.	❖ Knowledge was not appropriately defined, captured and retained.
❖ Employees did not have strong willingness to learn with new techniques and practices. ❖ Employees took a long time to acquire techniques yet hardly to retain the acquired techniques.	❖ Knowledge creation and development was not encouraged, motivated and nurtured systematically.

of knowledge to generate new thoughts or new perspectives.

With the above results, HS decided to devise and launch a KM program with an aim to institutionalize knowledge diffusion among employees and leverage knowledge creation for quality products. Instead of a top-down approach of policy making, the management adopted a middle-up-down approach (Nonaka, 1994) with supervisors as the major force to leverage and promote KM throughout the organization. To enhance acceptance and lessen resistance to change, HS chose a new product series to try out the KM initiative with a focus on the following four main aspects: strategic, organizational, instrumental, and output.

In the strategic aspect, it was considered that knowledge available and possessed at HS would fall short of the core competence necessary for business success (e.g., chic product design). Therefore, effort was needed to fill this gap by acquiring knowledge from both external and internal sources. From the organizational side, it was thought that knowledge was more valuable when it was shared and exchanged. Thus, a knowledge-friendly culture needed to be promoted through encouraging employees to socialize and share their ideas and thoughts such that new knowledge could be created to broaden their knowledge repositories. At the base level, it was determined that knowledge had to be acquired, stored, and disseminated in a systematic way to enable employees to access and reuse it easily. In doing so, essential knowledge, such as experienced practices in production skills and innovative ideas in product design, could be captured and recorded. Individual employees or teams who contributed knowledge useful and relevant to HS were to be rewarded. Last but not least, from an output perspective, it was realized that periodic reviews were crucial for evaluating KM effectiveness and for devising subsequent corrective action, if necessary. Performance indicators such as production efficiency, adoption rate of good practices identified, and clients' satisfaction were required.

A detailed implementation plan was devised based on the above analysis, which was then agreed to and approved by the top management of HS. The KM program was officially launched in April 2002.

CURRENT CHALLENGES/ PROBLEMS FACED BY HS

After 15 months, HS found that the KM initiative did not generate the positive impact on organizational performance as expected. Organizational performance remained stagnant, revenue continued to decrease, and staff turnover rate stayed high. Our involvement with HS as an external consultant began after the CEO had determined to find out why and/or what happened. Our assistance to HS was clear — to investigate the situation, to uncover the mistakes, and to look for remedies. A series of semistructured interviews with key employees in the managerial, supervisory, and operational levels were therefore conducted. Table 2 summarizes our findings.

As seen, a good start does not guarantee continuity and success (De Vreede, Davison, & Briggs, 2003). First, two crucial reasons were identified as to why HS was unable to bridge the knowledge gap. They were (1) the top management was too ambitious or unrealistic to grasp and incorporate the "best" knowledge in industry into the company and (2) their insufficient role support in encouraging the desired behavior. Similar to many other KM misconceptions, top management wrongly aimed at incorporating other enterprises' best practices (e.g., product design of the fad) or success stories (e.g., cost cutting and streamlining operational processes) into its repositories without considering the relevance, suitability, and congruence to its capabilities. Therefore, this "chasing-for-the-best" strategy soon became problematic and departed from its KM goals. HS did not gain business advantages, such as unique product design and value-added services to customers, and were still unable to respond to the marketplace swiftly.

Second, the mere presence of KM vision is not sufficient to guarantee KM success. Most employees commented that top management involvement in the KM implementation was volatile and appeared to be a one-shot exercise (Gold, Malhotra, & Segars, 2001). For example, the KM program started well with noticeable initiative to identify untapped knowledge from various sources, yet fell behind the expected goals as top management involvement was remote (e.g., leaving the KM effectiveness as departmental responsibility) and support was minimal (e.g., time resources available for knowledge sharing and creation). Thus, the two factors directly hampered the employees' dedication and belief in KM as a significant organizational move.

Third, from the organizational aspect, even though various social activities such as tea parties were used to foster a friendly and open organizational culture, we found that most of these knowledge-sharing activities were futile because no specific and/or appropriate guidelines for such sharing had been devised (Nattermann, 2000). As a result, instead of having discussions that were directly related to tasks, or least contributed to idea generation, frequent chats (e.g., gossiping) among employees and wandering around were found. Many employees were confused with what the sharing was all about. Some employees

Table 2. KM results from 2001 to 2003 in HS

KM Focus	Initiatives in 2001	Results in 2003
Strategic ❖ To determine knowledge gap	❖ Identified core knowledge that led to business success	❖ Unrealistic aims → created fallacies "All the best in HS" to direct KM development ❖ Volatile support → undermined the KM climate
Organizational ❖ To establish knowledge-friendly culture	❖ Shared knowledge in various socialization and informal gathering	❖ Unframed socialization → created more confusion or negative perceptions ❖ Ineffective human resources policy to retain knowledge workers → swifted loss of knowledge
Instrumental ❖ To acquire and stimulate knowledge creation	❖ Acquired knowledge in departmental handbook and rewarded knowledge sharing behaviors	❖ Unlimited definitions or views of sources of knowledge → left individual knowledge untapped ❖ Emphasized monetary rewards to stimulate contributions → created self-defeating mechanism and unfriendly team culture ❖ Perceived IT as cutting-edge solution → led to unduly investment on technology
Output ❖ To evaluate and audit KM development	❖ Conducted periodical review and measured organizational performance	❖ Reviewed infrequently → created pitfalls to learn from mistakes, then moved ahead ❖ Predisposed on efficiency and profitability → overwhelmed short-term benefits to exploit existing knowledge

even perceived KM negatively as interfering with activities important to their daily tasks, creating resistance to participation in what was perceived to be a temporary fad.

Fourth, the instruments used to help acquire and stimulate knowledge creation and sharing encountered problems during implementation. The fallacy of knowledge acquisition with reliance on external sources (such as the existing practices addressed by competitors) undermined employees' intent to explore the available but untapped knowledge resident in their minds (Bhatt, 2001; Nonaka, 1994). The use of information technology to drive knowledge storage and sharing, in principal, was conducive to employees. Yet, the silo organizational structure of HS with disentangled databases for knowledge capture caused more harm than good. Some employees asserted that they did not have the incentive to access or utilize the departmental knowledge handbook and procedural guidance (available from databases) as it is a time-consuming endeavor to dig from the pile of information. Some employees found knowledge incomprehensible as it was presented and stored in various formats, with jargons and symbols that were neither standardized nor systematized across departments.

Fifth, although a reward system was established for knowledge creation and/or sharing, the emphasis on extrinsic terms, such as a monetary bonus, turned out to have an opposite and negative effect on cultivating the knowledge-sharing culture and trust among employees. Some employees commented that knowledge should be kept as personal interest (i.e., not to be shared) until they felt that they could get the monetary reward when shared or recognized by management. Other employees found that harmony and cohesiveness within the team or among colleagues were destabilized as everyone maximized individual benefits at the expense of teamwork and cooperation.

Sixth, there was a misleading notion that IT could be "the" cutting-edge solution to inspire KM in organization. Despite the introduction of IT tools to facilitate knowledge capture, codification, and distribution, it was found that IT adoption and acceptance remained low due to employee preference for face-to-face conversation and knowledge transfer instead of technology-based communication, and the general low computer literacy that intensified the fear of technology. In addition, given the insufficient support from management for IT training and practices, employees, particularly those who had been with HS for a long time, had strong resistance to new working practices for facilitating KM.

Seventh, it was noted that the KM initiatives were left unattended once implemented. It remained unclear as to how to exceed existing accomplishments or overcome pitfalls of the KM initiatives, as there was no precise assessment available. For instance, the last survey evaluating the adoption of best practices from departmental knowledge was conducted a year ago, without a follow-up program or review session. Another example was that the currency and efficacy of the knowledge recorded in the departmental handbook appeared obsolete as no procedures were formulated to revise or update the handbook.

Last but not least, an undue emphasis and concern with the "best-practice" knowledge at HS to improve short-term benefits (e.g., to exploit existing knowledge in order to achieve production efficiency) at the expense of long-term goals (e.g., to revisit and rethink existing knowledge and taken-for-granted practice in order to explore innovation and creativity opportunities). Some employees pointed out that they were inclined to modify existing practices rather than create new approaches for doing the same or similar tasks as recognition and positive impacts can be promptly obtained.

EPILOGUE

To date, KM is considered an integral part of a business agenda. The dynamics of KM as human-oriented (Brazelton & Gorry, 2003; Hansen, Nohria, & Tierney, 1999) and socially constructed processes (Brown & Duguid, 2001) requires an appropriate deployment of people, processes, and organizational infrastructure. This failure case presents the challenges that could be encountered and coped with in order to accomplish effective KM implementation. The people factor is recognized as a key to the successful implementation of KM from initiation, trial, to full implementation. KM is a collective and cooperative effort that requires most, if not all, employees in the organization to participate. KM strategy and planning should be organized, relevant, and feasible within the organizational context. One's best practices and winning thrusts may not be well fitted to others without evaluation for fit and relevance. A balanced hybrid of hard (e.g., information technology) and soft infrastructure (e.g., team harmony and organizational culture) is needed for success.

LESSONS LEARNED

Knowledge management is increasingly recognized but its challenges are not well understood.

To institutionalize a KM program, organizations can draw lessons from this failure case so as to construe what imperatives are needed and what mistakes should be avoided. Management issues and concerns are highlighted as follows.

Lesson 1: Start with a KM Plan Based on Realistic Expectations

The mission and behavioral intentions of leaders have a strong impact on employees and where to aim and how to roll out KM processes (KPMG, 2000). In this case, it is appreciated that top management recognized its organizational ineffectiveness and initiated a KM plan as a remedy. We suggest, however, that planning based on unrealistic expectations undermined its ability to successfully direct future actions. Therefore, management has to be reasonable in setting KM goals, perceptions, and beliefs. It is suggested that a feasibility assessment of organizational infrastructures (e.g., financial resources, technology level) and organizational climate (e.g., employees' readiness to KM, resistance to change) be conducted to define the KM principles and goals. Inspirational aims, which can be reasonably and feasibly accomplished, encourage employees to assess their personal knowledge and transfer others' knowledge when it is shown to enhance existing practices and can help meet new challenges.

Lesson 2: Management Support is a Strong, Consistent, and more Importantly, Cohesive Power to Promote KM

It is evident that vision without management support is in vain and temporary. As valued most by the HS employees, continuous corroboration from top management is indispensable to motivate their commitment toward knowledge-centric behaviors for long-term competitiveness (Lee & Choi, 2003). Therefore, beyond visionary leadership, management should be willing to invest time, energy, and resources to promote KM. At its core, management could show their enthusiasm in a boundless and persistent way, including vocal support, speech, inaugural memo, and wandering around different business units to invite impulsive idea generation and knowledge creation from all levels of staff. Also, management could champion the KM process and lead by example with employees who are receptive to KM.

Lesson 3: Integration of Monetary and Nonmonetary Incentives

To stimulate KM behaviors, specifically sharing and creation, it is important to assure a balanced reward system integrating monetary and nonmonetary incentives that fit various forms of motivation (Desouza, 2003). In the beginning of the KM programs, employees needed to be shown that personal benefits could be obtained from KM success with improvement in products, processes, and competitiveness. Therefore, rewards that are direct, monetary-based, and explicit are useful. For this, management can provide salary increase or promotion. With the passage of time, rewards could be extended to something implicit. For instance, management can publicize those employees' names and respective ideas that contributed to organizational processes, or provide skills-enhancement program to enable employees to see their importance with extended job scopes. Moreover, management can consider rewards systems geared toward individual or team achievement so as to encourage more interaction, creativity, teamwork, and harmony among people.

Lesson 4: KM has to be Cultivated and Nurtured, which is not a Push Strategy or Coercive Task

As shown in this case, KM is not a singly motivated exercise. It requires a collective and cooperative effort to put into effect various resources. Other than the vision and top management support, operational staff can greatly affect the success of the KM program. Their influences affect attitudes, behaviors, and participation in KM and could exert positive impacts on KM effectiveness if managed properly. For attitudinal changes, efforts have to remove or at least alleviate employees' negative perception toward KM. For example, the fear and misconception that KM is a means to downsize organizations for efficiency or as heavy workload which requires much IT expertise. For behavioral changes, we highlight a supportive working environment where employees can have ample time to engage in KM endeavors, such as sharing and creation, a fair and positive culture where everyone is valued and encouraged to contribute to KM effectiveness, is needed. To encourage participation, pushing or mandatory activities are least effective. Coupled with the rewards systems, employees should be inspired to take risks as learning steps for KM success. Unexpected failure or unintended results may cause management to call for a break to identify the causes and remedy solutions. Do not quit or blame, otherwise, mutual trust and commitment to work with the KM processes will be lessened.

REFERENCES

Akbar, H. (2003). Knowledge levels and their transformation: Towards the integration of knowledge creation and individual learning. *Journal of Management Studies, 40*(8), 1997-2021.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Bhatt, G.D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-75.

Brazelton, J., & Gorry, G.A. (2003). Creating a knowledge-sharing community: If you build it, will they come? *Communications of the ACM, 46*(2), 23-25.

Brown, J.S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Desouza, K.C. (2003). Facilitating tacit knowledge exchange. *Communications of the ACM, 46*(6), 85-88.

De Vreede, G.J., Davison, R.M., & Briggs, R.O. (2003). How a silver bullet may lose its shine. *Communications of the ACM, 46*(8), 96-101.

Earl, M.J., & Scott, I.A. (1999). What is a chief knowledge officer? *Sloan Management Review, 40*(2), 29-38.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

King, W.R., Marks, Jr., P.V., & McCoy, S. (2002). The most important issues in knowledge management. *Communications of the ACM, 45*(9), 93-97.

KPMG Consulting. (2002). *Knowledge management research report 2000.*

Lee, H., & Choi, B. (2003). Knowledge management enablers, process, and organizational performance: An integrative view and empirical examination. *Journal of Management Information Systems, 20*(1), 179-228.

Nattermann, P.M. (2000). Best practice does not equal to best strategy. *The McKinsey Quarterly, 2,* 22-31.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Thomas, J.C., Kellogg, W.A., & Erickson, T. (2001). The knowledge management puzzle: Human and social factors in knowledge management. *IBM Systems Journal, 40*(4), 863-884.

ADDITIONAL SOURCES

Chen, M. (1995). *Asian management systems.* London: Thomson Business Press.

Fosh, P., Snape, E., Chan, A., Chow, W., & Westwood, R. (1999). *Hong Kong management and labour: Change and continuity.* London: Routledge.

Kaul, V.K. (2002). Knowledge management and innovation in technology-based small and medium sized enterprises. *Management Research News, 25*(8-10), 102-103.

McAdam, R., & Reid, R. (2001). SME and large organization perceptions of knowledge management: Comparisons and contrasts. *Journal of Knowledge Management, 5*(3), 231-241.

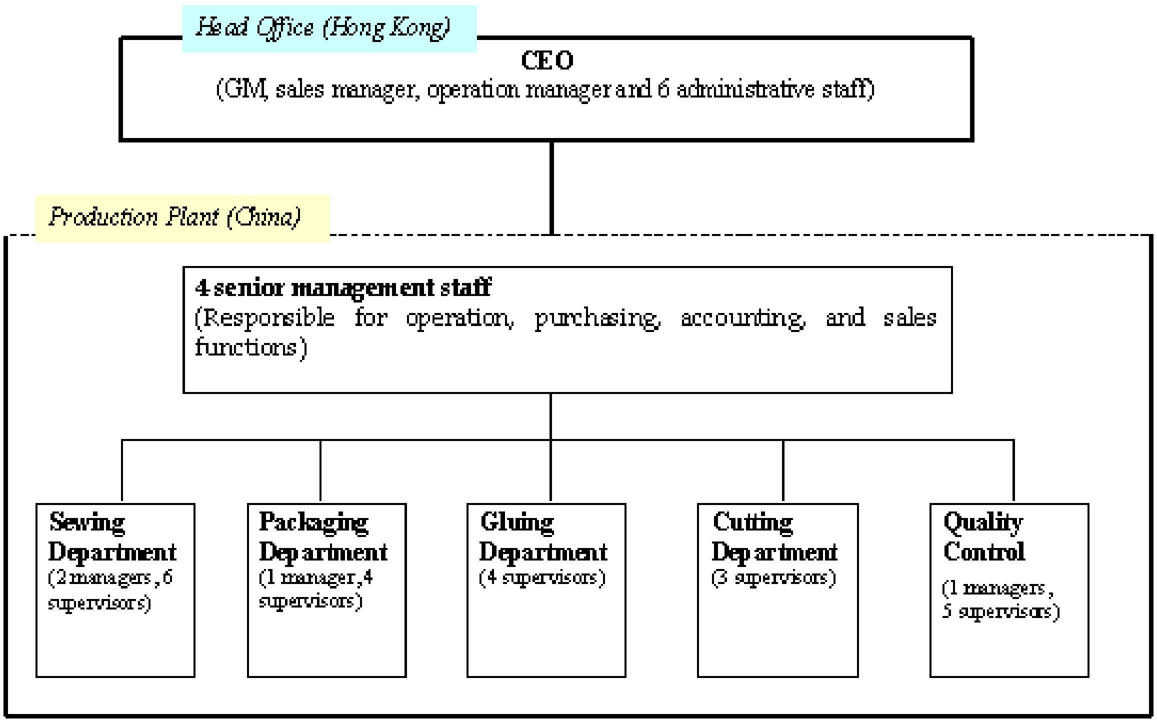
Sarmento, A., & Correia, A.M. (2003). Knowledge management: A rewarding challenge for SME's? *Proceedings of the Fourteenth Annual Information Resources Management Association International Conference,* Philadelphia.

Small and Medium Enterprise Center. www.tdctrade.com/sme/

Virtual Small and Medium Enterprises Center. www.sme.gcn.gov.hk/smeop/english/index.cfm

Zetie, S. (2002). The quality circle approach to knowledge management. *Managerial Auditing Journal, 17*(6), 317-321.

APPENDIX 1: ORGANIZATIONAL CHART OF HS



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Chapter 4.55
Getting Knowledge Management Right: Lessons from Failure

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ABSTRACT

Knowledge is increasingly recognized to provide a foundation for creating core competences and competitive advantages for organizations, making effective knowledge management (KM) crucial and significant. Despite evolving perspectives and rigorous endeavors to embrace KM intentions in business agendas, organizations cannot always realize expected benefits and improve their performances. This paper reports a case study of an organization in Hong Kong that shares typical characteristics with other organizations with strong awareness and expectations of KM, yet experienced failure of its program in two years. Our findings showed that KM activities carried out in the organization were fragmented and not supported by members. Based on this failure case, four lessons learned are identified for improving KM performance.

INTRODUCTION

Knowledge has been increasingly recognized as an important asset for improving organizational performance. The capability to manage knowledge is deemed crucial to advocate effective KM programs/systems in large-, small- and medium-sized organizations (Alavi & Leidner, 2001, KPMG, 2000, McAdam & Reid, 2001). While many KM success stories have been reported, there are also failure stories. As reported in many management research studies, the challenges of KM implementation are not only dependent on a company's technological abilities, but also its managerial and organizational capabilities (Akbar, 2003; King, Marks Jr. & McCoy, 2002). In this paper, we report on a case study of how an organization in Hong Kong initiated a promising KM project but failed in two years. We know the case because we were called in by the company's top management to uncover why the KM initiative failed. Findings are discussed that reveal a gap between the KM initiatives and unmet practices. Derived from the failure results, we present what we can learn from it and finally conclude with implications for future KM theory and management actions.

PAST STUDIES ABOUT KM

KM researchers have suggested various key elements that contribute to KM success. The mainstream thoughts can be classified as follows:

Knowledge Classification

According to resource-based theory, knowledge is regarded as an object that can be identified, traded like other organizational resources, and captured and documented in information systems (Fischer & Ostwald, 2001; Shin & Holden, 2000). Therefore, it is presumed that the more knowledge objects organizations possess the more likely they are to improve performance and productivity. According to the cognitive perspective, knowledge is viewed as a fluid mixture of experience, ideas and capabilities that are resided in minds of individuals (Kim, 1993; Nonaka, 1994; Tuomi, 2000). Therefore, it is asserted that procedural design in enhancing individual learning and understanding to leverage knowledge to direct decision and action will improve performance. The social view asserts that knowledge is a social asset and is embedded in social context as a dynamic state of knowing leveraged from individuals to groups through collective interaction and learning by doing (Nonaka & Konno, 1998; Swan & Newell, 2000). Therefore, the effectiveness of KM is primarily encouraged by knowledge sharing among and between groups and individuals who are committed for common interests or trust.

KM Frameworks

KM frameworks are categorized into two main groups: descriptive and prescriptive (Holsapple & Joshi, 1999). The descriptive framework characterizes the nature of KM phenomena: the fundamental capabilities that organizations manipulate in their KM activities. For example, APQC (2000) conceptualizes organizational members as engaging seven main KM processes, including create, identify, collect, adapt, organize, share and use of knowledge. It is stated that each process is designed and managed to support one another to ensure the right knowledge gets to the right people at the right time to improve organizational performance. Other studies depict the core work of KM as relying upon the development of organizational memory (Appleyard & Kalsow, 1999) or fostering networked communities (Bowonder, 2000) to enable individuals to share and acquire knowledge in various aspects.

The prescriptive framework characterizes how organizations should structure effective KM implementation guidelines. For example, Allee (1997) suggests that traditional ways of managing physical resources (such as raw materials) do not fit in the context of KM. She advances 12 principles for capitalizing the value of knowledge in regard to its fluid and diverse nature: Knowledge is embedded with individuals and social networks; knowledge is not accountable to a single party, meaning it should be a responsibility for each employee. Lee and Kim (2001) propose four KM stages where organizations nurture and grow their capabilities: initiation, propagating, integration and networking. The first stage, initiation, is regarded as the preparation for enterprise-wide knowledge management efforts. The second stage is focused on the intra-organizational activation of knowledge activities (e.g., reward systems, KM development). The third stage emphasizes integration of KM efforts to organizational outcomes, and the final stage expands knowledge activities with connection to external parties. They suggest that variations and coordination in management plans, organizational members and procedures are necessary for KM effectiveness.

KM Enablers

Enabling factors facilitate KM activities, such as codifying and sharing knowledge assets among individuals. One enabler is organizational culture. Organizational culture is critical to facilitating knowledge sharing norms and learning motivation among individuals (Amabile, 1997; Standing & Benson, 2000). For example, Roberts (1997) explains that KM effectiveness is an integration of people, relationship and technology. He furthers states that employees' enthusiasm and trust in others has direct influence on the ability of information and communication technology (ICT) to transfer knowledge across various departments. In addition, leadership and management initiatives are considered central to direct and evaluate knowledge management practices effectively (April, 2002; Brown & Woodland, 1999; Earl & Fenny, 1994). In a study of chief information officers and senior IS managers, Law and Lee-Partridge (2001) identified that the chief executive officer could be an effective champion and key figure in breaking through long-standing practices in daily work: encourage employees to pay more attention in identifying knowledge, share best practices and create new thoughts for innovative products or services. Other studies emphasize the role of technology and information systems as essential to enabling knowledge acquisition and dissemination (Armbrecht Jr. et al., 2000; Sher & Lee, 2004). Marwick (2001) proposes that a number of IT tools be applied in regard to the different knowledge creation processes. For instance, he states that e-meetings can be an effective means to enable people to chat and discuss for identifying tacit knowledge; while document categorization is useful for employees to retrieve and access explicit knowledge.

KM Strategies

KM strategies encapsulate the strategic directions in managing knowledge and its related processes. In general, there are two main orientations of KM strategy. First, technology-driven KM strategy is characterized by application of information systems such as knowledge directories and chat forums to maximize codification, connectivity, dissemination and reusability of knowledge resources (Hansen, Nohria & Tierney, 1999; Swan & Scarbrough, 2001). In an empirical investigation of KM, Choi and Lee (2001) found that some organizations emphasizing the capability to store and use the explicit and documented knowledge are more likely to put much attention on the technology infrastructure and deployment. Management focuses on a specified set of rules and procedures to determine what knowledge and how knowledge should be manipulated. As a different system emphasis, the human-driven KM strategy is characterized with provision of channels (not necessary technology enabled) such that people-to-people interactions, direct conversation and social contact networks are fostered (Choi & Lee, 2001). It is presumed that knowledge is originated from social networks, story telling or experience sharing through dialogue. Other empirical studies are identified that support similar views of the significant role of human as the knowledge agents (such as knowledge providers, seekers, re-users) (Markus 2001), and the trust and care among individuals to create knowledge communities in order to enable individuals to share, exchange and explore knowledge through personal and unstructured ways (Bhatt, 2000; Von Krogh, Ichijo & Nonaka, 2000).

These studies reveal that the field of KM proliferates with diverse approaches in research and practice. It is deemed that each study provides an explanation of a slice of the KM phenomena, but not in a comprehensive manner (Alvesson, Kärreman & Swan, 2002; Argote, McEvily & Reagans, 2003). A concern is that KM practices within an organization may reflect several or a blend of those elements addressed in past studies. Thus, our case study aims to present and reveal such complexity. The case study illustrates a KM experience that starts with a sound initiative but is not sustained throughout its implementation.

RESEARCH METHODS

The main focus of this research is to explore the underlying reasons why a sound KM initiative did not lead to its expected results. In regard to the complexity of KM issues, this study used case study methods to collect evidence from organizational records and in-depth interviews with employees at various organizational levels (Pettigrew, 1990; Yin, 1994). The analysis of organizational records, including employees' log books, departmental minutes, productivity charts and front-line supervisors' reports, was conducted to diagnose the causes of ineffective organizational performance from which to imply the possible directions of the KM program. Discussion and clarification were made with management in iterative rounds to develop a common discourse on the KM issues. The discussion results, in respect to knowledge categorization, KM enablers and strategies are presented in Table 1.

Interviews were used to investigate the underlying reasons for ineffective KM practices in 2003. Taking into account the complexity of the issues, we sought insights from key informants in various departments. From September to November 2003, 12 in-depth interviews were conducted. Based upon the guides in conducting case study method and qualitative research methods (Boyatzis, 1998; Denzin & Lincoln, 1994; Yin, 1994), the data were transcribed and scrutinized to identify eight flaws in the KM program.

ORGANIZATION BACKGROUND

Founded in 1983, HS (the actual name of the company is disguised for confidentiality) is a Hong Kong-based enterprise with a production plant in mainland China and that engages primarily in the manufacture and export of handbags and leather premium products for United States and European markets. Like many companies in Hong Kong, HS centralizes all its strategic planning and decisions, as well sales and marketing functions, at its head office in Hong Kong, while doing the production and assembly work across the border. The head office has 10 staff, including a CEO, general manager, sales manager, operations manager and six other administrative staff. The production plant in China has 450 staff, including 40 managerial, supervisory or administrative staff and 410 skilled workers. Over the years, HS has expanded its range of products and production capacities and resources in order to seize market opportunities and has enjoyed healthy growth in terms of sales turnover and profits.

Business, however, began to decline, with a double-digit revenue loss since 1998, primarily attributed to the fierce competition in the markets and soaring production costs. Because of this, the CEO and his senior management team began to plan the future of the company and look into ways to improve the efficiency and productivity of its employees. To find out what had gone wrong, in 2001, the CEO formed a strategic task force that consisted of all managers in Hong Kong, several key managers responsible for the production plant in China and himself to look into the matter. After two weeks of exploration (including observation and communicating with other staff in the company), the strategic task force concluded that the ineffective performance could be attributed to the practice in managing the knowledge assets within the organization, with low knowledge diffusion and high knowledge loss as two key issues. Therefore, it was decided to do a more detailed and in-depth investigation.

The strategic task force was responsible for carrying out the analysis. After three months of investigation and observation, they asserted that knowledge should be the strategic assets utilized and developed in their business agenda, despite their lack of experience in managing knowledge. To seek more opinions and perspectives, the strategic task force determined that open communication and discussion was necessary and effective to further examine the KM problems and therefore called for a meeting with managers and supervisors.

The results of the meeting were encouraging, as many participants expressed their opinions and comments eagerly. In particular, staff in the meeting agreed that KM was neither an extension of information management nor solely a technology application to capture, organize and retrieve information, to evoke databases and data mining (Earl & Scott, 1999; Thomas, Kellogg & Erickson, 2001). Instead, knowledge was embedded in people (e.g., skills and actions), tasks (e.g., production process) and the associated social context (e.g., organizational culture) that involved communication and learning among loosely structured networks and communities of people. Therefore, individuals/employees were crucial to drive KM initiatives by utilizing their knowledge and skills to learn, share, combine and internalize with other sources of knowledge to generate new thoughts or new perspectives.

KM IN 2001

In spite of the determination to leverage knowledge assets, the analysis of organizational documents showed that there was little systematic mechanism to collate and assimilate various feedbacks and findings from the employees. For example, the organizational annual plan in 2002 had implicit emphasis and objectives to devise a KM program and institutionalize knowledge diffusion among employees and knowledge creation for quality products. The long-term goal remains broad and conventional, with the aim "to provide quality products at effective cost," in which the role of knowledge is not considerably stated or embraced. In essence, the KM program at HS can be characterized with a sound plan but fragmented and flamboyant process.

Fragmented Plan

Table 1 highlights the ineffective organizational performance and relates it to previously discussed KM elements. Taking into account the categorization of knowledge, it was found that there is neither a working definition of knowledge nor a clear categorization mechanism available to identify knowledge. There is an extensive pool of knowledge existing in HS, as employees in different departments are required to record their tasks, procedures and suggestions in their log books. However, there is scant appropriate policy to unify the presentation and content. The records of critical success factors of a product were perceived and recorded differently and haphazardly across departments: choice of leather color that comply with those promoted in the latest fashion design (design team), the analysis of customers' preference or effective control of cost that contributes to competitive selling price (sales department) and so forth.

In regard to KM enablers, management did not put much effort into creating enablers for its KM activities. It was found that an effective human resources plan was not made to enhance knowledge sharing. For example, a number of supervisors stated that getting new employees to learn the skills is a painstaking process. The production department manager claims, "with inadequate time and people, and tremendous time pressure, as I spend 14 hours a day on my primary tasks, I may not be a trainer … subordinates are too passive and not willing to think out of box, they may not be effective learners or serious about improving their knowledge." Therefore,

Table 1. Diagnosis of KM problems in HS

Issues	Implications to KM initiatives
Knowledge categorization ❖ Supervisors did not have unified standard to extract best practices from experiences. ❖ Employees encountered difficulties in identifying success stories or effective production techniques for respective clients.	❖ Knowledge was not appropriately defined, captured and retained. ❖ Knowledge is diverse and not consistently stated.
KM enablers ❖ Supervisors complained about the heavy workload keeping them from training their team members. ❖ Supervisors had little interest in what other supervisors were doing and practicing as they considered their tasks were the most important agenda. ❖ Employees demonstrated passivity and taken-for-granted passion while they were learning new skills, e.g., they implemented instructions without asking.	❖ Knowledge was not shared across the company but kept by a small group of people. ❖ Learning initiatives among employees was low due to the silo effect of organizational structure.
KM strategies ❖ When skilled workers left HS, specific production techniques were swiftly acquired by other competitors who employed them. ❖ Employees did not have strong willingness to learn new techniques and practices. ❖ Employees took a long time to acquire techniques and had a hard time retaining them .	❖ Knowledge was lost to competitors. ❖ Knowledge creation and development was not systematically encouraged, motivated and nurtured.

there are usual complaints that overreliance on supervisors for advice and expertise affect their productivity on managerial roles and tasks. Employees from the production department and accounting department unanimously reflected that no strong culture promotes personal knowledge within organization. The employee (production department) stated, "if you discuss with your colleagues about knowledge gained from our established sewing procedures, or break-through practices on improving productivity, most of them will see you are self-conceited or extraordinary … I do have the heart and mind to embrace KM, but do not dare to implement it under a strong conformity environment."

In terms of KM strategies, it appears that HS has no clear direction and inclination towards technology or human aspects for coordinating KM processes. For example, a merchandizing supervisor revealed that most skilled workers are competent to their tasks at hand but have little computer literacy. He states, "only a few of people, including one of my subordinates, can manipulate the computers for recording our past experiences, such as details during negotiation with suppliers, or search the Web for prospective suppliers … Sometimes, I do worry about what will happen if he leaves our company …" This implies that the knowledge plan should also account for employee turnover causing knowledge loss. Another merchandizing manager recalled that ex-employees have a lot of good networks with suppliers or subcontractors; "now they use their knowledge to defeat us for their new employers."

Trial Run

Based upon their understanding and investigation of KM, HS intended to enhance employee acceptance and lessen resistance to change. Therefore, HS chose to pilot the KM initiative on a new product series. As mentioned before, there is scant documentation detailing the KM programs. This section uses various departmental minutes and supervisor reports, and presents the results in the following four main aspects: strategic, organizational and instrumental and output (Uit Beijerse, 1999).

In the strategic aspect, it was considered that knowledge available and possessed at HS would fall short of the core competence necessary for business success (e.g., chic product design). Therefore, effort was needed to close this gap by acquiring knowledge from both external and internal sources. From the organizational side, it was thought that knowledge was valuable when it was shared and exchanged. Thus, a knowledge-friendly culture needed to be promoted by encouraging employees to socialize and converse their ideas and thoughts such that new knowledge could be stimulated to broaden their knowledge repositories. At the instrumental level, it was thought that knowledge had to be acquired, stored and disseminated in a systematic way to enable employees to access and reuse it easily. By doing so, essential knowledge could be captured and recorded, such as key experiences in production skills and innovative ideas in product design. Individual employees or teams who contributed knowledge useful and relevant to HS were to be rewarded. Last, but not least, from an output perspective, it was realized that periodical reviews were crucial for evaluating the KM effectiveness and for devising subsequent corrective action, if necessary. Performance indicators such as production efficiency, adoption rate of good practices identified and clients' satisfaction were required.

An implementation plan was devised based on the above analysis, which was then agreed upon and approved by HS' top management. The KM program was officially launched in April 2002.

KNOWLEDGE MANAGEMENT IN 2003 – A FAILURE

After 15 months of implementation, HS found that the KM initiative did not have the expected positive impact on organizational performance. Organizational performance remained stagnant, revenue continued to shrink and the staff turnover rate stayed high. Our involvement with HS as an external consultant began after the CEO decided to find out why and/or what happened. Our assistance to HS was clear — to investigate the situation, uncover the mistakes and recommend remedies. A series of 12 semi-structured interviews with key informants at managerial, supervisory and operational levels were conducted. Table 2 summarizes our findings with respect to four KM focuses (Uit Beijerse, 1999). In essence, it is indicated that the initiatives designated in 2001 cannot be realized in 2003.

As indicated in previous research, a good start for a project does not guarantee its continuity and success (Davenport, Long & Beers, 1998; De Vreede, Davison & Briggs, 2003). First, two crucial reasons were identified as to why HS was unable to bridge the knowledge gap. Most middle managers found KM too difficult to implement, as "the top management was too ambitious or unrealistic to grasp and incorporate the 'best' knowledge in industry into the company, while we were starting as a small bush and couldn't grow into a forest within a short period of time." In addition, a number of operational staff stated: "there is insufficient role modeling to exhibit the desired behavior from our supervisors … we found KM is too vague." Similar to many other KM misconceptions, top management wrongly aimed

Table 2. KM results in 2003

KM Focus	Initiatives in 2001	Results in 2003
Strategic ❖ To determine knowledge gaps	❖ Identified core knowledge that led to business success	❖ Unrealistic aims → created fallacies "All the best in HS" to direct KM development ❖ Volatile support → undermined the KM climate
Organizational ❖ To establish knowledge-friendly culture	❖ Shared knowledge in various social and informal gatherings	❖ Unframed socialization → created more confusion or negative perceptions ❖ Ineffective human resources policy to retain knowledge workers → swifter loss of knowledge
Instrumental ❖ To acquire and stimulate knowledge creation	❖ Acquired knowledge in departmental handbook and rewarded knowledge sharing behaviors	❖ Unlimited definitions or views of sources of knowledge → left individual knowledge untapped ❖ Emphasized monetary rewards to stimulate contributions → created self-defeating mechanism and unfriendly team culture ❖ Perceived IT as cutting-edge solution → led to undue investment on technology
Output ❖ To evaluate and audit KM development	❖ Conducted periodical review and measured organizational performance	❖ Reviewed infrequently → created pitfalls to learning from mistakes, then moved ahead ❖ Predisposed on efficiency and profitability → overwhelmed short-term benefits to exploit existing knowledge

at incorporating other enterprises' best practices (e.g., product design of the fad) or success stories (e.g., cost cutting and streamlining operational processes) into its repositories without considering the relevance, suitability and congruence to its capabilities. Therefore, this "chasing-for-the-best" strategy soon became problematic and departed from its KM goals. HS did not gain business advantages such as unique product design and value-added services to customers and was unable to respond swiftly to the marketplace.

Second, the mere presence of KM vision is not sufficient to guarantee KM success. Most employees commented that top management involvement in the KM implementation was volatile and appeared to be a one-shot exercise (Gold, Malhotra & Segars, 2001). For example, the KM program started well, with a noticeable initiative to identify untapped knowledge from various sources; yet it fell behind the expected goals, as top management involvement was remote (e.g., leaving the KM effectiveness as departmental responsibility) and support was minimal (e.g., time resources available for knowledge sharing and creation). One supervisor recalled that, "the inauguration day for incorporating KM into our business agenda was great and impressive, yet we are not given explicit guides to assess and evaluate knowledge work." Another operational staff member (from the same department) stated that, "at present, I am not sure how KM benefits me; also, I do not find management reports showing how KM helped organizational performance over the past two years." Therefore, it directly hampered the employees' dedication and belief in KM as a significant organizational move.

Third, from the organizational aspect, even though various social activities such as tea gatherings were used to foster a friendly and open organizational culture, we found that most of these knowledge-sharing activities were futile because no specific and/or appropriate guidelines for such sharing had been devised (Nattermann, 2000). As a result, instead of having discussions directly related to tasks, or at least contributed to idea generation, frequent chats (e.g., gossiping) among employees and wandering around were found. Most respondents claimed that a sharing session is a time-killing exercise with superficial issues. One supervisor stated with disappointment that, "I can hardly get a piece of useful ideas from my colleagues through those sharing sessions … their best practices are locked up in the ivory towers and cannot be reached." Some employees even perceived KM negatively as interfering activities in their daily tasks and resisted participating in such a temporary fad.

Fourth, the instruments used to help acquire and stimulate knowledge creation and sharing encountered problems during implementation. The fallacy of knowledge acquisition with reliance on external sources (such as the existing practices addressed by competitors) undermined employees' motivation to explore their own available but untapped knowledge (Bhatt, 2001; Nonaka, 1994). The use of information technology (IT) to drive knowledge storage and sharing, in principle, was acceptable to employees. Yet, the silo organizational structure of HS, with unintegrated databases for knowledge capture, caused more harm than good. Some employees asserted that they did not have the incentive to access or utilize the departmental knowledge handbook and procedural guidance (available from databases), as it was a time-consuming endeavor to dig from the pile of information. Some employees found knowledge incomprehensible as stored using nonstandardized formats, jargons and symbols.

Fifth, although a reward system was established for knowledge creation and/or sharing, the emphasis on extrinsic rewards such as monetary bonuses turned out to have an opposite and negative effect on cultivating the knowledge sharing culture and trust among employees. Some employees commented that the "no free lunch" concept should be applied to the organizational KM program. Therefore, they stated that knowledge should be kept as a personal possession (i.e., not to be shared) until they felt that they would get the monetary reward when shared or recognized by management. Other employees found that harmony and cohesiveness within a team or among colleagues were destabilized as everyone maximized individual benefits at the expense of teamwork and cooperation.

Sixth, there was a misleading notion that IT could be "the" cutting-edge solution to inspire KM in the organization. Despite the introduction of IT tools to facilitate knowledge capture, codification and distribution, it was found that IT adoption and acceptance remained low due to employee preference for person-to-person conversation and knowledge transfer instead of technology-based communication. Another reason is that the widespread low computer literacy causes employee hesitation to use new technology. In addition, given the insufficient support from management for IT training and practices, employees, particularly those who had served HS for a long time, had a strong resistance to new working practices for facilitating KM.

Seventh, it was noted that the KM initiatives were left unattended once implemented. It was difficult to find existing accomplishments or to overcome pitfalls of the KM initiatives, as there was no precise assessment available. For instance, the last survey evaluating the adoption of good practices from departmental knowledge was conducted a year ago, without a follow-up program or review session. A manager recalled that the survey "is the only form I completed about the KM progress … in fact, I do not see how effective KM can be promoted if you do not receive suggestions or comments from the third party." Another example was that the currency and efficacy of the knowledge recorded in departmental handbook appeared obsolete, as there were no update or revision procedures for the handbook.

Last but not least, an undue emphasis and concern with how the "what-best" knowledge at HS could be leveraged for short-term benefits (e.g., to exploit existing knowledge in order to achieve production efficiency) at the expense of the long-term goals (e.g., to revisit and rethink existing knowledge, taken-for-granted practice in order to explore innovation and creativity opportunities). Some employees pointed out that they are inclined to modify existing practices rather to create new approaches in doing the same or similar task, as recognition and positive impacts can be promptly obtained. One manager mused that, "we are usually forced to imitate others' work, particularly those management believe as quality practices; however, the real and innovative ideas would not be reinventing the wheel."

IMPLICATIONS OF THE STUDY

Many organizations try to instill KM into their business agenda and expect to improve organizational performance and profit. Our investigation of this failure has increased our understanding of the challenges and complexity of KM implementations (Choi & Lee, 2003; Gartner, 1999).

Research Implications

This study investigates an unsuccessful experience in implementing KM within a particular organization. Through document analysis and in-depth interviews, the study provides an understanding of KM complexity—a blend of the KM elements and focuses (knowledge categorization, KM enablers, KM framework and KM strategies) that have been addressed separately by multi-disciplinary researchers. The results indicate that each element contributes to KM success or failure, and therefore should be harnessed in an integrative manner. In this regard, future researchers should expand this study to more organizations, industries and KM initiative maturity to identify variations in the KM elements and their interrelationships in influencing organizational performance.

The results also show that a good and sound KM plan is only the beginning of a KM program, while the vital task for management is that of coordinating people and processes for effective implementation. It indicates that the human factor, with employees' perception, motivation and participation towards KM work, is crucial to driving the KM process. In view of the advancement of IT and the expansion of business across different geographical territories, it is deemed appropriate to accommodate different research disciplines to foster KM discourse. Possible lines of inquiry (based upon the information systems field) can be directed to an investigation of knowledge workers in the adoption and deployment of KM systems: How should interdepartmental systems balance between customization and standardization to maintain accuracy and consistency of knowledge and expertise?

Management Implications

In the case of HS, we argue that planning permeated with unrealistic expectation would undermine its efficacy to direct future actions. Therefore, it is suggested that a feasibility assessment of organizational infrastructures (e.g., financial resources, technology level) and organizational climate (e.g., employees' readiness to KM, resistance to change) should first be conducted to define the KM principles and goals. Inspirational aims, which can be reasonably and feasibly accomplished, encourage employees to assess their personal repositories and infuse others' practices to improve existing practices and overcome new challenges.

In addition, employees from HS revealed that vision without management support is in vain and temporary. Therefore, beyond the visionary leadership, management should not downplay its willingness to invest time, energy and resources to promote KM. At its core, management could show its enthusiasm in a boundless and persistent way, including vocal support, speech, inaugural memo and wandering around different business units to invite impulsive idea generation and knowledge creation from all staff levels. Also, management should champion the KM process and lead by example those employees who engage a high receptive attitude towards KM. Furthermore, to stimulate KM behaviors, specifically sharing and creation, it is important to assure a balanced reward system integrating monetary (e.g., bonus) and non-monetary items (e.g., acknowledge excellent performer in creating new work and thoughts through organizational newsletter) that fit in various kinds of motivation.

Last, it is deemed that KM requires continual, collective and cooperative efforts to put various resources together in deployment. It is suggested that management direct an attitudinal change — remove or alleviate employees' negative perception towards KM. For example, the fear and misconception that KM is a means to downsize organizations; or as a heavy workload that requires lots of IT expertise; and behavioral change — requires a supportive working environment where employees can have ample of time to engage in KM endeavor, sharing and creation, a fair and positive culture that everyone is valued and possible to contribute to KM effectiveness is needed. We also advise, in case of unexpected failure or unintended results, that management should address problems positively, such as calling for a break to identify the causes and remedy solutions. Do not quit or look for someone to blame, otherwise mutual trust and commitment for the KM processes will end.

CONCLUSION

To date, KM is considered an integral part of the business agenda. The dynamics of KM, as human-oriented (Brazelton & Gorry 2003; Hansen et al., 1999) and socially constructed processes (Brown & Duguid, 2001), require an appropriate deployment of people, processes and organizational infrastructure. This failure case reflects the challenges that could be encountered and overcome in order to accomplish effective KM implementation. The people factor is recognized as the key to driving KM from initiation to full implementation. KM is a collective and cooperative effort that requires most, if not all, employees in the organization to support it. KM strategy and planning should be organized, relevant and feasible within the organizational context. One's best practice may not be well fitted to others unless evaluation and modifications are made. A balanced hybrid of hard and soft infrastructure (such as team harmony and organizational culture) is needed for success.

This study has the following limitations. First, the current study is based on a single organization from which results may not be generalized to all other situations. Therefore, more organizations with KM initiatives need to be researched to identify the extent and significance of various KM elements. Second, though analysis checklists and iterative rounds of discussions for analyzing the organizational documents are used, there is a possibility of the investigators' subjective judgment being involved during the evaluation. In this sense, future work may involve additional assistants to validate data interpretation.

REFERENCES

Akbar, H. (2003). Knowledge levels and their transformation: Towards the integration of knowledge creation and individual learning. *Journal of Management Studies, 40*(8), 1997-2021.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alvesson, M., Kärreman, D. & Swan, J. (2002). Departures from knowledge and/or management in knowledge management. *Management Communication Quarterly, 16*(2), 282-291.

Amabile, T. (1997). Motivating creativity in organizations: On doing what you love and loving what you do. *California Management Review, 40*(1), 39-58.

Appleyard, M.M., & Kalsow, G.A. (1999). Knowledge diffusion in the semiconductor industry. *Journal of Knowledge Management, 3*(4), 288-295.

APQC. (2000). *What is knowledge management?* Retrieved from www.apqc. org/best/km/whatiskm.htm

April, K.A. (2002). Guidelines for developing a K-strategy. *Journal of Knowledge Management, 6*(5), 445-456.

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), 571-582.

Armbrecht Jr., R.F.M., Chapas, R.B., Chappelow, C.C., Garris, G.F., Friga, P.N., Hartz, C.A., Mcilvaine, M.E., Postle, S.R., & Whitwell, G.E. (2001). Knowledge management in research and development. *Research Technology Management, 44*(4), 28-48.

Bhatt, G.D. (2000). Organization knowledge in the knowledge development cycle. *Journal of Knowledge Management, 4*(1), 15-26.

Bhatt, G.D. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-75.

Bowonder, B. (2000). Technology management: a Knowledge ecology perspective. International *Journal of Technology Management, 19*(7/8), 662-685.

Boyatzis, R.E. (1998). *Transforming qualitative information: Thematic analysis and code development.* Thousand Oaks, CA: Sage.

Brazelton, J., & Gorry, G.A. (2003). Creating a knowledge-sharing community: If you build it, will they come? *Communications of the ACM, 46*(2), 23-25.

Brown, J.S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Brown, R.B. & Woodland, M.J. (1999). Managing knowledge wisely: A case study in organizational behavior. *Journal of Applied Management Studies, 8*(2), 175-198.

Choi, B., & Lee, H. (2001). Justification on knowledge management strategies: A new perspective on knowledge creating process. *Proceedings* *of the Pacific Asia Conference on Information Systems,* 108-122.

Choi, B., & Lee, H. (2003). An empirical investigation of KM styles and their effect on corporate performance. *Information & Management, 40*(5), 403-417.

Davenport, T.H., Long, D.W.D., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

De Vreede, G.J., Davison, R.M., & Briggs, R.O. (2003). How a silver bullet may lose its shine. *Communications of the ACM, 46*(8), 96-101.

Denzin, N.K., & Lincoln, Y.S. (1994). *Handbook of qualitative research.* London: Sage.

Earl, M.J., & Fenny, D.F. (1994). Is your CIO adding value? *Sloan Management Review, 35*(3), 11-20.

Earl, M.J., & Scott, I.A. (1999). What is a Chief Knowledge Officer? *Sloan Management Review, 40*(2), 29-38.

Fischer, G., & Ostwald, J. (2001). Knowledge management: Problems, promises, realities, and challenges. *IEEE Intelligent Systems, 16*(1), 60-72.

Gartner Group Inc. (1999). *Knowledge management from academic concepts to fundamental business practices*. Stamford: InfoEdge Inc.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Holsapple, C.W., & Joshi, K.D. (1999). Description and analysis of existing knowledge management frameworks. *Proceedings of the Thirty-Second Hawaii International Conference on System Sciences,* Maui, Hawaii.

Kim, D.H. (1993). The link between individual and organizational learning. *Sloan Management Review, 35*(1), 37-50.

King, W.R., Marks Jr, P.V., & McCoy, S. (2002). The most important issues in knowledge management. *Communications of the ACM, 45*(9), 93-97.

KPMG Consulting. (2002). *Knowledge management research report 2000.* 1-24.

Lee, J.H., & Kim, Y.G. (2001). A stage model of organizational knowledge management: A latent content analysis. *Expert Systems with Applications, 20*(4), 299-311.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 53-97.

Marwick, A.D. (2001). Knowledge management technology. *IBM Systems Journal, 40*(4), 814-830.

McAdam, R., & Reid, R. (2001). SME and large organization perceptions of knowledge management: comparisons and contrasts. *Journal of Knowledge Management, 5*(3), 231-241.

Nattermann, P.M. (2000). Best practice does not equal to best strategy. *The McKinsey Quarterly, 2*, 22-31.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "Ba": Building a foundation of knowledge creation. *California Management Review, 40*(3), 40-54.

O'Leary, D.E., & Selfridge, P. (2000). Knowledge management for best practices. *Communications of the ACM, 44*(11), 281-292.

Pettigrew, A.M. (1990). Longitudinal field research on change: Theory and practice. *Organizational Science, 1*(3), 267-291.

Roberts, J. (2000). From know-how to show-how? Questioning the role of information and communication technologies in knowledge transfer. *Technology Analysis & Strategic Management, 12*(4), 429-773.

Sher, P.J., & Lee, V.C. (2004). Information technology as a facilitator for enhancing dynamic capabilities through knowledge management. *Information & Management, 41*(8), 933-945.

Shin, M., & Holden, T. (2000). Exploring the dimensions of knowledge flow: A preliminary process model. *Proceedings of the Americas Conference on Information Systems,* (pp. 1343-1348).

Standing, C., & Benson, S. (2000). Organizational culture and knowledge management. *Proceedings of the Fourth Pacific Asia Conference on Information Systems,* (pp. 1103-1113).

Swan, J., & Newell, S. (2000). Linking knowledge management and innovation. *Proceedings of the Eighth European Conference on Information Systems 2000.*

Swan, J., & Scarbrough, H. (2001). Knowledge, purpose and process: Linking knowledge management and innovation. *Proceedings of the Thirty-Fourth Hawaii International Conference on System Science*.

Thomas, J.C., Kellogg, W.A., & Erickson, T. (2001). The knowledge management puzzle: Human and social factors in knowledge management. *IBM Systems Journal, 40*(4), 863-884.

Tuomi, I. (2000). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems, 16*(3), 103-117.

Uit Beijerse, R.P. (1999). Questions in knowledge management: Defining and conceptualizing a phenomenon. *Journal of Knowledge Management, 3*(2), 94-109.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *From managing to enabling knowledge. Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. New York: Oxford University Press.

Yin, R.K. (1994). *Case study research design and methods.* CA: Sage.

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Section 5
Organizational and Social Implications of Knowledge Management

This section includes a wide range of research pertaining to the social and organizational impact of knowledge management technologies around the world. Introductory chapters provide a comprehensive introduction of the modern-day knowledge organization while further research explores the difference in the community approach versus the process approach to knowledge management within two cultural paradigms. Also investigating a concern within the field of knowledge management is research which provides a study of the varying challenges when implementing knowledge management systems. The discussions presented in this section offer research into the integration of technology to allow access for all.

Chapter 5.1
Knowledge Organizations

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INTRODUCTION

An important endeavor within the field of knowledge management (KM) is to better understand the nature of knowledge organizations. These are variously called knowledge-based organizations, knowledge-centric organizations, knowledge-intensive organizations, knowledge-oriented organizations, and so forth. One approach to doing so is to study the characteristics of specific organizations of this type such as Chaparral Steel (Leonard-Barton, 1995), Buckman Labs, World Bank, or HP Consulting (O'Dell, 2003). A complementary approach is to study various frameworks that have been advanced for systematically characterizing the elements, processes, and relationships that are found in knowledge organizations. Here, we examine three such frameworks that are representative of the variety in perspectives that have been advocated for understanding the nature of knowledge organizations. These frameworks share a view that sees knowledge as a key organizational asset that enables action. However, they differ in emphases (e.g., asset vs. action) and constructs.

This article is organized as a systematic review of the three frameworks. The content relies heavily on the original presentations found in the referenced publications. Space limitations do not permit a comparative analysis or synthesis of the frameworks. Nevertheless, taken together, the reviews do offer valuable vantage points for studying knowledge organizations and useful departure points for more detailed consideration of these as well as other frameworks concerned with knowledge organizations.

The Intangible Assets Framework of Knowledge Organizations, as developed by Karl Sveiby (1997), is considered first. It relies on the concept of intangible assets and characterizes companies for whom these assets are important. Second, the Knowledge Management Cycle Framework introduced by Wiig, de Hoog, and van der Spek (1997) emphasizes the cyclical nature and means of managing an organization's knowledge assets. Third, the Knowledge Flow Framework advanced by Newman (2003) emphasizes flows of knowledge assets in the sense of agents performing transformations on knowledge-bearing artifacts.

Each framework description starts with a brief overview of the framework from the perspective of its creator(s). It continues by describing and defining the elements, processes, and relationships of the framework in encyclopedic format. Additional references to related works by other authors also are provided for readers who wish to further explore the framework's perspective. Where pictorial renditions of a framework are available, they are reproduced to visually tie together the concepts.

BACKGROUND

Frameworks are cognitive structures used to organize our thinking about a particular domain of interest. They give us concepts pertaining to the domain and guidance about relationships among those concepts, thereby forming a basic understanding of what is observed in a domain, for formulating new ideas about a domain, and for operating or managing in a domain. As such, KM frameworks are useful to academicians in framing research and building theory, to practitioners in learning about and executing KM, and to educators for organizing and presenting KM. Here, the KM domain of interest involves knowledge organizations.

The notion of organizations that explicitly recognize and cultivate knowledge as a key resource began to gain prominence in the 1980s (Holsapple & Whinston, 1987; Paradice & Courtney, 1989). It was seen as being on a par with the traditional organizational resources of people, materials, and finances. Knowledge was seen as pervading all functional areas of organizational management from strategy to operations, from human resources to technological systems, from economics and accounting to finance and marketing. The processing of an organization's knowledge resources was seen as an important (or even indispensable) aspect of nearly all organizational work. A confluence of forces led to the widespread rise of knowledge organizations in the 1990s, and the accompanying interest in more fully understanding these organizations and their possibilities (Bennet & Bennet, 2003).

Growing out of this interest, various frameworks of the knowledge organization have been advanced by researchers and practitioners. Although we do not exhaustively survey them here, we do review three that represent a diversity of views about an organization's knowledge assets and its use of those assets. Thus, the article serves as an introduction to the realm of knowledge organization frameworks and a foundation for review, comparison, and contrast of perspectives on organizational knowledge assets and their utilization.

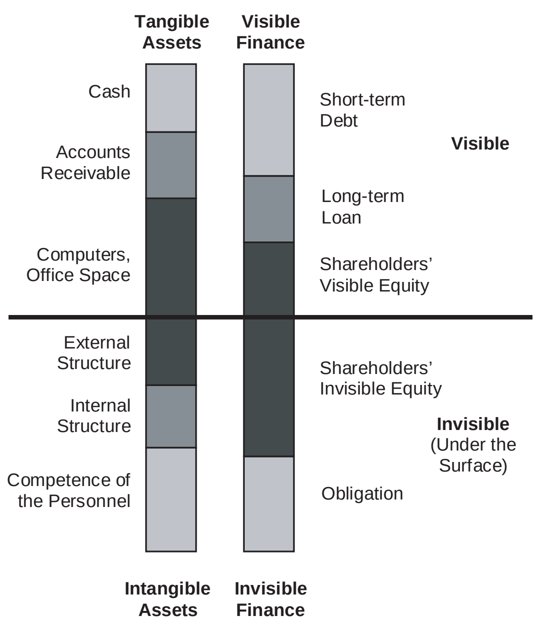
AN INTANGIBLE ASSETS FRAMEWORK OF KNOWLEDGE ORGANIZATIONS

Within the intangible assets (IA) framework, people are the only true agents in business. All assets and structures, whether tangible or intangible, are seen as being the result of human actions. The intangible assets of an organization are those embedded in the competences of its human resources and in its internal and external structures of interactions among these people. Knowledge organizations are those for which the greatest value lies in intangible assets (Sveiby, 1997).

Knowledge and Intangible Assets

The IA framework regards knowledge as being the capacity to take action. It is seen as tacit, action-oriented, supported by rules, and constantly changing (Sveiby, 1997). These assets are invisible in the sense that there is typically no accounting for them. They are intangible in that they are neither brick, nor mortar, nor money. They are comprised of two components: the competences of the organization's personnel and the organizational structures (internal and external) that allow them to interact (Sveiby, 1997). The IA framework does not regard structures as objects, but rather as being constructed in a constant process by people interacting with each other (Weick, 1995). They are not statically visible, but are events that link together. Knowledge management, based on the IA view, is "the art of creating value from intangible assets" (Sveiby, 1997, p. 1).

Figure 1. The balance sheet of a knowledge (Sveiby, 1997)



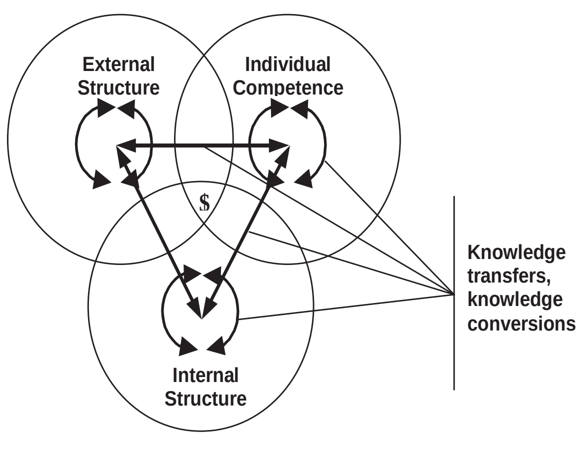
Knowledge Organizations

The IA framework conceives of knowledge organizations as having relatively few tangible assets, and having intangible assets that exceed tangible assets in value. In Figure 1, the dark line separates the visible and tangible from the invisible and intangible. The professional services or business services sector is a close equivalent of knowledge organizations (e.g., DeTore & Balliet-Milholland, 2003). Most employees of these companies are highly qualified and highly educated professionals, that is, they are knowledge workers. Their work consists largely of using their own competencies to produce or transfer knowledge, sometimes with the assistance of suppliers of information or specialized knowledge (Sveiby, 1997).

As indicated in Figure 2, the IA focus in a knowledge organization is on the key concepts of employee competence, internal structure, and external structure. They are defined as follows:

- Individual competence: Employee competence involves the capacity to act in a wide variety of situations to create both tangible

Figure 2. The organization from a knowledge-based organization perspective (Sveiby, 2001)



and intangible assets. Individual competence is comprised of five interdependent elements: (1) explicit knowledge, (2) skill, (3) experience, (4) value judgments, and (5) social network (Sveiby, 1997).

- Internal structure: Internal structure includes patents, concepts, models, and computer and administrative systems. These are created by the employees and are generally owned by the organization. However, they may be acquired elsewhere. In addition, organizational culture is part of the internal structure, as are management, legal structure, manual systems, attitudes, and R&D software (Sveiby, 1997).
- External structure: External structure includes relationships with customers and suppliers. It also encompasses brand names, trademarks, and the company's reputation or image. In the IA framework, to manage the external structure is to manage the flows of knowledge in customer and supplier relationships (Sveiby, 1997).

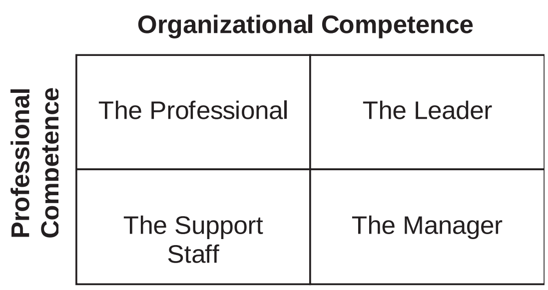
Value is created through knowledge transfers and conversions between and within these three elements. A knowledge organization would not exist if not for their personnel with competences in handling knowledge assets, internal structure that allows them to collaborate, and external structure that allow customers and suppliers to support and enhance their knowledge bases. For a knowledge organization, external structures are based not so much on financial flows as on knowledge flows involving intangible assets.

Personnel Categories in Knowledge Organizations

The IA framework categorizes personnel within a knowledge organization along two dimensions according to levels of professional and organizational competence. This yields the four categories shown in Figure 3, which are defined as follows (Sveiby, 1997, pp. 57-60):

- Support staff: "The support staff assists both the professionals and the managers. They have no special qualifications of their own to give them status in a knowledge organization."
- Professionals: "The most highly skilled professionals—the experts—are the genuine income generators. Experts are characterized by a dedication to their jobs and their professions, a love of solving problems, and a dislike of routine."
- Managers: "Managers are in many ways the opposite of professionals. They are capable of managing and organizing, have learned to work through other people, and enjoy doing so."
- Leaders: Leaders are the people whom others want to follow. They are informally "appointed" by their followers. "Leadership involves two tasks: deciding where the organization should go and persuading others to follow. The most successful leaders of knowledge organizations are usually former experts, but they are rarely the most outstanding experts."

Figure 3. Four personnel categories in knowledge organizations (Sveiby, 1997)



Ensuring suitable quantities, degrees of competence, and interaction structures for these four personnel categories, as well as the appropriateness of the mix among the categories, strongly influence a knowledge organization's performance and viability over time.

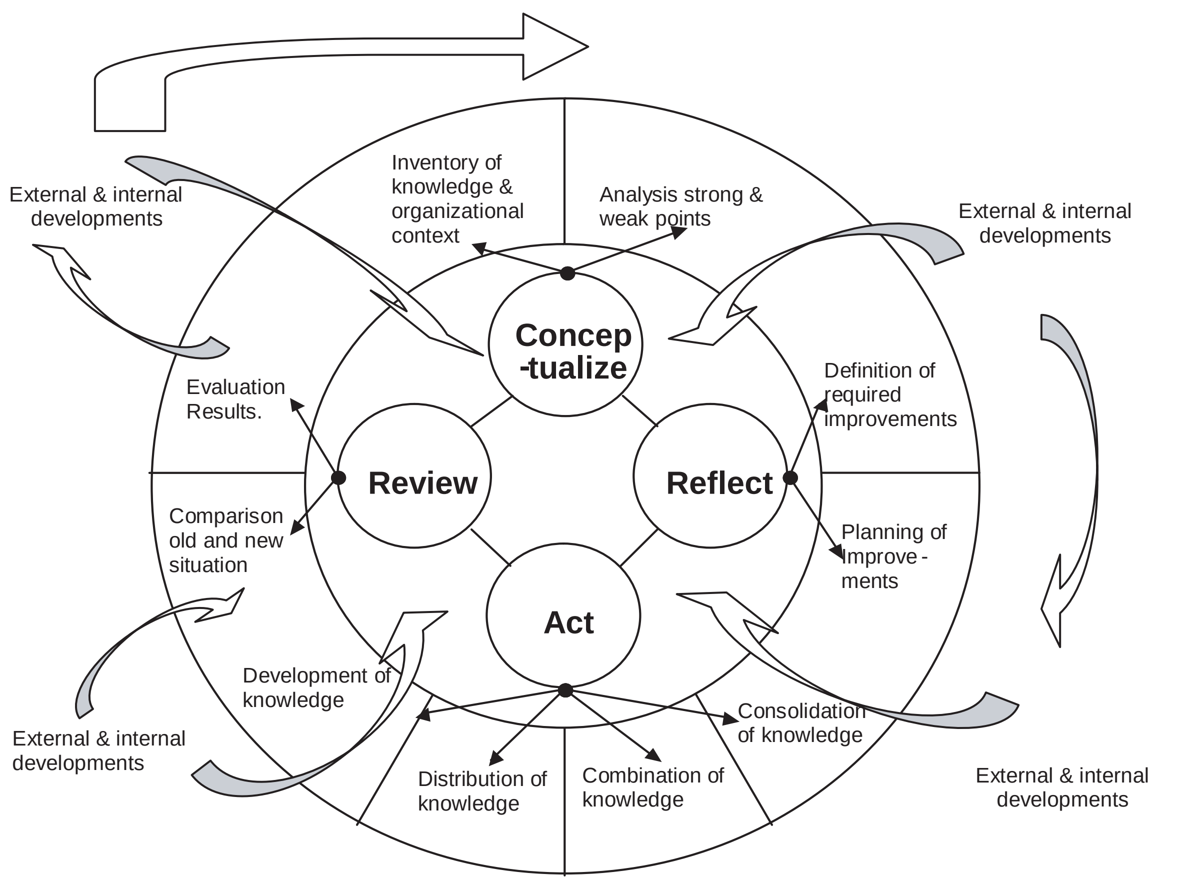
Further Reading

More information on this Intangible Assets Framework of Knowledge Organizations can be found at www.sveiby.com and Sveiby (2001). Related perspectives on the knowledge organization that emphasize intangible assets are found in Stewart (1997), Davenport and Prusak (1998), and Teece (2003).

A KNOWLEDGE MANAGEMENT CYCLE FRAMEWORK

Whereas the IA framework focuses on intangible knowledge assets in people and structures, the Knowledge Management Cycle Framework emphasizes the use of knowledge assets. A knowledge organization is viewed as manifesting a cyclic process of four activities: review, conceptualize, reflect, and act. During the cycle, analysis, plans,

Figure 4. The knowledge management cycle (Wiig, de Hoog, & van der Spek, 1997)



and actions are formulated in terms of four basic operations on knowledge that can be executed in organizations: development, distribution, consolidation, and combination.

Basic Concepts

The Knowledge Management Cycle Framework, illustrated in Figure 4, provides a model for how a knowledge organization's knowledge assets are used. Observe that the cycle proceeds in a clockwise fashion and that it can be impacted by both external and internal influences. The frameworks' specific definitions of terms are given in Figure 4 (Wiig, de Hoog, & van der Spek, 1997).

- Review: In this phase, a knowledge organization monitors and evaluates its performance. Review involves comparing old situations with the new, and evaluating the results of improvement plans relative to original goals and objectives.
- Conceptualize: This part of the cycle involves selecting a knowledge resource in the organization, and analyzing its strong and weak points. This analysis includes developing an understanding of the ways in which knowledge assets are bound to organizational roles participating in business processes.
- Reflect: Reflection is concerned with defining and deciding on knowledge management improvement plans. It includes developing the "optimal" plans for correcting knowledge bottlenecks and analyzing them for risks that accompany their implementation.
- Act: The final phase of the cycle implements plans chosen in the reflect phase. According to the framework, actions entail four basic operations on knowledge assets: development, distribution, consolidation, and combination (Wiig, de Hoog, & van der Spek, 1997).
- Development: Development of knowledge assets is said to occur through purchase, learning programs, and machine-based learning from databases.
- Distribution: Distribution is delivering knowledge assets to the points of action through knowledge-based systems, manuals, and network connections.
- Consolidation: This operation is described as taking steps to prevent an organization's knowledge assets from disappearing. It includes the knowledge-based systems, tutoring programs, and knowledge transfer programs.
- Combination: In this framework, combination refers to finding synergies among and reusing existing knowledge assets.

Within any iteration of the knowledge cycle, the organization takes action based on its knowledge assets. It is through knowledge cycle iterations that an organization's knowledge asset base is enhanced, thereby improving performance and viability of the knowledge organization.

Further Reading

More information about this Knowledge Management Cycle Framework can be found in van der Spek and de Hoog (1995), de Hoog et al. (1999), and van der Spek and Spijkervet (1995). In a related vein, a seven-phase knowledge life cycle has been advanced by APQC and Arthur Anderson: share, create, identify, collect, adapt, organize, apply (O'Dell & Grayson, 1997). Moreover, one portion of the KM ontology deals with specific kinds of manipulations that a knowledge organization can perform on knowledge resources in the context of KM episodes rather than KM cycles (Holsapple & Joshi, 2004).

A KNOWLEDGE FLOW FRAMEWORK

The Knowledge Flow Framework advanced by Newman presents "the foundations for a basic understanding of knowledge flows, agents, artifacts, and transformations critical to any examination of knowledge processing. In doing so, it attempts to bridge the gap between a conceptual understanding of how knowledge contributes to corporate objectives, and the practical issues of knowledge management and knowledge engineering" (Newman, 2003, p. 301). As such, it furnishes a unifying vision for some of the concepts provided by the other two frameworks. This framework focuses on enablers for organizational process tasks, rather than concentrating on knowledge assets or on sequences of knowledge utilization phases. It serves as a basis for analyzing knowledge flows that permeate a knowledge organization.

Knowledge Flows

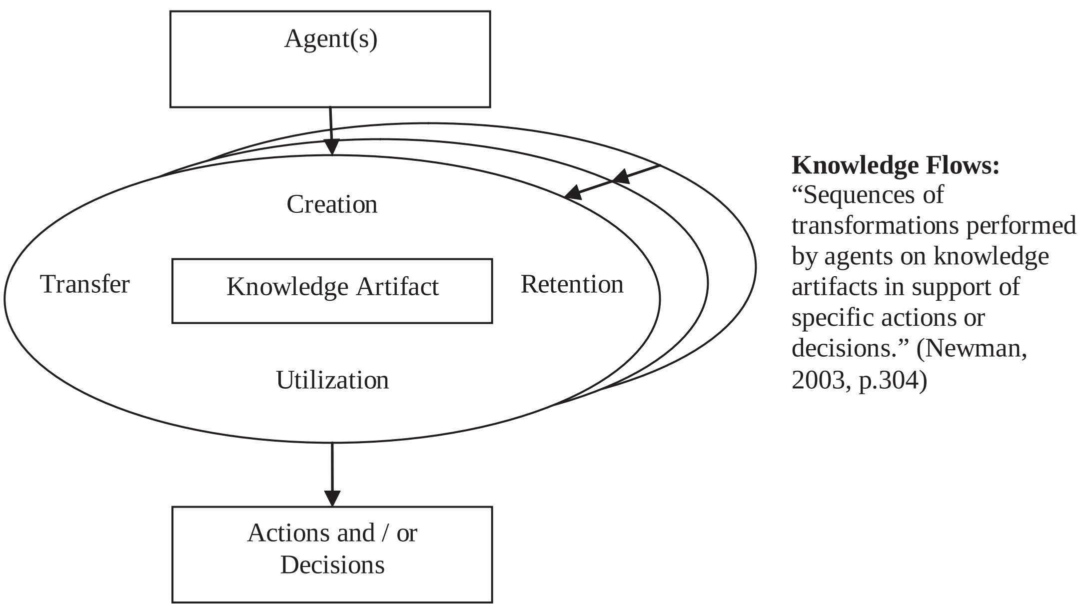
Knowledge flows are "sequences of transformations performed by agents on knowledge artifacts in support of specific actions or decisions" (Newman, 2003, p. 304). As depicted in Figure 5, these include knowledge creation, retention, transfer, and utilization flows.

Agents

Agents are specialized objects or roles played by people, organizations, societies, automata, and so forth. They are the knowledge processors within a knowledge organization and are the active components in knowledge flows (Newman, 2003):

- Individual agents: The framework defines these as being human processors. They sit at the center of every knowledge flow and

Figure 5. Knowledge flows



can deal with tacit artifacts that automated agents cannot.

- Automated agents: Automated agents are non-human processors. They are "any human construct that is capable of retaining, transferring, or transforming knowledge artifacts. They are not exclusively computers, e.g. a camera.…They can perform many types of transformations on explicit artifacts much faster and with a greater degree of repeatability than can individual agents" (Newman, 2003, pp. 308-309).
- Collective agents: Newman (2003) defines these as specific collection of individual and automated agents. They are not necessarily homogeneous and may exhibit characteristics unexhibitable by any single agent. They may possess "group"-level tacit knowledge and may retain knowledge beyond the life of any individual or automated agent.

Knowledge Artifacts

In this framework, knowledge artifacts are "documents, memories, norms, values, and other things that represent the inputs to, and outputs of, the knowledge-enabled activities of agents" (Newman, 2003, p. 303). Essentially, this framework uses the term "artifact" to refer to a representation that is usable for one or more agents in their knowledge work. This notion is consistent with Newell's (1982) conception of knowledge as that which is conveyed by representations that are usable to some processor (i.e., that give that processor the ability to take action).

The phrase "knowledge artifact" refers simultaneously to two kinds of representation: cognitive knowledge artifacts and physical knowledge artifacts. The former deal with mental and behavioral representations. The latter are more concerned with symbolic, audio, video, and digital representations.

- Cognitive knowledge artifact: This refers to awareness and understanding of a particular aspect of our real or metaphysical world. It is commonly referred to simply as knowledge (Newman, 2003).
- Physical knowledge artifact: This is a "representation of the associated cognitive knowledge artifact" (Newman, 2003, p. 305).

Along another dimension, the Knowledge Flow Framework partitions knowledge artifacts into three classes, depending on the extent to which the representation is capable of codification and transfer among agents:

- Explicit knowledge artifacts: These have been codified in a way that makes it possible to touch, see, hear, feel, and/or manipulate them. They can be readily transferred from one person to another (Newman, 2003).
- Implicit knowledge artifacts: These are artifacts whose meanings are not explicitly captured, but can be inferred (Newman, 2003).
- Tacit knowledge artifacts: These defy expression and codification. They may be more prevalent and influential than either explicit or implicit artifacts (Newman, 2003).

TRANSFORMATIONS

Transformations are the behaviors that agents perform on artifacts. The Knowledge Flow Framework organizes transformations into four general categories: knowledge creation, knowledge retention, knowledge transfer, and knowledge utilitzation. Newman (2003) defines them as follows:

- Knowledge creation: In this framework, "creation" refers to all behaviors through which new knowledge enters a knowledge-based system. It can occur internally through knowledge generation or from external sources via acquisition. It includes such activities as knowledge development, discovery, capture, and elicitation.

- Knowledge retention: This refers to an organization's storage, maintenance, and retrieval of previously created knowledge.
- Knowledge transfer: This kind of transformation refers to all behaviors through which agents share knowledge and knowledge artifacts. Knowledge transfer includes, but is not limited to, communication, translation, conversion, filtering, and rendering.
- Knowledge utilization: Finally, there are transformations in which agents use knowledge to further the goals and aims of the organization. All such behaviors are directly concerned with applying knowledge to enable decisions and actions. A "knowledge utilization event" is a specific decision or action enabled by the knowledge flow.

FURTHER READING

More information about the Knowledge Flow Framework can be found in Newman (1996, 2000). This framework's constructs are largely consistent with the KM ontology (Holsapple & Joshi, 2004). For instance, a knowledge utilization event is what the KM ontology recognizes as a particular kind of KM episode, knowledge artifacts are knowledge representations in KM ontology parlance, agents are what the KM ontology calls knowledge processors, and transformations map into the KM ontology's knowledge manipulations.

FUTURE TRENDS

Future efforts at better understanding knowledge organizations will proceed at both micro and macro levels. At the micro level, researchers will study the nature of knowledge work done by an organization's agents (Schultze, 2003). At the macro level, efforts will continue in the direction of devising increasingly complete and unified frameworks for characterizing knowledge organizations. It is likely that some of these efforts will integrate notions of knowledge assets, knowledge processing cycles, and knowledge flows with concepts from business process management (Smith & Fingar, 2002) and social networking (Brass, 1992).

In a prescriptive vein, frameworks of the knowledge organization will be applied to devise specific strategies or prescriptions for how knowledge organizations can enhance performance (Sveiby, 2001). Normative frameworks of knowledge organizations will be devised suggesting what the nature of these organizations should be, rather than describing what is or has been. For instance, knowledge organizations will be seen as intelligent complex adaptive systems (Bennet & Bennet, 2004) and as value networks (Allee, 2003)

CONCLUSION

The frameworks presented here are sampling of efforts made to describe elements and relationships that exist in knowledge organizations. The coverage is more suggestive than exhaustive. Frameworks of knowledge organizations will continue to appear and evolve, symptomatic of the rich and varied nature of these organizations. At some point the diverse frameworks may converge. However, for the present, creative tension still exists in the differing perspectives and, as Sveiby says so eloquently, (Lelic, 2002, p. 1):

The conceptual framework of knowledge management is unusual in its ambiguity, extraordinary in its depth, unfathomable in its rapid expansion, *and—best of all—has no single trademark or copyright owner.*

The frameworks represent a spectrum of current points of view about the nature knowledge organizations and are useful to those pursuing the study and execution of knowledge management. The diversity presented gives even the experienced knowledge manager or academician reason to pause and consider varying perspectives on this topic. For the novice, it presents an approachable and important introduction to the domain of knowledge organizations.

REFERENCES

Allee, V. (2003). *The future of knowledge: Increasing prosperity through value networks.* Amsterdam: Butterworth-Heinemann.

Bennet, A., & Bennet, D. (2004). *Organizational survival in the new world.* Amsterdam: Butterworth-Heinemann.

Bennet, A., & Bennet D. (2003). The rise of the knowledge organization. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 1: Knowledge matters* (pp. 5-20). Berlin: Springer-Verlag.

Brass, D.J. (1992). Power in organizations: A social network perspective. In G. Moore & J.A. Whitt (Eds.), *Research in politics and society* (pp. 295-323). Greenwich, CT: JAI Press.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge : How organizations manage what they know.* Boston: Harvard Business School Press.

de Hoog, R., et al. (1999). Investigating a theoretical framework for knowledge management. In J. Leibowitz (Ed.), *Knowledge management handbook* (pp. 1-18). Boca Raton, FL: CRC Press.

DeTore, A., & Balliet-Milholland, J. (2003). Transforming theory into fact: Hands-on knowledge management initiatives built on a reinsurer's pile of junk. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 2: Knowledge direction*s (pp. 533-548). Berlin: Springer-Verlag.

Holsapple, C.W., & Joshi, K. (2004). A formal knowledge management ontology: Conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Holsapple, C.W., & Whinston, A.B. (1986). Knowledge-based organizatio*ns. The Information Society, 5*(2), 77-90.

Lelic, S. (2002). The knowledge: Karl-Erik Sveiby. *Knowledge Management Magazine, 6*(1), 1.

Leonard-Barton, D. (1995). *Wellsprings of knowledge.* Boston: Harvard Business School Press.

Newell, A. (1982). The knowledge level. *Artificial Intelligence, 18*(1), 87-127.

Newman, B.D. (1996). *Knowledge management vs. knowledge engineering: The knowledge management theory papers.* Retrieved from www.km-forum.org#http://www.km-forum.org#

Newman, B.D. (2003). Agents, artifacts, and transformations: The foundations of knowledge flows. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 1: Knowledge matters* (pp. 301-316). Berlin: Springer-Verlag.

Newman, B.D., & Conrad, K. (2000). A framework for characterizing knowledge management methods, practices, and technologies. *Data Administration Newsletter (TDAN.COM).* (12)

O'Dell, C. & Grayson, C.J. (1997). *Identifying and transferring internal best practices.* Houston, TX: APQC.

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations.* New York: Doubleday/Currency.

O'Dell, C., et al. (2003). Successful KM implementations: A study of best practice organizations. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 2: Knowledge directions* (pp. 411-442). Berlin: Springer-Verlag.

Paradice, D. & Courtney, J. (1989). Organizational knowledge management. *Information Resource Management Journal, 2*(3), 1-13.

Schultze, U. (2003). On knowledge work. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 1: Knowledge matters* (pp. 43-58). Berlin: Springer-Verlag.

Smith, H., & Fingar, P. (2002). *Business process management.* Tampa, FL: Megan-Kiffer Press.

Sveiby, K.E. (1996, 2001). *What is knowledge management?* Retrieved July 16, 2003, from www.sveiby.com/articles/KnowledgeManagement.html

Sveiby, K.E. (1997). *The new organizational wealth: Managing & measuring knowledge-based assets.* San Francisco: Berrett-Koehler Publishers, Inc.

Sveiby, K.E. (2001). A knowledge-based theory of the firm to guide strategy formulation. *Journal of Intellectual Capital, 2*(4), 1-16.

Teece, D. (2003). Knowledge and competence as strategic assets. In Clyde W. Holsapple (Ed.), *Handbook on knowledge management 1: Knowledge matters* (pp. 129-152). Berlin: Springer-Verlag.

van der Spek, R., & de Hoog, R. (1995). A framework for knowledge management methodology. In Karl M. Wiig (Ed.), *Knowledge management methods: Practical approaches to managing knowledge* (pp. 379-393). Arlington, TX: Schema Press.

van der Spek, R., & Spijkervet, A. (1995). *Knowledge management: Dealing intelligently with knowledge.* Utrecht, The Netherlands: Kenniscentrum CIBIT.

Weick, K.E. (1995). *Sensemaking in organizations.* Thousand Oaks, CA: Sage Publication.

Wiig, K.M., de Hoog, R., & van der Spek, R. (1997). Supporting knowledge management: A selection of methods and techniques. *Expert Systems with Applications, 13*(1), 15-27.

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Chapter 5.2
Intellectual Capital

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INTRODUCTION

Today's economy is characterized by a rapid rate of change, globalization, and knowledge-intensive products. This makes knowledge management (KM) vital to organizations. The resource-based view of the firm postulates that a firm's profitability is not only a function of its market and competitive position but also a function of its internal capabilities and know-how in combining its resources to deliver products and services and to enhance organizational performance (Alavi, 2000).

The goal of an effective KM strategy should be to enhance the creation, transfer, and utilization of all types of organizational knowledge (Alavi, 2000). Corporations not only realize that knowledge is the critical resource but also try to manage organizational knowledge more intensely and effectively. For example, Stewart (1997) defined intellectual capital (IC) as the intellectual material—knowledge, information, intellectual property, and experience—that can be put to use for creating wealth.

Several researchers (Bontis, 1996, 2001, 2002a, 2002b; Van Buren, 1999; Mykytyn, Bordoloi, Mckinney, & Bandyopadhyay, 2002; Pike, Rylander, & Roos, 2002) identified the importance of intellectual capital (IC) with Bontis (2002a) indicating that human capital is a major component of IC. Human capital, as well as other components of IC (e.g., innovation capital) is an integral part of knowledge in KM research (Bontis, 2001, 2002a, 2002b; Van Buren, 1999; Pike et al., 2002).

Finally, it does the organization little good if effective KM does not lead to success. This success can be defined as how well an organization engages in KM to innovate and reduce uncertainty. Ultimately, an organization should hope to achieve a competitive advantage.

While there is no clear division between KM and IC, there is an intuitive link between them. Numerous researchers have investigated knowledge components, KM issues, and success achievement in organizations. However, none has included IC components into an integrated research framework. This article presents such a framework.

BACKGROUND

According to Barney (2002), firm resources are "all assets, capabilities, competencies, organizational processes, firm attributes, information, and knowledge that are controlled by a firm" (p. 155). These resources enable the firm to implement strategies that increase its effectiveness and efficiency. Most importantly, the resource-based view of the firm focuses the idiosyncratic, costly to duplicate resources that may give the firm a competitive advantage, such as highly skilled and creative workers, effective managers, and institutional leaders. Barney (2002) further defines these too-costly-to-copy resources as "resource immobility."

Dierickx and Cool (1989) point out that firm resources can be divided into tradable (i.e., unskilled labor, raw materials, and common intellectual property) and nontradable (i.e., firm-specific skills/capabilities, quality reputations, partners royalty, R&D capability, brand loyalty, and customer trust). Whereas tradable resources are mobile and can be acquired easily, the nontradable resources are immobile and must be developed, accumulated, and maintained through time (Hunt, 2000).

"Immobility" in this article differs slightly from Barney's definition. The argument is established by the "how" and "what" to produce those too-costly-to-copy resources. For example, a top management of Toyota can move to Ford but cannot perform at the same scale as in Toyota because of different organizational capabilities, structures, dynamics, processes, and culture. The immobile resources are those that cannot be physically moved from one firm to the others regardless of whether they are copied or stolen. This article attempts to distinguish between mobile and immobile assets, and perhaps establish the argument on increasing the value of mobile assets by the facilitation of immobile assets.

In the spirit of Barney (1991, 1997, 2002), a firm's resources were defined as "capitals." As such, the firm's resources can be divided into financial capital, physical capital, human capital, and organizational capital (Barney, 1991, 1997, 2002). Financial capital includes all money resources. Physical capital is physical technology in a firm. Human capital refers to the training, experience, judgment, intelligence, relationships, and insight of individuals. Organizational capital includes a firm's formal reporting structure; formal and informal planning, controlling, and coordinating systems; its culture and reputation, and its informal relations among groups within firm, between firms and those in its environment (Barney, 2002, p. 156).

Bontis (2002a) defined similar concepts, referring to them as human capital, structure capital, and customer capital. Van Buren (1999), however, replaces Stewart's "structure capital" with two new measures: innovation capital and process capital. Innovation capital is the capability of an organization to innovate and to create new products and services, and process capital represents an organization's processes, techniques, systems, and tools.

Among three definitions of IC, Stewart (1997), Van Buren (1999), and Bontis (2002) all include human capital. Customer capital is the relationship between firms and their customers. Pike et al. (2002) referred to customer capital as relational capital; however, customer capital and relational capital are defined similarly. Structure/process capital by Bontis (2002), innovation/process capital by Van Buren (1999), or organizational capital by Pike et al. (2002) are the most controversial components of IC. Those definitions are titled differently, but they are overlapped in terms of the categories of IC.

Quite controversially, the evaluation of IC also inherits split directions. One direction includes accounting cost base and financial value base. The conventional accounting-based evaluation adjusts its traditional instruments, such as historical transactions, and balanced scorecards (Norton & Kaplan, 1996). These accounting indices were criticized as "lagging measures" (Pike et al., 2002) because they are "cost-based." Acting as a supplemental evaluation to cost-based calculation, the financial value-based approach utilizes net present value to estimate a company's IC with a market value. However, it still demonstrates problems of homogeneity, nonfinancial benefits, and forecasting (Lewis & Lippitt, 1999).

Tobin's q gains its prevalence as an indicator of a firm's intangible value (Hall, 1993; Megna & Klock, 1993). It is a ratio of the capital market value of a firm to its replacement value of its assets. These assets incorporate a market measure of a firm value that is forward-looking, risk-adjusted, and less susceptible to changes in accounting practice (Montgomery & Wernerfelt, 1988). Tobin's q can be as high as 7.00 where intellectual capital is resourceful, such as software industry, whereas q is as low as 1.00 where firms have large capital assets (i.e., steel industry) (Bontis, 2002b).

Other than accounting and financial evaluations, a business-based model is assessed by relative effectiveness of different approaches. Four criteria were established by KnowNet Group (EU/ESPRIT, 2000): (1) it is auditable and reliable; (2) it does not impose a large overhead; (3) it facilitates strategic and tactical management; and (4) it generates the information needed by stakeholders in a firm. Incorporating those criteria of a business-based model into Gold's process capabilities becomes our conceptual model.

Knowledge content can be mobile, which is a characteristic of human capital and innovation capital. KM processes and structures can be immobile, and that is structure capital and KM processes capabilities. This article takes an inward look at an organization's KM processes capabilities that specifically include IC. Of particular interest is a firm's effectiveness captured from mobile and immobile assets, that is, IC, through KM processes capabilities and structure capital.

KM Processes Capabilities

In addition to knowledge capital, integral to KM are processes associated with KM, referred to by Gold, Malhotra, and Segars (2001) as organizational capabilities. Gold et al. (2001) studied KM in an organizational capability perspective, and knowledge processes are perceived as an enabler of the organization to capture, reconcile, and transfer knowledge in an efficient manner. Knowledge processes are acquisition-oriented, conversion-oriented, application-oriented, and security-oriented.

Their descriptions of processes are as follows: (1) The acquisition process includes accumulating knowledge, seeking brand new knowledge, and creating new knowledge out of existing knowledge; (2) the conversion process detects the ability to make knowledge useful; (3) the application process offers effective storage and retrieval mechanisms and enables the organization to quickly access the knowledge depository; (4) the protection process is designed to protect the knowledge within an organization from illegal or inappropriate use or theft.

Intellectual Capital (IC)

- Human Capital: Bontis (2001) defined human capital as the combination of knowledge, skill, innovativeness, and ability of a company's individual employees to meet the task. Based on Nonoka (2002), knowledge is created and organized by the very flow of information, anchored on the commitment and beliefs of its holder. Human capital refers to the tacit knowledge embedded in the minds of employees. Ulrich (1998) proposed a measurable definition of human capital which is the product of "competence" and "commitment."

Competence is defined with two aspects: (1) competencies must align with business strategy; (2) competencies need to be generated through more than one mechanism, such as buy, build, borrow, bounce, and bind (Ulrich, 1998). Commitment reflects in how employees relate to each other and feel about a firm (Ulrich, 1998). To foster commitment, Ulrich (1998) indicated three ways: (1) reduce demands, (2) increase resources, and (3) turn demands into resources.

- Structural Capital: Bontis (2002a) defined structure capital as the organizational routines and processes that contain the nonhuman storehouses of knowledge. Two components are included in structural capital: a technological component and architectural competencies (Bontis, 2002a). The technological component can be defined as the local abilities and knowledge that are important to day-to-day operation, such as tacit knowledge, proprietary design rules, and unique modes of working together (Bontis, 2002a). The architectural competencies refer to the ability of the firm to integrate its component competencies together in new and flexible ways and to develop new competencies as they are required, for example, communication channels, information filters, and problem-solving strategies that develop between groups, control systems, cultural values, and idiosyncratic search routines (Bontis, 2002a).
- Innovation Capital: Innovation capital stands out from all other IC research in that it separates structure/process capital from the companies' capabilities to innovate (Van Buren, 1999). A successful innovation occurs in a cycle, according to Clark (1961). It is developed, profitably utilized, and ultimately loses its value as a source of "rents." An innovation loses its value to produce rents when it is replaced by a latter invention or when it is diffused among rivals. In this article, both objective and subjective measures are accounted for in the intellectual property construct. The objective measure is aligned with Aylen's (2001) audit system of intellectual property, and it includes counts of patents and R&D expenditures (Mykytyn et al., 2002).

The subjective measure includes three dimensions suggested by Teece (1998) for capturing value from intellectual property: (1) appropriability is a function both of the ease of replication and the efficacy of intellectual property rights as a barrier to imitation; (2) markets for know-how are the killer sources to entitle a competitive advantage for intellectual properties, however, they become financial assets when they are traded on the market for monetary rewards; (3) dynamic capabilities are the abilities to sense and to seize new opportunities, and to reconfigure and protect knowledge assets, competencies, and complementary assets and technologies to achieve sustainable competitive advantage.

MAIN FOCUS OF THE ARTICLE

Our article discusses these important KM components in an integrated fashion. The components are addressed below.

Knowledge Process Capabilities and Organizational Effectiveness

Combining or integrating organizational knowledge reduces redundancy, enhances consistency, and improves efficiency by eliminating excess information (Davenport & De Long, 1998). Gold et al. (2001) utilized organizational effectiveness to evaluate the value-added aspect of the organizational resources. Three concepts are used to evaluate organizational effectiveness: improved ability to innovate, improved coordination of efforts, and reduced redundancy of information/knowledge (Gold et al., 2001). Gold et al.'s (2001) results suggested that knowledge infrastructure along with knowledge processes are essential organizational capabilities for effectiveness. Knowledge infrastructure consists of culture, structure, and technology that can be explained by structure capital (Bontis, 2002a, 2002b).

The Mediation of Knowledge Process Capabilities

- Human Capital and Organizational Effectiveness: As the service economy grows, the importance of human capital increases (Ulrich, 1998). An experienced, intelligent workforce can marshal the knowledge needed for an information/service economy. Based on research by Davenport and De Long (1998) involving 31 KM projects, it was found that a KM initiative demonstrated some commitment of human capital resources. Ulrich (1998), too, felt that human capital must include an individual's commitment in addition to competence.

An important element of knowledge creation is the focus on the active, subjective nature of knowledge represented by such terms as "belief" and "commitment" that are deeply rooted in the value systems of individuals (Nonaka, 2002). A human capital index created by Ulrich (1998) may predict other positive outcomes, such as customer loyalty, productivity, and profitability. Bontis (2002b) did not support the relationship between human capital and organizational effectiveness.

The KM processes capabilities are not only embedded in a KM system but also require knowledge workers' inputs and competencies to maneuver around the organizational routines, processes, and functionalities. Human capital is hypothesized to have a positive effect on organizational effectiveness as mediated by KM process capabilities.

- Innovation Capital and Organizational Effectiveness: The innovation-oriented approach focuses on explicit knowledge that will eventually facilitate organizational learning. The learned organization will then have better capabilities to innovate and compete. The explicit knowledge can be a database, intellectual property, business designs, business process techniques, or patterns. Technology held proprietary through patents, copyrights, or trade secrets can deter new entrants and achieve a competitive advantage by exploiting economies of scale and scope or through differentiation (Bharadwaj, Varadarajan, & Fahy, 1993). As a major component of innovation capital, intellectual property can be managed as explicit knowledge or act as repositories in a KM system or a database that can be retrieved and reused repeatedly.

The systematic structure of a KM system made intellectual property more accessible and usable. The emphasis on the development and exploitation of knowledge shifts attention from cost minimization to value maximization (Teece, 1998). Aylen (2001) suggested five steps to establish intellectual property capital: conduct an intellectual property audit, incubate new ideas, reduce the ideas to practical form, protect the idea, and exploit the idea. Aylen (2001) also recommended patent databases as a knowledge bank to track the costs and delay associated with the state of a particular product or process.

Besides intellectual property, research and development exspenditure are included in innovation capital that is further defined by appropriateness, markets for know-how, and dynamic capabilities (Teece, 1988). According to Lynn (1998), a significant component of initial management of intellectual assets at Dow Chemical has been its review of patent maintenance within R&D to create objective, major cost savings for the firm.

One famous e-commerce case involving a patent infringement action is Amazon.com vs. Barnesandnoble.com. This case is about Amazon's patented "1-click ordering system." In December 1999, Amazon won a preliminary injunction against Barnesandnoble.com prohibiting anyone else from employing the "1-click ordering system" (Mykytyn & Mykytyn, 2002). Now Amazon enjoys the increasing rent revenue by leasing the patent "1-click ordering system" to its competitors.

In another patent case involving a deeper understanding of patent application, VisorSoft's newly updated "face-recognition software" was copycatted (Maxwell, 2002) before it went on the market. This software is used in highly secured workplaces, such as airports and banks, that need an accurate identification. It can compare a stored face-print with a person's live image and determine if they were the same. The competitor's software operated exactly like VisorSoft's but was marketed differently. The "continuation patent" known as a "child patent" kept VisorSoft's patent infringement against the competitor, and its argument of being a different process as VisorSoft's was disapproved (Maxwell, 2002). VisorSoft can now recoup its development costs and realize licensing fee from users.

An innovative product goes through creation, conversion, and application processes to present it in the market. It also needs a thorough "protection" process to keep an innovation proprietary. Organizational effectiveness can be defined as a firm's attempts to control and reduce production and marketing costs (Dickson, 1992). Cost-cutting innovations are particularly attractive because their effects are more predictable than other innovations (Dickson, 1992). Innovation capital as evidenced by the accumulation of explicit knowledge is assumed to increase the organizational effectiveness with the facilitation of knowledge process capabilities.

The Mediation of Structure Capital

The essence of structure capital is the knowledge embedded within the routines of an organization (Bontis, 2002a). Also, Bontis' structure capital combined with Van Buren's (1999) process capital echoes knowledge infrastructure in Gold et al. (2001) that involves organizational structure, culture, and technology. Structure capital includes a technological component and architectural competencies (Bontis, 2002a).

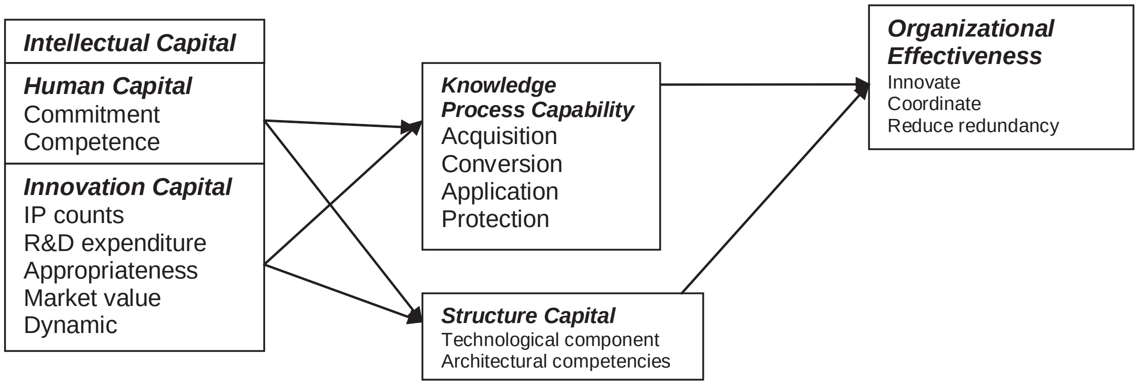
Bontis (2002b) found that human capital was not a significant path to a firm's performance, but that structure capital was. On the other hand, when structure capital was analyzed as a mediator, it facilitated human capital in relation to a firm's performance. It showed a valid path from human capital to structure capital, then to a firm's performance.

Bontis' (2002b) study established a relationship between human capital, structure capital, and a firm's performance in a student sample. This article further extends the rationale from structure capital to innovation capital, and attempts to offer some insights. The innovation capital is in response to the rapidly changing environment, and it leads to a constant learning environment for an organization. The constant learning processes are deeply rooted in formalization and routines of an organization, and, in turn, an organization becomes more innovative to compete.

FUTURE TRENDS

Breaking down these streams of ideas, this article tends to utilize four concepts to link to organizational effectiveness. Knowledge process capabilities and structure capital may be direct links to organizational effectiveness, or they may serve a mediating function between human/innovation capital and organizational effectiveness. The conceptual model underlying this article is shown in Figure 1.

Figure 1. Conceptual model



From the emergent research agenda, this article attempts to examine if there is a division or a link between IC and KM processes. If there is a division, this study attempts to examine the difference between IC and KM. If there is a link, what effect does one have on the other? This study intends to delineate the "mobile" and "immobile" parts of IC. Human and innovation capitals are content that belong to "mobile" category. On the other hand, KM process capabilities and structural capital are structure and/or process that are "immobile."

Alavi and Leidner (2001) drew some different perspectives on knowledge. They indicated knowledge could be data and information, state of mind, object, process, access to information, and capability. Different views of knowledge lead to different KM, and different knowledge management systems (KMS) are built upon different perceptions of KM. "The view of knowledge as capability suggests a knowledge management perspective centered on building core competencies, understanding the strategic advantage know-how, and creating intellectual capital" (Alavi & Leidner, 2001, p. 110). Most KM research focused on knowledge processes, organization structure, or technology utilization, but not knowledge content per se. On the other hand, IC researchers (Bontis, 1996, 2001, 2002a, 2002b; Van Buren, 1999; Pike et al., 2001) included KM in their studies, however, without a clear distinction from KM or definition of IC.

Finally, structure capital was incorporated to emphasize the importance of how to process knowledge, once it is defined. This study enhances the "understanding of know-how" with an organization's "state of mind" in creating intellectual capital. The organization structure becomes alive when information is actively processed in the minds of individuals through a process of reflection, enlightenment, or learning (Alavi & Leidner, 2001). Beyond organization structure, structure capital refers to the "immobile" organization capability that is also hard to imitate.

Many IC researchers have classified many different categories and/or properties to define IC (Bontis, 1996, 2001, 2002a, 2002b; Van Buren, 1999; Pike et al., 2001; Roos, Roos, Dragonetti, & Edvinsson, 1997; Brooking, 1996). Pike et al. (2002) stated, "There has been a steady convergence" (p. 658) in categorizing an IC model. They concluded a convergent IC model that combined elements created value for an individual company. Those elements include: (1) human capital is represented as attributes of the people (i.e., skill, creativity); (2) organizational capital refers to company-owned items (i.e., systems, intellectual properties); (3) relational capital is external relations with customers, suppliers, and partners.

Focusing on internal resources and a resource-based view with an intention, this article demonstrates an inward examination to a firm. Too, as an extended "immobile" concept, this article attempts to investigate the unique "innovation" capital that may be a valid property ignored by most IC researchers but Van Buren (1999). The focus of IC here is organizational flexibility and immobility that may contribute to organizational process capabilities that comply to any emergent competition a firm may encounter in a marketplace.

Additions to this article are the areas of risk and uncertainty, leading edcoordination, and co-competition among increasing numbers of external members, that is, networks of firms, networks of supply chains, make relational capital unpredictable yet vulnerable.

CONCLUSION

This article attempts to delineate KM and IC and more clearly provide definitions that were neglected by either KM researchers or IC researchers. The integration of KM and IC is another goal for this article. Combining the resource-based view and the more recent concept of emergent KM processes, we anticipate introducing innovation capital that consists of intellectual property and other properties. Following Van Buren's (1999) innovation concept, this article focuses more on emergent KM processes rather than static knowledge conversion. Following Ulrich's (1998) human capital index, this article moves forward to more dynamic rather than static working relationships within the firm. Further, we attempt to establish Barney's (1991, 1997, 2002) concepts of "mobile" vs. "immobile" in both KM and IC environment. Finally, this article tries to fill the gaps between the KM and IC research and move forward to an integral explanation to those fields.

REFERENCES

Alavi, M. (2000). Managing organizational knowledge. In R.W. Zmud (Ed.) *Framing the domains of IT management projecting the future…through the past* (pp. 15-28). Cincinnati, OH: Pinnaflex Education Resources, Inc.

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25,* 107-136.

Aylen, D. (2001). Knowledge management: harnessing the power of intellectual property. *Ivey Business Journal, 65.*

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17,* 99-120.

Barney, J. (1997). *Gaining and sustaining competitive advantage.* Reading, MA: Addison-Wesley.

Barney, J. (2002). *Gaining and sustaining competitive advantage.* Upper Saddle River, NJ: Prentice Hall.

Bharadwaj, S.G., Varadarajan, P.R., & Fahy, J. (1993). Sustainable competitive advantage in service industries: A conceptual model and research propositions. *Journal of Marketing, 57,* 83-99.

Bontis, N. (1996). There's a price on your head: Managing intellectual capital strategically. *Business Quarterly, 43.*

Bontis, N. (2001). Assessing knowledge assets: A review of the models used to measure intellectual capital. *International Journal of Management Reviews, 3,* 41-61.

Bontis, N. (2002a). Intellectual capital: An exploratory study that develops measures and models. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge*. New York: Oxford University Press.

Bontis, N. (2002b). Managing organizational knowledge by diagnosing intellectual capital: Framing and advancing the state of the field. In C.W. Choo, N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge*. New York: Oxford University Press.

Brooking, A. (1996). *Intellectual capital*. New York: International Thomson Business Press.

Clark, J.M. (1961). *Competition as a dynamic process*. Washington, DC: Brookings Institution.

Davenport, T.H., & De Long, D.W. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Dickson, P.R. (1992). Toward a general theory of competitive rationality. *Journal of Marketing, 56*, 69-83.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science, 35*, 1504-1511.

EU/ESPRIT (2000). *Knownet: Knowledge management with Intranet technologies*. Project EP28928. Retrieved from www.know-net.org/

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18,* 185-215.

Hall, B.H. (1993). The stock market's valuation of R&D investment during the 1980s. *AEA Papers and Proceedings, 70*, 259-264.

Hunt, S. (2000). *A general theory of competition: Resources, competences, productivity, economic growth*. UK: Sage.

Lewis, E., & Lippitt, J. (1999). Valuing intellectual assets. *Journal of Legal Economics, 9*, 31-48.

Lynn, L.E. (1998). The management of intellectual capital: the issues and the practice. Management accounting issues paper 16, *Management Accounting Practices Handbook*. Hamilton, Ontario: Society of Management Accountants of Canada.

Maxwell, R. (2002). Smart patents; Is your intellectual capital at risk? *Forthought,* April, 2-3.

Megna, P., & Klock, K. (1993). The impact of intangible capital on Tobin's q in the semiconductor industry. *AEA Proceedings Paper, 83*, 265-269.

Montgomery, C., & Wernerfelt, B. (1988). Diversification, *Ricardian rents and Tobin's q. Rand J. of Economic, 19,* 623-632.

Mykytyn, K., Bordoloi, B., Mckinney, V., & Bandyopadhyay, K. (2002). The role of software patents in sustaining IT-enabled competitive advantage: A call for research. *Journal of Strategic Information Systems, 11,* 59-82.

Mykytyn, P.P. Jr., Mykytyn, K. (2002). Computer software patents: A dilemma in competitive advantage IT research. *Communications of the Association for Information Systems, 8,* 109-130.

Nonaka, I. (2002). A dynamic theory of organizational knowledge creation. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge.* New York: Oxford University Press.

Norton, D., & Kaplan, R. (1996). *The balanced scorecard: Translating strategy into action*. Boston: Harvard Business School.

Pike, S., Rylander, A., & Roos, G. (2002). Intellectual capital: Management and disclosure. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge*. New York: Oxford University Press.

Roos, J., Roos, G., Dragonetti, N., & Edvinsson, L. (1997). *Intellectual capital: Navigating the new business landscape*. New York: Macmillan.

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations*. New York: Double-Day/Currency.

Teece, D.J. (1988). Capturing value from technological innovation: Integration, strategic partnering, and licensing decisions. *Interface, 18,* 46-61.

Teece, D.J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review, 40,* 55-79.

Ulrich, D. (1998). Intellectual capital = competence x commitment. *Sloan Management Review, 39,* 15-26.

Van Buren, M.E. (1999). A yardstick for knowledge management. *Training & Development, 53,* 71-8.

Chapter 5.3
Discovering Communities of Practice through Social Network Analysis

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INTRODUCTION

The concept of a community of practice is emerging as an essential building block of the knowledge economy. Brown and Duguid (2001) argue that organizations should be conceptualized as consisting of autonomous communities whose interactions can foster innovation within an organization and accelerate the introduction of innovative ideas. The key to competitive advantage depends on a firm's ability to coordinate across autonomous communities of practice internally and leverage the knowledge that flows into these communities from network connections (Brown & Duguid, 2001). But how does an organization do this? A key challenge for management is understanding how to balance strategies that capture knowledge without killing it (Brown & Duguid, 2000).

BACKGROUND

Typically, top-down business processes aimed at leveraging knowledge flows end up stifling creativity by institutionalizing structures promoting rigidity. In order to understand knowledge flows, managers need to change their focus away from a process view of knowledge creation to a practice-based view. When individuals have a common practice, knowledge more readily flows horizontally across that practice, creating informal social networks to support knowledge exchange

(Brown & Duguid, 2001). Therefore, the key to understanding knowledge flows within organizations is to switch the conceptualization of work away from formal processes to that of emergent social networks.

Social network perspectives focus on the pattern of relationships that develop between members of a community of practice, suggesting that individuals and their actions are interdependent, rather than autonomous occurrences. In contrast to focusing on work tasks as the unit of analysis, a social network perspective of work focuses on how relational ties between individuals lead to outcomes, such as knowledge exchange and innovation. The ties that develop between community members are characterized by their content, direction, and relational strength, all of which influence the dynamics of individual interactions. The content of ties refers to the resource exchanged, such as information, money, advice, or kinship. The direction of ties indicates the giver of the resource and the receiver. The relational strength of ties pertains to the quality of the tie. For instance, the relational strength of ties indicates the amount of energy, emotional intensity, intimacy, commitment, and trust connecting the individuals.

When the resource being exchanged in the network is knowledge, prior research indicates value is derived from bridging "structural holes" or gaps (Burt, 1992). As a result, individuals who develop ties with disconnected communities of practice gain access to a broader array of ideas and opportunities than those who are restricted to a single community of practice. In addition, individuals who network with others from diverse demographic categories benefit because different people have different skills, information, and experience. Such ties bridge structural holes in the larger organization, and thereby enhance its capacity for creative action.

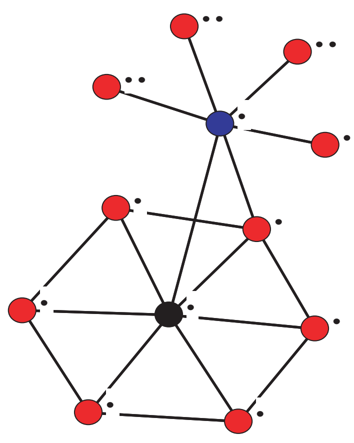
FUTURE TRENDS

Managers interested in understanding where the communities of practice are, and how these communities link to one another, could create a knowledge map of the organization using social network analysis. Social network analysis is a tool that can be used to depict the informal flows of knowledge both within and between communities of practice. By using social network analysis to examine the organization, managers are better able to understand what type of knowledge is being exchanged and the pattern of its exchange. This would facilitate not only the identification of barriers to knowledge exchange and areas of the organization that need better integration into the knowledge network, but would also indicate key personnel in the network through which knowledge is currently flowing.

A picture of a social network resulting from social network analysis is illustrated in Figure 1.

This knowledge map indicates two communities of practice that are bridged by individual 8.

Figure 1. Sample of a social network graph



Individual 1 is central to the network, yet if this individual left the organization, it would have relatively little effect on knowledge flows. Although this would increase the distance between certain individuals, knowledge flows among all individuals remain possible as there is no fragmentation.

CONCLUSION

Social network analysis should be considered an essential tool for mapping actual knowledge flows. In contrast to focusing on business processes to formalize knowledge flows, taking a social network perspective allows management to redesign knowledge flows by adjusting network structures. Using social network analysis techniques to discover communities of practice within the organization allows managers to influence knowledge flows without killing innovation.

REFERENCES

Brown, J.S., & Duguid, P. (2000). Balancing act: How to capture knowledge without killing it. *Harvard Business Review*, (May-June), 73-80.

Brown, J.S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science, 12*(2), 198-213.

Burt, R. (1992). *Structural holes: The social structure of competition*. Cambridge, MA: Harvard University Press.

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Chapter 5.4
Social Network Analysis

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INTRODUCTION

In knowledge management (KM), one perspective is that knowledge resides in individuals who interact in groups. Concepts as communities-of-practice, knowledge networks, and "encultured knowledge" as the outcome of shared sense-making (Blackler, 1995) are built upon this perspective. Social network analysis focuses on the patterns of people's interactions. This adds to KM theory a dimension that considers the effects of social structure on for example, knowledge creation, retention and dissemination. This article provides a short overview of consequences of social network structure on knowledge processes and explores how the insights generated by social network analysis are valuable to KM as diagnostic elements for drafting KM interventions. Relevance is apparent for management areas such as R&D alliances, product development, project management, and so forth.

BACKGROUND

Social network analysis (SNA) offers a combination of concepts, formal (mathematical) language, statistical, and other methods of analysis for unraveling properties of social networks. Social networks have two building blocks: nodes and ties among the nodes. Nodes may represent people, groups, organizations, and so forth, while the ties represent different types of relationships for example communication flows, collaboration, friendships, and/or trust. As illustration, Figures 1a and 1b represent graphs of the business and marriage network of Florentine families in 15th century (see Padgett & Ansell, 1993). The graphs are created with Netdraw (Borgatti, 2002).

SNA has its origins in the early decades of the 20th century. It draws on insights from a variety of disciplines, most notably social psychology, structural anthropology, sociology, and particularly the sociometric traditions (Scott, 2000). The formal

Figure 1a. Florentine families business network

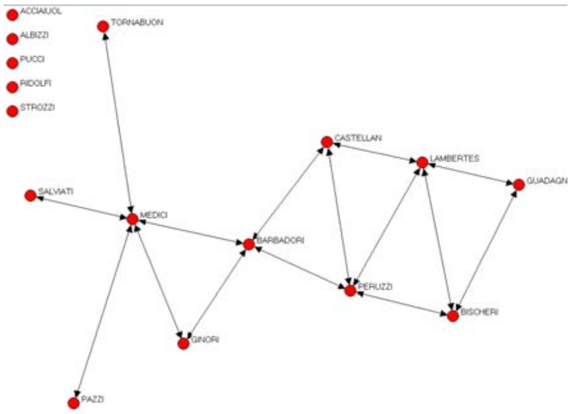
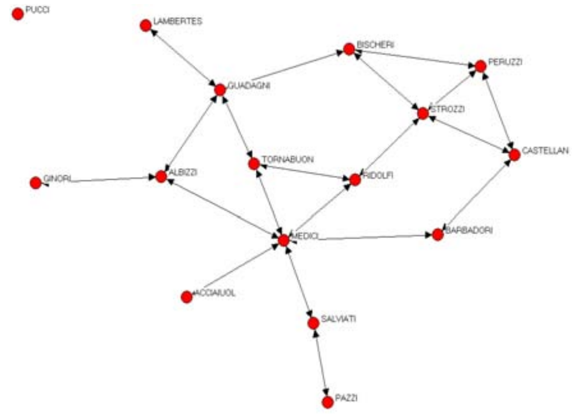


Figure 1b. Florentine families marriage network



language of SNA is based in the mathematical branch of graph-theory (e.g., Harary, Norman, & Cartwright, 1965).

Network statistics describe characteristics of a network and include network size, density, centrality, and so forth. Social network thinking has produced many such statistics (see Wasserman & Faust, 1994). However, only a limited number have been studied and have known consequences for knowledge management. To analyze and characterize networks, SNA provides statistics of the whole network, groups within the network, individuals, and relationships. The substantive meaning of these statistics often depends on the contents of the ties in the network.

Granovetter's (1973) seminal paper, titled "The Strength of Weak Ties," heralds the central place of social networks in knowledge management and shows the importance of relationship characteristics for knowledge transfer. Others show that social relationships and structures also are important for other knowledge processes, such as creation and retention (e.g., Burt, 2004; Hansen, 2002; Hargadon & Sutton, 1997; Reagans & McEvily, 2003). Granovetter's (1973) title may be a bit misleading. It suggests that "weak ties" will help individuals to get unique beneficial information. However, the paper demonstrates that it is the quality of "bridging ties" that brings this advantage. Bridging ties are relationships in a network that, when they would be removed, would leave the network in two unconnected components. These relationships are often weak in the sense that contacts are less frequent and affect is low. However, as Burt (1992) points out, this is a mere correlation. "Strong bridging ties" would offer the same or even more advantages than weak bridging ties. The advantage of bridging ties Granovetter refers to lies in the structure of all relationships, not the strength of the relationship.

This leads us to focus here on the structural characteristics of networks and their impact on KM goals. This allows tapping into accumulating insights in the KM domain generated by SNA applications. Several recent studies in network literature focus on the (contingent) effects of such dyadic qualities as tie strength, level of trust, and power on knowledge transfer and retention (e.g., Hansen, 1999; McEvily, Perrone, & Zaheer, 2003; Uzzi, 1997).

SNA AND KM GOALS

Many SNA concepts bear relevance for KM research. Recent studies show that four SNA concepts in particular affect KM. These are:

1. Brokerage: Affects creativity, the generation of ideas and knowledge exploration
2. Centrality: Shapes knowledge transfer
3. Cohesion: Influences both knowledge transfer and retention
4. Equivalence: Reflects knowledge retention through common knowledge

Elaborating how the inspection of organizations through the lens of these four concepts is relevant for KM debates presumes an understanding of KM. KM is about an organization selecting appropriate goals with regard to knowledge, selecting a management model, and executing interventions, also called KM practices. Commonly, three KM domains and sets of KM goals are discerned:

1. The domain of knowledge processes that constitute valuable knowledge for an organization, most notably knowledge exploration, knowledge exploitation, knowledge sharing or transfer, and knowledge retention (see Alavi & Leidner, 2001; Argote, McEvily, & Reagans, 2003; Hendriks & Vriens, 1999)
2. The domain of a knowledge infrastructure as the organization setting in which knowledge processes evolve
3. The domain of a knowledge strategy as the set of goals that refer to how knowledge may give an organization its specific competitive position

These three KM domains and the goals they involve are interconnected. The domain of a knowledge infrastructure concerns setting the appropriate conditions for knowledge processes to evolve in such a way that they fit strategic KM goals. Focusing on aspects of social network structure, as this article does, involves paying special attention to the KM domain of knowledge infrastructure and its link to the first domain, that of knowledge processes.

Knowledge managers may benefit from insights in the four SNA concepts that will be presented in more detail in the remainder of this article. As elaborated next, insights into the domain of knowledge infrastructure and knowledge processes may form the basis for an informed selection of interventions for reaching KM goals. These interventions may target individuals (nodes) and/or their ties. Such KM interventions directly change the way knowledge processes develop. As such, the efforts of KM target the level of the individual knowledge worker. For example, SNA may prove useful:

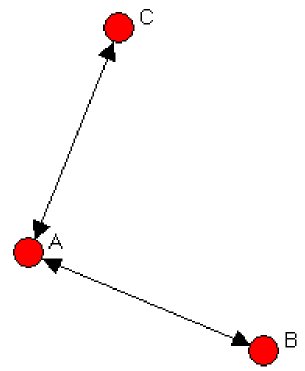
1. in helping these individuals review their personal networks
2. in showing the necessity for them to develop their networking skills (e.g., Baker, 2000)
3. for their career planning

Furthermore, the insights that SNA generates also may allow KM to facilitate conditions for establishing network relationships and affect the resources used in networks. Note that both concern KM at the level of the knowledge infrastructure.

BROKERAGE

The first concept discussed here is that of knowledge brokerage. A broker is defined as someone who holds a position in a network that connects

Figure 2. Node 'A' is a broker between nodes 'B' and 'C'



two or more unconnected parts of that network (see Figure 2). It is closely related to the idea of bridging ties because bridging ties imply brokerage. To emphasize that it is not the bridge itself, but the gap it closes that reflects value, Burt coined the term "Structural Hole" (Burt, 1992). A structural holes reflects the opportunity to connect two or more unconnected others.

Several authors suggest the value of brokerage for the creation of innovative ideas (Burt, 2004; Dekker, 2001; Hargadon & Sutton, 1997). Burt (2004) shows that there is strong evidence that brokerage generates good ideas. He states: "People with connections across structural holes have early access to diverse, often contradictory information and interpretations which gives them a competitive advantage in seeing and developing good ideas." They derive their value by enabling the flow of resources between otherwise unconnected subgroups within a larger network. This induces innovation (Hargadon & Sutton, 1997). Hansen (2002) shows that brokers work best when they use their own contacts and do not depend on other intermediaries. Dealing with fewer intermediaries who serve as boundary spanners provides search advantages, which leads to better knowledge acquisition.

The result that brokers may hold value is not without controversy. It has been shown that the value of brokers depends very much on the content of relationships (Podolny & Baron, 1997). Some relationship contents such as trust or tacit knowledge flow better through nonbridging relationships (Dekker, 2001; Gargiulo & Benassi, 2000).

In short, SNA identifies brokers and shows the conditions under which broker positions become valuable.

KM Interventions

The insights from knowledge brokerage analyses inspire, for example, the following KM interventions:

- Retention of key knowledge brokers in the organization. This could be done by aligning the reward systems with the recognition that informal reputation is central. Formal peer reviews should tap into those mechanisms
- Knowledge brokers need to be managed (or manage themselves) in such a way that they need as little other intermediaries as possible to acquire knowledge. Ideally, every team needs to organize its own "intelligence"
- The structure of work should confront some members of the workforce with a continuous flow of new problems, discourage them to overspecialize, and rotate them between projects on a regular basis. Only then is an "organic emergence of brokerage skills" conceivable
- Management style and the basic management model should reflect norms for collaboration. This could be implemented by avoiding management through normative control and by teaching newcomers the "attitude of wisdom" through brainstorming routines and regular meetings (e.g., Monday Morn-

ing meetings as described by Hargadon & Sutton, 1997)
- Recruitment and employee selection policies should respect the work and management styles and practices described. Peers should play a key role in those policies. Hargadon and Sutton (1997) describe how the product design firm IDEO only hires new personnel when at least 10 peers support these

Another KM intervention would be to find potential brokers to fill structural holes as starting points for idea generation. Other possible interventions include:

- The introduction of programs for team building and the development of networking skills and collaborative exercises may increase the chances that structural holes disappear
- Individuals' motivation to become knowledge brokers may be stimulated, through the reward system, career management, the selection of topics addressed in their development interviews, and personal commitment statements.
- Exit interviews and outplacement procedures may be considered for individuals who prove unfit for any boundary spanning activities

CENTRALITY

Centrality is a network structural characteristic of an individual or a whole network (for an overview, see Wasserman & Faust, 1994). The definition of various forms of centrality we will give focuses on individual centrality or point centrality. On a network level, similar measures have been developed (see Freeman, 1979). Several different types of centrality have been defined. Three well-known measures defined by Freeman (1979) are degree centrality, betweenness centrality, and closeness centrality. Degree centrality is measured as the number of ties an individual has in a network. This measure indicates the potential for communication activity that individual has. Betweenness centrality is based on the number of times that an individual stands between two others. Standing between two others here means being on the shortest path (geodesic) that connects two others. The more often an individual is on the shortest paths between any two others in the network, the higher that individual's "betweenness centrality." This form of centrality says something about control of communication within the network. Closeness centrality measures how close an individual is to the others in a network. Having relationships with everybody implies being closest, while having to depend on others to reach someone implies a greater distance toward that individual. Closeness centrality indicates independence. The higher the closeness centrality the more an individual can avoid the potential control of others (Freeman, 1979).

Centrality of networks has a close relationship to coordination in teams and particularly has an impact on knowledge transfer. For instance, Rulke and Galaskiewicz (2000) show that generalist teams do better than specialist teams in centralized networks. In decentralized networks, generalist and specialist teams perform equally well. Tsai (2002) shows that hierarchy has a negative impact on knowledge sharing, particularly in situations of inter-unit competition for market share. In such situations, informal lateral relations show a positive impact on knowledge sharing. Furthermore, Tsai (2002) shows that the drawbacks of hierarchy for knowledge transfer are less severe when competition among teams concerns usage of internal resources.

KM Interventions

Insights in the centrality of networks provide specific guidance for drafting control structures within project-based or team-based organizations:

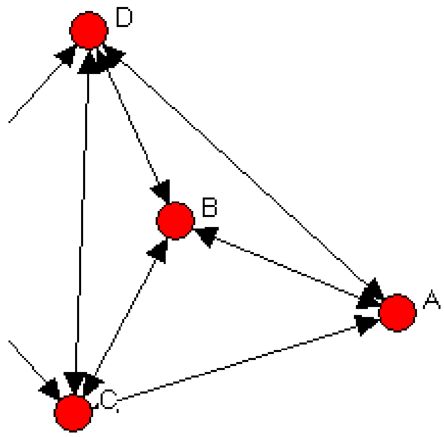
- Especially among specialists, if knowledge sharing is important, centralized, hierarchical control structures as coordination mechanisms in teams should be avoided
- Particularly in situations of inter-unit competition for market share, it may be wise to reexamine the degree of hierarchy in the prevailing control structures
- SNA research also has implications for staffing policies of teams: developing generalist teams puts less pressure on adequacy of existing control structures

COHESIVENESS

Cohesiveness in a network implies that all individuals or subgroups of individuals in that network have strong, direct, intense, frequent, and positive ties (Wasserman & Faust, 1994, p. 249). Several measures to detect cohesiveness have been developed. Probably the most well-known is the clique. Cliques are formally defined as maximal complete subgraphs of three or more nodes (Luce & Perry, 1949). This means a group is a clique if no individual in the network can be added to that group such that all those in the group have a direct tie with each other (see Figure 3). Ties in cliques are sometimes referred to as "Simmelian ties" after the renowned German sociologist Georg Simmel (Krackhardt & Kilduff, 1999). Simmel was the first to discuss the properties of triads, which are the smallest possible cliques. Simmelian ties are super strong, according to Krackhardt (1998), because they create opportunity for norms to arise and the means to enforce these norms (see also Coleman, 1990).

For knowledge management, this means that cohesiveness in networks allows the development, transfer, and retention of routines. Reagens and McEvily (2003) show that cohesion improves knowledge transfers. Hansen (2002) shows that cohesiveness between units may prove counterproductive under circumstances. He argues that

Figure 3. The group of nodes 'A,' 'B,' 'C,' and 'D' form a clique. In the group of nodes 'A,' 'B,' and 'C,' a fourth node 'D' can be added that has ties with all three others. Node 'E' doesn't belong to the clique because 'E' does not have ties with all clique members.



the direct relations that produce cohesiveness are most effective for the transfer of complex knowledge. His research shows that the higher the number of direct relations, the longer the completion time of projects that employ codified knowledge. As to the cost involved in maintaining strong ties, research by Borgatti and Cross (2003) shows that its negative impact on knowledge transfer cannot be substantiated. They do show that awareness of competent knowledge transfer partners and easy access to their knowledge furthers knowledge transfer.

KM Interventions

SNA research shows that stimulating cohesiveness within teams is crucial for the broad spectrum of knowledge processes. If there is a lack of cohesiveness in parts of the organizational network, concrete interventions to help achieve such objectives include:

- The introduction of programs for developing networking capabilities not just for team members but particularly for managers (Baker, 2000). Other research has shown that heavyweight project leaders are needed for successful projects. SNA research shows that networking capabilities skills are crucial in addition to other managerial competencies
- As research suggests that successful teams have both weak and strong ties with other units, recruitment and selection procedures for team composition should ensure an adequate balance between both types of ties
- The introduction of programs for team building including collaborative exercises
- SNA may identify those nodes in the network, for example, team members that contribute most to low cohesiveness scores. These insights may inspire exit interviews with such team members and starting out-placement procedures for them
- The identification and adoption of key tasks and deliverables of teams and subgroups, as these may provide a focus for cohesion
- The introduction of elements of networking by team members in personal commitment statements, career management, and development interviews
- All aforementioned KM interventions should not just focus on intra-unit communication, but also address inter-unit communication. However, it should be considered that cohesiveness based on direct relations across units may only be worth the cost of maintaining for noncodified knowledge

EQUIVALENCE

A fourth SNA concept is equivalence. Equivalence of two individuals in a network indicates that they are embedded in equal or very similar network structures. Note that this does not mean that both need to have a direct contact. Rather, equivalence measures indicate the extent to which two individuals have the same role in a network. Equivalence measures have been developed for sociometric positional and role analyses. These analyses group people on the bases of their similarity in relational patterns. For an overview of different equivalence measures, see Wasserman and Faust (1994). In their study, Reagens and McEvily (2003) suggest that knowledge flows more easily between two equivalent individuals, because they have more common knowledge. More research is needed to show the effects of equivalence on knowledge management outcomes.

KM Interventions

- To the extent that inter-team knowledge transfer is important, staffing policies of teams need to tap into the insights that the existence of common knowledge among team members of different teams is an important precondition for the ease of knowledge transfer between teams, particularly for complex, noncodified knowledge. One way to achieve this is to gather data on the networks of individuals and to use these data to maximize structural equivalence of teams, an insight that may be provided by SNA
- Installing a system of job rotation makes sense because experience at one task is shown to help in performing a related activity
- Dedicated network ability training programs also may help in expanding the capacities of individuals and teams to achieve equivalence with other individuals and teams

FUTURE TRENDS

The increasing attention for knowledge aspects in organizations is likely to boost the interest in SNA research and may be expected to influence the direction that research takes. The KM community may be expected to strengthen its embrace of SNA as a solid basis for diagnosis. As to the development of a knowledge-based SNA, a multitude of suggested research directions, ideas, and developments appear on the horizon. Two of these deserve special attention.

First, we anticipate SNA researchers that show an interest in the knowledge-based view of organizations to expand their focus that is currently mainly on the process of knowledge transfer. Other knowledge processes, particularly knowledge exploration and knowledge retention, have attracted the attention of SNA researchers, but not so much as knowledge transfer. The process of knowledge exploration, for instance, has been approached mainly via related concepts as creativity and idea generation. The process itself and the variety of learning and knowledge development models circulating in KM debates that involve elements of networks still remain largely outside the scope of SNA research. Also, an understanding of the core knowledge processes of knowledge exploitation and knowledge retention may greatly benefit from an inspection from a SNA standpoint. The same goes for the broad spectrum of supporting knowledge processes including knowledge acquisition, knowledge evaluation, knowledge identification, and knowledge combination.

Second, the further integration of SNA can be foreseen with qualitative studies that provide an in-depth examination of the intricacies surrounding the knowledge aspects of work. Hargadon and Sutton (1997) give an outstanding example of combining SNA with an extensive qualitative study of the mechanisms that shape the amalgamation of idea generation and knowledge retention. SNA addresses the crucial structural conditions for knowledge processes to develop. However, the intricate workings of the knowledge component in these processes remain a black box in a SNA. This is indicated by the fact that in much SNA research the term knowledge is easily substituted with the term information. Development of both knowledge-based SNA and qualitative inspections of organizational knowledge will advance due to their mutual connection.

CONCLUSION

Concepts from SNA strike a chord among adherents of a knowledge-based view of organizations. They recognize that knowledge, and especially organizational knowledge, is essentially situated on the fringes of connecting individuals with collectives. These concepts have inspired researchers from different origins and led to elaborations of network thinking into different directions, such as the economic theories of networks as governance modes and organizational theories around concepts of organization structure (Wijk, Bosch, & Volbeda, 2003). Both in the domain of knowledge management research and in the domain of individual organizations drafting their knowledge management diagnosis and design efforts, SNA has great potential to further develop the knowledge-based view of organizations.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly 25,* 107-136.

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), (571-582).

Baker, W.E. (2000). *Achieving success through social capital: Tapping the hidden resources in your personal and business networks.* University of Michigan Business School management series (pp. XVII, 238). San Francisco: Jossey-Bass.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies 16,* 1021-1046.

Borgatti, S.P. (2002). NetDraw: Graph visualization software. Harvard: Analytic Technologies.

Borgatti, S.P., & Cross, R. (2003). A relational view of information seeking and learning in social networks. *Management Science, 49*(4), 432-445.

Burt, R S. (1992). *Structural holes: The social structure of competition* (p. 313). Cambridge, MA: Harvard University Press.

Burt, R.S. (2004). Structural holes and good ideas. *American Journal of Sociology* (in press).

Coleman, J.S. (1990). *Foundations of social theory.* Cambridge, MA: Harvard University Press.

Dekker, D.J. (2001). *Network perspectives on tasks in account management.* Erasmus University: Rotterdam.

Freeman, L.C. (1979). Centrality in social networks conceptual clarification. *Social Networks, 1,* 215-239.

Gargiulo, M., & Benassi, M. (2000). Trapped in your own net? Network cohesion structural holes, and the adaptation of social capital. *Organization Science, 11*(2), 183-196.

Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology, 78*, 1360-1380.

Hansen, M.T. (Ed.) (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly, 44*(1), 82-111.

Hansen, M.T. (Ed.) 2002. Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Oraganization Science, 13*(3), 232-248.

Harary, F., Norman, R.Z., & Cartwright, D. (1965). *Structural models: An introduction to the theory of directed graphs.* New York: Wiley.

Hargadon, A., & Sutton, R.I. (1997). Technology brokering and innovation in a product development firm. *Administrative Science Quarterly, 42*, 716-749.

Hendriks, P.H.J., & Vriens, D.J. (1999). Knowledge-based systems and knowledge management: friends or foes?, *Information and Management, 35,* 113-125.

Krackhardt, D. (1998). Simmelian tie: Super strong and sticky. In M. Neale (Ed.), *Power and influence in organizations* (pp. 21-38). Thousand Oaks, CA: Sage.

Krackhardt, D., & Kilduff, M. (1999). Whether close or far: Social distance effects on perceived balance in friendship networks. *Journal of Personality and Social Psychology, 76,* 770-782.

Luce, R.D., & Perry, A.D. (1949). A method of matrix analysis of group structure. *Psychometrika, 14,* 95-116.

McEvily, B., Perrone, V., & Zaheer, A. (2003). Trust as an organizing principle. *Organization Science, 14,* 91-103.

Padgett, J., & Ansell, C. (1993). Robust action and the rise of the Medici, 1400-1434. *American Journal of Sociology, 98*(6), 1259-1330.

Podolny, J.M., & Baron, J.N. (1997). Resources and relationships: Social networks and mobility in the workplace. *American Sociological Review, 62*(5), 673-693.

Reagans, R., & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly, 48,* 240-267.

Rulke, D.L., & Galaskiewicz, J. (2000). Distribution of knowledge, group network structure, and group performance. *Management Science, 46,* 612-625.

Scott, J. (2000). *Social network analysis: A handbook* (2nd Ed.). London: Sage.

Tsai, W.P. (2002). *Social structure of "coopetition" within a multiunit organization: Coordination, competition, and intraorganizational knowledge sharing.* Unpublished manuscript.

Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 42,* 35-67.

Wasserman, S., & Faust, K. (1994). *Social network analysis: Methods and applications.* New York: Cambridge University Press.

Wijk, R.v., Bosch, F.A.J.v.d., & Volbeda, H.W. (2003). Knowledge and networks. In M. Easterby-Smith & M.A. Lyles (Eds.), *The Blackwell handbook of organizational learning and knowledge management* (pp. 428-453). Malden, MA: Blackwell.

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Chapter 5.5
A Social Network Perspective on Knowledge Management

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INTRODUCTION

Social networks—the sets of relations that link individuals and collectives—have implications for the speed and effectiveness with which knowledge is created and disseminated in organizations Both social networks and knowledge management (KM) are complex, multifaceted phenomena that are as yet imperfectly understood. Not unsurprisingly, our understanding of the interface between the two is similarly imperfect and evolving. There are, however, a number of foundational concepts upon which existing thought converges as well as a body of emerging research that offers practical and conceptual guidance for developing the kind of network best suited for managing different kinds of knowledge. In this article, we introduce rudimentary network concepts, briefly recapitulate KM and organizational learning concepts related to networks, and then explore some of the interfaces between social networks and KM.

RUDIMENTS OF SOCIAL NETWORK ANALYSIS

There are two fundamental dimensions of social networks: transactional content and configuration. These in turn have both direct and indirect interactions on each other and on knowledge dissemination if not on both creation and transfer of knowledge. Configuration refers to "shape" of a network (Nelson, 2001). For instance, some networks look like stars, with actors connected only to a central person. Some look like spider webs, with a dense center, but with some connections between peripheral actors (Handy, 1995). Other networks, such as those typified by unrestricted markets, exhibit more random patterns.

Important for an individual within a network is the degree to which he or she fills a "structural hole" between members of the network. A structural hole refers to a gap in a network which isolates one set of actors from another. Individuals whose personal ties bridge such gaps can exercise a "brokerage" role which benefits them personally and facilitates the flow of information and resources through the network. There are at least two other important configurational aspects of an individuals networks; centrality and structural equivalence. Together they constitute what Galaskiewicz and Wasserman (1993) identified as the core constructs defining of social structure:

1. Actor centrality is the degree to which the ties in a network converge upon an individual actor. Thus, if actor A is connected to everyone in a network and no other actors entertain ties to each other, actor A has maximum centrality. Centrality has been measured in various ways from simple counts of sociometric nominations to measures based on the number of geodesics linking each actor, but space will not permit a discussion of these nuances. Common to all measures is the idea that central actors can reach or directly contact other members of the network more easily than less central actors.
2. Structural equivalence is the degree to which the patterns of individual networks are similar. People who are tied to the same people are said to be structurally equivalent. For instance, two professors who team teach the same course would have rather similar patterns of ties, at least with their students. Supervisors on a day and night shift in the same factory also would have somewhat similar network patterns. Because strict equivalence is quite rare, scholars have sought to develop less constraining definitions of equivalence. Actors with similar network structures but with connections to different actors are said to have "regular equivalence" for instance. An example would be quarterbacks on opposing football teams. In practice, equivalence is usually measured using clustering algorithms which group similar network patterns together.
3. Bridging relationships are idiosyncratic relationships that link otherwise unconnected groups or individuals. This concept is very similar to both Burt's brokerage and Freeman's "betweenness" constructs.

To Glaskiewicz and Wasserman's constructs must be added a fourth—the concept of density. Density refers to the overall number of contacts in a network compared to the number of ties possible. In a "sparse" network, there are few connections between people. In a "dense" network everyone is connected. Density is expressed as a ratio of realized to possible ties. The network of four people sharing six ties has a density of 1. One containing three ties has a density of .5. The overall density of a network or a network's subregion is closely related to virtually every other network dimension.

Transactional content refers to the kind of relationship that exists between two actors rather than the shape of the network or the actor's position within the network. Many types of relationship are possible, including influence, information exchange, advice, emotional support, antagonism, and exchange of goods and services. However, to date, the most commonly used way to classify the transactional content of a network is the concept of "tie strength" developed by Grannovetter (1973). In addition to formalizing the concept of tie strength, Grannovetter was perhaps the first to recognize the relationship between tie strength, network configuration, and the dissemination of information.

The strength of a tie is a combination of the amount of time, the emotional intensity, and the extent of reciprocal services which characterize the tie. In general, the stronger the tie the more easy it is for one actor to influence and convey complex, multifaceted information to another. At the same time, strong ties tend to be resistant to change and stifle innovation. They also tend to clump together into incestuous cliques, creating many structural holes in a network that are difficult to bridge and that create conflict in social systems (Nelson, 1989; Uzzi, 1997). The relationship between tie strength, network configuration, and information transfer is probably the single most important network finding and its implications for KM and surfaces in one way or another in almost all studies of networks and KM.

DIMENSIONS OF KNOWLEDGE AND KM

Although most readers will be acquainted with KM and related concepts, it will be useful here to summarize a few central constructs so that our discussion of the relationship between networks and KM will be based on common understandings and definitions. We briefly restate commonly used definitions of knowledge and knowledge management. Nonoka (1994) defines knowledge as "a justified belief that increases an entity's capacity for effective action." He also affirms that knowledge is created and organized by the flow of information, anchored on the commitment and beliefs of its holder (Nonoka, 2002).

It is important to distinguish between data, information, and knowledge. The primary distinction between the three lies in the degree to which they are organized and useful. Data are raw stimuli with little organization or ready utility (Avali & Leidner, 2001). Data become information when they are processed and organized in a systematic way. Information becomes knowledge when it is ready to be used to orient action. In Davenport, Long, and Beers' terms, "Knowledge is a high value form of information that is ready to apply to decisions and actions (Davenport et al., 1998, p. 43). An important type of knowledge is tacit knowledge, which, while it is useful, is difficult to codify, transmit, and convey (Schön, 1983). Tacit knowledge contains data that are processed, organized, and useful, but the underlying logics of their organization are frequently complex, implicit, and ambiguous. Tacit knowledge is important to the solution of problems that are intractable, complex, extremely variable, or all of the above. As phenomena become better understood and solutions more routine, the knowledge necessary for their processing becomes more explicit, and solution procedures more codified, so that producing information from data becomes simpler and more routine.

Generating knowledge, be it tacit or explicit, is a complex task. Nonoka (1994) identifies four interrelated related processes leading to knowledge creation: knowledge socialization, knowledge internalization, knowledge externalization, and knowledge combination. Almost by definition, the processes of knowledge socialization and externalization if not combination and internalization will be influenced by the nature and distribution of individual and collective networks. Most views of KM recognize that it has both social and technological dimensions which need to be integrated, and that KM has broad aims involving organizational culture, transparency, and agility of processes, and the development of infrastructure that is harmonious with individual needs and organizational context.

For Davenport and Prusak (1998), most KM projects have one of three aims: (1) to make knowledge visible and show the role of knowledge in an organization; (2) to develop a knowledge-intensive culture by encouraging and aggregating behaviors (e.g., knowledge sharing); and (3) to build a knowledge infrastructure—not only a technical system, but a web of connections to encourage interaction and collaboration. Again, social networks would logically limit or enhance visibility, culture, and infrastructure.

Alavi (1997) believes that KM includes both technology and social-cultural factors. This view is supported by Tiwana (2001) who adds that: (1) KM should focus on the flow of information; (2) it is a foremost a management issue—and technology is only an enhancer driven "by the right people in the right place to support knowledge management." A similar but more individualistic perspective is expressed by Alavi and Leidner (2001). For them, KM involves enhancing individual's learning and understanding through provision of information. They also see the role of IT as providing the access to sources of knowledge rather than knowledge itself. Sources of knowledge are the nodes of a social network that create, acquire, or transfer the majority of information/knowledge.

From this brief overview, it would seem clear that: (1) Networks are an important part of the knowledge creation, acquisition, and transmission process; and (2) different network properties will come into prominence at different stages of this process. In the next section, we attempt to identify some of the likely specifics of this relationship.

NETWORKS AND KNOWLEDGE MANAGEMENT

The relation between networks and KM has been recognized and explored by several researchers, some of whom have made extensive use of formal network theory and methods, others who have made fairly little use of the existing network literature. It is generally recognized that early KM initiatives focused too heavily on IT, missing opportunities to improve performance through the knowledge and enhancement of employee networks (Parker, Cross, & Walsh, 2001). Practicing managers especially recognize that human relationships, their deployment, and configuration are critical to KM. For instance, the manager of the technical information center at Xerox emphasized that KM is not technology-driven but "people-driven" (Hickins, 1999). A case study of Xerox affirmed that 80% of KM systems involved adapting to the social dynamics of the workplace.

Beyond this general admission of the importance of human factors, literature on KM has frequently noted that formal vertical relations are not as effective at disseminating knowledge, as are lateral contacts. A number of studies suggest that hierarchical contacts (frequently, equated with "formal structure") are not as effective for knowledge sharing as "lateral" or informal contacts. Knowledge organizations are characterized by weak hierarchies, dense lateral connections, low departmental walls, and openness to the environment (Achrol & Philip, 1999). These studies, however, have made little or no use of network theories, which would help to explain the effectiveness of lateral ties.

Perhaps the most sophisticated work on KM and networks is that of Cross, Parker, Prusak, and Borgatti (2001). They identify four dimensions of network ties which influence a firm's KM capability: (1) Knowledge: "knowing what someone else knows" when managers face a problem or opportunity; (2) Access: being able to contact and secure useful information for an actor in a timely fashion; (3) Engagement: the expert understands the problem as experienced by the seeker and then adapts his or her knowledge to the needs of the person information; and (4) Safety: ease in admitting a lack of knowledge.

Although the work on networks and KM clearly establishes the importance of networks to KM, we as yet have found no integrative statements about the general contours of the relationship between network attributes and knowledge creation and dissemination. In an effort to move toward such a statement, we juxtapose the tacit/explicit knowledge distinction with the various network properties to offer the beginnings of a contingency perspective on networks and KM.

Knowledge creation generally begins with isolated and unintegrated insights, which are brought to bear on a practical problem until a desired result is achieved. At this point, the practitioner has a working ability which we defined above as tacit knowledge. Over time, this tacit knowledge may or may not be distilled into codified information, which is more easily conveyed through written or other transportable means. The degree to which knowledge is tacit is closely related to the kind of network that will best be able to convey and disseminate it.

When knowledge is at the tacit stage, it is only transferable (if at all) through very rich channels requiring frequent face to face interaction. When physical artifacts are involved, the artifact or physical setting must simultaneously be available to all parties. This demands both strong ties and a dense network configuration, which can be quite expensive to develop in terms of time and resources. Although relations in the network may be hierarchical (mentor and apprenticeship relations are prominent), little brokerage occurs because all members of the network know each other and relate on a face to face basis.

As tacit knowledge gives way to at least partial codification, formerly isolated communities of practice trafficking in tacit knowledge come into contact with one another. Brokers then emerge who retain a stake in their original community but who acquire the insights of rival groups or of other disciplines or crafts. These brokers often face ostracism from their own group and suspicion from other groups, but if they succeed in forging connections, they are often richly rewarded. The great tinker-inventors of the 19th century tended to build networks of this type, Edison and his famous Menlo Park facility being the most prominent example. These networks are characterized by tight cliques of strong ties connected by brokers with somewhat weaker ties to other communities. This tradition is carried on today and the organizational mechanisms used to manage such networks are lucidly portrayed in Hargadon and Sutton's (1997) pioneering work on Ebsco, the famed Silicon Valley design firm. Work of this type has generally been ignored by both network analysts and KM scholars and needs to be acknowledged by and integrated into both literatures.

As knowledge becomes codified but still somewhat volatile, networks with weaker ties, less density, and more brokerage are needed. These use channels with less richness and more agility, although even these networks ordinarily build associations and cartels to provide a forum for face-to-face contact and deal-making. Frequently, actors who develop high centrality may drive out other brokers and become dominant in managing and controlling information at this stage. Many of the incidental contacts of the general managers described by Kotter (1982) are with brokers of information which is largely codified but not routine or widely disseminated.

Finally, highly codified and relatively stable information is found in market-like networks which rely heavily on public mechanisms such as publications, bulletin boards, and wire services. These networks are low in density and weak in tie strength and require relatively little conscious understanding or management. Even these networks, however, can only be navigated by people who have been introduced to the conventions and protocols used by someone already initiated in the system. In these situations, information is more prominent than knowledge, but even in these settings, it may take a knowledgeable, initiated person to orient newcomers.

Understanding the continuum of tacit to explicit knowledge and its implications for social network strength and configuration may enhance current thinking and practice in knowledge management as well as the study of social networks. As an example, we return to Cross et al.'s categories of knowledge, access, engagement, and safety. When we examine their typology in the light of tacit knowledge, it seems reasonable to predict that the different dimensions and their configuration will vary by the state of knowledge being developed.

The knowledge (i.e., knowing what someone else knows) dimension will be relatively unimportant during the tacit phase if only because engagement will be almost impossible. When information is more transportable however, knowledge will be very important and will benefit by high density and connectivity with many brokerage relationships. Engagement (expert understands the problem of the seeker) becomes important during the intermediate stages when the ability to find the exact person who can "speak the language" of the information seeker becomes critical. Brokerage relationships become critical here and much time will be dedicated to forging brokerage relations and developing strong ties to diverse actors in a sparse network. When knowledge is generally codified and diffused, safety (ease in admitting lack of knowledge) becomes an issue because of the expectation that people should already know certain information or where to find it. Thus, strong mentoring relationships in otherwise sparse networks composed of weak ties become important when information is explicit rather than tacit.

Cross et al. describe a situation in one firm in which one executive provided the only bridge between two cliques. Their intervention established other brokerage contacts, generally taking pressure off the sole broker and speeding coordination and communication in the workgroup. It is our expectation that in situations high in tacit knowledge, such change in the network might not be practical. In one knowledge-intensive organization to which we consulted, the top executives of the company also occupied important bridging roles in a field high in tacit knowledge. Rather than making their networks denser and more egalitarian, we found it was best to buffer the most knowledgeable executives from administrative duties so they could devote more energy to a brokerage role that was harder to compensate for than their administrative role.

TIE STRENGTH AND KM

In our discussion, we mentioned tie strength, but our focus was chiefly on network configuration and knowledge generation and transmission. Before closing, we turn to a few more detailed predictions about tie strength and knowledge management. The presence of strong ties provides a rich communication channel, which facilitates the accurate transmittal of complex information, tacit knowledge, and development of trust. They also promote commitment and solidarity between actors which is necessary for communication and coordination of large projects that require intensive sharing of knowledge across many actors (Fukayama, 1995).

At the same time, the presence of strong ties requires large amounts of time and psychological energy to develop and maintain, generally reducing the efficiency of the system. They also reduce variability in thought and perspectives at the same time they stifle undesirable deviance and build loyalty. Thus, at the same time, they help convey tacit knowledge, they stifle the "reflection in action" that Schön deems necessary to perfect tacit knowledge. This, in turn, limits that ability to adapt to new circumstances and novel situations. The benefits of strong ties are most evident when producing knowledge for the incremental perfection or improvement of an existing system or technology—in sum, for exploitation rather than exploration.

When competence-destroying innovations are expected or intended, the strength of ties becomes a weight that renders the knowledge system less agile. Tacit knowledge tends to carry with it "irrelevant content" (Nelson, 1997) and superstitions that prevent the system from understanding or recognizing the value of competence destroying innovations. The literature on KM glimpses aspects of this paradox but generally does not see both horns of the dilemma at the same time and tends to be more aware of the value of weak ties than of strong ties. From a network perspective, then, the observation of the KM community that lateral ties are better for information diffusion may be because they are likely weak rather than strong. KM observations of the benefits of laterial ties should include caveats. Lateral ties are more likely to be more adaptable and flexible than contacts with hierarchical content. Lateral ties also would be desirable because they would bridge a number of structural holes in the organization, facilitating information flow. However, they do not convey the solidarity and coercive power of strong and/or hierarchical ties.

CONCLUSION

As the KM field continues to mature, we expect that the social network perspective will play a more prominent role in our understanding of knowledge in organizations. In closing, we suggest a few measures that may be taken to speed up this process. We suspect first that tighter theoretical linkages between social network theory, theories of knowledge, and theories of organizational learning would be useful. Students of organizational learning are generating ever more sophisticated studies using large archival data sets. These studies (Chuang & Baum, 2003; McDonald & Westphal, 2003) contain insights that could be exploited by students of knowledge management who have a basic grasp of network concepts. Second, more complete use of the sophisticated social network techniques available would be useful, especially those methods that consider multiple types of tie simultaneously. The techniques used in the KM literature to date tend to be quite rudimentary and therefore best for case-based research rather than comparative studies which yield higher generalizability. The normative orientation of KM could stimulate network analysts to be less coy about developing prescriptions for managing networks. Much is known about networks' content and morphology but not about how they are actually formed and what specific network properties are efficacious in what settings.

Early network analysts discussed the benefits and drawbacks of highly central networks but turned away from practical concerns in search of ever more esoteric theory. Very little thought at all has been given to the practical impacts of structural equivalence between actors, which would be a natural next step in terms of practical analyses. We suspect that different degrees and types of equivalence may have implications for KM, and research in this area by the KM community is likely to push network theory in interesting directions.

Granovetter's (1973) original formulation of strong and weak has been thoroughly exploited for its practical and theoretical value, and it is time to look at more fine-grained characterizations of relations. The KM community can be of considerable value in taking the notion of "transaction content" from network analysis and giving back a more practical and sophisticated view of the kinds of relations that people develop, how they develop them, and how these relations are mobilized to generate and distribute knowledge.

As is the case with most social endeavors, the different possible configurations of network attributes present contrasting implications for knowledge management, reflecting the tensions and tradeoffs that are inherent in almost any social setting in which goal-oriented performance is sought. Continued integration of these two bodies of thought should ultimately benefit both but also might contribute to the more general debates of our time about solidarity, innovation, change, and the fundamental nature of human systems.

REFERENCES

Achrol, S.R., & Philip K. (1999). Marketing in the networked economy. *Journal of Marketing, 63,* 146-163.

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alavi, M. (1997). *KPMG Peat Marwick U.S.: One giant brain*. Harvard Business School, Case 9-397-108.

Chuang, Y., & Baum, J.A. (2003). It's all in the name: Failure-induced learning by multiunit chains. *Administrative Science Quarterly, 48*(1), 33-60.

Cross, R., Parker, A., Prusak, L., & Borgatti, S.P. (2001). Supporting knowledge creation and sharing in social networks. *Organizational Dynamics, 30*(2), 100-121.

Davenport, T.H., De Long, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge*. MA: Harvard Business School Press.

Fukayama, F. (1995). *Trust: The social virtues and the creation of prosperity*. New York: Free Press.

Galaskiewicz, J., & Wasserman, S. (1993). Social network analysis: Concepts, methodology and directions for the nineties. *Sociological Methods and Research, 22*, 3-22.

Granovetter, M.S. (1973). The strength of weak ties. *The American Journal of Sociology, 78*(6), 1360-1380.

Handy, C.B. (1995). *Gods of management: The changing work of organizations*. New York: Oxford University Press.

Hargadon, A., & Sutton, R.I. (1997). Technology brokering and innovation in a product development. *Administrative Science Quarterly, 42*(4), 716 -750.

Hickins, M. (1999). Xerox shares its knowledge. *Management Review,* 40-45.

Kotter, J.P. (1982). *The general managers*. New York: Free Press.

Levitt, B., & March, J.G. (1988). Organizational learning. *Annual Review Sociology, 14,* 319-340.

McDonald, M.L., & Westphal, J.D. (2003). Getting by with the advice of their friends: CEOs' advice networks and firms' strategic responses to poor performance. *Administrative Science Quarterly, 48*(1), 1-33.

Nelson, R.E. (2001). On the shape of verbal networks in organizations. *Organization Studies, 22*(5), 797-823.

Nelson, R.E. (1997). *Organizational troubleshooting: Asking the right questions, finding the right answers*. CT: Quorum Books.

Nelson, R.E. (1989). The strength of strong ties: Social networks and intergroup conflict in organizations. *Academy of Management Journal, 32*, 327-401.

Nonaka, I. (2002). A dynamic theory of organizational knowledge creation. In C.W. Choo & N. Bontis (Eds.), *The strategic management of intellectual capital and organizational knowledge*. New York: Oxford University Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Parker, A., Cross, R., & Walsh, D. (2001). Improving collaboration with social network analysis. *Knowledge Management Review, 4*(2), 24-29.

Schön, D.A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Tiwana, A. (2001). *The essential guide to knowledge management: e-business and CRM applications.* Upper Saddle River, NJ: Prentice Hall.

Uzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 41,* 373-391.

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Chapter 5.6
Knowledge Management in Action:
The Experience of Infosys Technologies

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ABSTRACT

This chapter presents the detailed architecture that Infosys has deployed for implementing KM internally, and the company's experiences in using that architecture for managing its knowledge. A brief historical perspective of the evolution of the Infosys KM effort is discussed and a description of the Infosys Knowledge Shop (KShop), Infosys's integrated knowledge portal that we have built, is given. The real test of the maturity of any organizational initiative is when it becomes invisible, a part of the normal way people work. The aim of the KM initiative is thus to move towards a culture where knowledge sharing is built into the organizational fabric. The chapter elaborates on one key mechanism that has been devised to help create such a sharing culture — the Knowledge Currency Units (KCUs) scheme. Some of the key challenges and success factors the company has faced are discussed, and the approaches used to manage those are described.

INTRODUCTION

Today's organizations face a strategic landscape that is characterized by changing technology, rising stakeholder expectations, shifting competitor profiles and the emergence of new markets. The need to stay competitive in such an environment throws up immense challenges, and leveraging well on knowledge — internal as well as external to the organization — is a key imperative. Knowledge Management (KM) has thus, in recent years, acquired increasing management focus.

A central tenet of KM is to raise the speed and quality of learning, decision-making and customer service at the level of the organization as well as the individual. By institutionalizing best practices existing in pockets, facilitating greater reuse and helping better virtual teamwork, KM also raises the organization's ability to deliver higher quality and achieve faster time-to-market. Overall, KM also reduces risk and makes the organization more robust to thrive in a changing environment.

Given that most KM programs must start out with modest resources, a KM strategy must be optimized to extract the greatest effectiveness from these resources. A key success factor is getting the optimal emphasis on each of the four focal areas — people, process, technology and content — right from the early stages (see, for example, Davenport and Prusak, 1998). The specific emphasis laid on each of these is a function of the organizational culture and business context.

Infosys Technologies Limited (NASDAQ: INFY) is an IT consulting and software services organization headquartered in Bangalore, India. Founded in 1981, the company's revenues in 2001 were $413 million, having grown at a compounded rate of 70% over the preceding decade. The company primarily services Fortune 1000 clients located in North America, Europe and the Asia-Pacific. Infosys has consistently been rated among India's leading wealth-creators, and recorded a net profit of $131 million in 2001, representing 32% of revenues. It was the top-ranked Indian company in the Review 200 listing compiled by the Far Eastern Economic Review, and has been rated the most respected company in India by, among others, Business World and the Economic Times. The company operates globally, with eight development centers in India, five in North America and one in the UK, and has 10,500 employees on its rolls.

The mission of Infosys' KM effort is to ensure that all organizational learning is leveraged in delivering business advantage to the customer. The objectives are to minimize effort dissipated in redoing learning that has already happened elsewhere, and ensuring that Infoscions (as employees are called) in contact with the customer have the collective knowledge of the organization behind them. The company thus aims to move towards a "Learn Once, Use Anywhere" paradigm. Infosys uses the proprietary KMM, or Knowledge Management Maturity model (Kochikar, 2000a), a staged maturity framework, to underpin its KM strategy.

Infosys has devised and implemented a KM deployment architecture that has been found to work well. This chapter presents the detailed architecture that Infosys has deployed for implementing KM internally, and the company's experiences in using that architecture for managing its knowledge. While each company's KM journey is unique, we believe that sharing information about our architecture and experiences will prove useful to other organizations venturing along the KM path. Equally important, we believe that sharing the process by which we arrived at the architecture that is most optimal in our context holds meaningful lessons for other organizations seeking to define their own KM implementations. Thus, we also present here a brief historical perspective of the evolution of the Infosys KM effort.

A description of the Infosys Knowledge Shop (KShop), Infosys's integrated knowledge portal that we have built, is given. The real test of the maturity of any organizational initiative is when it becomes invisible, a part of the normal way people work. The aim of the KM initiative is thus to move towards a culture where knowledge sharing is built into the organizational fabric. We elaborate on one key mechanism that has been devised to help create such a sharing culture — the Knowledge Currency Units (KCU) scheme. This narrative also brings out some of the key challenges and success factors we have faced, and describes the approaches we have used to manage those.

KNOWLEDGE @ INFOSYS– A HISTORICAL PERSPECTIVE

The company started small but has grown explosively over the last 10 years, and now has operations spread out across multiple locations spanning the globe. The effective utilization of the company's knowledge base has always been seen as pivotal to success. Factors that have driven this belief include:

- The quality imperative: The primary mechanism for raising the quality of services delivered to the customer is the institutionalization of best practices residing in organizational pockets — a process which needs the sharing and adoption of these practices across departmental interfaces.
- The revenue productivity imperative: The constant search to provide greater value for each dollar spent by the customer means the company must raise the level of reuse; the cost and effort of redoing something that has been done earlier — and relearning something that has been learned earlier — grow less affordable.
- The risk reduction imperative: Diversifying into new technologies, domains, geographical areas and services means that the organization must learn new ways of doing things; managing changes in team composition resulting from attrition and personnel movements require that as much knowledge as possible be documented.
- The market awareness imperative: As customers as well as competitors become increasingly global, the company needs to have efficient mechanisms to pull in learning from new environments.
- The growth imperative: Maintaining a consistently high pace of growth means an ability to rapidly enable new recruits on technology, process and cultural issues; it also needs the definition and dissemination of scalable processes that support the delivery of high-quality software and consulting.
- The virtual teamwork imperative: Increasingly globalized operations and rising customer expectations have meant a more complex execution model, often requiring teams that are spread across continents to collaborate in delivering a single software service. Such virtual teamwork represents a microcosm of the issues arising in KM, needing good technologies to support communication and collaboration, and a mindset of working with co-workers who may be situated in different time zones, and who may possibly belong to different cultures.

Driven by the above imperatives, several practices have been evolved at Infosys for ensuring the effective sharing and use of knowledge. While many of these pre-date the formal term 'Knowledge Management,' they can nevertheless be retrospectively classified as practices that sought to implement the spirit of KM.

In 1992, the company felt the need for an organization-wide repository that would enshrine experiential learning gained during the execution of software projects, and make it available for 'posterity.' The Education & Research (E&R) department was charged with the responsibility of developing and managing such a system. The system developed by E&R, christened the Body of Knowledge (BoK), was initially implemented by means of a simple, homegrown software application. The BoK system envisaged entries being contributed by Infoscions, with a lightweight review mechanism to screen their content, applicability and presentation aspects. A pre-defined template required a declaration that the work was experiential, and that it did not violate third-party Intellectual Property Rights (IPR) — in case the IPR belonged to a third party such as the customer, clearance from that party was mandatory. In 1997, this system was re-hosted as a web-based application with HTML content, and made available on the then-fledgling intranet. The application — at the time the first to be developed in Infosys that was based on web technologies — featured an easy-to-use interface with search utilities. Incentives for contribution were also defined, as were mechanisms to publicize contributions.

Given the knowledge-intensive nature of Infosys's business, a clear understanding of its 'knowledge capital' has always been considered essential. Traditional financial statements are notoriously ill-equipped to reflect this intangible form of capital. Infosys has adopted a model for evaluating its intangible assets. The methodology used is based on Dr. Karl-Erik Sveiby's Intangible Assets Monitor framework (Sveiby, 1997).

By late 1998, the company was multi-locational and had reached an employee strength of 5,000 — which meant that it was no longer possible for people to rely on informal mechanisms for identifying 'experts' to be consulted for knowledge inputs at various stages of project execution. It was decided then that E&R would develop a knowledge directory, to be christened the People-Knowledge Map (PKM), which would provide pointers to experts within the organization. Before implementing this directory, two fundamental questions needed to be answered. The first was, would the registration of experts in this system be mandatory — i.e., would every employee who met certain pre-defined criteria for 'expertise' on a given subject be entered into the system? After extensive debate and considerable thought, it was decided to make registration purely voluntary, with incentives to promote it. The rationale behind this was that mandatory registration, while ensuring large numbers of registrants, would be unlikely to guarantee a very high degree of commitment to respond on the part of the registrant (unless responding too was made mandatory, which would be unlikely to guarantee a high quality of response!). Voluntary, incentivized registration, on the other hand, would be likely to attract a small number of highly enthusiastic registrants, thus ensuring that the credibility of the PKM system remained high.

The second question to be answered was, at what level of granularity would these experts register? Existing taxonomies, such as those of the IEEE, the ACM, the Dewey Decimal system and various other taxonomies used by the academic and research communities, were considered, but none was found to fit our requirement. Some of the reasons: the 'top levels' of standard taxonomies are too general, yet do not encompass many areas that we needed — for example, vertical domains, culture, etc.; most standard taxonomies have large portions that are not relevant to Infosys's business; many latest terms are not yet included in them; and, these are generally taxonomies of concepts, which do not contain many proper names (of products, technologies, etc.) that are important for our purposes.

The solution was to develop a proprietary knowledge hierarchy — a multi-level taxonomy of topics that represented knowledge in the Infosys context. At the time of definition, the hierarchy consisted of about 780 nodes, with the top level being Technology, Methodology, Project Management, Application Domain and Culture, and deeper levels representing a finer grain of topics. The PKM application developed featured an intranet-based interface that supported registration of or search for experts. Users could also see profiles of experts and contact them to satisfy their knowledge needs.

The company-wide intranet, called Sparsh, has acted as a central information portal since its inception in 1996. The intranet consists of about 10,000 nodes, spread throughout the global development centers (DCs), and marketing offices. Official policies, press releases and articles, and web-based in-house information systems are available from the home page. Sparsh also links project, Practice Unit, department and personal web pages. Protection from external intrusion is achieved by means of firewalls.

The company's e-mailing system, which every Infoscion has access to, supports bulletin boards for official announcements as well as technical and personal discussions. The technical bulletin board has been a vibrant knowledge exchange forum in its own right, generating discussions on technical topics.

A web-based virtual classroom, also developed and managed by E&R, has been deployed on the intranet, and allows access to various courses. This system incorporates a discussion forum where participants can post and respond to course-related queries.

Practices that have worked are also propagated through regular seminars and best-practice sessions, held both within units and organization-wide. There were also a few other knowledge-sharing practices and systems employed by various organizational units, primarily for use within their units.

An Organization-Wide KM Initiative

The formal KM initiative was born in late 1999 when Nandan Nilekani, president and COO, decided that all the knowledge-sharing mechanisms that had existed until then needed to be synergized under a common umbrella, with a clearly articulated vision and strategy for implementation. Widespread consultation and debate helped define the vision, which was to be an organization...

- ..where every action is fully enabled by the power of knowledge;
- ..which truly believes in leveraging knowledge for innovation;
- ..where every employee is empowered by the knowledge of every other employee;
- ..which is a globally respected knowledge leader.

Knowledge Management Adoption — A 'Maturity' View

The first step towards the development of a conceptual framework for implementing KM at Infosys was to define a knowledge life cycle as consisting of the following stages:

Knowledge Acquisition is the stage where the knowledge is first generated/absorbed by any organizational unit. Knowledge Sharing/Dissemination implies packaging the knowledge/expertise in a form fit for use, and delivering it to the point of use, at the time of use. Sharing may be synchronous — direct person-to-person, or asynchronous — through capture, storage and subsequent delivery. Knowledge Reuse represents the stage where the knowledge/expertise shared is actually put to use for performing a task.

In any given organization, each of these stages of the knowledge life cycle can exhibit varying degrees of maturity. Rising maturity of each of these life-cycle stages implies an increase in the overall maturity of KM in the organization. It is therefore possible to map a given degree of maturity of each of these stages to an overall level of maturity of KM of the organization. This is the concept behind the Knowledge Management Maturity model, which characterizes each maturity level of KM in terms of the efficacy of each of the three stages of the knowledge life cycle.

The KMM model, which draws philosophically from the Software Engineering Institute's CMM (Capability Maturity Model) (SEI, 1993), thus envisages five stages of KM maturity — Default, Reactive, Aware, Convinced and Sharing. It is worth noting that in the model:

- A given maturity level implies a certain level of organizational capability (from level 4 onwards, quantitatively) subject to the prerequisites being met.
- Each maturity level clearly maps on to the company's business goals (i.e., the meaning of each level in business terms is clear).

The concept of maturity level of KM thus helps an organization achieve two aims:

- It provides a framework which an organization can use to assess its current level of KM maturity.
- It acts as a mechanism to focus, and help prioritize, efforts to raise the level of KM maturity.

For further details of the Infosys KMM Model, the reader is referred to Kochikar (2000a). We now proceed to explain the architecture that was developed for deploying KM in the organization.

THE KM DEPLOYMENT ARCHITECTURE

As said earlier, deploying KM needs the four major areas of People, Content, Technology and Process to be addressed. In order to understand the most optimal distribution of effort in the Infosys business and cultural context, a detailed survey of various constituencies within the organization — from top management to programmer level — was carried out, and several rounds of discussion of the draft architecture helped converge on the final architecture that is described below. Detailed analyses of the issues faced in the process of evolving this architecture are discussed in Kochikar (2002a, b).

The People Architecture

The people architecture defines the roles and responsibilities for various aspects of the KM implementation. The distribution of responsibilities must strike the right balance between functions that will be managed by a central group, and those that will be performed in a decentralized way. Infosys has chosen a 'facilitated decentralized approach,' which envisages the following: the technology architecture management for KM — development, deployment and maintenance — is done by a central KM group. All stages of the content management process are anchored by the KM group — creation of internal content however must happen in the field, and is facilitated by the KM group.

The conception and implementation of the KM strategy is also anchored by the seven-member central KM group. The group has two sub-groups — one each to oversee KM research and content management, and technology architecture development and maintenance — each headed by a manager. A third managerial role — that of the brand manager — has responsibility for internal publicity and promotion. The research and content management group includes a knowledge content editor whose primary role is to anchor the content management process. Other roles — practice champions who devote time to facilitation of content generation, reviewers and Gurus — are part time and played by appropriately identified individuals from across the organization.

In the early stages of a KM effort, providing the right incentives is a key success factor. The reward and recognition program for KM at Infosys revolves around the Knowledge Currency Unit (KCU) scheme. The scheme incentivizes authors, reviewers and users of knowledge. Authors earn KCUs when their documents/artifacts are accepted for publication in the KM repository. Subsequently, each time a document is used, the user can award KCUs which accrue to the author's KCU account. The user of a document can give on-line feedback on its utility, and suggestions for improvement. The effort spent by subject area experts on reviewing documents for publication also earns KCUs.

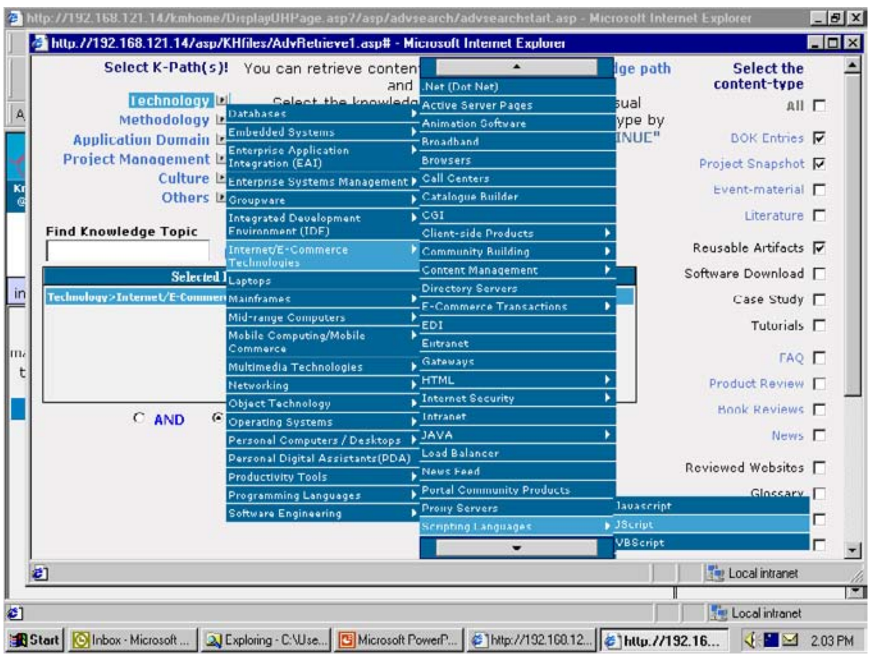
Employees thus build their KCU accounts, whose balance is a measure of their involvement in knowledge sharing. Accumulated KCUs can be redeemed for digital gift certificates that can be used at a specified Internet-based mall.

A successful KM incentive program must, however, go beyond material rewards, and public recognition is a powerful form of motivation. KShop features a KCU Score Board that gives visibility to top knowledge sharers. Periodic Knowledge Summits are held to celebrate knowledge-sharing activities, and publicly recognize and reward leading knowledge sharers.

The Content Architecture

The content architecture specifies how knowledge assets are organized for ease of retrieval. Eighteen distinct content types have been identified, a few examples being white papers, case studies, FAQs and web site reviews. Experiential learning is encapsulated in the form of Body of Knowledge (BoK) documents, which constitute a key content type in the current architecture — BoK entries existing in the legacy BoK system have been migrated to the new architecture. The four-level knowledge hierarchy, initially developed in 1998-99 as described earlier, has been expanded and now contains just over 1,200 topics or subject areas — the explosive growth of Internet technologies alone has contributed over 300 topics. To facilitate easy retrieval, each document is tagged by one or

Figure 1. A partial few of the knowledge hierarchy, showing a subset of topics



more paths through this hierarchy. Thus, a white paper on the eXtensible Mark-up Language (XML) would be tagged by the path Technology>Internet/E-Commerce Technologies>XML. A graphical view of a section of the hierarchy is shown in Figure 1.

Associated with each document is a composite KCU rating, which factors in the KCUs awarded by subject matter experts to the document at the time of reviews, those awarded by users over the document's life cycle, and also the frequency and recency of its use. The composite KCU rating is thus a market-determined indicator of document quality.

Documents are also tagged by the audience role(s) for which they are most suitable, and by security parameters that limit access to a desired subset of the audience.

The Technology Architecture

The Infosys Knowledge Shop (KShop) (Figure 2) provides all of the basic functionality expected of a knowledge portal as well as several applications that are customized to suit the Infosys business processes. Each of the 18 distinct content types has its own home page, which describes the kind of knowledge represented by that content type, and displays the top ranking (by composite KCU rating) documents in the repository of that content type. An advanced search engine helps users find content by knowledge paths, keywords, content types or the other parameters by which content is tagged. Content retrieved is displayed in decreasing order of composite KCU rating — the system thus aims to assist the user in sifting through a possibly large number of documents that may meet the search criteria specified.

Figure 2. Homepage of knowledge shop, the Infosys knowledge portal

KShop, built entirely by the KM group's technology team, also includes basic features such as an on-line document submission facility, a review and publication workflow, several ways of showcasing new and popular content, threaded discussion forums and on-line chat rooms. KShop supports interfaces that allow users to award KCUs to authors while rating their documents, and for KCU account redemption. KShop also hosts the revamped People-Knowledge Map expert locator application.

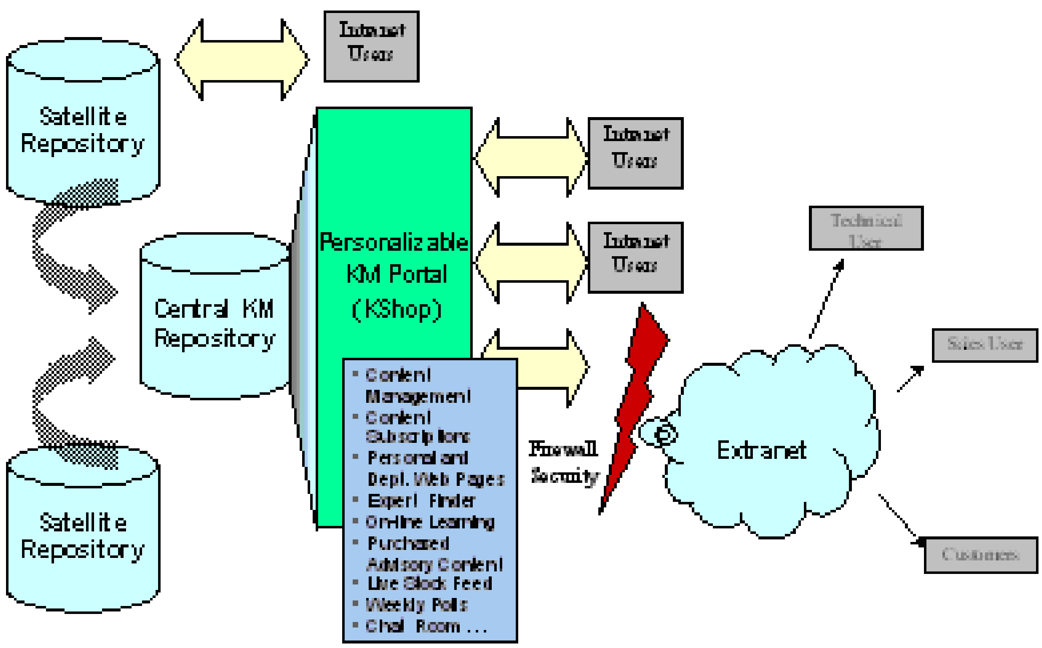
Several other incentives are offered for employees to use KShop on a daily basis. It provides live feeds of stock quotes and sports scores. Its homepage (Figure 2) can be personalized by each user to create their own myKShop, with a customized layout, sizes and colors. In addition, they can 'subscribe' to content by defining the content types and knowledge paths of their interest. Subscribers can see latest content additions that match their subscriptions when they visit the home page. They can also choose to be alerted to additions matching their subscriptions by e-mail at a frequency of their choice. The portal serves about 20,000 requests a day. Each access is also logged so that KM activity can be tracked by parameters such as location, practice unit, department or project.

KShop runs on five PCs, each of which acts as a server. Conventional wisdom has it that an enterprise-grade knowledge portal for a large company must run on high-end, "server class" machines running expensive software such as application servers. Our experience has thus shown that an effective and scalable technology infrastructure can be built for knowledge management without expensive hardware or special KM software products.

Satellite Repositories

The Technology architecture (Figure 3) distributes content storage and management by implementing locally managed content repositories that act

Figure 3. Technology architecture of knowledge shop



as satellites to the central KM repository. The rationale behind this satellite repository system is to permit specialized groups in the organization to own content relevant to their areas. However, the user interface is seamless — a search on KShop's home page retrieves content irrespective of whether it is located in the central repository, or on one of the satellites.

Back-End Data Integration

A variety of corporate data is drawn into the knowledge portal periodically by tight integration of its database with various corporate databases. Employee data, including contact information, location and current project assignment, are synchronized with the corporate HR database on a weekly basis. Data on encashment of KCUs (which are taxable perquisites!) are integrated with the payroll system so that appropriate taxes can be deducted.

The Process Architecture

The process architecture includes processes that are internal to the KM Group and which are used in the management of various KM functions, and those that are developed and deployed to facilitate KM in the field. The content management process comprises different stages such as review by identified internal experts, streamlining and editing, publishing, certification and maintenance. About 170 documents are submitted to KShop each month, and go through a two-tier review process — the first stage of review happens at the content editor's desk where conformance to usability, styling and IPR norms are checked. The second stage of review is done by subject matter experts, and checks for content quality, relevance and utility.

Other defined processes include those for publicity, branding, reporting and benefits measurement. Since the Infosys KM effort is relatively young, ensuring that outdated content is updated or removed is not yet a priority. However, a content maintenance process has been defined, and will use the KCU mechanism to identify documents that potentially qualify for revision or 'retirement.'

A key focus on the process front has been to minimize the overhead associated with creating content. Tweaking existing business processes to facilitate knowledge sharing, and automating certain types of content generation have been two solutions to this vexing problem. For example, 'project snapshots' are now generated 'on the fly' from existing databases containing project management and employee data, thus obviating the need for manual compilation of these snapshots.

In addition to its reward and recognition role, the KCU scheme also provides a mechanism for quantitative management of the KM processes. One aspect of quantitative management is the composite KCU rating mentioned earlier. KCUs are also used as metrics in the measurement of KM benefits and for measuring the level of KM activity in any organizational unit. The average rate of KCU generation is currently 8,000 per month.

EFFECTIVENESS AND BENEFITS OF KM AT INFOSYS

There are, in general, three forms of evidence that can be used in assessing the benefits of a KM program — anecdotal, survey-based and metrics-based. Evolving metrics-based methods to measure benefits is the most challenging — tracing business benefits attributable to knowledge-sharing, defining appropriate metrics, ensuring that the data required to compute the metrics is available, are some of the challenges involved.

In an internal survey based on a sample size of about 600, more than 99% of the respondents said that they believe KM is essential for the company; 79% said the knowledge-sharing environment in the company encouraged the documentation of knowledge for future use; 87% asserted that whenever possible, they tried to reuse existing organizational knowledge rather than start from scratch.

Content submission to the company's knowledge repository has increased nearly 10 fold since the transition from the BoK system to the organization-wide integrated KM implementation. A document is downloaded/viewed by users of KShop every two work minutes. The survey also revealed that users had received distinct benefits from the knowledge-sharing environment that is prevalent in the company:

- More than 80% believe that their team's quality of work and productivity have improved, while 70% said good knowledge-sharing practices had helped in delivering tangible benefit to customers.
- 73% felt they saved more than one person-day in the last six months by using the existing knowledge architecture, with 14% saying they saved more than eight person-days (and 13% saying they saved nothing). Three-quarters said that when needed, they were easily able to tap organizational knowledge in doing their work.

Our approach has been to measure in quantitative terms the impact of knowledge sharing on traditional indicators of project performance, using the KCU mechanism. Several projects have also been able to quantify savings in dollar terms, and also report various other benefits such as improved quality, faster turnaround times, etc. These projects are showcased during the periodic knowledge summits, thus allowing other projects to appreciate the relevance and potential benefits of knowledge sharing.

Up until the date of writing this, 185 employees have crossed the figure of 100 KCUs earned, with eight having crossed the figure of 1,000 (a measure of the vibrancy of the initiative is the fact that, during the time gap of two months between the two revisions of this chapter, the above figures went up from 102 and three, respectively!).

OTHER KM INITIATIVES AT INFOSYS

Apart from defining a greenfield architecture for managing knowledge, a successful KM strategy must usually also integrate existing knowledge-sharing mechanisms and collimate them so that they do not result in duplication or lack of visibility of effort. The satellite repository mechanism described earlier is an example of how the Infosys KM strategy has accommodated the need of groups that maintain specialized knowledge to continue to retain ownership of that knowledge. This section brings out illustrations of how the specific KM needs of a few other groups are addressed.

Infosys's Banking Business Unit (BBU), which provides software products and surround solutions to banks, has a knowledge base — "TechOnline," accessible from the internet home page, www.infosysinbanking.com — that serves to meet the reference needs of its customers, partners and employees at customer sites. This system is linked to the same database into which the global helpdesk logs calls and solutions, thus ensuring the solutions are current. Knowledge gained about the customer, product and deployment scenario is recorded and baselined in a version control system.

As a second example, an offshore development center within Infosys, dedicated to a large telecommunications client, has also developed a customized KM strategy. This center's client is acutely sensitive to intellectual property issues, and requires the center to be isolated from the rest of the Infosys network by a firewall — an artificial barrier to KM. This center thus uses a separate instance of KShop, tailored to its specific needs, which include a focus on the telecommunications domain and the use of local newsgroups.

Newsgroups have been found to be effective in supporting interaction with the client and Infosys communities, as well as between project members. The newsgroups, averaging about 40 posts a day, have contributed to the identification and growth of subject matter experts, reduction in bug-fix time and increase in productivity. Project processes have been tailored to include KM as a stated objective. This center has also included KM in its internal project reviews and performance appraisals.

ACHIEVING THOUGHT LEADERSHIP IN KM

The Infosys KM effort, featuring somewhat seminal aspects in concept as well as in implementation, has received its share of attention from practitioners and researchers worldwide. The KM architecture, the proprietary KMM model and Infosys's experiences in implementation have been published and presented at several academic and industrial events worldwide (see, for example, Kochikar, 2000b; Kochikar and Raghavan, 2000). There have also been several invited presentations and discussion sessions with several companies, including customers, with heartening feedback. The initiative also features in the curriculum at two business schools. An affirmation of Infosys's success on the knowledge-sharing front has been the fact that the company was featured as a finalist for the 2001 MAKE (Most Admired Knowledge Enterprises) awards (Chase, 2001). Infosys was among the 37 companies worldwide that qualified to reach the final round.

In addition to internal implementation, Infosys has also found considerable interest evinced by customers for possible KM services. A prototype of a productized KM solution has been built for a world-leading software product company. The customer has been quoted as saying that the decision to contract Infosys for this engagement came as a natural choice, after seeing the internal KM implementation at Infosys. Infosys has also carried out a KM implementation for a Fortune 250 Personal Computer manufacturing company, with a focus on managing their customer knowledge. The expected benefits of this system were retaining the customer for life, and creating the ability to conduct focused marketing campaigns to get higher return on each advertising dollar spent.

GETTING THERE — CREATING A SHARING CULTURE

Creating a culture of sharing is governed by principles that have much in common with Metcalfe's law — as more people grow convinced of the benefits of participating in the knowledge-sharing movement, it becomes easier to convince still more people to buy in. Thus, as long as steady progress is made on the road towards achieving greater sharing, the pace of adoption accelerates with time. Once a 'critical mass' of users has been reached, the movement reaches a take-off stage beyond which it becomes self-sustaining, without significant effort being devoted to publicity and promotion. Until this stage is reached, however, considerable effort needs to be focused on promoting the initiative. For this reason, the KM group has a full-time brand manager, whose mandate is to constantly promote KM with a view to pushing it higher on the agenda for every quarter of the organization. Over time, as the initiative matures, the brand manager's role is expected to evolve towards sustenance of the initiative. Similarly, as KM becomes part of the organizational fabric, we expect more of KM to happen as an integral part of a variety of roles across the organization, without needing additional staff dedicated to KM.

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REFERENCES

Chase, R. L. and the KNOW Network. (2001). *2001 most admired knowledge enterprises*. Available at http://www.knowledgebusiness.com/make/index.asp

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Kochikar, V. P. (2000a, September 13-15). *The knowledge management maturity model: A staged framework for leveraging knowledge*. KMWorld 2000 Conference, Santa Clara, CA.

Kochikar, V. P. (2000b). Learn once, use anywhere. *Knowledge Management Magazine, 4*(1).

Kochikar, V. P., & Raghavan, S. (2000, July 4-7). Managing knowledge in the e-organization: The IT perspective. *Proceedings of ICEIS 2000, The International Conference on Enterprise Information Systems*. UK: Stafford.

Kochikar, V. P. (2002a). Creating the KM infrastructure at Infosys: The technology challenge. *IIMB Management Review, 13*(4), 104-110.

Kochikar, V. P. (2002b). *Building an organizational architecture for knowledge sharing: Challenges faced*. Working Paper, Infosys Technologies.

Software Engineering Institute. (1993). *The Capability Maturity Model*.

Sveiby, K.-E. (1997). *The new organizational wealth: Managing and measuring knowledge-based assets*. San Francisco: Berret-Koehler.

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Chapter 5.7
The Readiness of IDSC to Adopt Knowledge Management

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ABSTRACT

Over the last two years Knowledge Management has become the latest hot topic in the business world. Companies are realizing that their competitive edge is mostly the brain power or intellectual capital of their employees and management. Many organizations are drowning in information, but starving for knowledge. In order to stay ahead of the pack, organizations must leverage their knowledge internally and externally to survive. Knowledge management is believed to be the current savior of organizations. Creative and innovative people form the core of any organization. In turn, those people form the corporate memory. The Information Decision Support Center for the Cabinet of Ministers for the Egyptian Government (IDSC) faces a problem of employees' high turnover rate (17%), which threatens to cause IDSC to lose its memory. One common mistake many organizations make when they implement KM initiatives is to place too much emphasis on the technological aspect of KM and ignore the human resources aspects. IDSC developed a knowledge management system called the Organizational Memory (http://www.home.idsc.gov.eg/), but ignored the human factor of KM. The purpose of this chapter is to test the readiness of employees and managers working at IDSC to adopt knowledge management. Human issues were clearly shown to outweigh any technology constraints, and views of managers and employees differed to some extent. It is recommended that these human and managerial concerns be addressed if KM is to be successful in organizations.

INTRODUCTION

Background

A study conducted by KPMG consulting (2000) on 500 companies in USA and UK reveals that 81% of the respondents said they had or were considering a KM Program; 38% had a KM program in place; 30% were currently setting one up; and 13% were examining the need for a KM program.

This chapter focuses on various human issues with regard to KM in the Egyptian Cabinet Information and Decision Support Center (IDSC). These issues are often overlooked and their importance underestimated, and attention needs to be paid to these human aspects so that IDSC can effectively achieve the benefits of KM.

Problem Definition

Creative and innovative people form the core of any organization. In turn, those people form the corporate memory. IDSC faces a problem of employees' high turn-over rate (17%) which threatens IDSC with losing its memory. One common mistake many organizations make when they implement KM initiatives is to place too much emphasis on the technological aspect of KM and to ignore the human resources aspects. IDSC developed a knowledge management system called the Organizational Memory (http://www.home.idsc.gov.eg/), but ignored the human factor of KM .The purpose of this study was to test the readiness of employees and managers working in IDSC to adopt knowledge management by focusing on the various human aspects related to knowledge management.

Research Questions

In order to determine the human factors influencing the development of a successful KM program in IDSC, the research, therefore, focused on questions such as:

- Was IDSC ready to adopt a knowledge management program?
- Are employees and managers working at IDSC ready to be part of a knowledge management program?
- What was the knowledge management environment in IDSC?

And additionally:

- What were the employee perceptions of sharing knowledge?
- What were the impediments to sharing knowledge in IDSC?
- Was privacy of employee information an issue in IDSC?
- What were the difficulties in managing knowledge in IDSC?
- Did IDSC maintain innovation and creativity in its problem solving approaches given the availability of the knowledge base?
- Did conflict arise between an employee's career ambitions and the knowledge management culture of the organization?

Research Methodology

Collected data is the heart of the study. There are many sources of data such as interviews, meetings, etc. Other important sources of information are theory and personal experience. In order to determine the human factors influencing the development of a successful KM program in IDSC, we developed two questionnaires, one aimed at the senior and middle managers in the IDSC and the other aimed at lower ranking employees. Questions were adapted from previous research on KM conducted by Jordan and Jones (1997) amongst others.

The sample was restricted to managers and employees who have spent more than two years working in IDSC and have direct or indirect relation to the success or failure of the KM program. The sample size was 40 employees and 20 managers.

Assumptions and Limitations

Assumptions

This study assumed that there was stability in the organization structure, no management change, cultural stability and no major technology change.

Limitations

However, there were a number of limitations. The number of participants was relatively small. The survey also relied on self-reported responses, and as such is subject to limitations of all such surveys. IDSC can also not be considered to be representative of all market sectors in Egypt. These limitations should be taken into account when considering the findings of this research.

KNOWLEDGE AND KNOWLEDGE MANAGEMENT

What is Knowledge?

The word knowledge can, at a first glance, seem easy to define, but a literature search would seem to indicate otherwise. It defines some abstract material, which we cannot see. We try out apparent synonyms, like information, data or competence, but this does not give us the truth. Discussions of knowledge are becoming increasingly important the more it is recognized that a company's future is largely dependent on its ability to handle this intangible asset. A common element in the discussion and definition of knowledge is that knowledge basically takes two forms, tacit and explicit knowledge.

- Tacit Knowledge: is seen as being subjective, practical, and analog. It is highly personal, hard to formalize and, therefore, difficult to communicate to others. It is deeply rooted in action and in an individual's commitment to a specific context - a craft or profession, a particular technology or product market, or the activities of a work group or team.
- Explicit Knowledge: is seen as being objective, theoretical, and digital. Explicit knowledge is formal and systematic and can therefore be easily communicated and shared, in product specifications or a scientific formula or a computer program (Nonaka & Takeuchi 1995).

A detail that we question in this definition is that explicit knowledge would, by definition, be objective. Is a subjective thought put on paper an objective truth? No! But the words can also have a different meaning. Tacit knowledge is part of a person, a subject, while explicit knowledge exists as an object, a visible form. Sveiby (1997) seems to agree with Nonaka and Takeuchi's definitions, but he gets there in an awkward and sometimes contradictory way. Sveiby reasons that knowledge has four characteristics:

- Knowledge is tacit;
- Knowledge is action-oriented;
- Knowledge is supported by rules;
- Knowledge is constantly changing.

The first characteristic suggests that explicit knowledge is not knowledge. This characteristic derives from a view that knowledge, in a strict sense, cannot exist outside an individual. Some knowledge can be formalized, made explicit, but then it becomes static, whereby it loses another of

Sveiby's characteristics. This means that knowledge that has been made explicit/static must be interpreted and mixed with personal knowledge in order to make it true knowledge again.

Sveiby also splits knowledge along another dimension; he separates know-how from know-what. Know-how is closely related to tacit knowledge. Know-what is closely related to explicit knowledge because it can easily be put on paper. Both are important for the ability to act. It would seem that all knowledge has a dimension of tacitness and is, therefore, difficult to explain in words. Knowledge is also action-oriented through the way we generate new knowledge by analyzing the sensory impressions we receive and because we are constantly losing knowledge. This dynamic quality of knowledge is reflected in verbs like learn, forget, remember, and understand. There are also rules for conscious and unconscious processing of knowledge. These rules help us to act and save us a lot of energy when we do not need to think before we act. The knowledge is, also, constantly changing, but when tacit knowledge is made explicit through language, it becomes static.

Data, Information, and Knowledge

Earl and Scott (1998) characterize knowledge as the final product in a chain where data combined with other data and a context transforms into information; information together with experiences and already known knowledge make up knowledge; see Figure 1.

Theorists do not think that the model can be dismissed that easily. In the light of static knowledge not being "real" knowledge that needs human processing to form "real" knowledge, reminds us of Earl and Scott's model. Additionally, data, and perhaps information, is the only thing we can actually store in computers. The process should also be viewed in reverse. The way it is presented by Earl and Scott, it gives the impression that we should gather as much data as possible in order to transform it to knowledge. A knowledge manager would be at least as interested in the opposite direction. He would want to identify valuable knowledge and then look for the information needed to build that knowledge; and in the end, what data he needs to build the information.

Knowledge Hierarchy

The Knowledge Pyramid

Theorists and practitioners of knowledge management often open the what – is-knowledge discussion with the knowledge pyramid , which portrays the world of knowledge as rising from raw transaction data at the bottom to wisdom

Figure 1. Data, information and knowledge (Earl & Scott,1998)

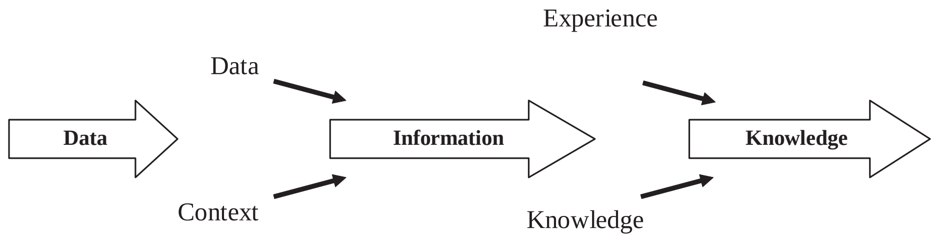
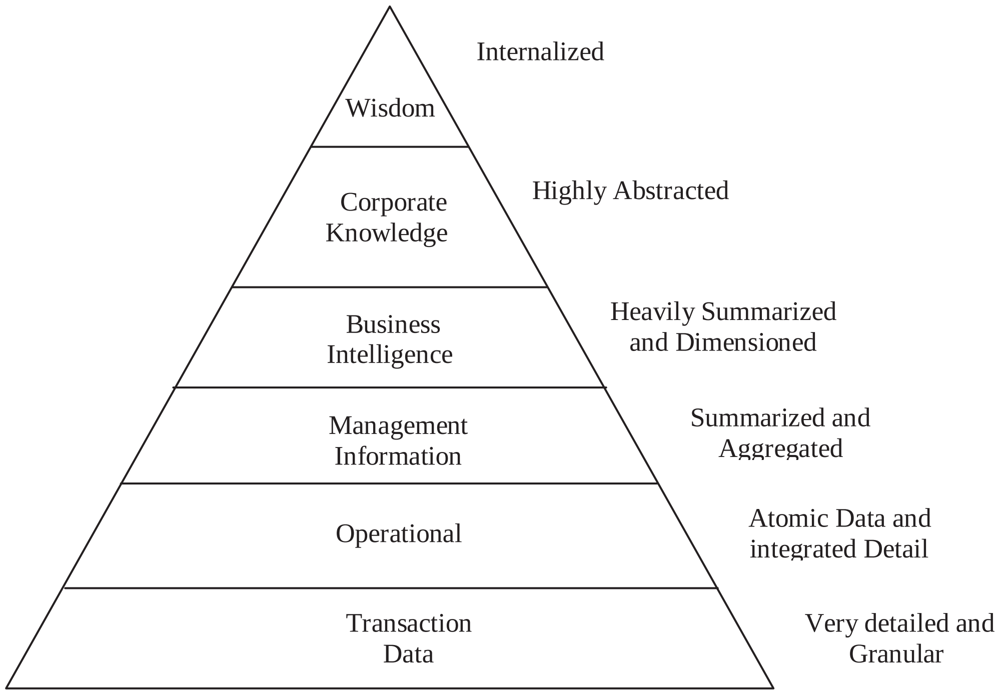


Figure 2. Knowledge pyramid (Alan, Raddund,1998)



at the top. Some disagreements exists among various parties about specific details, but general consensus has been reached concerning the overall thrust and composition of the knowledge pyramid (see Figure 2).

- Raw transaction data and tacit data are the bottom of the knowledge pyramid. Transaction data is recorded in databases and other data stores and used in a variety of ways.
- Operational data reflects complete, integrated transactions, referred to as atomic detail.
- At the management information level, more significant changes occur. This level contains lightly summarized data that has been grouped, stored, filtered or organized to reveal a context.

Information usually takes the form of aggregated numbers, words, and full statements. It often combines the numbers and statements in a summarized form that conveys a meaning that is greater than any revealed by the raw data alone. Knowledge theorists and practitioners agree, however, that knowledge and information are unclear, and several differentiate between the two (see Table 1).

- Continuing up the knowledge hierarchy, highly summarized information, which many refer to as business intelligence. Busi-

Table 1. Attributes of data, information, and knowledge

Attribute	Data	Information	Knowledge
Level of Detail	• Low level of detail • Atomic detail	Integrated, aggregated detail	• Highly abstracted • Detail removed
Context	No context	Full context	Extended context
Scope	Very narrow scope	Scope limited to the particular context	Extends beyond the scope of the information
Timelines	No timelines	Limited timelines	Timeless

ness intelligence results when data and information are heavily processed, organized, filtered, selected, correlated, and analyzed extensively.

- Further summarization of the initial information leads to knowledge. Knowledge, in this case, can be described as insights derived from the information and data that can be acted upon and shared in a variety of ways and circumstances.
- Finally, at the top of the knowledge pyramid is wisdom. Wisdom appears to be the most abstract and timeless of knowledge.

Knowledge Management

The purposes and tasks for knowledge management must be clarified and defined in order to suggest proper measures for knowledge management.

A Definition of Knowledge Management

Knowledge Management (KM) has had a pervasive presence in recent research and is well recognized as a possible contributor to organizational success and a determinant of sustained competitive advantage. Organizations have embraced KM as a primary focus area, recognizing intellectual capital as an asset that can be leveraged to create value for stakeholders.

Gartner Group (1998) defined Knowledge Management as: "Knowledge Management promotes an integrated approach to identifying, capturing, retrieving, sharing and evaluating an enterprise's information assets. These information assets may include databases, documents, policies, procedures, as well as the un-captured tacit expertise and experience stored in individual heads."

KPMG consultants (2000) define KM as "The systematic and organized attempt to use knowledge within an organization to improve performance." Malhotra (2000) offers the following definition of KM : "KM caters to the critical issues of organizational adaptation, survival, and competence in the face of increasingly discontinuous environmental change. Essentially, it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings."

The Components of Knowledge Management

The components of knowledge each support the other, but one does not depend on the other. An individual may very well protect his knowledge, but without sharing it with others or without using past experience when faced with similar problems.

Knowledge may be captured and shared without anyone ever taking advantage of it. An individual may recycle his personal knowledge in similar situations without sharing it with others.

It is, hence, important to be aware of all of them in order to achieve maximum benefit from Knowledge Management.

Identify Valuable Knowledge

To quote Stewart (1997), "In the new economy, the scarce resource is ignorance." This may seem like a contradiction, but it is very important. Because we collect too much knowledge and information, both personal and corporate, the less important overshadows and hides what is important. We share too much knowledge just-in-case, and too little just-in-time. Today we have so many information systems that provide us with information and knowledge that people get overloaded. It is important to stress that the selection of what knowledge to handle in the KM-Process is a critical success factor and very important to analyze. It must then be presented in a way so as to attract the attention of the person who needs it.

It is, hence, important for Knowledge Management to identify both what knowledge is needed and what ignorance can be accepted. This last point is so important that we grant it its own place in the definition of Knowledge Management. When businesses use a lot of effort and investments to implement Knowledge Management, little or no benefits will derive if the company handles knowledge that is unimportant to the business's activities.

Capture Knowledge

One aspect of Knowledge Management, stressed by some authors including Stewart (1997) - is that the knowledge that is captured in the Structural Capital and, therefore, belongs to the company, is most valuable. These assets - company processes, cook-book solutions, information systems, and computer programs do not leave the office at five o'clock.

One of Knowledge Management's tasks is to capture the individuals' knowledge in a form that is stable explicit knowledge. This makes it more valuable in two senses:

- It makes the company less dependent on the individual (reduced risk),
- and the knowledge can be distributed electronically (made available to the whole organization, independent of time and space).

This is under the condition that the captured knowledge is put to use by someone. Value is only created when the knowledge is used. It is not certain that Structural Capital will be used the most and, thereby, generate the most value. Hence, the Human Capital may still be the most valuable.

Davenport and Prusak (1998) try to differentiate when an organization should capture its knowledge in structural capital and when it is not worth the effort. They argue that small companies (less than 300 employees) have little or no need of capturing knowledge into the Structural Capital. Instead, they should concentrate their efforts on sharing information about who knows what. In a large organization, such as IDSC, the potential gains from mass distribution make the cost of capturing worthwhile.

This also brings us to a more general task for Knowledge Management in connection to sharing, protecting and recycling: "Knowledge Management should connect people to data and it should do this on a just-in-time basis" (Stewart, 1997), not just-in-case.

Create Knowledge – Innovate

Particularly, there are two different views of how knowledge is created. The first is a linear view, building on the view that knowledge is the last step in a refining process of data; data is refined to information, which in turn is refined to knowledge. Nonaka and Takeuchi (1995) criticize this (as they see it, western) view of knowledge creating as an information processing activity. Instead they suggest that it is the interaction and communication of tacit and explicit knowledge that creates new knowledge and innovation. It is through socialization, externalization, combination and internalization that we will create new knowledge and change already existing knowledge. This knowledge spiral will support and catalyze innovation and knowledge creation.

Share and Reuse Knowledge

With Sveiby's (1997) knowledge view in mind, there are two ways of information sharing: through tradition and through information.

By tradition is meant a person-to-person transfer, where I watch you and learn by imitating. Nonaka and Takeuchi would call this a tacit to tacit transfer, or socialization. Through information, knowledge can be transferred with the use of other media, such as paper, drawing, database, etc., i.e., the knowledge is transferred via externalization (combination) and internalization.

If true knowledge can only exist in an individual, this means that knowledge that has been captured in some kind of explicit form - instruction or case description - must be made alive in a person. This is accomplished through interpretation, reflection, testing and mixing with personal experience and knowledge already in the individual's possession. It is a process that takes time and effort.

Both tradition and information have their respective pros and cons. Information has the advantage that it can be mass distributed independently of time and place. The process of making knowledge explicit, and making explicit knowledge tacit, are time consuming processes and much of the knowledge is lost in the process. This can be compensated for by the large potential for sharing. Tradition is the only way to transfer many types of knowledge. On the negative side, its effects are very limited by time and space even if some new technologies, such as video-conferencing, may compensate for some of its limitations.

Reduce Risk

By reducing risk is meant to avoid the loss of important knowledge or experiences. One way of accomplishing this is by capturing the knowledge in an explicit form. Another way is by sharing it with others, thereby also sharing the responsibility of protecting the knowledge. In this second way, reduced risk is achieved through sharing and recycling knowledge.

A negative effect of Knowledge Management is an increased risk of knowledge theft. When tacit knowledge is captured in digital format, it is easier to copy the knowledge and spread it to competitors.

Create Value

To justify Knowledge Management, it must add value or cut costs. Knowledge Management creates value of various kinds. Davenport and Prusak (1998), Stewart (1997), and Nonaka and Takeuchi (1995) echo many of the same values when talking about how Knowledge Management creates value. They argue that Knowledge Management will enable a more efficient way of working and generate revenue in the form of higher productivity and efficiency. With Knowledge management, the employees' motivation when they have access to others knowledge will improve their ability to act, as well as their personal learning.

Values in financial terms can also be distinguished through growth in shareholder value, and lower costs when Knowledge Management enables sharing of knowledge to more people and results in higher quality of delivered products and services. The most important common argument for Knowledge Management is that knowledge is the only source of sustained competitive advantage.

Stewart (1997) argues that when capturing knowledge into Structural Capital, it shortens the lead time between learning and knowledge sharing. Hence, the employees can share the knowledge quicker. Nonaka and Takeuchi (1995) hold that through Knowledge Management, improved innovation rather than higher efficiency is to be expected.

Knowledge Management (KM) Systems

Knowledge management (KM) systems are designed to gather, store and retrieve/disseminate information. These three basic functions are then complemented by incentive structures to ensure that the system is fully exploited.

Establishing the basic requirements of a KM system is fairly straightforward, We are involved in the:

- Gathering of information – to gather information, the company needs to establish procedures for documentation of projects, findings, and so on. The procedures should include how to document the information and how to control the relevance and quality of the selected material. It is important to avoid nonessential information. The main feature should be ease of use.
- Storage of information – storage should be in a database with easy access from all organizational levels.
- Retrieval of information – the system should also be able to compile data according to user needs and preferences. The structure of the database - the number of retrieval dimensions – depends on intended use.

Having established the KM market structure, implementation is not simply a question of employing a suitable IT solution. The challenge is to encourage people to come to market with their information.

Focus on Behavior, not Technology

One common mistake many organizations make when they design KM systems is to place too much emphasis on the technological aspects of the system. Knowledge is primarily a personal and social commodity and should be treated accordingly. The social aspects of knowledge sharing are crucial to the system's success. In order to make the system work it is important that it is easy to use and provides sample opportunities and incentives for personal interactions. This is particularly important for complex and contextual information that is best conveyed person-to-person.

Incentive Systems

Information has a price. It takes time to produce it and to find and consume it. It is, therefore, important to establish an incentive system that rewards knowledge sharing. Usually, employees are rewarded neither for sharing information, nor for searching for it. This lowers the motivation to use the KM system. It is thus extremely important to compensate employees for their work with the KM system, by perhaps providing extra time for them to document their work or by giving a bonus based on their diligence in recording their work.

Challenges Facing Knowledge Management

KPMG Consulting (2000) gave the following reasons for KM failing to meet expectations: lack of user uptake owing to insufficient communication, failure to integrate KM into everyday working practices, lack of time to learn how to use the system, a perception that the system was too complicated, lack of training, and a sense that there was little benefit in it for the user. Suggestions for successfully implementing KM projects also included: focusing on a department or group and building on that success; revamping the incentive system to reward information-sharing behavior (publishers of knowledge), and allocating a specific person(s) to the function of KM (Davenport, 1997; Kowalkowski, Angus, 1998).

Qualitative Research – Exploratory Research

Objectives

The research aimed at testing the readiness of IDSC's people to adopt knowledge management.

Design

The research design is the logical plan for how the study is conducted. It tells us how we got from here to there, where here may be defined as the initial set of questions to be answered, and there is some set of conclusions (answers) about these questions (Yin, 1994).

It is a logical model of proof that allows the researcher to draw inferences concerning causal relations among the variables under investigation. The research design also defines the domain of generalizability, that is, whether the obtained interpretations can be generalized to a larger population or to different situations (Yin, 1994). Also, the research design is the key to validity and reliability.

Two methods were used in the exploratory research:

- Surveys;
- In-depth Interviews.

Surveys

Two questionnaires were developed: one aimed at the senior manager in the IDSC and another aimed at lower ranking employees. The questionnaire aimed at testing the readiness of IDSC's people to adopt knowledge management. The questionnaire covered items such as:

- knowledge acquisition (do employees look for knowledge from internal or external sources, and is knowledge acquired deliberately or opportunistically?).
- ownership (do the employees generally regard their knowledge as highly personal or as being owned at the collective level?).
- memory (is knowledge chiefly held explicitly or tacitly?).
- challenges in implementing KM and in managing knowledge, and how IDSC encourages employees to share, contribute and reuse knowledge.

The employee questionnaire had some similar sections, but also covered areas on sharing of knowledge and barriers, impact on creativity, incentives, and privacy issues. The findings of these questionnaires helped in answering the major and minor research questions.

In-depth Interviews

The in-depth interviews were with the IDSC senior managers in order to assess the current knowledge management environment in IDSC and impediments facing managers in sharing knowledge. The interviews lasted around one hour and were conducted while the managers were filling out the questionnaire.

Defining the Population

IDSC consists of three branches located in three different buildings. There are 600 employees and managers in IDSC, 300 of them are working in support departments (as drivers, security, office boys, etc.). Those 300 were excluded; the other 300 was the survey population.

The sample consisted of 40 employees who spent more than one year in IDSC and 20 middle and senior managers.

About IDSC

The Information and Decision Support Center (IDSC) was initiated to support the Egyptian Cabinet's decision-making process in socio-economic development. It also acts as a catalyst for building Egypt's information infrastructure. Ever since its initiation in 1985, IDSC has been working on the process of building up Egypt's Information Technology (IT) industry and decision-support infrastructure, in addition to developing a base for the nation's software and hi-tech industries.

IDSC evolved around Egypt's dedicated efforts to join the international IT revolution, and institutionalize the decision-making process through accessing information. IDSC was also established with the long-term vision of providing public access to information, particularly business people and investors.

Over the past one and a half decades, the Center has successfully achieved its basic goals of setting up an information core for the Cabinet's decision-making process, and has also created channels for the local and international flow of information.

IDSC Objectives

- Developing information and decision-support systems for the Cabinet and top policy makers in Egypt.
- Supporting the establishment of end-user information and decision-support centers in the different ministries and governorates.
- Encouraging, supporting and initiating informatics projects that will accelerate Egypt's management and technological development.
- Participating in international cooperation programs and agreements, particularly in the areas of information and decision support.

The Organizational Memory

Some months ago, IDSC decided to build an online organizational memory (http:/ /www.home.idsc.gov.eg/) which is a part of a knowledge management initiative in IDSC. The main reason for this initiative was the high employee turnover of experienced staff which threatened the loss of IDSC's human memory .

The main objectives of this organizational memory were to:

- Prevent Knowledge Loss – It enabled IDSC to retain critical expertise and prevent critical knowledge loss resulting from retirement, downsizing.
- Improve Decision-Making – It identified the type and quality of knowledge required for effective decisions and facilitates access to that knowledge.
- Permit Adaptability and Flexibility – It allowed employees to develop a better grasp of their work, propose innovation solutions, work with less direct supervision.
- Provide Competitive Advantage – It increased the competitive advantage of IDSC.
- Develop Assets – It improved the organization's ability to capitalize on legal protection for intellectual property.
- Leverage Investment in Human Capital – Provided through the ability to share lessons learned, document processes, and the handling of exceptions, and capture and transmit tacit knowledge.

THE QUESTIONNAIRE

Part 1: Personal Information

The questions in this part were designed to get general information about the respondent.

Part 2: Questions Concerning the Methods Used by Staff to Acquire Information in IDSC

Questions in this part were each designed to:

- Discover whether the respondents had an overview of the knowledge available in IDSC or not.
- Measure a specific part of the knowledge management definition: identification, capturing, retrieval, sharing and evaluating. The aim was to identify weaknesses and strengths.
- Show how well the external and internal contacts and sources of information were used to spread and gather knowledge.
- Identify IDSC efforts to encourage the capturing and sharing of knowledge.

Part 3: Questions Concerning Knowledge Management in IDSC

- The first two questions in this part were each designed to measure if the IDSC employees understand what is knowledge management and what is the purpose of knowledge management.
- The third question in this part was designed to measure the degree of knowledge sharing between employees in IDSC.
- The fourth question in this part was designed to measure the degree to which tacit knowledge is shared between employees in IDSC.
- The fifth question in this part was designed to identify the barriers to sharing knowledge in IDSC. Employees and managers were asked to rank these barriers in a descending order, from the most important barrier to the least important one.
- The sixth and seventh questions in this part were designed to assess the impact of knowledge management and the availability of a knowledge base on creativity.
- The last three questions in this part were concerned with the privacy issues regarding knowledge sharing and the relation between competitiveness and knowledge sharing from the employee and manager point of view.
- In Part 3 two questions were added to the manager's questionnaire. The first question (question number 16) asked managers to rank difficulties facing them in the management of knowledge, the second question (question 17) asked managers to rank the impediments to knowledge transfer in IDSC.

ANALYSIS

The response rate was 100%, as the authors accompanied the respondent until he/she finished the questionnaire.

Analysis of Part 1

This part tried to find groups of respondents with different or common result profiles (see Table 2).

Analysis of Part 2

Questions in Part 2 concerned the methods used by employees to acquire information in IDSC (see Table 3).

Table 2

Name	31% of the respondents mentioned there names.
sex	62% of the respondents were females.
Group of age	60% of the respondents were under 30, 30% were under 45, 10% were under 60.
Job title	60% of the respondents are technicians(programmers, Web developers), 30% are researcher, 4% are executives, 5 % are head of department, 6% are managers, 1% were general managers.

Table 3. Questions concerning methods used by employees and managers to acquire information in IDSC

Which external sources do you use to obtain information ?	
Internet	90%
Universities	10%
Research institutes	6%
Testing institutes	3%
Other (governmental agencies)	60%
What kind of media do you use predominantly to obtain information?	
Telephone	80%
Facsimile	13%
E-mail	94%
Internet	90%
Intranet	14%
Magazines/Catalogues	4%
Professional literature	11%
Other	-
What additional private efforts do you undertake to obtain personal information benefits ?	
None	30%
Further education and training in my leisure time	55%
Private relation ships	9%
Private research work	20%
Magazines	5%
Others	-
What Kind of information do you need in your work ?	
Technical	40%
Commercial	50%
Product information	8%
Information about other companies	2%
Information about clients	5%
Latest news	18%
Others	6%

Do you have an overview on the knowledge available in IDSC?

This question was designed to test whether employees and managers had an overview of the knowledge available in IDSC as the more they were aware of what knowledge exists in IDSC the higher the chance of sharing knowledge and using knowledge-based and organizational memory.

44% of the respondents proved to have a good general overview of the knowledge available in IDSC; they were mainly managers, heads of departments and team leaders. 36% of the respondents proved to have a good general overview in their field of activities mostly researchers and technicians. The remaining 20% which do not have an overview of the knowledge available in IDSC were executives and technicians (see Figure 3).

How do you start to solve a problem?

This question were designed to test how managers and employees start to solve a problem, with the answer giving us a chance to see how much they depend on know-how available from previous projects which increase the importance of knowledge management as a tool to create organization memory and give IDSC the ability to become learning organization.

59% of respondents started solving a problem by using know-how from previous projects, 21% by telephone inquiries, 14% would establish a team and 7% would delegate the problem to others.

The next four questions were designed to show how well external and internal contacts and sources of information are used to spread and gather knowledge in IDSC and what kind of information they need. Employees and managers were able to choose more than one item.

It is obvious that the Internet and governmental agencies were the main source of information used by employees and managers. Internet, mail, and telephone were the main media used to obtain information. Technical and commercial information was the main kind of information obtained by employees and managers in IDSC.

Figure 3. Staff overview of the knowledge available in IDSC

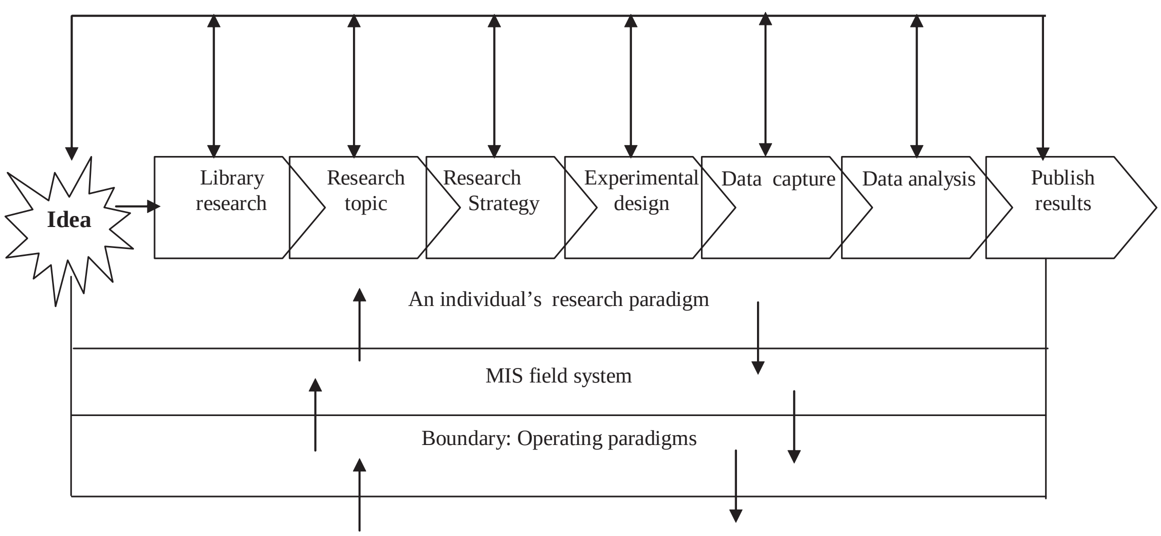


Figure 4. Information exchange occasions in IDSC

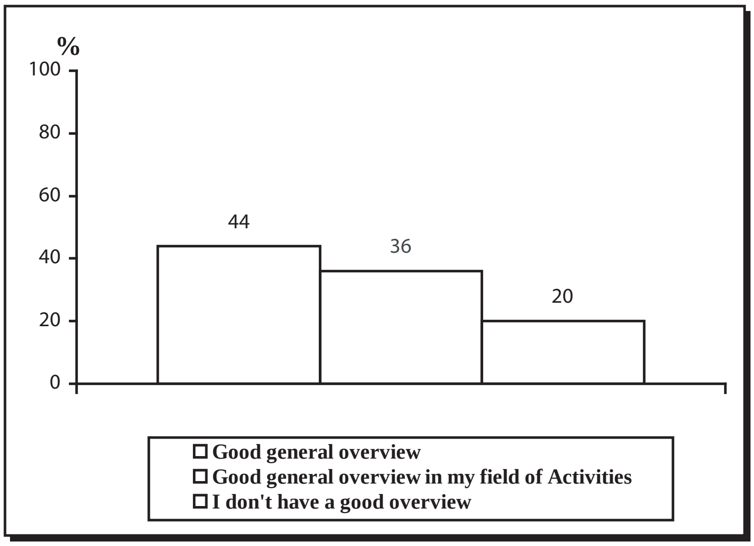
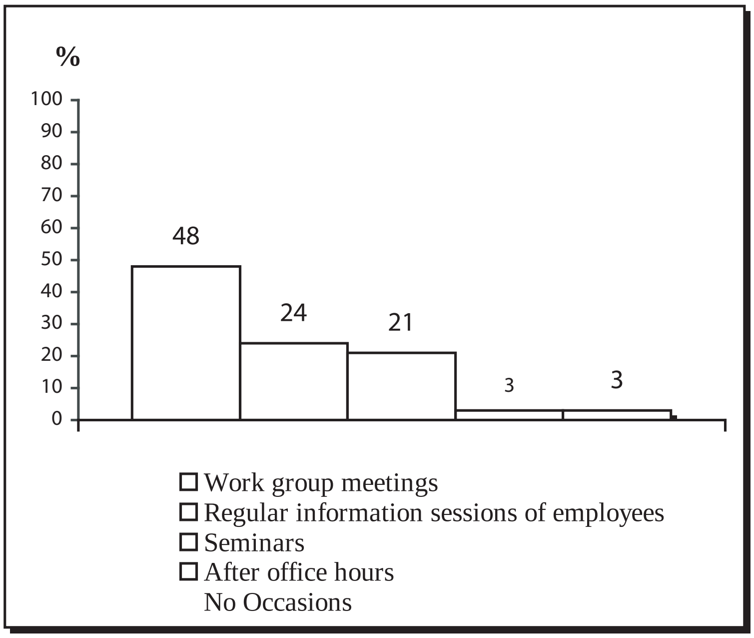


Figure 5. Information exchange among staff in IDSC



What occasions exist for an exchange of information in IDSC?

This question was designed to identify on what occasions employees and managers share information. Also, there was a weekly meeting for the whole IDSC and every employee can attend the meeting, but only 24% of employees said that it was a useful meeting. 48% of employees said the work group meeting was the most useful occasion to share information in IDSC (see Figure 4).

How does information exchange take place between older experienced employees and younger employees?

This question was developed to investigate whether the tacit knowledge was transferred from managers and experienced employees to new ones and how it was transferred. 54% of the respondents revealed that there was no regular exchange of information, 46% revealed that there was a regular exchange of information through mixed project teams (40%), individual training (4%) and (2%) other ways, like personal contacts inside IDSC (see Figure 5).

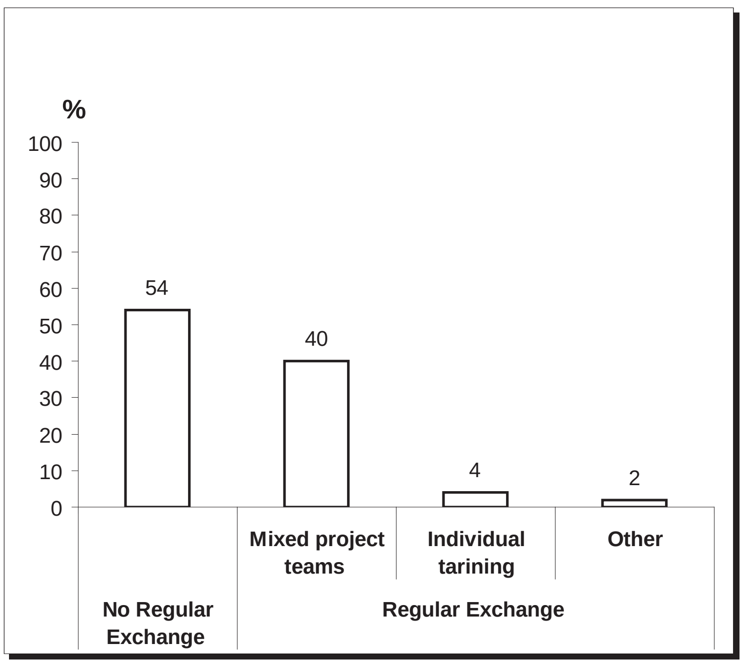
Analysis of Part 3 (Employees Questionnaire)

Questions in Part 3 concern the knowledge management environment in IDSC.

Do you have a general overview of what knowledge management is about?

Even though the IDSC has a KM system in place, 74% of respondents did not have a general overview of what KM is about. This shows that the IDSC management created the Organizational memory system to preserve, share and retrieve information and knowledge without taking into

Figure 6. Staff perception about purpose of knowledge management



consideration the necessity of increasing KM awareness among employees.

What do you think should be the purpose of knowledge management?

Figure 6 shows that 14% of employees and managers who had a general overview on knowledge management thought that the main purpose of KM was knowledge transfer ,10% thought the main purpose of KM was to avoid repetition of mistakes, and 2% think it was for time saving.

Employee Perceptions on Sharing Knowledge

Table 4 shows that 30% of employees in the survey shared knowledge "often" or "always" and 70% "occasionally." Despite this, 28% of the employees felt that it was common or very common for key information to be too localized, creating problems of access.

Employee Barriers to Sharing Knowledge

Employees were asked to rate a list of potential barriers or obstacles to knowledge sharing in their organizations. They were allowed to add any other items to the list (see Table 5).

In the literature, items such as "turf protection" and "people scared that their ideas will get hijacked" were sometimes given as high barriers to knowledge sharing. These research findings indicate that these barriers were ranked second and third respectively.

Table 4. Employee perceptions of sharing of knowledge

How well do employees share data, information and knowledge?	**Do Not**	**Poorly**	**Occasionally**	**Often**	**Always**
	0%	0%	70%	20%	10%
How often is essential Know how available only in the heads of a few employees, (and difficult to access when they are unavailable?	**Very Rare**	**Rare**	**Occasional**	**Common**	**Very Common**
	0%	12%	60%	20%	8%

Table 5. Employee barriers of sharing of knowledge

Average Ranking	***Employee Barriers to Sharing Knowledge***
1	Strong departmental barriers
2	"Turf protection" knowledge is power
3	People scared that their ideas will get hijacked
4	Lack of communication
5	Culture of working alone in closed offices
6	Expert knowledge in the heads of individuals
7	Distrust in other colleagues data
8	Personal data stores are common
9	Organizational rigidity and specialization- lack of multi-skilling
10	Rapidly changing technology- makes keeping up difficult

There was a lot of personal information kept by individuals (often only in their heads) which was not being shared, and there was not enough communication.

Employee Privacy Issues

Some 20% of the employees indicated that they felt compelled to share knowledge with their colleagues because of the knowledge sharing environment at IDSC. They were asked if they felt that privacy was a concern when it came to sharing knowledge. Although most were satisfied, 30% indicated that their privacy was invaded during the process of sharing knowledge. This percentage increased to 90% when personal work documents and e-mails were specifically included. 74% of the employees felt that their sharing of knowledge decreased their competitiveness with other colleagues for promotion. Table 6 shows a summary of the results in this area of research.

Difficulties in Managing Knowledge

Senior and middle managers were asked to rate a set of items which from past research had been shown to cause difficulties in managing knowledge in organizations. Their responses highlight the uncertainty experienced by many organizations with KM. Identifying the right leader/team

Table 6. Summary of employee opinions on privacy issues

Employee Privacy Issues	***Yes***	***No***
Do you feel that privacy of employees is an issue concerning the sharing of knowledge?	30%	70%
Does sharing of knowledge in your job situation decrease your competitiveness with other colleagues for promotions?	74%	26%
The knowledge gathering process may require reviewing your personal work documents and / or emails so as to add information to the knowledge repository. Do you feel this invades your privacy?	90%	10%
Do you feel compelled to share your ideas with colleagues because of the knowledge sharing culture at your firm?	20%	80%

Table 7. Difficulties in managing knowledge in IDSC

Rank	***Managers' Difficulties in Managing Knowledge***
1	Identifying the right leader/team for knowledge initiatives .
2	Attracting and retaining talented people
3	Determining what knowledge should be managed
4	Defining standard processes for knowledge work
5	Changing people's behavior
6	Mapping the organization's existing knowledge
7	Expert knowledge in the heads of individuals

Table 8. Management viewpoint on impediments to knowledge transfer

Rank	***Impediments to Knowledge Transfer***
1	Organizational culture
2	Staff turnover
3	Non-standardized process
4	Incentive system
5	Lack of ownership of the problem
6	Resistance to cultural change
7	Configuration /physical feature of workspace
8	Information/communication technology restraints

for knowledge initiatives, what knowledge should be managed, attracting and retaining the right staff, measurements and standards were added as further problems. And a major concern was the necessity of changing people's behavior. Noticeably "overcoming technical limitations" is last of the 10 items. This shows that IDSC was less concerned about the technical issues than the human and managerial ones. Table 7 gives an ordered listing of the managers' biggest difficulties in managing knowledge.

Management Viewpoint on Knowledge Transfer

Senior knowledge management personnel were given a list of impediments to knowledge transfer, based on prior research, and asked to rate them. Table 8 shows that they ranked organizational structural changes and staff turnover as the key impediments to knowledge transfer. Other management issues were also important, but technology concerns only came in eighth.

CONCLUSION AND RECOMMENDATIONS

Employees in IDSC acknowledge change management efforts to date, but do not feel that they are actively resisting the process of knowledge sharing. They are concerned about losing power they may have through sharing knowledge, and think that this will affect their competitiveness and promotion possibilities. They also perceive that the available knowledge base will aid creativity and productivity. They perceive that the major barriers to sharing knowledge are departmental barriers, expert knowledge often being held in the minds of individuals and lack of communication. Invasion of privacy is particularly an issue with them, especially when personal e-mails and documents are expected to be reviewed for possible addition to the knowledge base. Rapidly changing technology was their tenth rated concern.

A successful KM implementation clearly requires a culture of sharing, and a focus on human beings more than technologies and tools. This research has confirmed this. IDSC is not ready to implement a successful KM program.

There is a need to communicate the role of KM in the IDSC more fully to employees. Job descriptions and performance reviews should take into account the efforts made by employees in this regard. IDSC needs a strong incentive and reward system to encourage employees to share knowledge and to help in building the culture of sharing knowledge. Departmental barriers must be eliminated by forming cross functional teams to foster an environment where employees could walk into anyone's office to seek help. In addition, individual career successes should be tied to leveraging knowledge.

Measures of knowledge sharing must be built into everyone's performance objectives. A tool like the Balanced Scorecard (Kaplan and Norton 1996) could for instance be used to weigh the results of IDSC's knowledge-management initiative. IDSC should not only emphasize on the technological aspect of KM and must increase its effort to improve the humanitarian aspects.

REFERENCES

Davenport, T.H. (1997, June). Known evils: Common pitfalls of knowledge management, *CIO Magazine*.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Earl, M., & Scott, I.A. (1999, Winter). Chief knowledge officer. *Sloan Management Review,* 22-38.

Earl, M., & Scott, I.A. (1998). *What on earth is a CKO?* London Business School.

Gartner Group. (1998, November). 21st century vision. *Information Strategy, 3*(9).

Jordan, J., & Jones, P. (1997, June): Assessing your company's knowledge management style, *Long Range Planning, 30*(3), 392-398.

Kaplan, R.S., & Norton, D.P. (1996) *Using the balanced scorecard as a strategic management system*. Boston: Harvard Business School

Kowalkowski, F., & Angus, J. (1998, March). Implementing knowledge management projects, *Information Week*, March 16.

KPMG Consulting. (2000). *Knowledge Management Report 2000.* Retrieved from http://www.kpmg.co.uk/kpmg/uk/services/manage/pubs/km2000.pdf

Malhotra, Y. (2000, Summer). Knowledge management for e-business performance: Advancing information strategy to Internet time. *Information Strategy: The Executive's Journal.*

Nonaka & Takeuchi, H. (1995). *The knowledge-creating company.* New York: Oxford University Press.

Radding, A. (1998). *Succeeding in the unformation-based global economy* (1st ed.). Computer Technology Research Crop. ISBN 1-56607-059-7.

Stewart, T. (1997). *Intellectual capital The new wealth of organizations.* Doubleday.

Sveiby, K.-E. (1997). *The new organizational wealth: Managing and measuring knowledge based assets.* Berrett-Koehler.

Yin, R.K. (1994) *Case study research: Design & methods* (2nd ed.). London: Sage.

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Chapter 5.8
The Role of Culture in Knowledge Management:
A Case Study of Two Global Firms

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ABSTRACT

Knowledge management (KM) approaches have been broadly considered to entail either a focus on organizing communities or a focus on the process of knowledge creation, sharing, and distribution. While these two approaches are not mutually exclusive and organizations may adopt aspects of both, the two approaches entail different challenges. Some organizational cultures might be more receptive to the community approach, whereas others may be more receptive to the process approach. Although culture has been cited widely as a challenge in knowledge management initiatives, and although many studies have considered the implications of organizational culture on knowledge sharing, few empirical studies address the influence of culture on the approach taken to knowledge management. Using a case study approach to compare and contrast the cultures and knowledge management approaches of two organizations, the study suggests ways in which organizational culture influences knowledge management initiatives as well as the evolution of knowledge management in organizations. Whereas in one organization, the KM effort became little more than an information repository, in the second organization, the KM effort evolved into a highly collaborative system fostering the formation of electronic communities.

INTRODUCTION

Knowledge management (KM) efforts often are seen to encounter difficulties from corporate culture and, as a result, to have limited impact (DeLong & Fahey, 2000; O'Dell & Grayson, 1998). An Ernst and Young study identified culture as the biggest impediment to knowledge transfer, citing the inability to change people's behaviors as the biggest hindrance to managing knowledge (Watson, 1998). In another study of 453 firms, over half indicated that organizational culture was a major barrier to success in their knowledge management initiatives (Ruggles, 1998). The importance of culture is also evident from consulting firms such as KPMG who report that a major aspect of knowledge management initiatives involves working to shape organizational cultures that hinder their knowledge management programs (KPMG, 1998). These findings and others (Hasan & Gould, 2001; Schultze & Boland, 2000) help to demonstrate the profound impact that culture may have on knowledge management practice and of the crucial role of senior management in fostering cultures conducive to these practices (Brown & Duguid, 2000; Davenport, DeLong, & Beers, 1998; DeLong & Fahey, 2000; Gupta & Govindarajan, 2000; Hargadon, 1998; KPMG, 1998; von Krogh, 1998).

Studies on the role of culture in knowledge management have focused on such issues as the effect of organizational culture on knowledge sharing behaviors (DeLong & Fahey, 2000; Jarvenpaa & Staples, 2001) and the influence of culture on the capabilities provided by KM (Gold, Malhotra & Segars, 2001) as well as on the success of the KM initiative (Baltahazard & Cooke, 2003). More specifically, Baltahazard and Cooke (2003) ascertained that constructive cultures (emphasizing values related to encouragement, affiliation, achievement, and self-actualization) tended to achieve greater KM success. Similarly, Gold, et al. (2001) found that more supportive, encouraging organizational cultures positively influence KM infrastructure capability and resulting KM practice. Finally, Jarvenpaa and Staples (2001) determined that organizational cultures rating high in solidarity (tendency to pursue shared objectives) will result in a perception of knowledge as being owned by the organization, which, in turn, leads to greater levels of knowledge sharing.

While studies have shown that culture influences knowledge management and, in particular, knowledge sharing, there is little research on the broader aspects of the nature and means through which organizational culture influences the overall approach taken to knowledge management in a firm. The purpose of this research is to examine how organizational culture influences knowledge management initiatives. We use a case study methodology to help ascertain the relationship of the organizational culture to the knowledge management approaches within two companies. The following section discusses knowledge management approaches and organizational culture. The third presents the methodology. The fourth section presents the two cases and the fifth, and discusses the case findings, implications, and conclusion.

LITERATURE REVIEW: KNOWLEDGE MANAGEMENT APPROACHES AND ORGANIZATIONAL CULTURE

Knowledge Management Approaches

Knowledge can be defined as a form of high value information (either explicit or tacit) combined with experience, context, interpretation, and reflection that is ready to apply to decisions and actions (Davenport et al., 1998). While all firms may have a given pool of knowledge resources distributed throughout their respective organization, they may be unaware of the existence of these resources as well as how to effectively leverage them for competitive advantage. Therefore, firms must engage in activities that seek to build, sustain, and leverage these intellectual resources. These types of activities, generally characterized as knowledge management, can be defined as the conscious practice or process of systematically identifying, capturing, and leveraging knowledge resources to help firms to compete more effectively (Hansen, Nohria, & Tierney, 1999; O'Dell & Grayson, 1998).

There are two fundamental approaches to knowledge management: the process approach and the practice approach. The process approach attempts to codify organizational knowledge through formalized controls, processes, and technologies (Hansen et al., 1999). Organizations adopting the process approach may implement explicit policies governing how knowledge is to be collected, stored, and disseminated throughout the organization. The process approach frequently involves the use of information technologies, such as intranets, data warehousing, knowledge repositories, decision support tools, and groupware (Ruggles, 1998), to enhance the quality and speed of knowledge creation and distribution in the organizations. The main criticisms of this process approach are that it fails to capture much of the tacit knowledge embedded in firms and that it forces individuals into fixed patterns of thinking (Brown & Duguid, 2000; DeLong & Fahey, 2000; Hargadon, 1998; von Grogh, 2000).

In contrast, the practice approach to knowledge management assumes that a great deal of organizational knowledge is tacit in nature and that

Table 1. The process vs. practice approaches to knowledge management

	Process Approach	**Practice Approach**
Type of Knowledge Supported	Explicit knowledge—codified in rules, tools, and processes	Mostly tacit knowledge- unarticulated knowledge not easily captured or codified
Means of Transmission	Formal controls, procedures, and standard operating procedures with heavy emphasis on information technologies to support knowledge creation, codification, and transfer of knowledge	Informal social groups that engage in story telling and improvisation
Benefits	Provides structure to harness generated ideas and knowledge Achieves scale in knowledge reuse	Provides an environment to generate and transfer high value tacit knowledge Provides spark for fresh ideas and responsiveness to changing environment
Disadvantages	Fails to tap into tacit knowledge. May limit innovation and forces participants into fixed patterns of thinking	Can result in inefficiency. Abundance of ideas with no structure to implement them.
Role of Information Technology	Heavy investment in IT to connect people with reusable codified knowledge	Moderate investment in IT to facilitate conversations and transfer of tacit knowledge

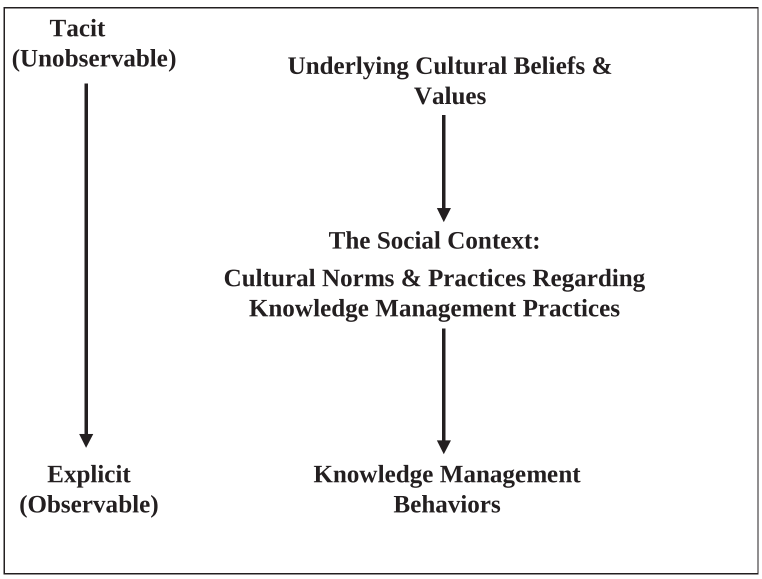
formal controls, processes, and technologies are not suitable for transmitting this type of understanding. Rather than building formal systems to manage knowledge, the focus of this approach is to build social environments or communities of practice necessary to facilitate the sharing of tacit understanding (Brown & Duguid, 2000; DeLong & Fahey, 2000; Gupta & Govindarajan, 2000; Hansen et al., 1999; Wenger & Snyder, 2000). These communities are informal social groups that meet regularly to share ideas, insights, and best practices.

Drawing from this discussion, some key questions emerge. First, how does culture affect organizations' approaches (e.g., process or practice) to knowledge management? Second, as organizations pursue these initiatives, how do cultural influences affect the KM activities of knowledge generation, codification, and transfer? To address these questions, it is necessary to explore the concept of organizational culture.

Organizational Culture

Schein (1985) defines organizational culture as a set of implicit assumptions held by members of a group that determines how the group behaves and responds to its environment. At its deepest level, culture consists of core values and beliefs that are embedded tacit preferences about what the organization should strive to attain and how it should do it (DeLong & Fahey, 2000). These tacit values and beliefs determine the more observable organizational norms and practices that consist of rules, expectations, rituals and routines, stories and myths, symbols, power structures, organizational structures, and control systems (Bloor & Dawson, 1994; Johnson, 1992). In turn, these norms and practices drive subsequent behaviors by providing the social context through which people communicate and act (DeLong & Fahey, 2000). Putting this into the context of knowledge management, organizational culture

Figure 1. The impact of organizational culture on knowledge management behaviors



determines the social context (consisting of norms and practices) that determines "who is expected to control what knowledge, as well as who must share it, and who can hoard it" (Delong & Fahey, 2000, p. 118). Figure 1 illustrates this conceptual linkage between culture and knowledge management behavior.

As Figure 1 depicts, the social context (consisting of norms and practices) is the medium for transmission of underlying values and beliefs into specific knowledge management behaviors. While Figure 1 is useful to explain the conceptual linkage between culture and knowledge management behavior, further explanation is needed to inform our understanding of the types of cultures that exist within organizations.

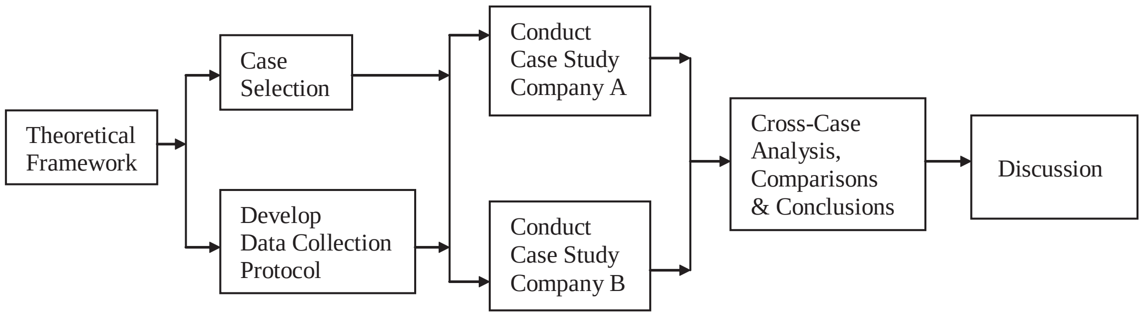
A number of theories have attempted to define culture at the organizational level. Wallach (1983) conceptualizes organizational culture as a composite of three distinctive cultural types: bureaucratic, innovative, and supportive. In bureaucratic cultures, there are clear lines of authority, and work is highly regulated and systematized. Innovative cultures are characterized as being creative, risk-taking environments where burnout, stress, and pressure are commonplace. In contrast, supportive cultures are those that provide a friendly, warm environment where workers tend to be fair, open, and honest. From Wallach's (1983) standpoint, any given firm will have all three types of culture, each to varying levels of degree. Wallach's (1983) cultural dimensions were developed based upon a synthesis of other major organizational culture indices. Wallach's (1983) cultural dimensions were applied by Kanungo, Sadavarti, and Srinivas (2001) to study the relationship between IT strategy and organizational culture. Part of the attractiveness of Wallach's (1983) dimensions, in comparison with other commonly used cultural indices such as the Organizational Culture Profile scale (O'Reilly, Chatman, & Caldwell, 1991); the Competing Values Framework (Quinn & Rohrbaugh, 1983); and the Organizational Value Congruence Scale (Enz, 1986), is that it is highly intuitive. Managers readily can identify with the descriptions of the three general culture types. Consistent with Kanungo, et al. (2001), we will employ Wallach's (1983) approach to describe organizational cultures. Specifically, we are interested in the following question: How does organizational culture influence knowledge management initiatives?

Methodology

A case study method involving multiple (two) cases was used. The approach of the study is depicted in Figure 2. The figure, based on the work of Yin (1994), displays the replication approach to multiple-case studies. As illustrated in Figure 2, the initial step in the study involved the development of a theoretical framework on the relationship between organizational culture and organizational knowledge management (KM) strategies. This step was then followed by the selection of the two specific cases (the data collection sites) and the design of the data collection protocol. Following the case selection and data collection steps, the individual case reports were developed. A cross-case analysis of the findings was then undertaken. This analysis provided the basis for the theoretical and normative discussions and implications presented in the final section of the article.

The two case studies involve two very large global corporations: Company A and Company B. Company A is a global consumer goods company with 369,000 employees worldwide. The company is headquartered in the U.S. and operates in four other regions: Europe, the Middle East and Africa, Central and South America, and Asia. Company revenues consistently exceed $20 billion. In Company A, large-scale knowledge management projects were initiated at the North American region in 1996. Company B is a high-tech global company with multiple product lines and services. Similar to Company A, Company B is headquartered in the U.S. and operates globally

Figure 2. Case study methodology adapted from Yin (1994)



in other regions of the world. With approximately 316,000 employees, its revenues exceed $80 billion. Large-scale knowledge management projects were initiated in Company B in 1995.

These two companies were selected for the purpose of this study for the following reasons. First, significant opportunities and challenges are associated with knowledge management activities in large and geographically dispersed companies. Thus, identification of factors such as organizational culture that may influence KM outcomes in this type of organizations potentially can lead to high payoffs. Second, considering the high levels of organizational resources required for implementation of large-scale knowledge management initiatives, these initiatives most likely are encountered in very large firms. Thus, the phenomenon of interest to these researchers could be best investigated in the context of very large firms with an established track record in KM projects. Finally, past contacts that one of the researchers had with these two firms facilitated their recruitment as case study sites.

Data Collection

Data for this study were collected through semi-structured interviews with a small group of managers and professional employees at the two company locations in the U.S. Identical approaches to data collection were used at Company A and Company B1. Six individuals at each of the two companies were interviewed. In each of the two companies, three of the interviewees were the current or potential users of the KM systems. The remaining three interviewees in each company were the KMS sponsors or supporters. The interviews took between 45 and 85 minutes and were conducted between October 2001 and January 2002. All the interviews were tape recorded and then transcribed for data analysis. The interviews all followed the same protocol. The informants first were asked to characterize their organization's culture in their own words. The three cultures described by Wallach (1983) were then portrayed, and the informants were requested to identify which one best described their organization. The interviewees next were asked to describe and characterize the KM practices in their company. A set of specific questions guided the discussions of these practices. For example, informants were asked to describe the specific KM activities that they engaged in and to discuss the effects of these activities on themselves and/or their peers. Informants were also asked to describe any resistance and impediments to KM that they might have noticed in the organization. The same interviewer, using identical data collection protocols, conducted all the interviews in Company A and Company B. The interviewer carefully read the transcripts to ensure accuracy.

Data Analysis

An author not involved in the interviews and, hence, having no predisposed interpretation of the transcripts, conducted the data analysis. Based upon the transcribed interviews, 12 profiles were written, each one based upon the perspective of a single informant. These profiles described the informants' perspective of culture and their perspective of KM. The profiles of informants for Company A were compared and contrasted with each other, as were those of Company B. Cases for each company, reported in the next section, then were written, based upon the within-case analysis. The cases for each company then were interpreted from the perspective of how the culture appeared to be influencing the organizational KM initiative. This is also reported in the next section. After the two cases and their within-case analysis were complete, a cross-case comparison and contrast was undertaken, leading to the formulation of the discussion section.

CASE DESCRIPTIONS AND ANALYSES

Knowledge Management at Company

Knowledge management at Alpha began as a top-down idea, courted by senior management "as a way of helping the company become more leading edge" according to one informant. A small group of eight or nine individuals at headquarters was charged with driving knowledge management and facilitating knowledge sharing. As a result of larger issues surfacing, most notably the economic downturn that rocked U.S.-based businesses in early 2000, the top-level initiative fell into the background, and the small, dedicated group was disbanded. Thus, at the organizational level, KM was an idea that received neither funding nor action. However, at the business unit level, successful KM initiatives have been built around an intranet or around Lotus Notes team rooms.

Intranet-Based KM Projects

One initiative in the marketing area of corporate headquarters is called MIC — marketing information center. MIC serves the global marketing community of several thousand individuals around the world. It is an intranet-based library containing links to agencies, compensations, human resource information, and contracts, among other things. MIC is opportunity-oriented rather than problem-oriented. The members do not use the community to post a problem inquiry and await responses but rather to look for ideas performed in other parts of the company and think about adopting the ideas to their local group.

MIC is intended to be a catalyst for collaboration and to propel a universal worldwide marketing community. Because the chief marketing officer no longer allows the budgeting of glossy manuals or brochures, MIC is widely accepted as the primary means of obtaining such static information. In fact, as attempts were made to include best practices in MIC, the initiative encountered resistance. Explains one informant, "We could never nudge the culture enough to have people understand and be motivated to enter their information." Another informant felt that there were challenges in overcoming "people's fear of being judged for their ideas and their indifference to yet another information site."

CM connection (CMC) is another KM initiative within the North American marketing unit. This is a Web-based marketing repository used to disseminate information so that wholesalers that are responsible for store-level execution can have access to the most recent information on how to merchandise the latest promotions. As with MIC, the major impact of CMC has been the reduction of the number of printed catalogs; in this case, by 80%. Among the challenges experienced with CM connection has been convincing content providers to own the information in the sense of both providing it and keeping it up-to-date. Another issue has been that CM connection is seen by some as distracting from their relationships with clients. Even while MCC may reduce the amount of time spent traveling, this is not necessarily welcome in "a sales and marketing oriented relationship company because you are taking away relationship points."

The Human Resources unit with the Corporate Functions unit also has an intranet-based KM, referred to as My Career. My Career is designed for managers and employees to help provide information about what tools, classes, and coaching are available for development. One of the goals of My Career has been to merge all of the training information into one place.

Many such intranet-based KM have been developed throughout Alpha, so many that the portal project was initiated to alleviate the problem of "too much information in too many places, different IDs and passwords for each database, having to remember what is in the database to even go to get the information." However, despite some initial receptiveness to the idea from the head of the New Business Ventures unit, IT budgets were frozen and the project never got underway.

The common thread running through the intranet-based KM projects at Alpha is that they all are geared to housing static information with the most major impacts being the reduction in printed catalogs. Among the greatest resistance, according to informants, is that these KM projects appear to try to standardize work practices in a company comprised of "creative assertive people who want to do it their way and make their own individual mark."

Lotus Notes-Based KM

Lotus Notes forms the basis of other KM initiatives within Company A. What distinguishes the Lotus Notes-based KM projects from the intranet-based KM projects is the added focus on facilitating teamwork. The Lotus Notes-based initiatives developed independently from the intranet-based initiatives. The North-American marketing group developed a Lotus Notes-based community of interest. The system contains examples of briefs, shared research, shared examples of different sites, and information on internal research. This micro KM has 50 to 60 regular users. An important feature of the system is that whenever new information is added, community members receive an e-mail. In this way, members visit the community when new information that is relevant to them has been posted. This KM project has served as a means of sharing best practices. For example, a marketing manager from the UK posted information concerning a successful auction initiative, which was then emulated by five other countries. On an individual level, KM has helped to increase the frequency of communication among members of the community. Similarly, HR developed HR Source, a Lotus Notes-based general bulletin board, where meeting notes, follow-up action items, strategy documents, and work plans are placed. It is shared by the HR community on a global basis.

Lotus Notes is also the platform used to develop team rooms. The individual responsible for managing team rooms for North America has what he calls the six-month rule: if a team room is not getting regular utilization for more than six months, it is deleted so that they can save money on the server expense. He says that he deletes about 70 to 80% of team rooms. He thinks the lack of reward is the biggest barrier toward KM system usage: "People who don't have technology in their title don't take it upon themselves and are not generally rewarded for exploiting technology." Also, content management is a barrier: "This is the responsibility of the end user but it is perceived as the responsibility of the technology group." However, a marketing manager had another opinion, attributing lack of use of the team rooms to self-preservation: "Even if someone took the time to put something out there, even if I knew it was there, went and got it, had the time to review it, and understand it, I am going to create this other thing by myself. I might look at that as input, but then it is the new XYZ program and I created it."

ANALYSIS OF ALPHA'S KNOWLEDGE MANAGEMENT: THE IMPACT OF CULTURE ON KM BEHAVIORS AND OUTCOMES

The Perceptions of Culture

While each individual interviewed gave their own perception of the culture at Alpha, and while the perceptions naturally contain some variance, there is a marked theme running throughout the individuals' views. Informants describe Alpha as risk averse and bureaucratic. They speak of an environment where people don't want to be noticed, where direction is unclear, and where individual survival trumps teamwork. Moreover, informants state that people work in silos, feel isolated, and are afraid of being criticized for their ideas. The slow, bureaucratic, hierarchical culture at Alpha has resulted in silos of information. As a consequence, managers indicate that even though they have great consumer and customer information, they end up reinventing the wheel 1,000 times. However, our informants also maintained that although they characterize the culture as bureaucratic, they also sense that Alpha is striving to become more innovative and supportive.

The Possible Impacts of Culture on KM

The statements and observations of our informants point to two largely shared perspectives: (1) the culture emphasizes the individual, and (2) the culture is in a state of transition. In understanding the impacts of KM, one can see the influence of the individuality within Company A. Table 2 lists the characteristics of culture, characteristics of the KM initiatives, and characteristics of KM behaviors as expressed by the informants.

At work within Alpha seems to be a tension between a culture that demands individuality and the communal aspects of KM. The informants talk about a culture that is one of "individual survival" where individuals "fear being judged for their ideas," where there is individual "isolation," and where individuals try to go unnoticed. The overall feeling is that of individuals trying to avoid being noticed. Such a culture does little to foster the sense of community that may be necessary to enable KM to move beyond static repositories of information into the kind of dynamic system envisioned by developers, where ideas flow freely and where KM provides a catalyst for collaborative engagement. Not only are individuals reluctant to share their information for fear of being criticized for their ideas, they also are reluctant to use information posted in a KM for lack of credit for the idea. Such behaviors can spring from a culture that emphasizes individual ideas and contribution.

The individual aspects of the culture go well beyond individuals behaving in a certain way because of a rewards system but reflects an underpinning notion that to succeed in a marketing-oriented organization, one must be creative and that creativity is perforce, of an individual nature, so that to survive as an individual, one must capture ideas and only share them if they are going to be favorably judged. One must not look to others for learning or for problem solving but might look to

Table 2. Characteristics of culture, KM initiatives, and KM behaviors

Culture Characteristics	KM characteristics	KM behaviors
Dominant culture is Bureaucratic Emphasis on individual: *individuals are “risk averse” *individuals fear being criticized for ideas *individuals are uneasy and prefer to go unnoticed *individuals relationships externally, particularly within the marketing unit, are perceived as critical to their success	Intranet-based “static” repositories of information Failed top-down effort Bottom-up initiatives largely targeted creation of repositories Some use of Lotus-Notes to create team rooms Team rooms have high failure rate	Individuals access information on “as-needed basis” Individuals reluctant to contribute information Individuals reluctant to own and maintain content Individuals uncomfortable using ideas from the systems, since they do not own the idea Individuals use repository when rules prohibit printing brochures Individuals reluctant to use tools that would result in a loss of touch points with customers

reuse creative ideas in some circumstances (like the auction site example from the UK) where one may tailor the idea to one’s environment. It is telling that the informants speak of using outsiders (e.g., consultants) to assist with problem solving and learning instead of attempting to use any of the existing KM to post queries, and this in spite of the fact that it is recognized that the company reinvents the wheel 1,000 times.

Another tension within Alpha seems to stem from the expectations of what should occur in a bureaucratic culture and what was occurring. The top-down approach to KM, an approach that would be consistent with a bureaucratic organization, had failed at Alpha. Yet, despite the failure of the top-down approach to KM and the seeming success of several bottom-up approaches, such as MIC and the marketing team room for the community of 50, one informant still proffered the need for top management leadership to be the key to success with KM. He considered the bottom-up approaches as “band-aid-approaches.” In his opinion, power within Alpha comes “from knowledge hoarding, not knowledge sharing.” In order for KM to be assimilated in this environment, “behavior really has to come from the top. Leadership needs to walk the walk.” In a bureaucratic culture, individuals become accustomed to clear guidance from senior management. The absence of clearly stated support from senior management may be sufficient to deter many from experimenting with the KM tools available to help them.

Summary

Alpha has many KM initiatives that were developed largely as bottom-up initiatives. The KM tools seem well designed and housed with valuable information. The informants are able to use the tools to facilitate the retrieval of information that they need in the performance of their jobs. However, the tools have not progressed yet to the level of fostering collaboration. While there are some successful communities from the standpoint of providing a place to share meeting notes and plans, the majority of team rooms remain unused and, if used, become as much a library of information as a communication tool. In some ways, the culture of Alpha appears to foster the types of KM behaviors observed, in that the individual is seen as the primary source of innovation and ideas as opposed to the community being the ultimate source of success. Thus, individuals will use the systems as needed but are occupied mostly with their individual roles and work and do not attribute value to the collaborative features of technology.

The Case of Beta

Beta is organized into seven major units. Our interviews were concentrated within the Innovations Services group of the consulting wing (referred to as Worldwide Services Group, or WSG) of Beta.

Knowledge management at Beta began in 1996 with the view that KM was about codifying and sharing information, leading to the creation of huge repositories of procedures and process approaches. It was assumed that people would go to a central site, called Intellectual Capital Management System (ICM), pull information down, and all would be more knowledgeable. ICM is under the protection of the Beta Corporation. There is a process one must undertake to have information submitted and approved. The process is complicated by legalities and formalities. As a result, ICM is not used as widely as it could be. What was discovered from the initial foray into knowledge management was that the information was not being refreshed and that the approach was not complementing the way people really learned, which was through communities. Consequently, the KM initiative began to shift to providing tools to communities that would help foster collaboration both within teams and within locations and around the globe. Among the tools are team rooms and communities.

Team Rooms

Lotus Notes-based team rooms are widely used at Beta to coordinate virtual teams and to share important documents. Access to team databases are limited to the members because of the confidential nature of a lot of the issues. The project manager or someone delegated by the project manager takes the responsibility of sanitizing the material and posting the most relevant parts to a community system such as OC-zone (to be discussed later) and/or to the ICM after the team's project has been completed.

The team rooms are valuable tools to help members keep track of occurrences as well as to help newly assigned members get quickly up to speed. Because of the itinerant nature of the Beta consultant's life, it is invaluable to have the documents they need stored in an easily accessible manner that does not require sending and receiving files over a network. Team room databases also are used for managing the consulting practices. It is important in helping new people with administrative tasks (e.g., how to order a piece of computer equipment, how to order business cards). The team rooms keep track of such metrics as utilization so that members of the team know "who's on the bench and who's not." One informant gave the example of a recent project she was put on at the last minute that involved selling a project to a government department in another country. She was able to access all the documentation from the team room and become a productive member of a new team very quickly: "I can go in and start getting information about a particular topic and work with colleagues almost immediately. It allows me to work more easily with colleagues across disciplines."

Although team rooms are invaluable in organizing and coordinating project teams, there are also some potential drawbacks. Some view the team rooms as engendering "a false sense of intimacy and connectedness." This sense of intimacy can be productive for the team as long as things are going well. However, "if things go south," says an informant, "you don't have the history or skill set to really deal with difficult situations." As a result, instead of dealing with the conflict, the team is more likely to just take someone off the team and replace the person with another. In this sense, problems are not solved so much as they are avoided, and team members take on an expendable quality.

Communities

Communities serve members based not upon project or organizational position but upon interest. By 2000, a group referred to as the organizational change (OC) group had established a successful community of 1,500 members cutting across all lines of business and was beginning to act as consultants to other groups trying to set up communities. The OC community has gone so far as to quantify the business return of such a community in terms of cycle time reductions and sophistication of responses to clients. The OC community is comprised of tools, events, and organization.

1. Tools. The technology tools at the disposal of the OC community are databases of information submitted by team rooms, including such things as white papers, projects, and deliverables, as well as client information. The databases also contain pictures of community members with personal information about the members.
2. Events. An important aspect of the OC community is the events that are organized for community members. These include monthly conference call meetings, which generally are attended by 40 to 90 members, and replay meetings, which draw another 40 to 70 members. In the past, the community has sponsored a face-to-face conference for members. Members often meet others for the first time, yet they already feel they know each other.
3. Organization. The organization of the community is managed by two community leaders. When people request information or have queries to post to members, they send their messages to one of the community leaders. The leader first tries to forward the message directly to a subject-matter expert (SME). If the leader does not know offhand of an appropriate SME, the leader will post the question to the entire group. In this event, the group members respond to the leader rather than to the community in order to avoid an inundation of messages. The leader normally receives responses within an hour. The leader then forwards the responses to the individual with the query. Later, the leader sends an e-mail to the person who made the inquiry, asking how the response was, how much time it saved, and so forth. The leader normally gets back as many as 28 responses to a particular inquiry. The leader has manually loaded a portion of what he or she has developed in the past seven months. There are 114 pieces of intellectual capital that the leader has loaded, and it is just a portion of what the leader has received.

The community has a structure that consists of a senior global board of 30 members representative of different parts of the business. There is a subject matter council that constantly scans the intellectual capital, as well as an expert council and the health check team.

The health check team examines such things as how well members communicate with each other. They conducted an organizational network analysis to help better understand the communication networks. The team has a series of questions to help assess how they are doing in terms of high performance teaming. They use a survey that measures perceptions from the community members about what they see is happening and do a gap analysis on what is actually happening. Finally, the team does a self-assessment of where it is compared to the community maturity model developed by the OC community leaders. There is a community mission, vision, and goals, and they are working on capturing data to support the metrics to demonstrate value to the company and community members.

The goal is to attain level-5 maturity, which is considered an "adaptive organization." There are 13 areas of focus at which the community leaders look in building a sustained community. While communities are felt to be organic, there is also a community developers kit with an assessment tool to determine at what level of maturity a community is and what steps need to be taken to move the community forward. One community leader says that the purpose of the development kit "is not to confine, but to provide a road map in which to navigate and build." For this leader, the essence of community is continuous learning. Of the initial KM efforts focused on information repositories, the leader says, "I could see the technology coming that was going to enslave people, like an intellectual sweat shop." By contrast, the primary tools for a community are "passion and environment."

Impact of OC

Among the major impacts of the OC zone is that having a community helps people not feel isolated. "People feel they are affiliated, that they are part of the company." Thirty percent of Beta employees do not have offices and work from home or the client sites. Such a work environment easily can be associated with isolation. However, the community is claimed by some to provide clarity of purpose. "I see it as a conduit for both developing thought leadership and enabling thought leadership to get into the hearts and minds of the workers so that they all have a common vision, goals, and objectives."

Community members view the purpose of the community as a knowledge-sharing forum and as a means to create a sense of belonging. One member went so far as to suggest that she would "not be at Beta any longer if it wasn't for this community." The reason is that most of her connections at Beta have been made through the community. Also, being in the community helps her to get assigned to projects. For example, the leader of a new project will call someone in the community and say that they are looking for a person with a certain profile. She finds that she gets asked to work on projects this way.

Other members refer to the community as a supportive family and state that within the community is someone who has already encountered any issue they will encounter on a project, so the community keeps them from reinventing the wheel. The norms of operation exist to help the OC zone be as effective as possible. No one is under obligation to contribute, but individuals contribute in order to help other people. One member credits the success of the community to the two leaders, whom she feels "in their hearts, care about the members of the community." She feels that the community is more than a community of people who like the topic of organizational change, but it is a community of people who support one another.

The primary resistance to the OC community has been the practice managers. Most of the community members report to practice managers. The practice managers are used to thinking in terms of billable hours. Indeed, the performance evaluation system requires that an individual's goals support those of his or her boss, which support those of his or her boss, and so forth. The community leaders hope that one day, participating in a community will be included as a standard part of this evaluation system.

ANALYSIS OF BETA KNOWLEDGE MANAGEMENT: THE IMPACT OF CULTURE ON KM BEHAVIORS AND OUTCOMES

The Perceptions of Culture

All of the respondents from Beta work within the same business unit. The respondents describe the culture of Beta as a blend of hierarchical and innovative. The hierarchical aspects are evident in that little innovation is undertaken until senior management has officially supported the innovation, but once senior management does give the green light to an idea, "everybody jumps on it."

One aspect of culture that is highlighted by the informants is the importance of collaboration. Informants characterize the street values within Beta as win, team, and execute. Beta informants recognize a duality of culture that, on the one hand, gives individuals control over their work and, at the same time, is highly supportive of the individual. The culture is autonomous in the sense of not having someone looking over your shoulder and telling you what to do. While there is certainly competition (i.e., everyone has objectives that they are trying to meet), things "are always done in a collaborative helpful spirit."

The other dominant aspect of culture, as related by the informants, is hierarchy. The hierarchy is as much a hierarchy of experience as of structure. Community members, for example, proffered that becoming a subject matter expert is more about length of service to the company than to one's inherent knowledge. Another aspect of the bureaucratic culture is that "there is very much a correct way to do things."

Table 3 lists the characteristics of culture, KM initiatives, and KM behaviors expressed by the Beta informants.

Table 3. Characteristics of Company B culture, KM initiatives, and KM behaviors

Culture Characteristics	KM characteristics	KM behaviors
Hierarchical, yet collaborative and innovative Individuals largely responsible for their own careers, yet competition is undertaken in a cooperative manner The team is the unit of success, more so than the individual Absence of extreme supervision of individuals' work--individuals have a sense of control	Company-wide information repository consisting of hundreds of information databases Team rooms used by project teams Communities of practice emerging. These communities include: tools, events, and structures The OC community is used as an example of a successful community and as a consultant to other emerging communities	Team members actively coordinate via the team rooms Community members obtain a sense of belonging to the community Community members post information from completed team projects to the community out of a sense of commitment, not coercion Community members are more loyal to the company (less likely to depart) because of their belonging to the community Assignments to projects made through community references

Beta's emphasis on collaboration seems to have enabled the progression of KM from a static information repository system into active, vital communities of interest, wherein individuals feel a sense of belonging to the extent that they identify themselves first with the community and second, if at all, with their actual formal business units. One informant claimed to not identify herself at all with the Innovation Services unit. Of course, one could ponder whether such identity transfer from the business unit to the community serves the best interest of the unit.

At the same time, the bureaucratic and innovative aspects of the culture also have helped. Having senior management show interest in KM was a catalyst to individual groups undertaking KM initiatives with great enthusiasm. In addition, rather than ad hoc communities that are entirely organic, the community model emerging at Beta is a relatively structured one.

While one can make the argument that Beta's culture influences KM development and use, one also can argue that KM at Beta is influencing Beta's culture. OC members claim that without a sense of connection provided by the OC community, Beta would be nothing but a "big and scary" company in which individuals "get lost." The community, though, allows and enables a culture of connection. In effect, one informant believes that the OC community attempts to shift a very technical, phone-oriented, work-product-oriented way of communicating with each other into a more personal work-in-process movement toward what Beta refers to as "thought leadership." When asked why members take the time to participate in the community when there is no formal reward for doing so, one informant said simply, "It's just how we do business." Thus, the community has infused the culture of the members.

Yet, this does not suggest that an organizational utopia has been or will be achieved. While the culture is becoming more connected, there is another angle. One informant believes that when you have widespread access to knowledge management, you also can have a culture where people that know very little about something have access to enough information to be dangerous. People get too comfortable with having access to knowledge and then feel free to share it. This informant remained unconvinced that the knowledge one acquires through the network is as solid a foundation as the knowledge one has acquired through experience and traditional learning. Moreover, she feels that the notion of dialogue can get redefined in a way that you lose the quality of participation that one might be looking for.

Summary

Beta has many KM databases, collectively referred to as Intellectual Capital Management. While these databases serve an important role of housing and organizing information in a huge organization, they do not go so far as to foster collaboration. Instead, team rooms and communities of interest, largely left to the discretion of team members and community members, have proven to be vital tools to achieving collaboration, community, and belonging. As the culture of Beta has been receptive to individual groups setting and pursuing their community agendas, the culture also is being subtly altered by the communities as members feel that they belong more to the community than to their business units.

DISCUSSION

The two cases offer insights into the role that organizational culture plays in the inception and maturation of KM. This section summarizes the key findings that help us to answer the following question: How does organizational culture influence KM approaches? We suggest four responses to this question.

1. Organizational culture influences KM through its influence on the values organi-

zational members attribute to individual vs. cooperative behavior. The two companies we examined share several similarities. Both huge multinational organizations are regarded widely by organizational members as being predominantly bureaucratic in culture. Both organizations had initial KM approaches that were strongly supported by senior management. And both had initial KM approaches focused on the creation of a large centralized repository of organizational knowledge to be shared throughout the organization. These two large bureaucratic organizations began their KM quests with the process approach. The most striking difference between the organizational cultures of these two companies was the emphasis at Alpha on the individual and the emphasis at Beta on collectivity — the team or community. This evinces itself even in the interpretation of innovation. While individuals at both companies spoke of the need for innovation in their organizations and of the striving of their organizations to develop an innovative culture, in the case of Alpha, innovation was perceived as an individual attribute, whereas at Beta, innovation was perceived as a team-level attribute.

The individualistic view of innovation at Alpha seemed to militate against the requisite sharing and cooperation that makes the evolution of KM from process approach to a community of practice approach possible. In both companies, micro-level experimentation of the various possibilities of KM was undertaken within teams or business units. The value placed on individualism vs. cooperativism seems to have played a significant role in the nature and form of the KM approach. The micro-level experimentations by teams or business units were carried out with their own assumptions about the usefulness of repositories of knowledge and the usefulness of communities or practice. We suggest that it is not organizational culture at the organizational level or even the subunit level that has the most significant influence on KM approach, but it is organizational culture as embodied in the individualistic vs. cooperative tendencies of organizational members. Thus, organizational culture influences KM approaches through its influence on individualism vs. cooperativism. From a theoretical view, it seems that Wallach's (1983) cultural dimensions and those of Earley (1994) were both valuable at explaining organizational level culture. However, Earley's (1994) cultural dimensions at the organizational level seem best able to explain why a KM approach tended to become more process or more practice-based.

2. Organizational culture influences the evolution of KM initiatives. Our findings suggest that firms do not decide in advance to adopt a process or practice approach to KM, but that it evolves. The most natural starting point is one of process, perhaps because the benefits seem more evident and because it can align more closely with the existing organizational structure. Moreover, the practice approach may not only fail to align with existing structure, but it may engender a virtual structure and identity. It is interesting that at Beta, a culture that is viewed dominantly as bureaucratic, once the initial organizational change community was established, the evolution of the community then became a highly structured process of maturation. The community leaders developed a toolkit to help other communities develop and developed a maturation model to help them to determine how mature a community was and to develop a plan to move the community forward. What some might see as an organic process (i.e., establishing and developing a community or practice) became a structured process in a bureaucratic organization. Even if the idea for the community emerged from

interested potential members, the evolution took on a structured form with tools, kits, assessments, and plans. The cooperative aspect of culture at the individual level made the community possible; the bureaucratic elements of culture at the organizational level enabled the community to mature. Hence, the evolution of the community was highly dependent on the individual willingness of organizational members to sustain and nurture their community. This appeared tied to the importance they placed on cooperation with their community members, most of whom they had never met.

3. Organizational culture influences the migration of knowledge. In the case of Alpha, where the informants seemed to identify the individual as the ultimate unit of responsibility in the organization, the individuals also were viewed as the owners of knowledge and had the responsibility to share their knowledge. This, in fact, created a major challenge, since the individuals rejected this new responsibility. At Beta, where the team seemed to be the focus of responsibility, knowledge migrated from the team to the community to the organizational level system and back down to the team. The leader of the team would take responsibility for cleaning the team's data and submitting it to the community and to the central information repository. Thus, knowledge migrated upward from the team to the central repository. Interestingly, the most useful knowledge was claimed to be that at the team and community level. Once the knowledge had completed its migration to the central repository, it was seen primarily as an item of insurance for use in case of need. Knowledge sharing and transfer occurred primarily at the team and community level, whereas knowledge storage was the function of the central repository.

   The migration of knowledge also is influenced by the structural processes put in place to ensure that knowledge finds its way to the appropriate persons. Of key importance seems to be the way the queries are handled. The marketing group at Alpha adopted the approach of notifying individuals when new information had been added to the KMS. However, little interference was put in place to either guide people to the appropriate knowledge or to encourage people to contribute knowledge. Conversely, believing that the community should not become a bulletin board of problems and solutions, the leaders of the organizational change community at Beta worked arduously to learn the subject matter experts so that queries would be submitted to the community leader who would serve as an intermediary between the individual with the query and the expert.

   It has been reported widely that the use of knowledge directories is a primary application of KM in organizations. Our study suggests that the facilitated access to experts rather than direct access via the location of an individual through a directory or via a problem posted to a forum may lead to a more favorable community atmosphere.

4. Knowledge management can become embedded in the organizational culture. Over time, as KM evolves and begins to reflect the values of the organization, the KM can become a part of the organizational culture. At Beta, individuals spoke of their community involvement and their team rooms as simply the "way we work." In fact, the communities became so much part of the culture that even though they were not part of the organizational structure, they were part of an individual's implicit structure. The sense of belonging that the individuals reported feeling toward their community suggests

that the community had become an essential aspect of their value system and, hence, had become part of organizational culture. That the organizational change community members at Beta identified themselves first and foremost with their community, in spite of receiving neither reward nor recognition within their formal reporting unit for participating in the community, indicates the extent to which community participation had become a value and an aspect of the individual culture.

Implications and Conclusion

The findings of our study suggest that a dominantly bureaucratic culture seems to tend toward an initial process-based KM approach. Furthermore, a bureaucratic culture seems to create the expectation among organizational members that senior management needs to provide a vision of purpose for KM before the organizational members should embark on KM activities. As well, the members view senior management support as validating any KM activities that they undertake. Innovative cultures, even if not the dominant culture at the organizational level, seem to enable subgroups to experiment with KM or create micro-KMs. In essence, in organizations having dominant bureaucratic cultures with traces of innovativeness, senior management support legitimizes KM, but the innovativeness of the culture enables it to expand far beyond an organization-wide repository. Specific KM behaviors such as ownership and maintenance of knowledge, knowledge sharing, and knowledge reuse seem to be influenced largely by the individualistic or cooperative nature of the culture. Individualistic cultures inhibit sharing, ownership, and reuse, while cooperative cultures enable the creation of virtual communities. Earley's (1994) work on organizational culture emphasized the individualistic and collectivistic aspects of culture. Organizations encouraging individuals to pursue and maximize individuals' goals and rewarding performance based on individual achievement would be considered to have an individualistic culture, whereas organizations placing priority on collective goals and joint contributions and rewards for organizational accomplishments would be considered collectivist (Chatman & Barsade, 1995; Earley, 1994). This dimension of organizational culture emerged as critical in our examination of the influence of culture on KM initiatives. These findings are summarized in Table 4.

Table 4. Summary of organizational culture's Influence on KM

Cultural Perspective	**Influence of Culture on Knowledge Management**
Bureaucratic (Wallach, 1983)	Favors an initial process approach to KM Creates expectation among members that senior management vision is essential to effective KM
Innovative (Wallach, 1983)	Enables subgroups in organization to experiment with KM and develop KMs useful to their group
Individualistic (Earley, 1994)	Inhibits sharing, ownership, and reuse of knowledge
Cooperative (Earley, 1994)	Enables the evolution of process oriented KM to practice oriented KM Enables the creation of virtual communities

This research set out to examine the influence of organizational culture on knowledge management approaches. Using a case study approach, we have gathered the perspectives of individuals in two firms that share some cultural similarities yet differ in other aspects. The findings suggest that organizational culture influences the KM approach initially chosen by an organization, the evolution of the KM approach, and the migration of knowledge. Moreover, the findings suggest that KM eventually can become an integral aspect of the organizational culture. Much remains to be discovered about how organizational cultures evolve and what role information technology takes in this evolution. This case study is an initial effort into a potentially vast array of research into the issue of the relationship of information technology and organizational culture.

REFERENCES

Alavi, M., Kayworth, T., & Leidner, D. (2005). *Organizational and sub-unit values in the process of knowledge management* (Working Paper). Baylor University.

Baltahazard, P. A., & Cooke, R. A. (2003). *Organizational culture and knowledge management success: Assessing the behavior-performance continuum* (Working Paper). Arizona State University West.

Bloor, G., & Dawson, P. (1994). Understanding professional culture in organizational context. *Organization Studies, 15*(2), 275-295.

Brown, S. J., & Duguid, P. (2000). Balancing act: How to capture knowledge without killing it. *Harvard Business Review, 78*(3), 73-80.

Chatman, J. A., & Barsade, S. G. (1995). Personality, organizational culture, and cooperation: Evidence from a business simulation. *Administrative Science Quarterly, 40*(3), 423-443.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management. *Sloan Management Review, 39*(2), 43-57.

DeLong, D. W., & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *Academy of Management Executive, 14*(4), 113-127.

Earley. (1994). Self or group? Cultural effects of training on self-efficacy and performance. *Administrative Science Quarterly, 39*(1), 89-117.

Enz, C. (1986). *Power and shared values in the corporate culture*. Ann Arbor, MI: University of Michigan Press.

Gold, A. H., Malhotra, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Gupta, A. K., & Govindarajan, V. (2000). Knowledge management's social dimension: Lessons from Nucor Steel. *Sloan Management Review, 42*(1), 71-80.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-115.

Hargadon, A. B. (1998). Firms as knowledge brokers: Lessons in pursuing continuous innovation. *California Management Review, 40*(3), 209-227.

Hasan, H., & Gould, E. (2001). Support for the sense-making activity of managers. *Decision Support Systems, 31*(1), 71-86.

Jarvenpaa, S. L., & Staples, S. D. (2001). Exploring perceptions of organizational ownership of information and expertise. *Journal of Management Information Systems, 18*(1), 151-183.

Johnson, G. (1992) Managing strategic change — Strategy, culture and action. *Long Range Planning, 25*(1), 28-36.

Kanungo, S., Sadavarti, S., & Srinivas, Y. (2001). Relating IT strategy and organizational culture: An empirical study of public sector units in India. *Journal of Strategic Information Systems, 10*(1), 29-57.

KPMG Management Consulting. (1998). *Knowledge management: Research report.*

O'Dell, C., & Grayson, C. J. (1998). If only we know what we know: Identification and transfer of best practices. *California Management Review, 40*(3), 154-174.

O'Reilly, C. A., Chatman, J., & Caldwell, D. F. (1996). Culture as social control: Corporations, cults, and commitment. *Research in Organizational Behavior, 1*8, 157-200.

Quinn, R. E., & Rohrbaugh, I. (1983). A spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. *Management Science, 29*(3), 363-377.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Schein, E. H. (1985). *Organizational culture and leadership.* San Francisco, CA: Jossey-Bass.

Schultze, U., & Boland, R. (2000). Knowledge management technology and the reproduction of knowledge work practices. *Journal of Strategic Information Systems, 9*(2-3), 193-213.

von Krogh, G. (1998). Care in knowledge creation. *California Management Review, 40*(3), 133-153.

Wallach, E. J. (1983, February). Individuals and organizations: The cultural match. Training and *Development Journal.*

Watson, S. (1998). Getting to "aha!" companies use intranets to turn information and experience into knowledge — And gain a competitive edge. *Computer World, 32*(4), 1.

Wenger, E. C., & Snyder, W. M. (2000). Communities of practice: The organizational frontier. *Harvard Business Review, 78*(1), 139-145.

ENDNOTE

[1] After this initial data collection, we returned to Company B a year later and conducted more widespread interviews across different business units. This data collection and analysis is discussed in Alavi, Kayworth, and Leidner (2005).

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Chapter 5.9
External and Internal Knowledge in Organizations

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INTRODUCTION: KNOWLEDGE MANAGEMENT AND COMPETITIVE ADVANTAGE

In this article we discuss how knowledge and learning contribute to developing sustainable competitive advantages in firms. We argue that effective knowledge management (KM) initiatives for this purpose should support appropriate learning initiatives (which we define in terms of learning trajectories [LTs] of individuals and groups within the firm) in order to ensure that knowledge needs are adequately covered over time.

Trends in today's environment such as globalization, technological evolution, and deregulation are changing the competitive structure of markets in such a way that the effectiveness of traditional sources of firms' competitive advantage is blurred. More and more, any firm can have access to physical or financial assets, and even to technology, in exactly the same open-market conditions. Consequently, firms need to develop distinctive capabilities, their own "ways of doing things" that are difficult to imitate by competitors. Such capabilities are eventually related to persons in the firm, who at the end of the day develop and apply their abilities and skills, organized in certain ways and based on what these people know. Thus, developing idiosyncratic knowledge that gives meaning to a firm's distinctive ways of doing is increasingly important (Bell, 1973; Drucker, 1993). Idiosyncratic knowledge of this kind is difficult to imitate because it cannot be bought in open markets. That is, it has to be learned, requiring resources, time, effort, and a specific context (organizational, social, etc.) that makes it so path dependent that reproducing it in a firm different from that in which it originated is very difficult (Andreu & Sieber, 2001). In addition, knowledge has three fundamental characteristics that make it especially interesting. First, it is personal in the sense that it originates and resides in persons who assimilate it as the result of their own experiences. They incorporate it into their "base" once convinced of its meaning and implications, articulating it in the context of an organized whole that gives structure and meaning to its different "pieces" (Kolb, 1984). Second, its utilization (through which it does not dissipate) allows persons to understand perceived phenomena (each in his or her own way) and evaluate them, judging how good or convenient those phenomena are for each person at a given time. Third, it serves as a guide for action, helping to decide what to do at a given juncture because action endeavors improve the consequences of perceived phenomena (Andreu & Sieber).

These characteristics make knowledge a solid basis for competitive advantage. As far as it results from the accumulation of persons' experiences, therefore being mainly tacit (Polanyi, 1962), imitating it will be difficult unless precise representations (in the form of explicit knowledge) exist that facilitate its transmission and sharing. The personal experience-accumulation process leading to new knowledge takes place in a social or organizational context (Pentland, 1995; Tyre & von Hippel, 1997), and it unfolds following a different path for each person (dependent, among other things, on his or her previous experience and knowledge). Thus, knowledge is both path and context dependent. To the extent that duplicating contexts and paths in this sense is difficult, knowledge imitation will be costly, and consequently competitive advantages based on it will tend to be sustainable (Grant, 1996; Teece, Pisano, & Shuen, 1997). As a result, knowledge value tends to be higher in the context in which it was developed than it would be in a hypothetical open market. Nevertheless, not all knowledge is the same in terms of potential competitive advantage as we discuss in the next section.

EXTERNAL AND INTERNAL KNOWLEDGE

Competitive forces put pressure on firms not only to streamline their business processes, but also to be able to incorporate relevant knowledge from the environment. In other words, any firm needs access to knowledge that allows it to do something that, although also done by competitors, is demanded and valued by clients. We call this kind of knowledge external knowledge. It is brought into a firm from the environment and is useful not only to a particular firm, but also to their competitors in the marketplace. Hence, its market value is approximately equal to its value within the firm. It can be traded in the market and, in general, it tends to be rather technical and explicit, which makes it relatively easy to acquire, be it through training or simply by hiring or buying it (Becker, 1962; Williamson, 1981).

Relying on external knowledge alone, however, does not lead to competitive advantage. Although it may be a competitive necessity, it needs to be complemented by a different kind of knowledge more idiosyncratic and capable of differentiating a firm's offer in the marketplace. It is an organization-specific knowledge that refers to the firm's particular modes of functioning and to its particular organizational context. It acts as an organizational glue when the fast incorporation of external knowledge into a firm may threaten its cohesiveness and sense of unity. It is therefore more valuable inside the organization than in the market, and is less prone to imitation. Developing this kind of knowledge is much less environment driven, and it belongs more to the realm of organizational routines and organizational idiosyncrasy. We call this kind of knowledge internal knowledge. Although not valued directly by the labor or factor market, it contributes to achieve competitive advantage as it adds critical value for the customer1. Internal knowledge can be understood as the organizational context that

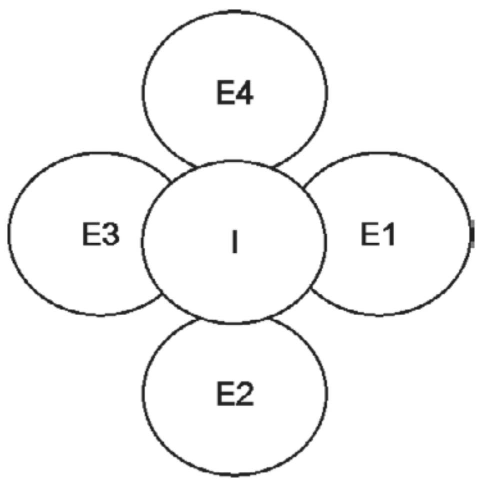
(a) plays the role of a skeleton where new knowledge pieces are attached so as to "make global sense" to the firm tradition, culture, and "ways to understand things" (Spender, 1996); and (b) defines the way in which new knowledge will be put to work, hence giving it the idiosyncratic firm's touch that will distinguish its utilization from that of other firms.

The distinction between these two kinds of knowledge is not new. The economics literature has analyzed the differences between general and firm-specific knowledge basically from three perspectives. Becker (1962) adopted a human-capital approach to study how to price the training of employees, concluding that the firm should cover all firm-specific training while the worker should cover general training as the involved knowledge has a direct market value. Williamson (1981) takes up this argument from a transaction-cost point of view, considering the necessity to protect "skills acquired in a learning-by-doing fashion and imperfectly transferable across employers" (p. 563). From an institutionalist point of view, Doeringer and Piore (1971) consider that the formation of internal labor markets is a consequence of firm-inherited knowledge.

From a more managerial standpoint, there are also contributions that suggest the distinction above. Porter, interviewed by Hodgetts (1999), is very close to the same concept when he distinguishes between "operational improvement" and "positioning." In a similar manner, Edvinsson and Malone's (1997) definition of intellectual capital is close to our concept of internal knowledge. The classic management literature also proposes a similar distinction: Selznick (1957), for example, is very close to the concept of internal knowledge by saying "…we must create a structure uniquely adapted to the mission and role of the enterprise..." More recently, Burton-Jones (1999), starting from a conception of the firm as a "knowledge integrator," proposed the so-called Knowledge Supply ModelTM, where the distinction is made between three internal sources of knowledge and four external sources, the former demanding firm-specific knowledge.

Understood as we propose, a coherent knowledge management initiative has to ensure a proper

Figure 1. Knowledge base of a firm in terms of internal and external knowledge



balance between internal and external knowledge creation and deployment. Our contention is that, thinking in terms of the adequate learning processes leading to the creation and deployment of the appropriate mix of internal and external knowledge in a firm, it is possible to draw conclusions regarding what knowledge management approaches have more or less potential effectiveness for a given firm. Of course, the specificities of each particular firm influence the suitability of a concrete KM approach, but still, a general framework can guide action.

In the context of a generic firm, we propose to think in terms of its knowledge base, understood as a combination of external and internal knowledge components. A schematic representation is shown in Figure 1, where I represents a piece of internal knowledge and E1 to E4 represent four pieces of external knowledge.

We depict I in the center to give the idea of a core, and the different Es around it to indicate both the fact that they are closer to the environment and the relative independence there is among each other. Some overlap between I and the different Es indicates that the part of I geared to put the Es into idiosyncratic action needs to be aware of some of the corresponding Es' characteristics.

Using this knowledge-base representation of a firm, the next section introduces the concept of learning trajectories and explores the different LTs that can be adopted within a firm. Next, we use these concepts to derive general conditions and goals for effective knowledge management initiatives.

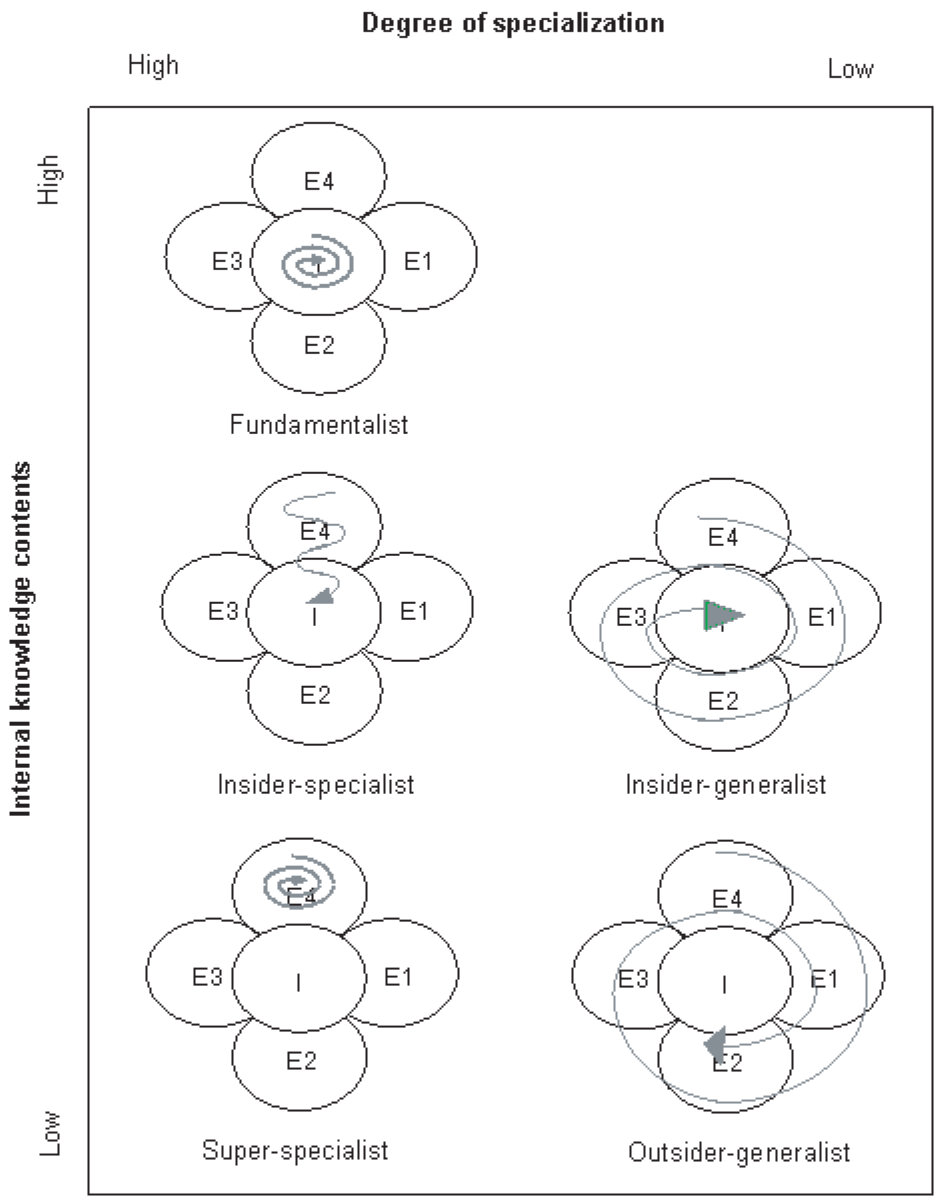
KNOWLEDGE CREATION AND DEPLOYMENT IN THE FIRM: LEARNING TRAJECTORIES

The concept of knowledge-based competitive advantage assumes that a firm has a view of the knowledge base it needs at a given moment. Any firm needs to develop and maintain a mix of internal and external knowledge geared to its particular competitive positioning. One way of configuring this process is through the identification of adequate learning patterns—learning trajectories—that lead to the desired mix of internal and external knowledge. In other words, a firm develops its appropriate mix of knowledge when its members evolve through a right combination of LTs. Thus understood, the LT of an individual is a representation of his or her evolution toward a certain degree of significance to the organization in terms of contributing external or internal knowledge to its relevant knowledge base. Of course, many different individual LTs can be imagined in a firm. Choosing the appropriate ones is a question of matching the knowledge base needed to compete according to the firm's strategy and mission on the one hand, the profiles of the different individuals and groups involved on the other, and the learning procedures judged most effective for each combination of knowledge base and individual or group. Thus, it is impractical to give specific answers for all possible cases. However, the idea of LTs permits us to set up a basic framework useful to design the collection of learning efforts needed and the corresponding KM-based support that might make sense.

One version of such a framework is depicted in Figure 2, where LTs are classified in terms of Internal Knowledge Contents and Degree of Specialization, be it in internal or external knowledge. LTs are represented here as learning paths drawn on the knowledge map of the firm. Depending upon what kind of knowledge the firm needs to develop in order to match its competitive positioning needs, one LT might be more appropriate than another, or a combination of them can be useful across a number of individuals or groups in the firm.

Hence, one can define sorts of stylized LTs that correspond to different career paths of individuals in the organization. In this sense, for example, one LT develops what can be called superspecialists. It corresponds to a career as a

Figure 2. A classification of LTs



specialist in some external knowledge without much idiosyncratic, organization-dependent knowledge. Superspecialists resulting from this kind of LT will probably be highly valued in the market and not as much internally. A firm will not be able to develop competitive advantage with only superspecialists of this kind, however. An extreme example could be that of a movie star who has developed her acting know-how in several movies, but who is not tied to any of them (or their producers) in an organizational sense. The so-called "Hollywood organization" is based in this idea. It consists of a combination of persons, each of whom has excellent knowledge in some specific field, that join efforts toward the achievement of a specific, short-term goal. They stop working together as soon as the goal is achieved as they do not contribute any idiosyncratic knowledge that would give sense to any cooperation over a longer period of time.

On the opposite, an LT targeted only at the development of internal knowledge content is that of the fundamentalist, an organization insider with virtually no external expertise. A firm in which all members have such an LT would not develop competitive advantages, either: It would be like a good movie director without actors. LTs of this kind may make sense in extreme cases, but only if they can be complemented with relevant and valued external knowledge holders.

A more balanced LT can be called an insider generalist: A person starts with some external knowledge and proceeds to integrate other Es while incorporating more and more I. The result, depending on the competitive positioning of the firm, could be an appropriate mix of internal and external knowledge with high competitive-advantage potential. This would correspond to the classical careers of persons who start in one functional department, then pass through other relevant functions, and finally end up at a managing position. During the early stages, these careers incorporate technical skills and add value to the organization through making operating decisions and solving rather structured problems. At later stages, they are valued because they develop integrating capabilities, solving unstructured problems and giving strategic insight to organizational routines.

In contrast, an insider specialist could start from being knowledgeable in an E and intensifying in it while incorporating relevant pieces of internal knowledge. This is a typical trajectory of a person who, without ever abandoning a particular function or department, gets more and more involved in firm-specific issues.

Finally, an LT that we call outsider generalist belongs to a person who keeps incorporating different kinds of external knowledge without complementing them with any internal knowledge element. The result is a profile that can be highly valued in the market, but that has difficulties in being well rooted in a specific enterprise.

We could continue with more archetypical LTs. This would miss the point, however. Taken as individual LTs in the context of a desired knowledge map such as that of Figure 1, the idea is that a proper balance of LTs should be designed and managed in order to develop an organization with competitive-advantage potential. Although not a single LT can be considered to be inherently inadequate for the firm's success over time, failure to balance different LTs may give rise to a collection of LTs that might be detrimental to the organization. Although a firm will hardly be able to successfully compete without a good external knowledge base, it will also need to develop a certain critical mass of internal knowledge. This is important for at least two reasons. First, people that follow outsider-generalist or superspecialist LTs may easily leave the firm because they are likely to be highly valued by the market. Second, especially in conditions of soaring environmental change, it is important to have people who are able to give a sense of unity to the organization, which means taking care of internal knowledge development.

LEARNING TRAJECTORIES' GOALS AND CONDITIONS: A BASIS FOR KM SUPPORT

In order to build up, support, and maintain the appropriate external- and internal knowledge bases of a firm, thus contributing to its sustainable competitive advantage, different kinds of LTs need to be fostered in an organization. A variety of initiatives can be designed and deployed for this purpose.

For the development and maintenance of a firm's external knowledge base, two of the LTs above seem particularly adequate: those of the superspecialist and the outsider generalist. Most actual KM initiatives (intra- or extranets, knowledge databases, distance learning arrangements, groupware and communication infrastructures, etc.) are targeted to the development of a good external knowledge base as they typically cover the following areas.

- Infrastructures for experience sharing: Standard best practices and routines, databases, and so forth
- Infrastructures to facilitate coordination among specialists: To the extent that more effective coordination is possible, specialists can concentrate more on their fields of expertise.
- Yellow-pages-type systems to locate who in an organization or the environment has specific experience or knowledge
- Systematized, well-indexed access to market and industry information from standard sources
- Systems that force the utilization of best practices such as ERP, CRM, and so forth
- Training in standard capabilities, available in the open market

Of course, for these supports to be effective they might need to be complemented with others of a more organizational character. For example, adequate control and incentive systems are important when individuals are not willing to share knowledge with others because it is one major source of their value in the marketplace.

Hence, in order to devise adequate organizational supports, questions about market knowledge and its evolution the main technical constraints, possibilities, and innovations and so forth have to be taken into account. Also, the corresponding external knowledge must be codified to the extent possible in order to reduce the impact of workers leaving the organization.

At least three main areas of external knowledge development need to be taken into account. First is the specialization and coordination knowledge for both individuals and teams inside the organization (using ICT-based initiatives to improve coordination efficiency and effectiveness, for example) and between the organization and its environment: structuring relationships with suppliers and clients, formulating strategic alliances for knowledge-sharing purposes, and so forth.

Second is work practices that may enhance external knowledge development and transfer. For example, these include training and education initiatives, the identification of groups of excellence for practice sharing, or the designing and implementing of systems that encapsulate and foster the utilization of general good practices.

Third is the organizational area: incentive and control systems, convenient information-access structures, and so forth.

On the other hand, from the internal knowledge base standpoint, the appropriate LTs differ significantly from those adequate for external knowledge. We argued that internal knowledge has more of a tacit nature, blurred across the organization and "sticky." It cannot be acquired in the market; it has to be developed within the organization. In this context, the insider generalist, insider specialist, and fundamentalist types of LTs in Figure 2 come to mind. They aim at fostering (a) the organization's basic values, (b) routines that facilitate the effective use of these values, (c) the idiosyncratic behavior styles of the organization, both individual and collective, and (d) personal capabilities that fit these styles, facilitating their adoption by organization members.

The sticky nature of internal knowledge implies, as a first consequence, that the usefulness of technology-based traditional KM initiatives will probably be limited as those systems require the encodability of knowledge. In addition, as internal knowledge is context dependent and blurred among organizational members, LTs aimed at its development have to deal with it more as an aggregate than as a set of individual pieces.

According to Szulanski (1996), stickiness is caused mainly by five factors: (a) causal ambiguity and the unprovable nature of the knowledge transferred, (b) the lack of motivation by the knowledge source, which is perceived as unreliable, (c) the characteristics of the knowledge recipient, (d) the lack of absorptive capacity and retentive capacity, and (e) context characteristics such as a barren organizational context and arduous relationships. As a consequence, knowledge-related barriers due to a lack of absorptive capacity, causal ambiguity, and the arduousness of the relationship between the source and the recipient are the main barriers to knowledge transfer within a firm.

Therefore, to enhance internally focused LTs, it is advisable to respond to these three dimensions. The issue about a lack of absorptive capacity, which Cohen and Levinthal (1990) define as the inability to exploit outside sources of knowledge or radical new ways of doing things, suggests exploring ways of broadening the mind-sets and searching mechanisms of the organization's members. Fostering an open attitude is a first step in this direction. Systems that "are an integral part of the context" because they are deeply embedded in it can contribute to enhance the understanding and transmission of internal knowledge as they render the organization context "more obvious" to its members.

Regarding causal ambiguity, Tyre and von Hippel (1997) see it as a consequence of imperfectly understood idiosyncratic features of the context. Of course, one way of naturally reducing causal ambiguity is by staying in the organization over long periods of time; this increases the individual's tacit understanding of how the organization functions, its power structure, its culture, and so forth. To the extent possible, the unambiguous recognition of the organization's mental model and value applications to everyday situations contributes to reduce causal ambiguity in this sense. This includes practices such as after-the-fact revisions of why things were done the way they were, be it through mentoring or coaching, or, if possible, concrete mental model representations that contribute to reduce ambiguity.

Finally, implicit in the notion of internal knowledge is its contextual and embedded character. Consequently, in order to develop and deploy it effectively, numerous and multiple individual exchanges are needed so that the appropriate critical mass builds up. In this context, arduous (i.e., distant and laborious) relationships hinder the formation of internal knowledge. Again, this implies that an open and good work atmosphere can enhance internal knowledge formation.

Therefore, internally focused LTs are more likely to be implemented in organizations that have in place initiatives to enhance their absorptive capacity, and that allow for open debates of new ideas or new ways of doing things. Also, the degree of employee retention, especially of those persons who have developed a good understanding of the organization's idiosyncrasies, as well as the encouragement of good relationships between key members and its fostering and nurturing, has a positive impact on the development and maintenance of internal knowledge. For this purpose, mentoring and coaching seem to be especially relevant. Finally, a systematic approach putting adequate organizational structures and systems in place that contribute to making values, styles, and context more obvious and easy to assimilate and understand is a fundamental piece to internal LTs.

As an example, we can refer to the case study of Unión Fenosa and its corporate university (Andreu, Grau, Lara, & Sieber, 2004). The very conception, design, and organization of the corporate university and the courses offered there follow the guidelines that a good combination of external- and internal knowledge development and deployment via LTs would advise. Internal knowledge is subtly interspersed with external knowledge, for example, in the organizational structure of the corporate university itself, which mimics the structure of the company and assigns responsibilities according to it. In fact, learning and teaching from experience as an explicit goal in the company's strategy and mission puts the emphasis on well-balanced LTs in the sense above from the start. Accordingly, managers and employees at all levels are evaluated and promoted by taking explicitly into account, to some extent, the degree to which LTs match the company's needs as they evolve over time in response to environmental and competitive conditions.

CONCLUSION

In this article we have proposed to think in terms of learning trajectories in order to analyze how to achieve the development of a balanced knowledge base in a firm. Such a standpoint puts the emphasis on knowledg development needs and somehow de-emphasizes specific technology-based support, although we recognize the potential of such KM initiatives. Our approach has distinguished between external and internal knowledge in order to characterize a set of archetype LTs with which it is possible to describe the most appropriate knowledge-development course for a specific firm at a given point in time. A particular set of LTs considered appropriate for a specific firm situation gives clear clues about how different kinds of knowledge management systems and supports could help to strike the right internal- and external knowledge balance for that firm. A natural consequence of the proposed analysis is that the KM initiatives that a firm identifies are not all strictly technology based; there is an important complement that in fact defines the critical core of an integrated KM proposition. Thus, we join the view of some notorious recent research efforts that favor a view that enlarges the conception of knowledge management from a system-based view to an organization-wide conception.

REFERENCES

Andreu, R., Grau, A., Lara, E., & Sieber, S. (2004). *Unión Fenosa Corporate University: Teaching and learning from experience* (IESE Business School case).

Andreu, R., & Sieber, S. (2001). Knowledge management and organizational learning: What is the link? In Y. Malhotra (Ed.), *Knowledge management and business model innovation*. Hershey, PA: Idea Group Publishing.

Becker, G. (1962). Investment in human capital: A theoretical analysis. *Journal of Political Economy,* (Suppl. 70), 9-44.

Bell, D. (1973). *The coming of post-industrial society: A venture in forecasting.* New York: Basic Books.

Burton-Jones, A. (1999). *Knowledge capitalism: Business, work, and learning in the new economy*. Oxford University Press.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-153.

Doeringer, P. B., & Piore, M. J. (1971). *Internal labor markets and manpower analysis.* Lexington, MA: Lexington Books.

Drucker, P. (1993). *Post-capitalist society.* Oxford: Butterworth-Heinemann.

Edvinsson, L., & Malone, M. S. (1997). *Intellectual capital: Realizing your company's true value by finding its hidden brainpower.* New York: Harper Business.

Grant, R. M. (1996). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375-387.

Hodgetts, R. M. (1999). A conversation with Michael E. Porter: A "significant extension" toward operational improvement and positioning. *Organizational Dynamics, 28*(1).

Kolb, D. A. (1984). *Experiential learning.* Englewood Cliffs, NJ: Prentice Hall.

Pentland, B. T. (1995). Information systems and organizational learning: The social epistemology of organizational knowledge systems. *Accounting, Management and Information Technologies, 5*(1), 1-21.

Polanyi, M. (1962). *Personal knowledge.* New York: Anchor Day Books.

Selznick, P. (1957). *Leadership in administration: A sociological perspective.* Evanston: Row, Peterson and Company.

Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17*, 45-62.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17*, 27-44.

Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

Tyre, M. J., & von Hippel, E. (1997). The situated nature of adaptive learning in organizations. *Organization Science, 8*(1), 71-83.

Williamson, O. (1981). The economics of organization: The transaction cost approach. *American Journal of Sociology, 87*, 548-577.

ENDNOTE

[1] Value for the customer is a necessary condition for internal knowledge leading to competitive advantage as otherwise it would complement external knowledge in a meaningless way.

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Chapter 5.10
Siemens:
Expanding the Knowledge Management System ShareNet to Research & Development

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EXECUTIVE SUMMARY

The case study describes the issues surrounding the expansion of the community-based knowledge management system (KMS) ShareNet to the research and development (R&D) function at Siemens Information and Communication Networks (ICN). It sets the stage for a decision situation that Siemens ICN's vice president business transformation and knowledge management, Janina Kugel, faced in 2003. While R&D usage rates differed not remarkably from other Siemens ICN functions, a strategic emphasis on innovative products and services — as well as ambitious targets for leveraging offshore development resources — necessitated a stronger penetration of this highly relevant function. Could this extension build on earlier experiences gained with the best practice implementation approach at the sales and marketing function? The case description provides a chronological account of ShareNet's conceptualization, development, international rollout, and operation. It pays attention to information systems (IS) implementation issues, change management, and current developments in the field of knowledge management (KM).

ORGANIZATIONAL BACKGROUND

Siemens, headquartered in Munich, is a German-based multinational corporation with a balanced business portfolio of activities predominantly in the field of electronics and electrical engineering. With sales of EUR 74.2 billion and a net income of EUR 2.4 billion in fiscal 2003, it was Europe's industry leader with strong positions in the North American and Asian markets (in August 2003, EUR 1.00 was equivalent to about USD 1.13). Approximately 50,000 researchers and developers were employed; research and development (R&D) investments totaled EUR 5.1 billion. Exhibit 1 shows Siemens' financial performance from 2000 to 2003. Siemens was a conglomerate of six business segments: Information and Communications, Automation and Control, Power, Transportation, Medical, and Lighting. Each business segment was split into several groups with independent profit responsibility and regional sales organizations (local companies) around the globe.

The decentralized matrix structure allowed for entrepreneurial responsibility and the development of close ties to customers. Global, interdivisional cooperation and systematic sharing of best practices enabled the provision of comprehensive and customer-focused solutions. Siemens' managing board confirmed that the "global network of innovation" — over 400,000 employees in 190 countries — was the firm's greatest asset. Linked in a global knowledge network, they were key for innovation and finally for offering technologies, tailor-made solutions, and services.

Siemens' largest business segment, Information and Communications, comprised three

Exhibit 1. Siemens' financial performance from 2000 to 2003 (EUR in millions)

	2003	2002	2001	2000
Net sales	74,233	84,016	87,000	77,484
Cost of sales	(53,350)	(60,810)	(63,895)	(55,949)
Gross profit on sales	20,883	23,206	23,105	21,535
Research and development expenses	(5,067)	(5,819)	(6,782)	(5,848)
Marketing, selling, and general administrative expenses	(13,534)	(15,455)	(16,640)	(14,173)
Other operating income (expense), net (therein gain on issuance of subsidiary and associated company stock)	642	1,321	2,762	7,549
Income (loss) from investments in other companies, net	142	(114)	49	299
Income (expense) from financial assets and marketable securities, net	61	18	173	2,732
Interest income (expense) of operations, net	31	94	(32)	(35)
Other interest income (expense), net	214	224	43	180
Income (loss) before income taxes	3,372	3,475	2,678	12,239
Income taxes	(867)	(849)	(781)	(3,017)
Minority interest	(96)	(29)	(191)	(362)
Net income (loss)	2,445	2,597	2,088	8,860

groups. Siemens Business Services (SBS) offered single source IT solutions and services. Information and Communication Mobile (ICM) covered all mobile communication requirements with network technology, terminal devices, and mobile applications. The case study focuses on Information and Communication Networks (ICN) that developed, manufactured, and sold public communication systems, private business communication systems, as well as related software and services. Impacted by the telecommunications equipment industry's continuing difficulties, Siemens ICN's sales of EUR 7.1 billion resulted in a negative EBIT of EUR 366 million in fiscal 2003 (Siemens, 2003). The 38,000 employees in over 160 countries focused on improving the product base, cost structure, and sales channels.

It was Siemens ICN's strategy to become a solution provider for other "global networks of innovation". Its three business units would provide the physical components of a sales project while the local companies were responsible for customizing and integration into the customer network: Enterprise Networks (EN) offered communications solutions for enterprise customers, Carrier Networks (CN) comprised IP-based convergence solutions, circuit-switched networks, optical networks solutions, and a portfolio of broadband access solutions, and Carrier Service (CS) provided local maintenance, system support, and general services for circuit-switched, IP-based, and hybrid networks (Siemens Information and Communication Networks, 2003). Exhibit 2 depicts Siemens ICN's organizational structure.

Exhibit 2. The Siemens ICN organization

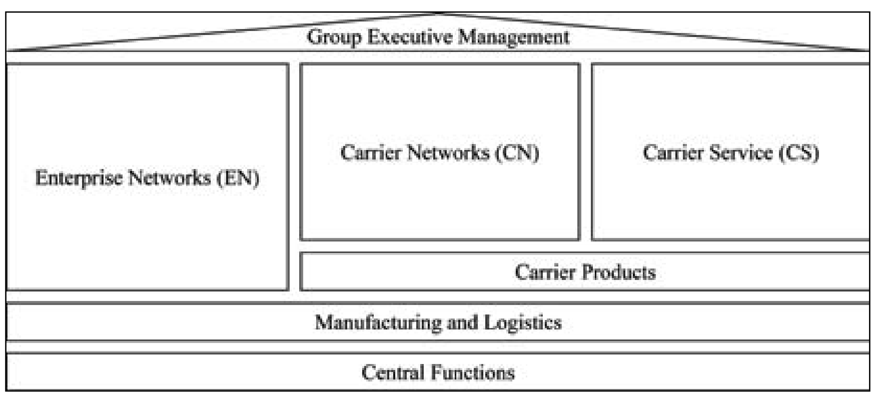


Exhibit 3. Mission statement of the central function knowledge management

- We foster the knowledge management activities within Siemens ICN and leverage our global knowledge sharing network with ShareNet.
- Managing knowledge is not just a matter of transferring information from one place to another, it is a social process which must motivate and encourage people to share that information proactively.

For the case study, mainly the complementary central functions business transformation (BT) and knowledge management (KM), as well as the local companies, are relevant.

Headed by Janina Kugel, vice president of business transformation and knowledge management, a six-person team drove and supported knowledge sharing initiatives in order to enhance Siemens ICN business processes and global cooperation. Exhibit 3 presents the mission statement of the central function KM. Responsibilities included the mapping of business processes to establish supportive KM platforms, the creation of a common knowledge infrastructure and culture, and fostering the awareness that knowledge sharing generates value. This was supposed to facilitate cooperative global learning, as well as cross-divisional and cross-country reuse of global best practices.

SETTING THE STAGE

The case study illustrates the issues surrounding the implementation of the community-based knowledge management system (KMS) ShareNet at Siemens ICN over the period 1998-2003. It sets the stage for a range of decision options that Kugel must incorporate in her upcoming proposal to extend the KMS to Siemens ICN's research and development (R&D) function, by presenting a chronological account of ShareNet's history. Specific attention is paid to information systems (IS) implementation issues (e.g., Ginzberg, 1981; Zmud & Cox, 1979) as well as to change management interventions (e.g., Earl, 2001; Fahey & Prusak, 1998; Seeley, 2000). Kugel was convinced that much could be learned from the sales and marketing rollout history but that recent challenges in the telecommunications sector — as well as the specific needs of the R&D function — would make several adaptations to the system's functionalities and implementation strategy necessary.

ShareNet, a global knowledge sharing network initially developed for the global Siemens sales and marketing community, was conceived in 1998. With the market environment in constant flux, Siemens realized it had to be able to provide flexible bundles of services and products that could be easily adapted to individual customers. To this end, the company recognized that a major improvement in the fast and purposeful identification and exchange of relevant information and knowledge was needed. Hence, Siemens ICN started the development of a community-based KMS under the name ShareNet. For "explicit knowledge," the aim was to provide structured knowledge objects in the form of project descriptions, functional and technical solutions, customers, competitors, and markets. For "tacit knowledge," the system was intended to provide functionalities such as newsgroups, discussion forums, and chats.

As explained next, ShareNet's implementation and rollout across the global sales and marketing function was overall successful. Kugel's challenge now was to extend this success to the R&D community in a much grimmer economic environment. Facing a difficult business situation and outlook in 2003, Siemens ICN's group executive management continuously emphasized the need for innovative products and services. At the same time, all organizational functions had to meet strict cost criteria. In 2003, Siemens developed 5% of its software in low-cost countries. An ambitious program was started to extensively use offshore development resources in order to reduce costs. In addition, Siemens aimed to consolidate development activities to shorten the time to market, to concentrate on core competencies and, thereby, to strengthen its innovative power.

Cost cuttings through decentralization to low-cost sites seemed easy. Keeping R&D quality high — while scattered across the globe — was the real challenge. Knowledge sharing between employees and partners in remote areas was seen as a key driver, again strengthening the call for

ShareNet's R&D expansion. Fueled by the KMS' successful, large-scale rollout at the sales and marketing community, as well as by first evidence for related culture change, the ShareNet operating team had conducted first pilot implementations at R&D.

Besides heading the KM team, Kugel also directed a team of business consultants — the BT team. Just when Kugel had to decide on ShareNet's expansion to R&D, those employees had successfully finished a project to define and implement a process to foster radical new innovations (labeled "disruptive innovations") within ICN and feed these innovations into the well-defined product and service development processes for the carrier and enterprise business. The BT team envisioned a central role for ShareNet in this process, which could give ShareNet a jump-start into the R&D environment. Now Kugel saw basically three options to proceed: first, to simply replicate the sales and marketing implementation approach for the entire R&D community; second, to adapt the implementation process for R&D and to establish several smaller groups of R&D employees; or third and last, to customize the implementation process and expand ShareNet usage step-wise along the R&D process.

CASE DESCRIPTION

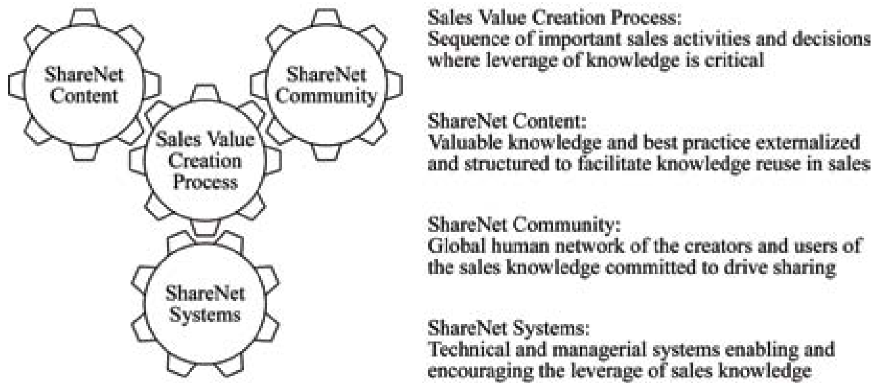
Definition & Prototyping

The initial development of ShareNet started in 1998. ShareNet's first key project stage — "definition and prototyping" — lasted from August 1998 to the end of March 1999. Objectives were to establish the ShareNet project team, to create conceptual definitions and refinements, to start prototyping the technical platform, and to ensure early executive and user buy-in. Soon, the ShareNet project team developed the vision of a structured KM initiative for the sales and marketing function: "ICN ShareNet is the global knowledge sharing network. We leverage our local innovations globally. We are a community committed to increase value for our customers and ICN by creating and re-applying leading-edge solutions." The aim was to change Siemens ICN's communication flow from a broadcast-oriented "enabling" approach that is, headquarters to local companies, to a meshed network approach required for fast global learning.

Several benefits were emphasized: costs should be reduced by avoiding expensive mistakes made in the past, or simply by reusing technical and functional components that had already been developed; project delivery times ought to be shortened through reuse, leading to higher project throughput/utilization by the sales force; quality should improve as reusable modules were repetitively sold and improved; lastly, besides representing benefits in their own right, these would lead to more successful tenders and higher revenues. Four crucial elements were defined to guide the KMS' conceptual development, prototyping, and later implementation. Exhibit 4 depicts the basic components: Sales Value Creation Process, ShareNet Content, ShareNet Community, and ShareNet Systems.

ShareNet's central part — the Sales Value Creation Process — was a sequence of important sales activities and decisions where knowledge ought to be reused. It served as an abstract global sales process definition, where each individual local sales process could be mapped. The ShareNet project team and four consultants from The Boston Consulting Group (BCG) realized early that the KMS' development should be no isolated effort, and later parachuted into the local companies. Consequently, the team was augmented by 40 sales representatives from headquarters and 15 local companies. Their involvement served three distinct change management goals: they specified KMS solutions, supported a network of people experiencing similar difficulties, and set examples

Exhibit 4. ShareNet as an interplay of four crucial elements



for the combined KM and change initiative's progress. Siemens ICN's group president and high ranking sales managers formed the steering committee responsible for project supervision and top management support.

The ShareNet project team was assembled for the first time in October 1998 at the kick-off workshop at Frankfurt airport. Goals were the definition of the KMS' content, objectives, and structure. The project team and BCG presented first ideas for ShareNet's vision, basic concept, and graphical user interface (GUI) mock-ups for prototyping. Afterwards, the participants' team engaged in a joint diagnosis of business problems in order to make sure that the KMS provided value-add to the sales and marketing process. The structure of the KMS was tailored to tackle these problems through global collaboration. All sales representatives were asked to identify projects, solutions, and practices in their home regions that could be leveraged globally, that is, early win-showcases. An Intranet site with a preliminary database, discussion and feedback groups, and core team member profiles was soon established. Altogether, the knowledge of 18 sales projects was captured, more than 30 sales tips and tricks identified, and a first concrete sharing of knowledge initiated.

All content gathered was reviewed in November 1998 at the global exchange workshop in Garmisch. Based on their previous experiences, the ShareNet project team decided early on two ShareNet applications. First, the IS should serve as a document repository for the coding and sharing of best practices in selling solutions. It included structured knowledge about everything needed to create a solution. Second, ShareNet should foster the creation of knowledge networks. Employees should virtually exchange personalized knowledge to promote global cooperation, human networking, and quick help. The option of adding a corporate directory for the mapping of internal expertise (yellow pages functionality) — often found in KMS — was seen as less promising due to a perceived lack of data quality (see Alavi & Leidner, 2001; Earl, 2001, for a typology of KMS and KM strategies).

To accommodate the first application, the explicit knowledge derived from different stages of the solutions-selling process fell into distinct categories of ShareNet solution objects (e.g., technical or functional solution knowledge) and

ShareNet environment objects (e.g., customer or market knowledge). Technical solution components were all technology-related parts of solution packages provided to the customer. Functional solution components were all the non-technical tips and tricks or generic methods offered, for example consulting service, financing, and so forth. Useful documents (e.g., customer presentations, spreadsheets) could be linked and references to other content in ShareNet were supported. The linkage was to some extent inherent in the structure, for example a sales project naturally contained a pointer to a customer, and so forth. Additionally, contact persons were named for further help.

To accommodate the second application, ShareNet's tacit content consisted of urgent requests, discussion forums, news, and chats. The urgent request feature allowed ShareNet members to post an urgent message or question to alert the other ShareNet users. If feedback on general ideas or suggestions to solve low priority issues was needed, discussion forums should rather be chosen. ShareNet news was a specific type of forum that served as a bulletin board for the ShareNet Community. ShareNet chat was the global virtual meeting room for the KMS' members based on Internet relay chat (IRC). The final element in ShareNet's people-to-people section was the ShareNet member directory, comprising a directory of all users with contact information, organizational details and the individual list of contributions to ShareNet.

The ShareNet Systems included both the technical systems to facilitate low effort global publishing and searching, and the managerial systems to encourage the capturing, sharing, reuse, and global leverage of knowledge and best practices. These comprised — among others — incentives and rewards, methodologies to externalize knowledge, and dedicated resources for maintaining and evolving the KMS. The core team decided to start with rapid prototyping of the technical platform and to leave the definition of the managerial systems for the final workshop.

The technical systems employed three-tier client/server architecture. The first tier was the user inter-face/personal workspace accessible via regular Web browsers. The second tier did most of the processing: a SUN SparcServer served as the designated application and Web server for all local companies and business units. It ran a software toolkit based on open Internet standards: open source Web server (AOLServer) and open source community system (ACS - ArsDigita Community System). ShareNet's dynamic Web implementation was based on AOLServer Dynamic Pages (ADP), an HTML derivate. Web pages were generated by scripts loading meta-data (e.g., object structure and graphical layout) and actual data (e.g., customer description) from the relational database management system (Oracle 8i). It was housed on the same server and comprised the third tier.

The third and final workshop in the "definition and prototyping" stage was held at Munich airport in February 1999. Content gathered and reviewed from three regions was posted on the prototype system and set an example for the successful application of managerial innovations. However, the participants were unsure about incentives, rewards, and culture change: how could they ensure that ShareNet was adopted by the whole organization? Joachim Doering, president group strategy, estimated that 80% of KMS failed for non-technical reasons: lack of capability to execute, missing readiness or commitment to change, defunct change communications, limited top management support, and poor strategy. To side-step these traps, he wanted the initiative to simultaneously address all domains of change management: strategic change, process change, technological change, and especially organizational and people change.

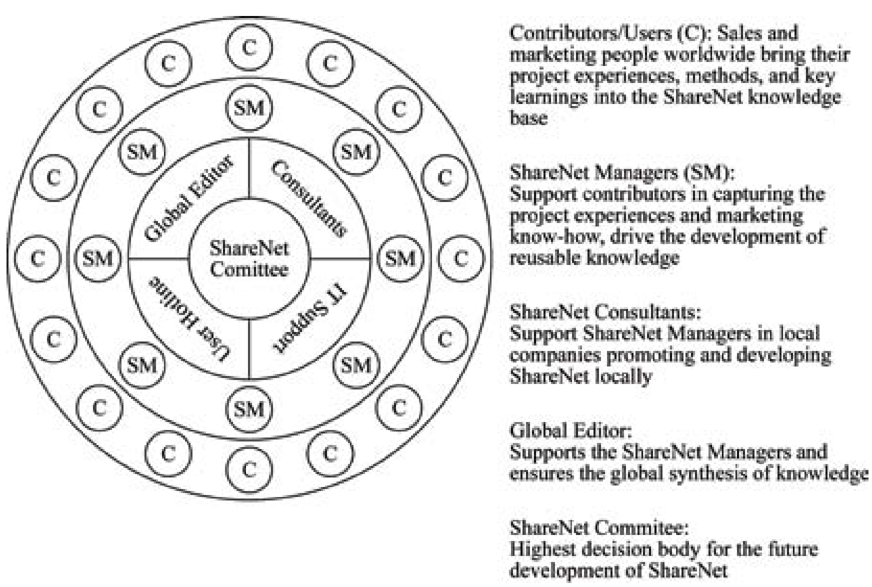
For the managerial systems, the Munich workshop decided on a range of objectives: first, to increase the usage of ShareNet and thereby improve value creation in sales; second, to support the capturing of knowledge created in the sales processes; third and last, to enable ShareNet's further development and growth by rewarding knowledge sharing. In order to ensure that all ShareNet crucial elements (processes, content, community, and systems) were developed and improved further, the Munich workshop participants proposed a consistent organizational structure. Exhibit 5 shows the resulting ShareNet organization, roles, and tasks.

Top management support mainly relied on explicit means of change communications to bundle organizational resources and individual commitment to the project. Line managers rather served as neutral intermediaries to spread ShareNet's idea across organizational levels and functional departments. Nevertheless, in the long term the ShareNet Community should assume responsibility for the KMS' maintenance and evolution through its input and formulation of requirements. In March 1999, Roland Koch, ICN group president, decided to continue the project and to proceed with the next development stage: "This [ICN ShareNet] network will be of key importance for the success of ICN's solutions business, because the company that is able to make use of existing experiences and competencies quickest has a distinct competitive edge over the other players. We need to be among the first to realize this strategic competitive advantage through efficient knowledge management."

Setup & Piloting

The second key project stage — "setup and piloting" — lasted from April to mid July 1999. Objectives were to test and improve the technical platform, to ensure local company commitment to the project, and to develop a phased implementation approach including training material. BCG's assignment ended with the final workshop in Munich. The KMS was rolled out in four pilot countries (Australia, China, Malaysia, and Portugal) chosen for the following reasons: they

Exhibit 5. The ShareNet organization



showed good "fit in" with the core team, represented Siemens' global operations well, and their first cross-regional sharing of experiences set examples for the entire company. A pilot project team conducted informal training sessions with workshops developed by Rolf Meinert, vice president of change management.

The ShareNet team project saw the pilots as an important means to rapidly establish buy-in at headquarters and local companies. Team members and managers from the ShareNet committee began to meet key executives in local companies (i.e., local ICN heads, local company heads) and at headquarters. They made sure that the managers were committed to KM, informed the team about local particularities, and nominated or supported ShareNet managers. Besides the training material, the ShareNet project team had no formal change management strategy, but rather a range of measures to overcome common implementation barriers. Keeping the right balance between challenging and realistic goals avoided "scope creep". Involving users in developing their own KM solutions helped to build personal networks, to create buy-in and trust with internal customers, and to secure top management support.

The team strongly believed in a bottom-up approach for ShareNet manager nominations. Koch sent a personal letter to all local companies to create awareness for the KMS and to request the nomination of one part-time ShareNet manager per country. In addition, Meinert approached potential ShareNet managers all over the world, making use of his large personal network. Only in the case where countries without voluntary participants were detected were the local company heads asked to nominate some of their employees as ShareNet managers. Lack of competence and commitment or too strong a focus on technology were often the result of forced nominations. In very few cases, a removal of ShareNet managers who did not live up to their obligations was necessary.

Technical systems accounted for only 25% of total project costs; the majority was spent on the selection and training of prospective ShareNet managers, communication campaigns, and training material. The ShareNet project team and the external consultancy Change Factory jointly developed a range of user trainings/workshops and tools for the global rollout, for example training videos, illustrated pocket references, and giveaways. A mission statement concretized ShareNet's vision and explicitly linked it to economic benefits: "ICN ShareNet intends to network all local sales efforts to facilitate global learning, local reuse of global best practices, and the creation of global solution competencies. ICN ShareNet shall realize considerable and measurable business impact through time and cost savings and through the creation of new sales opportunities. ICN ShareNet shall be integrated in the daily work of every sales person. ICN ShareNet is a self-organizing growing system."

The ShareNet project team decided on two-sectioned local company workshops as a central element of the change management initiative. The first section — creating necessary know-how for using ShareNet — followed the participants' working routines. They would learn about ShareNet's philosophy, discover its benefits for daily work, and get to know the structure and handling of the technical platform. Coaches would provide walk-through examples, live exercises, and stimulate discussions about the value-add of global knowledge exchange. During the second section — capturing knowledge with ShareNet — the participants would start to capture and peer review some sample projects they brought to the workshop. A positive, knowledge-oriented attitude was considered the basis for success.

The pilot project team began to test the KMS' database, GUI and usability, response times, and reliability. Objectives were to have secure and stable technical systems available for the "global rollout" stage. To ensure smooth integration with Siemens' Intranet, the ShareNet project team took a close look at Siemens ICN's global technology infrastructure and the level of the local sales representatives' Intranet know-how. Early on, the core team planned for integration with other Siemens knowledge sources and systems. However, the full mapping of all content into the ShareNet data model was never realized since speed of implementation was favored over lengthy coordination with other IS owners.

Global Rollout

The third key project stage — "global rollout" — lasted from mid July 1999 to mid February 2000. Objectives were to have ShareNet implemented in 30 major countries, to establish the ShareNet organization and managerial processes, and to capture and reuse valuable knowledge. The ShareNet project team provided user trainings, controlling to steer the global rollout, and communication material. Four phases for the international rollout were decided: buy-in and preparation (partly accomplished in the preceding stage), ShareNet manager handover, ShareNet workshops in local companies, and ShareNet manager review meetings.

Early in the "global rollout" stage, the introduction of the consistent incentive system "bonus-on-top" put even more emphasis on top management support. Some local executives felt threatened by ShareNet because their employees were bypassing traditional hierarchies in search of solutions. A one-time promotion scheme in fiscal 2000 should link knowledge sharing with economic benefits: local ICN heads should now be rewarded for inter-country business generated through substantial international knowledge exchange. "Business generated" was the total order income of projects secured with knowledge from other countries and the revenues from other countries created with knowledge from the ICN head's local company. "Substantial international cooperation" comprised reuse of knowledge via ShareNet and/or a verifiable exchange of human resources, which together accounted for more than 10% of the order income generated, and/or more than 10% of total project cost or time savings.

To be eligible for a bonus of approximately 10% of their fixed annual salary, the overall revenue achieved should sum up to at least 5% (up to 30%) of local ICN revenue (Gibbert, Kugler & Völpel, 2002). The local ICN heads had to complete forms that contained all cases of collaboration, that is, success stories. Several restrictions applied: since a successful knowledge transfer was described, knowledge giver and taker had to work in distinct departments and project groups and the amount of time and money saved or additionally earned turnover had to be stated. For approval, the ShareNet project team required written proof, for example, invoice, purchase order, or delivery confirmation. The success stories could be checked against each other just like consolidated balance sheets to ensure accuracy. Bonus-on-top yielded remarkable results: during fiscal 2000, Siemens ICN reported additional revenue of EUR130.9 million from international knowledge exchange, some 50% obtained through ShareNet.

The ShareNet manager handover took place at the end of July 1999. Participants from some 30 countries were assembled for the first time at a one-week boot camp in Feldafing, Germany. The ShareNet team selected rollout countries primarily on the basis of annual sales, availability of local ShareNet project team members, advanced market stage, and advanced technology infrastructure. The ShareNet managers received in-depth formal training enabling them to take over the responsibility for the introduction and utilization of ShareNet in local companies.

Moreover, the ShareNet project team intended to build-up committed social networks, first among ShareNet managers, and later throughout the sales and marketing community. Team building events, for example, trying to build a raft without tools to cross the Lake Starnberg, and a friendly and relaxed climate were important change management measures. Doering recalled the team spirit at the boot camp: "All they had to work with were steel drums, logs, pontoons, and some rope. Another catch: no talking. The managers, who gathered from offices around the world, could only scribble messages and diagrams on a flip chart. For the better part of the day, it was knowledge sharing at its most basic. Yet the group managed to put together a small fleet of rafts, which they paddled about triumphantly on the placid waters of the lake."

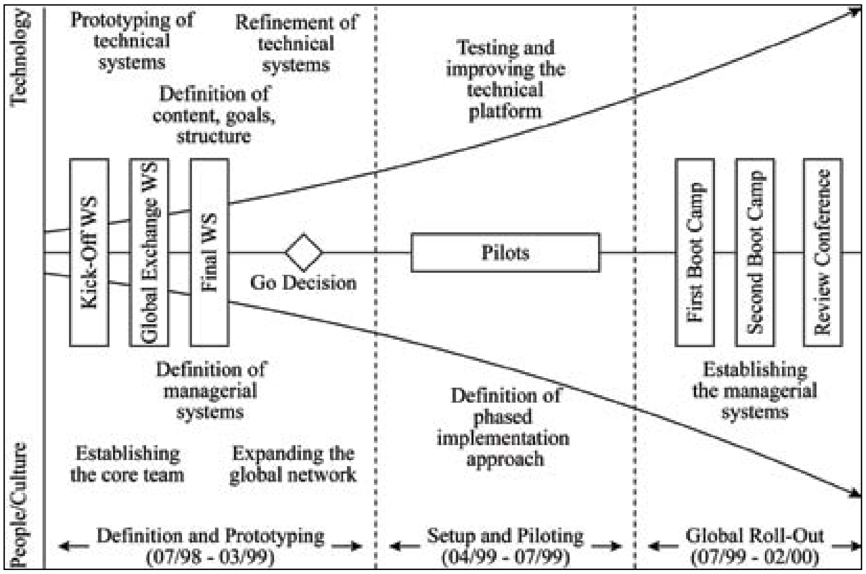
There was low headquarter participation at the first boot camp and the business units showed higher implementation resistance than local companies: they were afraid to lose sales opportunities for internal services, questioned ShareNet's positioning among other IS, and did not fully appreciate value creation in local companies. In addition, headquarters were afraid of sharing centralized knowledge, that is, a source of influence and power. Whereas more than half of the local companies' employees supported the KMS and some 20% resisted its implementation, numbers at headquarters were roughly vice versa. Resistance came in several flavors: inactivity and lack of implementation support, postponing decisions, preventing employees from posting safeguarded knowledge, denying the right to use ShareNet, and all kinds of politics. The ShareNet project team decided to continue the implementation with central funding and a focus on key impact areas, that is, the local companies.

Soon after the boot camps, the ShareNet managers began with the local rollouts. On average, each local implementation required project work for two or three months: one week for "selling" ShareNet in the local companies, three weeks for user training/workshops to teach the necessary skills to capture knowledge, up to two weeks for the review of captured content, two to three weeks for the support of local staff, and two days for a final review meeting. The ShareNet project team and ShareNet committee members visited 18 countries to support the implementation with communication campaigns and workshops. The entire implementation process was centrally driven and monitored, for example, rollout targets, resources, and workshops. Country-specific metrics were tracked and discussed with the local ShareNet managers on a monthly basis.

To formally conclude the KMS project, the ShareNet project team organized a ShareNet manager implementation review conference at Sun City, South Africa in February 2000. Goals were to reinforce community spirit, to exchange experiences with the international rollout, and to define future implementation ideas. Exhibit 6 recapitulates ShareNet's key project stages. Doering felt a substantial commitment to change: "ICN ShareNet is more than a database; it is a new spirit, a new way to cooperate worldwide across country and organizational boundaries. Knowledge reuse is the key to success, e.g., innovation, time to market, etc. With ICN ShareNet we take advantage of our strengths: local innovations and creativity and global leverage of sales power." Approximately 4,200 ShareNet users had registered and posted more then 2,100 public knowledge objects and 490 urgent requests; news and discussion groups enjoyed significant traffic.

To emphasize the project closing's importance, Koch participated via videoconference on the conference's last day. The participants consolidated their key learnings. Everybody acknowledged that ShareNet needed political attention and ongoing top management support, that is, Siemens ICN's group executive management and local ICN heads. Otherwise, time resources and prioritization for ShareNet rollout activities would consequently be too low. An adjustment of goals, incentives, and rewards was required for all members of the ShareNet organization and individual users. ShareNet managers needed sufficient time for support; that is, 25%-50% of their working time; other tasks had to be reduced. During a formal handover ceremony, the ShareNet project team transferred the KMS' ownership to a regular line organization, that is, the new ShareNet operating team. Through their new representatives, users

Exhibit 6. How ShareNet was developed



should finally assume ownership and responsibility for ShareNet's maintenance and evolution.

Operation, Expansion, & Further Development

The fourth key evolution stage — "operation, expansion, and further development" — lasted from mid February 2000 to the end of November 2001. Objectives were to continuously expand ShareNet throughout Siemens ICN and to further refine and develop the technical platform. The ShareNet operating team felt that knowledge exchange did not come naturally to the corporate culture. There were old boys' networks, risk adverse decision making, and a strong engineering "do-it-all yourself" culture that made it difficult to get accustomed to new rules of competition (Gerndt, 2000). Top engineers had adopted a "hero mentality," showing respect only for individual design achievements (Davenport, De Long & Beers, 1998). Innovations no longer originated in central R&D; rather they were derived from customers' needs. Strong hierarchies counteracted an atmosphere of openness, mutual respect, and ambiguity tolerance since they placed value on individual achievements at the expense of teamwork.

The ShareNet operating team recognized that people were slow to change their behavior; first results from culture change after a few years showed that the whole processes needed a decade to become self-sustaining. Albeit "bonus-on-top" had been successful beyond expectations, it was unclear whether ShareNet itself was benefiting. Users commented: "Receiving some […] award naturally serves as an incentive to sharing our knowledge with colleagues worldwide, but it is not the most important aspect. Getting direct recognition for how much our daily job is appreciated is the most important thing. That's what counts and motivates us." The new team decided to focus incentives and rewards more on the users themselves to get a critical mass of content into the system, to make users active contributors, and to create awareness.

Consequently, the ShareNet quality assurance and reward system went live on March 1, 2000. There were no monetary incentives since they encountered ambiguity in local companies; a share system, comparable to frequent flyer miles, faced less obstacles. ShareNet shares could be collected, accumulated, and finally turned into knowledge-related rewards. The share system was a flexible incentive scheme that could be adjusted according to needs for motivation and guidance: for example, objects published and forum responses yielded between three and 20 shares, dependent on a pre-assigned value. One share was equivalent in value to approximately EUR 1.00. ShareNet's technical systems automatically distributed the shares for contributions.

During the first four months, the share system yielded remarkable results: there was more awareness for ShareNet (35% new users), more activity (50% additional active contributors), and increasing content quantity (plus 90% knowledge objects posted). In July 2000, the competitive reward system was turned into an "online shop" where shares could be traded for a defined range of products, for example professional literature and Siemens laptops. But the success in quantity imposed drawbacks on quality. Lots of users — especially ones that joined ShareNet in earlier stages — lamented the decrease of content quality. Thousands of new objects brought the ShareNet managers' formal review process to its limits.

The ShareNet operating team introduced a peer-to-peer review process, that is, feedback from users to contributors. The change became visible through a five-star-rating of objects and urgent request answers. The stars were multiplied by a certain factor to compute the amount of shares the contributor earned. Introducing this new review process boosted the quality (plus 50% reuse feedback per knowledge object). The "ShareNet Special Weeks," that is, doubled shares for promising knowledge objects, aroused even more interest in July 2001. Though many knowledge objects were posted and several new users registered, the ShareNet operating team criticized special events: an artificial and expensive hype was created that rapidly ebbed off.

The ShareNet operating team continued with "networking people" at a second ShareNet manager conference in Istanbul in December 2000. Some 60 participants revised the quality assurance steps, discussed the inclusion of other communities into the KMS, and defined ShareNet manager targets. The basic requirement for the latter was general user support, for example, user trainings, presentations, and monthly reports. Complementary was the establishment of a constant knowledge input, that is, 1.5 knowledge objects per registered user per year, plus/minus 30% flexibility according to local peculiarities (knowledge givers vs. knowledge takers). Further required were the documentation of two success stories per 100 registered users per year and high performance knowledge exchange, that is, an average of 10 shares per registered user per month. As a result some 20 ShareNet managers received 50-120% of an additional fixed monthly salary as a bonus at the end of 2001.

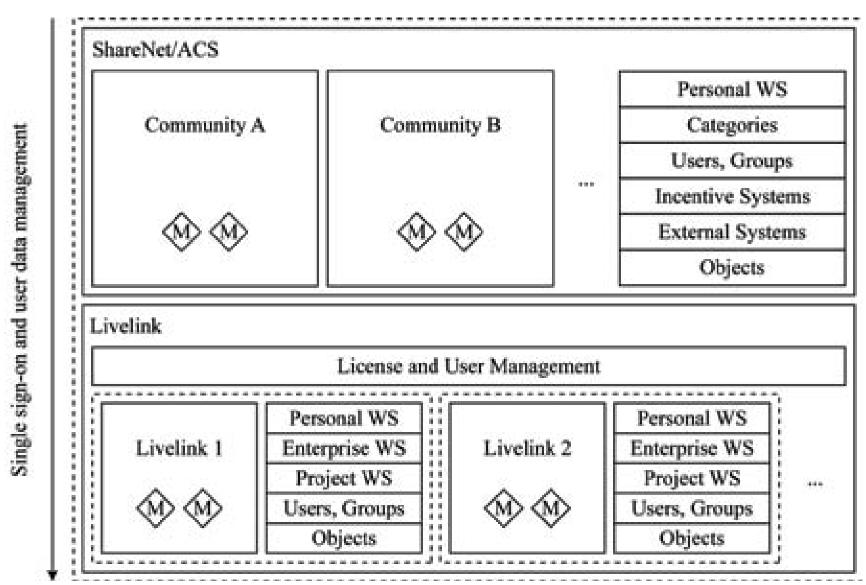
Shifting to a Multi-Community Concept

The fifth and last key evolution stage — "shifting to a multi-community concept" — began in December 2001. ShareNet had aroused much interest within Siemens. Heinrich von Pierer, Siemens CEO and president, declared ShareNet a Siemens-wide KMS best practice. Objectives of this stage were to sharpen the focus on topics leading to more efficiency, to foster the development and progress of smaller communities-of-practice (CoPs), and to delegate maintenance responsibilities to new user groups. The ShareNet operating team had gathered many requests for CoPs focusing on specific topics of interest. Those were seen as a good indicator for an institutionalization of the concepts and meanings inflicted by the culture change. Siemens ShareNet V1.x marked the introduction of a company-wide, multi-community platform.

The former ShareNet became one CoP amongst others but retained the largest number of users. The conceptual change necessitated a personal workspace (WS) with personal data, e-mail alerts, bookmarks, and links to all CoPs for which users had registered. Community homepages provided an overview of community-specific content for each user, for example, new threads since last login. Designated functional modules (M), that is, knowledge libraries, discussion forums, chat, and news, could be flexibly adapted to each CoP's businesses processes to win over users. This design also reflected the security requirements of sub-communities dealing with sensitive topics. In cooperation with other Siemens group divisions an interface/bridge license and user management was designed to ensure information exchange between ShareNet and Livelink Communities (the corporate document management system). Exhibit 7 shows the underlying technologies.

When the new technical platform went live, some users complained about the new layout (adapted to Siemens' corporate identity guidelines), many bugs, and weak performance. The majority of bugs were resolved quickly, while performance tuning required more time. Due to unclear specifications, former functionality was missing in Siemens ShareNet V1.x. ShareNet consultants and the global editor were badly prepared and encountered many obstacles over the first weeks. High user demand could not be met due to a shortage of resources: the central IT function needed additional human resources for timely development, implementation, and documentation; ShareNet consultants lacked money to travel and to train users globally. Top management could no longer provide the usual level of support due to other pending problems, that is, the collapsing telecommunications sector.

Exhibit 7. Application overview Siemens ShareNet V1.x



Through its successes in the sales and marketing functions, ShareNet had always attracted attention from R&D employees. As a result, just before the introduction of the new ShareNet technical platform, the ShareNet team was approached by an R&D department that focused on the development of "carrier products". This specific development process was well established and had not changed for many years. It, however, lacked formal mechanisms to share experiences and ideas across individual projects, for which R&D employees had to rely on their personal networks. As ShareNet had proven its ability to extend private networks within the sales and marketing environment, the R&D initiators expected the same for their community.

Discussions between the ShareNet team, the initiators, and several potential key users led to the development of R&D-specific knowledge objects and a corresponding capturing wizard. Since no further user involvement was desired by the community leaders, only brief training sessions were conducted at headquarters. The first results were disappointing: a general lack of traffic with a narrow focus. The ShareNet operating team members explained this in part by pointing out the proprietary R&D applications as well as (perceived) security concerns that made possible users cautious. A virtual R&D conference set a more positive example. Participants could post presentations with links to discussion threads and knowledge objects. Similar to traditional conferences, presentations were organized by time sequence and were available for a window of time. After a slow start on the first day, lots of comments were posted the following days and active discussions evolved among the virtual participants (MacCormack, 2002).

In September 2002, the ShareNet operating team announced a change in the knowledge sharing incentive system. Two main reasons were given: first, implementation success was established; second, both the current business situation and the business outlook were gloomy. Users could still keep and accumulate shares, but the incentive catalog was discontinued. There was no consensus within the ShareNet operating team whether the intrinsic motivation of knowledge exchange had already made ShareNet's usage self-perpetuating. For compensation, visibility and expert recognition, invitations to high-level events, and integration with business processes, for example employee target agreements, were planned. However, most decisions were neither taken nor implemented since Siemens' decentralized matrix structure required such decisions from local companies and not from Siemens ICN's executive management.

On the one hand, some team members were confident that the power of the ShareNet Community was not founded on incentives only. Users would keep their motivation on a high level since knowledge sharing was needed more than ever with globally distributed expertise and experiences. Thomas Ganswindt, Siemens ICN's new group president, exclaimed: "global networking and sharing knowledge is key to the success of ICN, even more since we will no longer have all the necessary knowledge in all local companies. The same counts for headquarters. And, if people really contribute to the success of ICN, it has to be beneficial to them." On the other hand, some team members argued that a discontinuation of extrinsic motivators would lead to significant drops in contributions and usage or even to a deadlock situation. Existing users might become passive and it would be difficult to attract others.

CURRENT CHALLENGES/ PROBLEMS FACING THE ORGANIZATION

The collapse of the telecommunications sector in 2001 did hurt Siemens ICN as seriously as any of its competitors. As a response, the group executive management started the Profit and Cash Turnaround (PACT) program. Its first phase, "clean-up," aimed for cost reductions through organizational redesign, headcount reduction, and improved asset management. This phase lasted until fiscal 2003. In the same year, the overlapping second phase, "rebuild," started — continuing until 2004. It comprised customer-orientated portfolio adjustments, as well as the implementation of innovative concepts for leveraging the synergies of enterprise and carrier solutions. Beginning in fiscal 2004, the third phase, "growth," emphasized intense customer relationships, streamlined processes, and a balanced portfolio of products and services.

"Rebuild" and "growth" were fuelled by major efforts in the field of innovation. On one hand, the group executive management required Kugel's BT team to design and kick-start a common innovation process and a technology roadmap. In addition to an existing product line process for incremental innovations, Kugel's team implemented a process to fuel disruptive innovations. Linked with ICN's strategy and based on ideas from internal and external sources, both defined innovative projects to be handled in the carrier and enterprise business' product development processes. The technology roadmap unified the view on existing and emerging technologies for all these processes, in order to foster synergies and to avoid double work. On the other hand, the existing R&D function and its product development processes were reconsidered in order to shorten new products' time to market. As one outcome of this revision, the new group president Thomas Ganswindt requested Doering to expand ShareNet throughout the R&D function. In turn, Doering asked Kugel to provide him with a detailed roadmap within one week.

Kugel knew that the "clean-up" phase's headcount reduction had struck the whole organization. Not only was her KM team reduced to three full-time employees — just about able to maintain the existing ShareNet — but the local companies were reducing their ShareNet managers as well. Additionally, the targeted R&D departments were made leaner while simultaneously speeding up their cycle times. Those developments limited the organization's ability and willingness to devote resources to KM. Cost reductions made it impossible to increase funding for external resources unless a striking business case could be presented. This was the only way to imagine a rollout comparable to the sales and marketing implementation.

The extremely difficult business situation and outlook also had severe impact on ShareNet usage. More than ever, employees were complaining about their lack of time for knowledge sharing. Facing massive layoffs, knowledge hoarding was again taken up as a means to make oneself irreplaceable. The discontinuation of the highly efficient ShareNet incentive and reward system and its less successful substitution with the recognition of ShareNet "masters and experts" added to the general challenges. In result the number of visiting users had fallen from some 4,600 (in August 2002) to some 2,100 (in August 2003). Page views declined from 179,000 to 75,000, and the number of contributing ShareNet users dropped from 432 to 190.

Though PACT led to more centralization in terms of target definition and controlling, it still made use of the "networking company" that ShareNet had fostered. Most employees recognized the need to identify and leverage Siemens ICN's knowledge globally in order to remain competitive and innovative. A majority shared knowledge freely without ever making personal contact; rather they were bound together in a global corporate network, worked within the same industry, and had a common code of conduct. It had become a habit for Siemens ICN people to involve local companies into strategic decisions. This approach ensured global applicability and established early buy-in.

While looking at the Alps from her office, Kugel wondered how to capitalize on the earlier experiences and accomplishments. Would the existing ShareNet line organization, training material, user base, brand identity, and culture change allow for a cheap and fast expansion into R&D? What would she present to Doering? A first meeting with her team led to the identification of three major expansion alternatives: first, replicating the original — but expensive — sales and marketing implementation approach with only minor modifications; second, identifying and fostering a range of smaller, topic-driven R&D communities (e.g., for technologies on the roadmap); third and finally, expanding ShareNet step by step along the R&D processes — starting from the recently defined innovation process, taking the adjacent process elements next and finally covering the full R&D process.

REFERENCES

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Davenport, T.H., De Long, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Earl, M.J. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Gerndt, U. (2000). Serving the community. *KM Magazine, 3*(9), 7-10.

Gibbert, M., Kugler, P., & Völpel, S. (2002). Getting real about knowledge sharing: The premium-on-top bonus system. In T.H. Davenport & G.J.B. Probst (Eds.), *Knowledge management case book: Siemens best practices* (2nd ed., pp. 260-278). Erlangen and New York: Publicis Corporate Publishing and John Wiley & Sons.

Ginzberg, M.J. (1981). Key recurrent issues in the MIS implementation process. *MIS Quarterly, 5*(2), 47-59.

MacCormack, A. (2002). *Siemens ShareNet: Building a knowledge network* (pp. 1-27). Boston: Harvard Business School Press.

Rothnie, D. (2001). ShareNet: Siemens information and communication networks. In V. Mellor, E. Barnfield & N. Aitken (Eds.), *Strategies for best practice intranet management* (pp. 186-194). London: Melcrum Publishing.

Seeley, C. (2000). Change management: A base for knowledge-sharing. *Knowledge Management Review, 3*(4), 24-29.

Siemens. (2003). *Annual report 2003.* Berlin.

Siemens Information and Communication Networks. (2003). *Facts and figures 2003.* Munich.

Zmud, R.W., & Cox, J. F. (1979). The implementation process: A change approach. *MIS Quarterly, 3*(3), 35-43.

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Chapter 5.11
Strategic Knowledge Management in Public Organizations

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INTRODUCTION

New public management and the more recent concept of new public governance have become the dominant management doctrines in the public sector. Public organizations have become increasingly network-like units with various governance relations with actors from the public, business, and voluntary sectors. Their organization is based more on networks than on traditional hierarchies, accompanied by a transition from the command-and-control type of management to initiate-and-coordinate type of governance.

Among the most critical factors in this transformation is knowledge, for most of what has happened has increased the overall demand to create and process knowledge and to utilize it in the performance of governmental functions. The success of public organizations depends increasingly on how efficiently they utilize their knowledge assets and manage their knowledge processes in adjusting to local and contextual changes, as illustrated in Figure 1 (cf. Fletcher, 2003, pp. 82-83; Gupta et al., 2004, p. 3; Skyrme, 1999, p. 34). This requires that special attention be paid to strategic knowledge management.

In the early organization theories of public administration, knowledge was predominantly conceptualized within the internal administrative processes, thus to be conceived of as bureaucratic procedures, rationalization of work processes, identification of administrative functions, and selected aspects of formal decision-making. New perspectives emerged after World War II in the form of strategic planning and new management doctrines. The lesson learned from strategic thinking is that we need information on the external environment and changes therein in order to be

Figure 1. The public organization as an institutional mediator (Adopted from Anttiroiko, 2002, p. 272)

able to adapt to and create new opportunities from these changes (see Ansoff, 1979; Bryson, 1995). As the complexity in societal life and related organizational interdependency has increased due to globalization and other trends, new challenges of managing organization-environment interaction also emerged (cf. Skyrme, 1999, p. 3).

BACKGROUND

The branch of management doctrine that became known as knowledge management (KM) reflected actual changes and new ideas in the business world. Classic works that inspired later developments included Polanyi (1966) and Drucker (1969). During the 1980s knowledge became widely recognized as a source of competitiveness, and by the end of the 1990s, knowledge management had become a buzzword. Among the best known thinkers who contributed to the rise of this field are Peter Senge (1990), Ikujiro Nonaka and Hirotaka Takeuchi (1995), Karl-Erik Sveiby (1997), and Thomas A. Stewart (1997). (On the evolution of knowledge management see Barclay & Murray, 1997; Gupta et al., 2004, pp. 8-10). It is becoming common understanding that in essence knowledge management is about governing the creation, dissemination, and utilization of knowledge in organizations (Gupta et al., 2004, p. 4; Lehaney et al., 2004, p. 13).

Knowledge cannot be managed in the traditional sense of management. The processing and distribution of information can surely be managed, but it is only one part of the picture. The other concerns knowledge and especially managers' ability to create conditions that stimulate active and dynamic knowledge creation, learning, and knowledge sharing within the organization (e.g., Nonaka, Toyama & Konno, 2000). To systematize this picture we may say that knowledge management includes four core areas (cf. Gupta et al., 2004; Lehaney et al., 2004):

- Information management: managing data and information, and designing information and knowledge systems
- Intellectual capital management: creating and utilizing knowledge assets, innovations, and intellectual capital
- Knowledge process management: organizing, facilitating, and utilizing sense-making and other knowledge processes
- Organizational learning: creating learning and knowledge sharing environments and practices

Traditionally the most widely applied areas of knowledge management in public organizations used to be data and transaction processing systems and management information systems serving mainly internal administrative functions. Yet, since the 1980s authorities started to facilitate the exchange of information by local area networks, followed by the Internet revolution of the 1990s. In the early 2000s the knowledge management agenda has focused increasingly on knowledge sharing and learning, and in inter-organizational network and partnership relations (see e.g., Wright & Taylor, 2003). As reported by OECD (2003, p. 4), knowledge management ranks high on the management agenda of the great majority of central government organizations across OECD member countries, followed with some time lag by regional and local authorities. Many public organizations have even developed their own KM strategies. The leading countries in this respect include France, Sweden, Finland, and Canada (OECD, 2003, pp. 28-29).

As to more operational actions, there has been a wave of intranet projects at all levels of public administration since the late 1990s. The result is that some 90% of state agencies surveyed by OECD in the early 2000s had their intranets in place. Sectors that really stand out as being well above the OECD average include organizations in charge of finance and budget, of justice, and of trade and industry (OECD, 2003, pp. 20-30). To give a concrete example from local level, New York City's Office of Technology set up extranet and intranet projects – the Human Services Extranet Project, to link the city agencies with human service contractors and the NYC Share Project, a citywide intranet that intended to improve the exchange of information among agencies – to facilitate external and internal knowledge processes. Such projects are typical in the public sector in the early 2000s. They indicate a transition from information management towards genuine knowledge management.

FOCUSING ON THE STRATEGIC ASPECT

Combining strategic thinking with knowledge management brings us to the very core of the life of organizations. Strategic knowledge management is a set of theories and guidelines that provides tools for managing an organization's knowledge assets and processes of strategic importance for the purpose of achieving organizational goals. The basic idea of strategic knowledge management in the public sector is to ensure that public organizations are capable of high performance by utilizing knowledge assets and knowledge processes when interacting with their environment.

What is essential in strategic knowledge management is that it needs to be strategic in the true sense of the word, as opposed to operational. Public employees have sometimes a tendency to view their knowledge requirements from the point of view of their current work practices. At an organizational level, too, there is sometimes a temptation to map out the future on the basis of current strengths and well-defined short-term challenges. The strategic approach to knowledge aims to overcome such inertia and narrow perspectives by creative knowledge processes, which help to transform views from introspective to outward-looking, from resources to outcomes, and from formal duties to actual impacts and customer satisfaction.

In the knowledge management literature, knowledge has primarily been approached either as an object or a process (cf. Sveiby, 2001). The main focus of public organizations is on knowledge processes framed by certain institutional arrangements. Among the most important of these are the political dimension and democratic control and legally defined functions, competencies and procedures within territorially defined jurisdictions. This theme will be discussed next.

FACILITATING STRATEGIC KNOWLEDGE PROCESSES

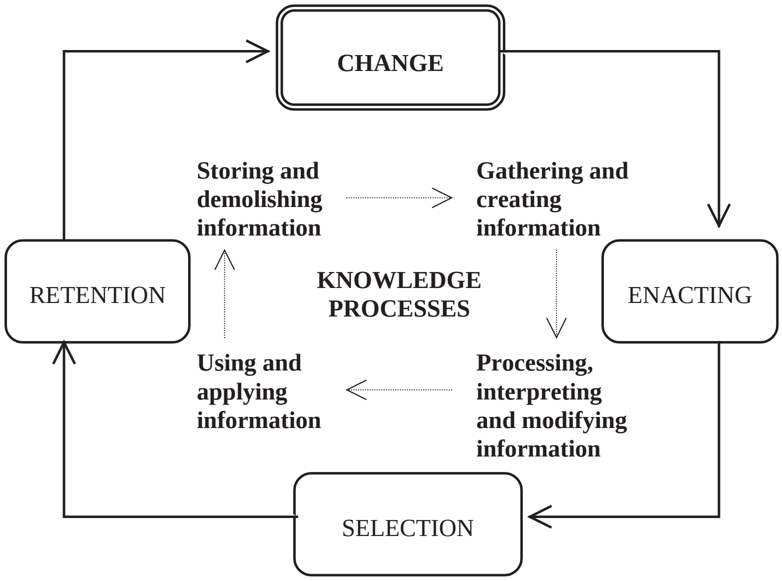
Public organizations possess and process a huge amount of information in their internal operations and external exchange relations. This is why the most important function of their knowledge management practice is to manage knowledge processes and to support knowledge-sharing practices.

Nonaka (1994) considers an organization's ability to accomplish the task of acquiring, creating, exploiting, and accumulating new knowledge. This formulation takes us very close to how the knowledge process can be operationalized. The knowledge process can be defined as an organizational process in which information is gathered, created, processed, used and dissolved in order to form an enriched orientation base for taking care of organization's basic functions (cf. Gupta et al., 2004, p. 3; Mendes et al., 2004, p. 153).

It is important to note that in the actual knowledge process it is more or less meaningless to make a clear-cut distinction between knowledge and information, for both are processed in such a process. For example, knowledge is not simply extracted from information, for knowledge is possessed by human beings and serves as a background and in-built epistemic frame to deal with complexity, novelty, and the requirements of innovativeness (cf. Wiig, 2000). Thus, genuine aspects of the category of knowledge are in question when we deal with statements, assumptions, and understandings and such learning and communicative processes in which these knowledge assets can be shared, assessed, and enriched. Many theorists consider that it is tacit knowledge in particular that is the most challenging and important form of knowledge in organizations (Nonaka, 1994; Polanyi, 1966). It also needs to be stressed that it is not knowledge as something abstract but a "generative dance" or interplay between (a) knowledge we possess and (b) knowing as an epistemic aspect of the interaction with the world that generates organizational innovation and strategic understanding (Cook & Brown, 1999).

Strategic knowledge processes are those aspects of knowledge processes that have the most profound and far-reaching impact on an organization's adjustment to contextual changes and on its core competencies. A paradigmatic form of a strategic knowledge process is the sense-making or strategy process in which an organization devotes effort to analyzing its internal attributes and external conditions and decides on that basis about the action lines in order to achieve its overall goals (cf. Weick, 1995). In such a strategic knowledge process the organization seeks information on environmental changes and utilizes this in strategy formulation, in which such tools as SWOT analysis have traditionally been used. A basic model of the organizational knowledge-based adaptation process is presented in Figure 2 (Anttiroiko, 2002). This model serves as a heuristic tool to conceptualize knowledge processes. Yet, it is important to keep in mind that this is only a starting point. When taking this idea further, clear-cut sequential stages or phases of the KM life cycle need to be "recontextualized" as a set of continuous interdependent sub-processes (cf.

Figure 2. Strategic sense-making and related knowledge process of the organization



Mendes et al., 2004, p. 165). Thus, context-related and situational aspects of knowledge need to be integrated with all essential connections to their environments into the key functions and operations of an organization in order to assess their meaning as a part of actual strategic adaptation and sense-making processes.

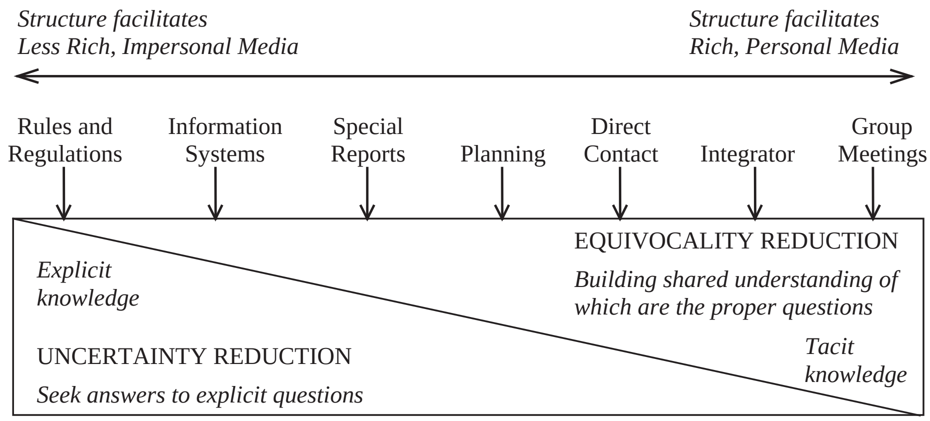
Applying Daft and Lengel (1986), we may ask how organization structures and systems should be designed in order to meet the need to manage knowledge processes. Well designed systems help to decrease the uncertainty and ambiguity faced by an organization by ordering the amount of relevant information and by enabling clarification of problems and challenges. Daft and Lengel propose seven structural mechanisms that can be used to deal with uncertainty and ambiguity in varying degrees, as illustrated in Figure 3. This model resembles the continuum of communication that has explicit knowledge and tacit knowledge as its extremities (Lehaney et al., 2004, p. 21).

The idea is that these mechanisms form a continuum starting from tools to be used to tackle well defined problems and thus to reduce uncertainty, and proceeding towards more communicative mechanisms designed to facilitate sense-making processes that aim at reducing equivocality or ambiguity (Anttiroiko, 2002).

As stated, a paradigmatic case for strategic knowledge management is the strategy process of an organization (on strategy and information resources, see Fletcher, 2003, pp. 82-84). What is of utmost importance is that managers ensure that people feel involved in the strategy formulation process. The staff also needs to understand the meaning of strategy in their own situations. This would help to make strategy documents living guidance that is owned by all in the organization, as concluded by Wright and Taylor (2003, p. 198).

Another important premise relates to organization culture and work practices that often

Figure 3. Continuum of knowledge facilitation mechanisms (Daft & Lengel, 1986)



impede the development of knowledge management. For example, employees may resist a new knowledge management initiative if they perceive it only as extra work. Similarly, employees may be reluctant to share their knowledge if there are no rewards or tangible benefits for themselves or their organizations. In all, the human factor is essential for improving KM practices, for most of the positive outcomes are the result of the commitment of all employees, successful structural changes in the organization, and the development of the organizational culture and climate (OECD, 2003, p. 4).

THE ROLE OF TECHNOLOGY

Information technology (IT) provides a range of new tools that can be effectively used in knowledge management. Relevant applications can support decision making, executive functions, planning, communication, and group work.

Tools and technologies available for knowledge management include generic communication tools (e.g., e-mail), computer-based information and decision support systems, document management systems, intranets and extranets, groupware, geographic information systems, help desk technology, and a range of knowledge representation tools. (Grafton & Permaloff, 2003; Gupta et al., 2004, pp. 17-24).In general, the Internet may be suggested as the KM infrastructure due to its widespread availability, open architecture, and developed interfaces (Jennex, 2003, p. 138).

In real life most of the tools applied in knowledge management are more or less conventional, such as training, seminars, meetings, and the like. Various KM-specific organizational arrangements had been adopted by about half of the organizations studied in the OECD survey on ministries, departments, and agencies of central government in the early 2000s. These measures include central coordination units for KM, quality groups, knowledge networks, and chief knowledge officers. Another important application area is the classification of information, referring to new filing mechanisms, e-archives, and new types of databases. In internal knowledge sharing Intranet projects form the mainstream, combined with wide access to the Internet and having e-mail addresses for the staff. The external knowledge sharing goes largely hand in hand with the emergence of new practices of e-governance. These practices have increased the knowledge sharing in both local and wider governance processes (Anttiroiko, 2004; OECD, 2003, pp. 17-20).

FUTURE TRENDS

The future challenge for public organizations is to increase their responsiveness to stakeholders, especially to citizens. At the same time they need to be capable of strategic institutional mediation in the increasingly turbulent environment, thus bringing an element of continuity and stability to social life and guaranteeing democratic and civic rights at different institutional levels. All this requires increasing capacity to manage knowledge of strategic importance.

CONCLUSION

Strategic knowledge management refers to the theory and practice of managing knowledge assets and processes of strategic importance. Public organizations need to create favorable organization structures and environments for knowledge sharing, organizational learning, and other aspects of knowledge management in order to create all the knowledge they require in their adjustment and trend-setting processes.

A main return of strategic knowledge management is better capability to adjust to contextual changes. This is difficult to measure, even if such tools as Balanced Scorecard (BSC), the Intangible Assets Monitor (IAM), and Intellectual Capital Index (ICI) are available. This is because they provide only a partial picture of KM performance, as claimed by Chaudhry (2003, p. 63). What seems to be needed is more process-focused assessments that are able to analyze the steps of KM processes, thus highlighting the actual changes in organizational knowledge base, capacities, and processes. As usual, there is no measurement system that fits all organizations in all situations. Rather, measurement should be tailored to the actual needs of the organization.

REFERENCES

Ansoff, H.I. (1979). *Strategic management*. London: Macmillan.

Anttiroiko, A.-V. (2002). Strategic knowledge management in local government. In A. Grönlund (Ed.), *Electronic government: Design, applications & management* (pp. 268-298). Hershey, PA: Idea Group Publishing.

Anttiroiko, A.-V. (2004). Introduction to democratic e-governance. In M. Malkia, A.-V. Anttiroiko & R. Savolainen (Eds.), *eTransformation in governance*. Hershey, PA: Idea Group Publishing.

Barclay, R.O., & Murray, P.C. (1997). *What is knowledge management?* Knowledge Management Associates. Retrieved February 11, 2004, from http://www.media-access.com/whatis.html

Bryson, J.M. (1995). *Strategic planning for public and nonprofit organizations. A guide to strengthening and sustaining organizational achievement* (rev. ed.). San Francisco: Jossey-Bass Publishers.

Chaudhry, A.S. (2003). What difference does it make: Measuring returns of knowledge management. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges*. Hershey, PA: IRM Press.

Cook, S.D.N., & Brown, J.S. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 10*(4), 381-400.

Daft, R.L., & Lengel, R.H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554-571.

Drucker, P. (1969). *The age of discontinuity. Guidelines to our changing society*. London: Heinemann.

Fletcher, P.D. (2003). The realities of the Paperwork Reduction Act of 1995: A government-wide strategy for information resources management. In G.D. Garson (Ed.), *Public information technology: Policy and management issues*. Hershey, PA: Idea Group Publishing.

Grafton, C., & Permaloff, A. (2003). Computer tools for better public sector management. In G.D. Garson (Ed.), *Public information technology: Policy and management issues*. Hershey, PA: Idea Group Publishing.

Gupta, J.N.D., Sharma, S.K., & Hsu, J. (2004). An overview of knowledge management. In J.N.D. Gupta & S.K. Sharma (Eds.), *Creating knowledge based organizations*. Hershey, PA: Idea Group Publishing.

Jennex, M.E. (2003). A survey of Internet support for knowledge management organizational memory systems. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges*. Hershey, PA: IRM Press.

Lehaney, B., Clarke, S., Coakes, E., & Jack, G. (2004). *Beyond knowledge management*. Hershey, PA: Idea Group Publishing.

Mendez, M.M., Gomes, J.F.S., & Bátiz-Lazo, B. (2004). Management of knowledge in new product development in Portuguese higher education. In J.N.D. Gupta & S.K. Sharma (Eds.), *Creating knowledge based organizations*. Hershey, PA: Idea Group Publishing.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(2), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company. How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*, 5-34.

OECD. (2003, April 3-4). *The learning government: Introduction and draft results of the survey of knowledge management practices in ministries/departments/agencies of central government*. 27th Session of the Public Management Committee, Public Management Committee (PUMA). Paris: Organisation for Economic Co-operation and Development (OECD).

Polanyi, M. (1966). *The tacit dimension*. Garden City, NY: Doubleday & Company.

Senge, P.M. (1990). *The fifth discipline. The art and practice of the learning organization*. New York: Doubleday.

Skyrme, D.J. (1999). *Knowledge networking. Creating the collaborative enterprise*. Oxford: Butterworth-Heinemann.

Stewart, T.A. (1997). *Intellectual capital: The new wealth of organizations*. New York: Currency/Doubleday.

Sveiby, K.E. (1997). *The new organizational wealth. Managing and measuring knowledge-based assets*. San-Francisco: Berrett-Koehler Publishers.

Sveiby, K.-E. (2001). *What is knowledge management?* Retrieved February 10, 2004, from http://www.sveiby.com/articles/KnowledgeManagement.html

Weick, K. (1995). *Sense-making in organizations*. Thousand Oaks, CA: Sage.

Wiig, K. (2000). Knowledge management: An emerging discipline rooted in a long history.

In C. Despres & D. Chauvel (Eds.), *Knowledge horizons. The present and the promise of knowledge management*. Boston, MA: Butterworth-Heinemann.

Wright, G., & Taylor, A. (2003). Strategic knowledge sharing for improved public service delivery: Managing an innovative culture for effective partnerships. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges*. Hershey, PA: IRM Press.

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Chapter 5.12

Secure Knowledge Management for Healthcare Organizations

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ABSTRACT

As the healthcare industry enters the era of knowledge management it must place security at the foundation of the transition. Risks are pervasive to every aspect of information and knowledge management. Without secure practices that seek to avoid or mitigate the effects of these risks, how can healthcare organisations ensure that knowledge is captured, stored, distributed, used, destroyed and restored securely? In an age where risks and security threats are ever-increasing, secure knowledge management is an essential business practice. The cost of security breaches in a healthcare context can range from the unauthorized access of confidential information to the potential loss or unauthorized modification of patient information leading to patient injury. In this chapter the authors highlight different approaches to minimising these risks, based on the concepts of authentication, authorization, data integrity, availability and confidentiality. Security mechanisms have to be in-depth, rather like the layers of an onion, and security procedures have to be dynamic, due to the continually changing environment. For example, in the past, cryptographic algorithms that were proven to be safe, e.g., 56 bit key DES, have succumbed to advanced computer power or more sophisticated attacks, and have had to be replaced with more powerful alternatives. The authors present a model for ensuring dynamic secure knowledge management and demonstrate through the use of case studies, that if each of the security layers are covered, then we can be reasonably sure of the strength of our system's security.

THE CONTEXT FOR SECURE KNOWLEDGE MANAGEMENT

Knowledge is intangible, expensive to obtain, easy to lose and invaluable to organizational success. An organization's knowledge can also be easy to view, steal, manipulate and delete. In the physical world knowledge is protected by structures such as non-disclosure agreements, filing cabinets and shredding machines. In the digital world the same kind of mechanisms are required to ensure our knowledge is well protected.

Security threats to organizational data are increasing exponentially both within organizational boundaries and externally. According to the respected CSI/FBI Computer Crime and Security Survey 2002 (Power, 2002), the largest majority of attacks on computer networks are internal. In this chapter initially we present a conceptual model for ensuring secure knowledge management in healthcare. Then we introduce key security technologies which can be used to implement components of the model, as well as providing background information on how these components have traditionally been implemented within IT systems. Finally we provide case studies of recent implementations that illustrate use of the model. We believe this will convince the reader that security is a necessity in the implementation of Knowledge Management Systems (KMS).

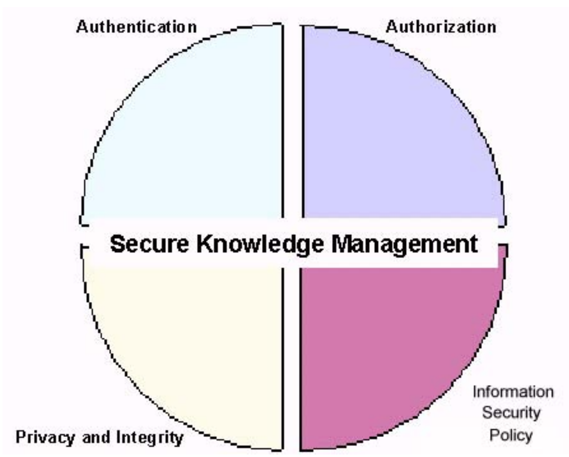
ENSURING SECURE KNOWLEDGE MANAGEMENT IN HEALTHCARE

A model for ensuring secure knowledge management in healthcare is shown in Figure 1.

- authentication: (1) Security measure designed to establish the validity of a transmission, message, or originator; (2) a means of verifying an individual's eligibility to receive specific categories of information (NIS, 1992) (see "Authentication Mechanisms");
- authorization: (1) The rights granted to a user to access, read, modify, insert, or delete certain data, or to execute certain programs; (2) access rights granted to a user, program, or process (NIS, 1992) (see "Authorization Mechanisms");
- data security (privacy): (The) protection of data from unauthorized (accidental or intentional) modification, destruction, or disclosure (NIS, 1992);
- data integrity: 1. (The) condition that exists when data is unchanged from its source and has not been accidentally or maliciously modified, altered, or destroyed (NIS, 1992) (see "Data Security and Integrity during Transfer");
- information security policy: organizational guidelines, rules, regulations and procedures that are used to protect an organisation's information (see "Security Policy").

Each of the four components is essential and mutually supportive. Authentication without authorization would mean that only valid users

Figure 1. Model for secure knowledge management



could gain access, but could execute any operations they wish to within the KMS. For example, in a patient records system, secretaries (who might be authorized to update a patient's name and address only) could execute a command to access health details for all patients or change diagnoses. Conversely, authorization without authentication would mean that anyone could masquerade as anyone else and thus gain his or her access rights. Information security policy provides the risk management, the appropriate controls, the recovery procedures, and the auditing procedures, etc. Without an information security policy there would be no apparent requirement for secure practices, and security would either be ignored or implemented in an ad-hoc manner, with the result that some controls could be too rigid and others completely missing. Finally, a system without privacy and integrity would be untrustworthy, so the knowledge contained within the system would be virtually worthless. For example, in a knowledge base containing details about clinical procedures, erroneous changes could be made to the information without detection, possibly leading to fatal consequences for patients. This model will be examined in greater depth in the next few sections, which provide information about mechanisms for implementing each segment of the model. Following these sections case material will be provided demonstrating the model in action.

AUTHENTICATION MECHANISMS

Authentication

How can you be sure that the user requesting access to your KMS is who they say they are? Traditionally, weak authentication systems, typically based on a username and/or password, have been a key source of unauthorized access to networks and computer systems. From a healthcare KMS perspective, authentication mechanisms provide a means to ensure that external parties that we do not wish to access the KMS cannot gain access without acquiring an authentication token. If we choose a strong authentication mechanism, then it should make it extremely difficult, if not impossible, for these parties to gain access to our KMS. Particular risks of poor authentication in healthcare would include potential unauthorized access to a KMS containing information, for example, on patient conditions, quality of patient care or hospital procedures. All attacks potentially could result in decreased patient care and liability or negligence cases.

In the US and other countries, government regulations such as the Health Insurance Portability and Accountability Act (HIPAA) mandating the privacy of patient identifiable information require that access only be granted to those parties authorized to view the information. Strong authentication of users seeking access to a KMS containing patient-related material will be essential in achieving compliance with these kinds of regulations.

Present Practices: Passwords and their Frailties

Traditionally, authentication to networks and computer systems has been provided by the use of usernames and passwords. In early password authentication schemes, users would simply log on using their username and password and the computer system would do a simple lookup that the password given matched the password stored for the user. However, password files could frequently be obtained from the system itself and then posted for all to see. So developers were required to secure the scheme by taking the password and passing it through a programming routine called a onetime hashing algorithm. The hashing algorithm mathematically reduces the data into a small (typically 128 or 160 bits), indecipherable series of bits. The hashed password can then be stored in the system instead of the clear text password. When the user logs into the system, the password they input is hashed and the new hash and the stored hash are compared to see if they match.

Password hashing is now commonplace, but hashed passwords are still vulnerable to dictionary attacks. This is where the attacker runs all the words in a dictionary through the hashing algorithm, and compares the generated hashes with the stored hashed values. Bad as this might seem, a potentially far greater threat than poorly protected password storage is the threat of human weaknesses. Users are prone to picking poor passwords, writing passwords down, and giving their passwords out, etc. Management steps should be taken to educate users and strengthen password usage. Simple information security policy statements, such as passwords must be eight characters or more in length and must contain a mixture of capital letters, lowercase letters and digits, provide improvements to the basic system and usually render the passwords impervious to dictionary attacks. User education can also lead to a movement away from bad habits such as leaving passwords on post-it stickers and giving passwords out to other people.

However, even with the various protection mechanisms mentioned above, passwords are still relatively weak. To be effective they rely on secrecy and strict policy management. In health environments where perhaps access to PCs is not strictly controlled, especially on wards where patients or other parties could gain unauthorized access to the PC, passwords are not an effective authentication mechanism. To gain effective authentication other mechanisms can be used both in conjunction with and as replacements for passwords.

Key Technology Focus: Biometrics

Biometrics allow users to authenticate themselves using personal characteristics that are less easily stolen or copied. On a user there are certain uniquely identifying attributes that can be used to determine identity, e.g., fingerprints, retinal scans, facial imaging, voice recognition, hand readers, etc. Biometric authentication comprises three phases. Firstly, a template of the user's biometric feature is recorded by the system. A biometric device reads the user's biometric feature several times and stores the average of the readings in the system. Several readings are needed because biometrics vary according to temperature, humidity, blood pressure, etc. Then when the user wishes to authenticate to the system, a biometric device records the user's biometric feature (phase two). Finally, the reading is compared with the stored template using some predefined matching algorithm (phase three). Unfortunately, due to the imprecise nature of the matching, biometric authentication is prone to false positives and false negatives. False positives are when an attacker is wrongly identified as being the user, and false negatives are when the user is not recognised by the system.

Biometrics technology has been piloted in a number of organizations (e.g., Essex Police and Securicor (UK), Washington Hospital Centre (DC)) and full-scale implementations are already in place in a number of business sectors (e.g., Nigerian electoral process, and the City of Glendale (CA)). In future KMS, biometric authentication will increasingly become the authentication mechanism of choice.

Key Technology Focus: Public Key Cryptography, Public Key Infrastructure (PKI) and Digital Signatures

The concept of Public Key Cryptography was introduced to the academic community in 1976 by two researchers called Whitfield Diffie and Martin Hellman (Diffie & Hellman, 1976). Public Key Cryptography was initially applied to encryption (covered in "Key Technology Focus: Data Encryption," basically encryption means to disguise data and decryption means to retrieve the data that was previously disguised), but it also solved the problem of authentication. The basic idea of Public Key Cryptography is to have two different security tokens, called the public and private keys, which work together as a pair. They can be used to perform mathematical operations on data, either digital signing/verification or data encryption/decryption. The public key is viewable to all users whilst the private key remains a secret to the entity to whom the keys have been given. If data is encrypted with the private key, it can only be decrypted with the public key, and vice versa. It is not possible to both encrypt and decrypt the data with the same key, nor is it usually possible to determine one key from the other. When data is encrypted with the private key of a user, this allows the data to be authenticated as coming from that user. When data is encrypted with the public key of a user, this allows the data to be made confidential for that user.

However, public key cryptography is slower to execute than conventional cryptography, which uses a single key. For this reason, when data authentication is required, the data is first condensed using a hashing algorithm. The hash value is called a message digest. The private key of the user is then used to encrypt the message digest. The encrypted digest is known as the digital signature of the data. The digital signature, along with the original data, are then sent to the recipient. On receipt the receiver takes the digital signature and decrypts it using the signer's public key, to reveal the message digest created by the signer. The recipient then creates his own message digest from the data sent by the signer and compares the two. If the two message digests match then the recipient can be sure that the data was sent by the signer and it has not been changed en route.

However, this presupposes that the recipient is in possession of the genuine public key of the signer. Whilst it would be possible for all users to personally meet and exchange their public keys with each other, this is not a scalable solution. Consequently, we need a reliable and trustworthy way of distributing public keys. A trusted third party, called a Certification Authority (CA), is used to digitally sign the public keys of users, to ensure that they cannot be tampered with. A CA would be contained within and managed by a hierarchical authority, for example the Department of Health and Human Services or a hospital's Human Resources department. The CA signs a message containing the name of the user and their public key, and its own name, and these certified public key messages are called Public Key Certificates (PKCs).

Should a user's private key become compromised (e.g., stolen), then we have a requirement to communicate this knowledge to other users. This is generally done using a particular construct called a Certificate Revocation List (CRL). A CRL contains a list of all the public key certificates no longer considered to be valid because the private key has been compromised or revoked, and the CRL is signed and dated by the CA.

A Public Key Infrastructure is seen as, "the set of hardware, software, people, policies and procedures needed to create, manage, store, distribute, and revoke PKCs based on public-key cryptography" (Arsenault and Taylor, 2002). Recently mechanisms for digitally signing the popular eXtensible Markup Language (XML) documents have been introduced (Eastlake et al., 2002). Within a healthcare KMS, users would generate XML documents. The content of these documents would then be digitally signed with the user's private key. When any user wishes to retrieve the document, they can then check the verification of the XML Signature using the public key of the signing user.

Key Technology Focus: Smartcards

Modern smart cards contain a computer embedded chip and user-specific data, which can be used to provide authentication when placed in a smart card reading device. The user-specific data can be anything linked to the user, such as a private key or a digital fingerprint. Traditionally this user-specific data would have been stored as a software token on a PC, making it liable to theft or deletion. Smart cards provide increased security because the user specific data is never allowed to leave the smart card. All processing operations are carried out via the on-board chip so the user-specific data can never be copied. Usually the data is further protected via the use of a password.

Previously high costs and unreliability (Chadwick, 1999) have been a significant factor in the slow adoption of smart card technology. Costs have significantly decreased recently and reliability has improved, so the adoption of smart cards becomes a viable option to the other authentication alternatives.

AUTHORIZATION MECHANISMS

Authorization

Authorization provides assurance that the users accessing the KMS have permission to do so. When authorization is combined with a suitable authentication scheme, we can be sure that the users accessing the system are who they say they are and are authorized to access the resource. Different access control models have been developed to ensure that only authorized users can access resources. From a healthcare KMS perspective, we wish to ensure that users are, for example: authorized to access the system, authorized to generate new knowledge within the system, and authorized to make changes within the system.

Discretionary Access Control (DAC)

Discretionary Access Control (DAC) can be viewed as owner-based administration of access rights. In DAC the owner of an object has discretionary authority over which other users can access the object. For example, Alex has just set up his own KMS and he grants access to Kate and Lee, but denies access to Spencer. There are various types of DAC including a strict DAC where Kate and Lee would not be able to grant access to other users, and a liberal DAC where delegation is allowed either with a strict limitation on the number of delegation levels or with no restriction (i.e., Kate could grant access to Sophie who could grant to Johnny, etc.). The DAC approach has some limitations, the most notable being how the owner can delegate his discretionary power to other people.

Mandatory Access Control (MAC)

Mandatory Access Control (MAC) can be thought of in terms of security labels given to objects and users. Each object is given a label called a security classification and each user is given a label called a security clearance, which includes a classification list. This list identifies which type of classified object a user has access to. A typical hierarchical classification scheme used by the military is unmarked, unclassified, restricted, confidential, secret, and top secret. A MAC policy using such a hierarchical scheme would typically be "read down and write up," which would help stop information leakage. A user with clearance of restricted could read from objects with classifications of unmarked to restricted but only write to classifications of restricted to top secret. The same user could log in as unmarked to enable them to write to levels up to restricted.

Role Based Access Control (RBAC)

In the basic Role Based Access Control (RBAC) model, permissions are granted to roles, then these roles are assigned to users who, therefore, acquire the roles' access permissions. Roles typically represent organisational roles such as secretary, consultant, etc. Roles confer both access rights to resources and the right to assign roles to users. For example, a physician may have read access to a KMS but not have the access right to alter data within it. A KMS security officer may have the right to assign people to roles, but no access rights to the resources itself. A role and its permissions tend to change infrequently over time whereas the users associated with the role will change more regularly. This basic premise makes associating permissions with roles easier than associating permissions with users. Users can change roles and new users can be allocated roles. As needs change, roles can be granted new permissions or permissions can be removed. The main advantages of RBAC are in maintenance and scalability.

Key Technology Focus: Privilege Management Infrastructure (PMI)

Privilege Management Infrastructure is a new development in the world of authorization. A PMI is to authorization what a PKI is to authentication. In a PMI a user is allocated digitally signed privileges, called attribute certificates, and these attribute certificates can be presented to a resource in order to gain access to it. The resource is governed by an authorization policy that says which privileges users must have in order to gain access and under which conditions.

Attribute certificates are allocated to users by attribute authorities (analogous to certification authorities in a PKI). They are digitally signed by the attribute authority, and because of this they can be stored in a public repository or held by the user on their PC. In order to gain access to a resource, the user must first be authenticated by the resource to prove that he has the right to assert the privileges contained within his attribute certificates. This authentication could be by any means, e.g., Kerberos, or a digital signature and Public Key Certificate. After successful authentication, the attribute certificates containing the user's privileges are verified and checked against the authorization policy. If the policy states that the privileges are sufficient then the user is granted access, else access is denied. A number of different PMI solutions are available including PERMIS and AKENTI.

DATA SECURITY AND INTEGRITY DURING TRANSFER

Data Security and Integrity

A healthcare KMS without data security and data integrity should be thought of as being untrustworthy. The information held within the system could have been altered, modified or had key sections removed. Even more importantly a KMS without data security may have leaked sensitive information to unauthorized parties. One of the key stages at which information leakage can occur is during data transfer over the network, Intranet or Internet. From a healthcare KMS perspective, looking at regulations such as HIPAA, poorly configured data security could result in unauthorized users gaining access to patient information and noncompliance. Without data integrity, staff will not be able to use a healthcare KMS effectively, as the information it provides will be unreliable.

Key Technology Focus: Data Encryption

In data encryption understandable data (plain text) is transformed using an encryption algorithm into incomprehensible data (cipher text) under control of a key. When the previous plain text is required the encryption algorithm, the key and the cipher text are used in conjunction to retrieve it. The cipher text looks like a random bit stream and there is no way of establishing the plain text from the cipher text without the key. The key is usually a randomly generated bit string consisting of 64-256 bits (the longer the key, the stronger the encryption). Various symmetric encryption algorithms exist with the most popular being CAST (Adams, 1997), RC2 (Rivest, 1998) and Triple DES (ANSI, 1985).

Encryption provides protection of the information within a KMS from unauthorized viewing as long as the text is cipher text and the attacker does not have access to the key. There are two forms of encryption that can be used, single key (symmetric) or dual key (asymmetric or public key). In single key encryption both parties use the same key for encryption and decryption. Dual key encryption follows the same principles described in the Public Key Infrastructure section. Therefore, encryption comes with the disadvantages of key management (who should generate keys, how to distribute keys, what to do if keys are lost) and a decrease in system performance due to the encryption/decryption process. Also encryption does not actually provide any assurance that the data has not been altered in transit and only some assurance that the data came from the person it is stated to have come from.

Secure Data Transfer Technologies, e.g., Secure Sockets Layer (SSL)

SSL is a security protocol, which can be used to provide a secure channel between two machines (server and client) across an insecure network such as the Internet. The protocol has provisions for the protection of data in transit, using Message Authentication Codes (MACs) (Krawczyk, 1997), and strong authentication of the server using X.509 public key certificates. It can also provide authentication of the client and encryption of the data whilst in transit. An SSL connection consists of two phases; the handshake and data transfer phases. The handshake phase authenticates the server and optionally the client, and also establishes the shared secret that will subsequently be used in the MACs and optional encryption mechanism that will be used to protect the data. Once the handshake phase is completed the data is split up and transmitted in protected packets.

There are a large number of SSL implementations available, ranging from the free and high quality Open SLL implementation (www.openssl.org) to vendor toolkits from organisation such as RSA (www.rsasecurity.com) and IAIK (www.iaik.at). Other mechanisms exist which provide secure data transfer including Transport Layer Security (TLS) (Dierks & Allen, 1999), which is essentially an improved version of SSL, S/Mime (Dusse et al., 1998) to secure email transactions and Secure Shell (SSH) (Ylonen et al., 2000) often used for configuration management. In a healthcare KMS, SSL would be used to provide a protected channel for users to access information from the KMS.

Key Technology Focus: Firewalls

A firewall is a system designed to prevent unauthorized access to and from your private network. The firewall consists of a number of components:

- The Internet Use security policy for the organization. This stipulates at an organizational level the expected security required when connecting to the Internet. (For example, all external access must be through a strong authentication system.)
- The mapping of the policy onto designs and procedures to be observed when connecting to the Internet. (For example, SSL client authentication may be required.)
- The firewall hardware and/or software used to protect the network

Each of the components is required. Without a policy the firewall cannot be correctly configured, as the technical staff will not know which traffic to let in and which to exclude. Without enforcing the procedures then many aspects of the policy may simply be ignored, such as inspecting the logs on a daily basis. Firewalls can be complex. A couple of the techniques used are shown below.

- Packet Filtering. Filters network data packets based on their Internet Protocol (IP) and UDP/TCP source and destination addresses.
- Stateful Packet Inspection. Inspects data packets as they are arriving and filters on a specific set of security rules.

Firewalls help prevent attacks against insecure services, can secure external access to required network services and provide a cost advantage over securing each host on an organizational network. However, firewalls are not without their disadvantages. Like any computer system without regular updates/patches, intruders can gain access to the healthcare network. They may also make it difficult for legitimate users to be able to access required network services. Hackers can also often circumvent firewalls by using "backdoors" into the healthcare network, provided for example by modems situated behind the firewall. However, the biggest disadvantage of firewalls is they provide no protection against the internal hacker. Given that hospitals are public places, this can pose a serious problem. By placing a second firewall directly in front of the healthcare KMS server, this can ensure that requests to that server are authenticated and only passed through on certain ports, thereby restricting the attacker's options.

Key Technology Focus: Wireless Data Transfer

Wireless technology, based on the IEEE 802.11 standard, is increasingly being adopted, especially in areas such as healthcare where the benefits of mobility are great. Unfortunately 802.11 offers only a basic level of security (open or shared-key authentication and static wired equivalent privacy (WEP) keys). But worse still, many wireless LANs are installed with no security at all or are left in default out-of-the-box configurations, thus allowing all comers to gain access to the network. Wireless LANs should always be configured with 128-bit WEP as a minimum, but even this can be compromised by the determined hacker, so wireless technology should not be used for mission critical KM applications unless the basic security is enhanced with technologies such as TLS, VPNs, IPSEC or 802.1X/EAP.

Wireless Access Points are used to set up wireless networks and connect the wireless network to the physical hard-wired network. We can compare a Wireless Access Point directly to an internal modem on the organizational network (i.e., it is a "backdoor"). The addition of wireless to the healthcare network must not come at the cost of reduced security. Therefore, we must think about the key elements in securing this new technology.

- access and authentication – Open authentication involves configuring the correct service set ID (SSID) to the client. This is no more than a shared password, which, without WEP, is transferred in the clear over the airwaves, so anyone with a wireless receiver can capture it and thus gain access. By using WEP (see below), the SSID is encrypted prior to transfer, thus making it difficult for hackers to decipher the SSID. Shared-key authentication on the other hand simply uses the shared WEP key for authentication. The access point sends the client a challenge and the client must then encrypt this with the shared key and return it to the access point to gain access;
- data privacy (provided by using WEP encryption and shared symmetric keys);

- network location and access point security (physically placing the Wireless Access Point outside the healthcare organisations firewall may limit any damage).

Notwithstanding the security concerns above, the benefits of using wireless technology within KMSs are numerous. Specialists can record procedures in places where there might be limited "wired" access and doctors can be permanently online whilst doing their ward rounds.

SECURITY POLICY

Secure Data Management: Storage, Backup and Disposal

An information security policy is the key to secure data management. Without policies in place governing the storage, backup and disposal of information, no attention will be given to the procedures that need to be in place to enforce the policy. A security system is only as strong as its weakest link and the actual computer/storage device on which a KMS is situated can be an easy target if the attacker can gain physical access to it. Therefore, in circumstances where a machine stores confidential information or business critical information its physical security must be assured. Access restrictions to the room holding the machine must be in place and strictly enforced. Furthermore, the machine itself must be protected by secure authentication and authorization mechanisms.

Backup tapes must be treated with the same amount of physical security as the systems they are used to restore. This is because the information stored within your KMS is also stored on the backup medium. If a backup medium is stolen then it is reasonable to expect that your system has been compromised. Thus backup media should be physically secured by either storing them in a locked room or safe. In addition to physical security, the backup medium may also be logically protected either by using data encryption and/or an authentication mechanism to activate the restore process.

Secure disposal of storage media also needs to be an information security policy requirement. There have been instances where confidential data has been left on computers that have been passed on to other organizations. Even worse, computers can be left still set up to access your network or KMS. Simply deleting information on computers is not enough to erase the data from the hard drive. The data either has to be securely deleted using a commercial "secure delete" application or the media destroyed. Without secure deletion procedures the healthcare organization and its systems are not only at potential risk from release of confidential information but also at risk from backdoors into the system.

Key Business Focus: Business Continuity Planning/Disaster Recovery

KMSs are invaluable resources. Losing the knowledge stored within such systems would invariably affect patient care and business continuation. In extreme cases the loss of an IT system can lead to the liquidation of an organisation. In the health community the loss of such a system could have results such as inefficient patient service, inaccurate diagnosis and loss of specialist practices. In extreme cases it could lead to the loss of human life (e.g., if important patient records are lost and diagnoses are lost or inappropriate drugs are prescribed).

The first step in the contingency process is to look at the business impact of losing the particular KMS combined with a risk and threat analysis. This will help to highlight areas of significant risk, which will need to be covered in detail by the contingency plan or mitigated by another measure.

An analysis of the risks and threats facing the KMS will lead us in the second step to the development of a comprehensive contingency and recovery plan, plus risk-mitigating actions. The recovery plan will highlight procedures for ensuring business continuity should any of the risks and threats be realised. The third step will be to test out the recovery plan. A recovery plan which does not work is of little use in an emergency. If backup links and servers have been installed, then time needs to be set aside to test that an operational service can be brought back into use with them. If a third party backup service provider is being used, they will usually allow you time each year to test that their system can run an operational service for you.

The final step in the contingency process is the continual audit, review and update of the contingency plan and risk mitigating actions over the lifetime of the KMS. In other words, this is a continual process that never ends, so as to ensure that the recovery plan remains up-to-date and workable. Further, new risks are continually arising and these have to be taken into account and new mitigating actions devised. It is essential to ensure that key personnel know the recovery plan or know where to obtain it. If, for example, a change has been made in IT personnel between the last audit and the new one then the audit would record if the new personnel knew about the contingency plan.

CASE STUDY: PMI IMPLEMENTATION (AUTHORIZATION SEGMENT OF MODEL)

In this section we present an example of how a PMI implementation can be used to provide strong authorization in our recently developed Electronic Prescription Processing (EPP) Application Programming Interface (API). In the EPP API we have integrated the PERMIS PMI API (Chadwick & Otenko, 2002) so as to control who is authorized to execute commands such as prescribe and dispense prescriptions and also to ascertain patients' rights to exemption from charges (Chadwick & Mundy, 2003). In a KMS one could envisage using PERMIS to control rights to access the system, modify the data, etc.

The overseer of the UK National Health Service, which for all intents and purposes is the Secretary of State for Health in the UK Government, would generate and electronically sign a PERMIS policy stipulating who can carry out which actions in the Prescription Processing System. For example, the policy might state that the General Medical Council is trusted to allocate the role of Doctor to qualified Doctors, and that anyone with the role of Doctor is allowed to prescribe. Therefore, a signatory member of the General Medical Council indirectly gives all General Practitioners in the UK NHS the right to prescribe when they are issued with a Doctor role privilege certificate. When the GP is generating a prescription their prescription program will use the EPP API, and the latter will call the PERMIS decision engine to determine if the GP is authorised to prescribe according to the rules laid down in the policy. As long as the prescriber has the role of Doctor, they will have been granted permission to prescribe and they will be allowed access to the operation to generate an electronic prescription. Similar mechanisms exist for dispensers within the prescription processing system and for determining the exemption qualification of patients.

In a KMS we could reasonably expect the system administrator or systems manager to be the policy owner. The system manager could define roles such as reader, editor, administrator, and grant appropriate permissions to each of the roles. Each of the staff would be allocated one or more role attribute certificates according to their job functions. If for example an editor wished to modify information in the KMS then they would request access, the PERMIS decision engine would be consulted, their role attribute certificates would be retrieved and access granted or denied according to the policy.

CASE STUDY: SECURE DISTRIBUTION OF PATIENT DIABETES INFORMATION

Hospitals in the UK keep a large number of patient information databases recording information about patients with chronic diseases, for both research purposes and clinical health purposes. Most of the information is only available internally to the secondary carers, and no access is provided to other healthcare professionals who may also be involved in the patient's care. The sharing of information between primary and secondary carers will provide a more efficient disease control system and enhanced patient care through a combination of a reduction in the number of duplicate investigations, more accurate information being available to all, and a speeding up of the business processes.

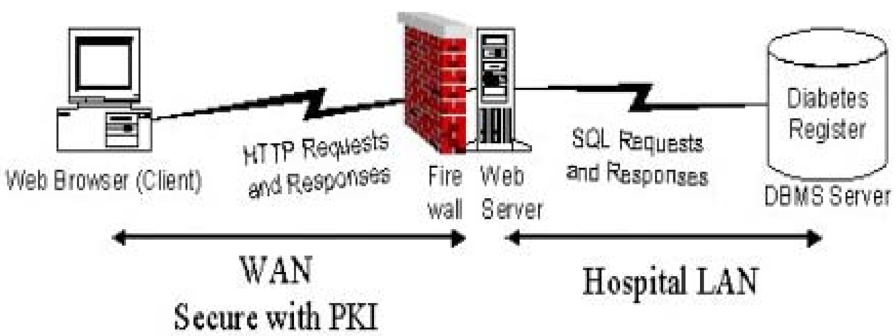
As an example of secure knowledge management, we ran a project to provide primary healthcare professionals with secure Internet access to a hospital Diabetes Information System (DIS). The DIS was implemented in 1992 and provides a complete record of all registered diabetic patients in the local hospital area.

The DIS is situated on the secure hospital Intranet and to provide Internet access to the system we required a strong security infrastructure (Figure 2). This is because the Internet is a highly insecure network and not suitable for the transfer of unprotected, confidential patient information. The backbone behind our secure solution was a Public Key Infrastructure (PKI). The PKI provides the required prerequisites of strong authentication and data privacy through the use of strong encryption from accessing the hospitals internal trusted network.

Requests for patient data are transmitted from the primary carer's PC via the Hyper Text Transmission Protocol (HTTP) using a standard web browser. The HTTP requests are encrypted and digitally signed prior to transmission, using PKI software installed on the user's PC, thus forming a private channel to the hospital firewall from the PC.

The messages are decrypted and the digital signatures checked on the firewall, and then

Figure 2. Distributed diabetes information system security infrastructure



transferred to a web server on the hospital Local Area Network (LAN). Scripts on the web server convert the HTTP requests into Structured Query Language (SQL) requests for information from the DIS. The DIS processes the requests and sends SQL responses back to the web server. The patient information is then routed back to the client PC and displayed as web pages in Hyper Text Markup Language (HTML) format. All information transferred over the private channel is encrypted and digitally signed using either the user's private signing key (for requests) or the hospital's private signing key (for responses). If the user's digital signature is successfully authenticated, that person is allowed access through the firewall and into the DIS. If the hospital's digital signature is successfully authenticated, the patient information is displayed (otherwise it is discarded).

This example shows that secure distribution of knowledge is possible across the Internet, using new security mechanisms with legacy databases. A full description of this is provided in Young et al. (2001). Looking at how the segments of our model for secure KMS have been filled in this example; we have used PKI services to secure the channel between the client and the server thereby protecting the privacy and integrity of the transaction. Authentication is provided by means of the user's digital signature. Authorization is provided through ACLs within the DIS. Security policy is in place at the hospital with strict rules for who can gain access through the firewall, and who can access patient data. A firewall is positioned in front of the hospital network to prevent undesirable users.

SUMMARY

This chapter has provided an introduction to the wide range of different security techniques that can be used to secure knowledge management applications, none of which on their own can be seen as a panacea to all of your security requirements. Simply put, a combination of authentication, authorization, privacy, transmission security and good information security policies and practices are needed to help to ensure a more secure knowledge management environment.

Returning to our model, we have demonstrated through the case studies that if each of the segments is covered, then we can be reasonably sure of the strength of our system's security. We believe the implementation of PKI or the use of third party certification services will become widespread, not only in healthcare environments but also in the general business world. PKI services for authentication, data security and integrity coupled with PMI for authorization and firewalls for restricted access, all underpinned by an enforceable information security policy and procedures, combine together to provide a sound basis for secure KMSs.

REFERENCES

Adams, C. (1997). The CAST-128 encryption algorithm, RFC2144.

ANSI. (1985). American National Standard for Financial Institution Key Management (wholesale). ANSI X9.17.

Arsenault, A., & Turner, S. (2002). Internet X.509 public key infrastructure: Roadmap. PKIX Working Group Internet Draft.

Chadwick, D. W. (1999). Smart cards aren't always the smart choice. *IEEE Computer, 32*(12), 142-143.

Chadwick, D. W., & Mundy, D. P. (2003). Policy based electronic transmission of prescriptions. *IEEE 4th International Workshop on Policies for Distributed Systems and Networks,* Como, Italy.

Chadwick, D. W., & Otenko, A. (2002). The PERMIS X.509 role based privilege management infrastructure. *Seventh ACM Symposium On Access Control Models And Technologies* (pp. 135-140).

Dierks, T., & Allen, C. (1999). The TLS Protocol Version 1.0. RFC2246.

Diffie, W., & Hellman, M. E. (1976). New directions in cryptography. *IEEE Transactions on Information Theory, 22*(6), 644-654.

Dusse, et al. (1998). S/Mime Version 2, Message Specification, RFC2311.

Eastlake, D., Reagle, D., & Solo, D. (2002). (Extensible Markup Language) XML-Signature Syntax and Processing. RFC 3275.

Krawczyk, H., Bellare, M., & Canetti (1997). HMAC: Keyed-hashing for message authentication. RFC2104.

NIS. (1992). *National information systems security glossary.* NSTISSI, 4009.

Power, R. (2002). CSI/FBI computer crime and security survey, computer security issues and trends, *Computer Security Institute. VIII,* 1.

Rivest, R. A. (1998). Description of the RC2(r) Encryption Algorithm. RFC2268.

Ylonen, T., Saarinen, M., Rinne, T., & Lehtinen, S. (2000). SSH Transport Layer Security. SECSH Working Group Internet Draft.

Young, A. J., Chadwick, D. W., & New, J. (2001). Providing secure remote access to legacy applications. *IEE Computing and Control Engineering Journal, 12*(4), 148-156.

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Chapter 5.13
Knowledge Management in Telemedicine

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ABSTRACT

Knowledge management (KM) can be defined as the discovery and dissemination of new knowledge. It has also been defined as the efficient utilisation of the existing intangible knowledge-related resources available in every sector of the economy to enhance the productivity of all factors of production. Telemedicine is a tool to enhance equitable distribution of healthcare across the world. In this chapter the author discusses the various aspects of knowledge management and telemedicine and proposes to globalize telemedicine.

INTRODUCTION

Organizations all over the world are adapting to rapid changes in many ways, and an approach that has made significant contributions to the resurrection of postwar Japanese industry is Deming's philosophy of total quality management (TQM). Deming's TQM is indeed applicable to the management of Internet businesses and eminently suitable for telemedicine and data-mining projects in life sciences. The apparent complexity of the system may appear as a deterrent to many, but the inherent simplicity is clear on examination of the Deming charter points. Leaders of Internet business houses will derive rich benefits from applying Deming's TQM to their organization, while investors will find it comfortable to interact with such organizations.

There is an urgent need for healthcare professionals to be multiskilled. Doctors and nurses have to introspect periodically and adopt a plan for self-improvement that should include acquiring new knowledge, developing a positive mental attitude, and learning new skills to meet the rapidly changing health needs of people across the globe.

The methods of diagnosis and treatment of human diseases have altered significantly in the last decade. In the early 1990s, the first signals of change began to surface with patients expressing dissatisfaction and discontent with one or more aspects of their care. Unknown to their primary-care physicians, they began to talk about their experiences with the hope that a degree of attitudinal change would emerge in some physicians, and permanent solutions to chronic health problems would start emerging. Direct patient-doctor communication was not in evidence, and institutions committed to healthcare chose not to encourage free discussions with their clients. This pattern persisted over the best part of that decade and led to strained communications between physicians and patients. This at one time resembled an estranged love affair, with neither party willing to move forward to resolve the conflict. However, before long, the Internet revolution became a phenomenon and made its presence felt in healthcare activities. Curiously, the initial recognition of the value of this phenomenon was made by suffering patients who realized the Internet was a handy tool to share their tales of woe amongst themselves and to obtain a degree of temporary relief and comfort. It was fortunate that some physicians had woken up to this phenomenon simultaneously and had begun to address the different scientific aspects in a proactive manner.

During the period of 1998 to 2000, the undercurrents of rapid information exchange were being felt, with different nations discovering its effects through a variety of experiences. Limiting the discussion on the influence of the Internet phenomenon on healthcare, we begin to see certain common patterns emerging across a wide spectrum of diseases across the globe, making data mining an exciting and profitable activity. The need is to automate:

- The right process,
- To the right population,
- At the right time,
- Through the right channel.

It is obvious that there are many elements of equal importance that have to be brought together in order to succeed at biomedical computing and data mining. What then has to be done to amalgamate these elements into a single whole in order to begin the process of data mining? Simply stated, if we have a foolproof system and the necessary human intelligence, it is possible to build a data warehouse and then mine it into saleable data marts for global consumption. I believe that the global scientific community possesses both the system and the intelligence to do this successfully.

The purpose of this chapter is to highlight the capability of Deming's total quality management to provide the directions and impetus to establish a framework for data mining in life sciences, and to demonstrate through a simple application the different ways to apply Deming's 14 charter points in actual practice (Creech, 1995). The future possibilities are varied and some thoughts will be shared toward creating an international consortium for the research and development of telemedicine applications (Paraki, 2001).

THE CONTEXT

In the last decade, observations of results of treatment with allopathy show it is incomplete and inadequate. This applies to both the outpatient and inpatient care of those with acute and chronic ailments. Patient dissatisfaction is evident in patients with chronic diseases such as arthritis, bronchial asthma, and many functional disorders like migraines, obstinate constipation, and irritable bowel syndrome. Furthermore, extensive interaction with professionals from other disciplines like management, IT, telecommunications, fundamental sciences, psychology, and philosophy has provided a solid basis for the development of holistic medicine as a preferred approach to the prevention and treatment of acute and chronic disease. This is keeping in tune with the current changes in developed nations such as the USA and those in Europe where holistic medicine is gaining popularity.

Management in this context not only implies the way hospitals and health universities function, but also the need for a change in the healthcare systems and processes themselves. Data mining in life sciences will truly and correctly provide the right evidence and direction to nations keen on making holistic medicine a viable, cost-effective alternative to meet their healthcare challenges and needs.

In the year 2000, in a report titled To Err is Human: Building a Safer Health System, the Institute of Medicine estimated that as many as 98,000 deaths per year occur in the United States because of medical errors that could have been prevented. The additional cost in pain and suffering as well as in dollars—estimated between $17 billion and $29 billion—as a result of preventable medical errors is unconscionable in an age where the technology exists to virtually eliminate such occurrences. Worse, these studies account only for hospitals. They do not begin to address the errors and their resulting consequences in other healthcare settings such as nursing homes, home care, day surgery, outpatient clinics, and care delivered in doctors' offices.

According to the Institute of Medicine, the majority of medical errors do not result from individual recklessness, but from "basic flaws in the way the health system is organized."

These flaws reach into every aspect of the healthcare enterprise, from illegible, paper-based medical charts to large segmented health systems that fail to provide for adequate communications among caregivers. Medical care today can be a complex combination of therapeutic treatments and sophisticated drug regimens administered by many different healthcare professionals at different sites. Under these conditions and given more than ample opportunity for human error, it is no mystery we have a problem. Long-term solutions require considerable political will and the ability to attract champions who can help craft answers that will not cripple the process with malpractice litigation. The Institute of Medicine has sounded the alarm. Are we prepared to answer it?

WHY DEMING?

The 1994 Survey on Change Management published by the AMA and Deloitte & Touche says, "It seems that many organizations have to change in order to change. Their present structures and cultures tend to disallow the successful implementation of change initiatives." I find the same in the healthcare industry, too. This change is of a global dimension, and Deming's TQM (Creech, 1995) will be able to bring many organizations and nations together on a common platform to strive for a higher global cause. Telemedicine technology coupled with Deming's TQM will ensure that change initiatives will meet with success. Networked organizations thrive better than others and are ideal for live projects in life sciences (Woodcock, 2001).

Application of Deming Charter Points

Point 1: The constant improvement of health services is a must. Technology integration speeds up the process. Holistic medicine offers paths to total quality health for those with the following diseases: cancer, AIDS (acquired immunodeficiency syndrome), and mental depression. TQM is ideal for securing global cooperation to fight these diseases with vigor and vitality.

Point 2: The philosophy of holistic medicine is the need of the hour. There are different schools of thought, and each nation has to harmonize their philosophical thinking with scientific temper to allow proven benefits to reach the masses.

Point 3: Dependence on laboratory tests alone is to be avoided, and close personal interaction with patients is a must. Furthermore, the careless repetition of tests, too-frequent tests, and inappropriately timed tests are some of the sources of avoidable drain of financial resources to the individual and the organization. Herein lies one of the values of a robust, correctly designed informational database. Later, we will see its relationship to an operational database, which is a part of a data warehouse and its different uses.

Point 4: I have deliberately left out addressing this point at this stage. I believe that this is a very personal issue at this stage of global telemedicine technology development, and while there are several financial and revenue models that have proved successful, none have evolved fully to become a reference model for global following. Continued learning and mature knowledge sharing is essential to enable unshakeable clarity of perception to be gained in the economics of telemedicine technology,1 and this may well prove to become a major aspect of global research study in the future.

Point 5: Improve constantly and forever the diagnostic and therapeutic processes. To do this successfully, baseline data have to be recorded, stored, and retrieved at will. Database systems and data-mining methodology will influence the outcome of disease research and hence is of overriding importance.

What is data mining? Data mining, by its simplest definition, automates the detection of relevant patterns in a database. However, data mining is not magic. For many years, statisticians have manually mined databases, looking for statistically significant patterns. In traditional business use, data mining uses well-established statistical and machine-learning techniques to build models that predict customer behavior. When discussing models in life sciences, the definition of a customer undergoes a bit of a modification in the sense that a patient is not viewed as a customer, and a customer need not be a patient. The need for building models in life sciences exists in diverse situations, and when viewed globally, is a healthy exercise physically, mentally, and financially.

Data Mining and Data Warehousing: The Connection

Data mining describes a collection of techniques that aim to find useful but undiscovered patterns in collected data. The goal of data mining is to create models for decision making that predict future behavior based on analyses of past activity. Data mining supports knowledge discovery, defined by William Frawley and Gregory Piatetsky-Shapiro (1991) as "the nontrivial extraction of implicit, previously unknown, and potentially useful information from data" This definition holds the key to the substantial interest in data warehousing and data mining. The method used today in data mining, when it is well thought out and well executed, consists of just a few very important concepts. The first of these is the concept of finding a pattern in the data. In many cases, this just means any collection of data that occurs a surprising number of times. Usually, surprising is better defined, but in general it means any sequence or pattern of data that occurs more often than one would expect it to if it were a random event. For example, the occurrence of breast cancer in unmarried women in the age group 30 to 40 is significantly higher than in married women of the same age group. What is the relationship between marriage and the incidence of breast cancer? The answer lies in the simple fact that in unmarried women, the intended natural function of pregnancy and subsequent child rearing being denied renders them more susceptible to the development of breast cancer. This piece of data makes it easy to suspect early breast cancer in susceptible women in the age group 30 40, and alerts doctors and/or patients to request for further tests to confirm or refute the suspicion. Data mining will throw further light on various subgroups within this larger main group, allowing far greater precision and control in designing breast-cancer screening programs and the clinical evaluation of various treatment protocols including that drawn from alternative and complementary medicines.

Another very important concept associated with data mining is that of validating the predictive models that arise out of data-mining algorithms. For example, if lesbian women remain unmarried in their lifetime and if it is proved that the incidence of breast cancer is statistically higher in them, then an intervention program based on alternative and complementary medicines is already available for implementation and may prove valuable in the age group 20 to 30 to ward off future threat from this dreaded disease. There is a growing body of scientific literature attesting to this fact, and multination clinical trials are justified to validate the data. If the four parts of data-mining technology are patterns, sampling, validation, and the choosing of the model, then the study of the incidence of breast cancer in lesbian women and its diagnosis and treatment is warranted and justified, and is suitable for multination trial since the disease is ubiquitous in distribution. Equally suitable is the use of data-mining technology to gather data from many different breast-cancer centers around the world.

Point 6: Institute training for both vendor and client organizations is of vital importance vital importance if the intended product or service is to be marketed successfuly. Healthcare professionals engaged in telemedicine activity can ill-afford to neglect this vital exercise. The ranges of skills are varied and are determined by functional needs. Training can be as simple as learning how to use Microsoft Word or as complex as learning Oracle Database Management. Nevertheless, training flows seamlessly with the rest of the activities of the organization and does not usually pose a serious problem.

Point 7: Adopt and institute leadership (Adair, 1993). Successful Leaders are those who convert ideas, contexts, and discoveries into practical undertakings. Greater success will be achieved through the optimal use of technology and team functioning. Highly focused efforts with minimal scattering of energies are more likely to produce noticeable results than diverse activities aimed at several goals. Scaleable-systems development is the need of the hour in life sciences, and it is essential to recognize what the ideal fundamental system is.

Point 8: Drive out fear. Fear as an incentive to improve work performance has been explored at length. Universally, it has a finite limit to induce consistent elevation of performance or to produce quality products and services. Deming realized this during his experience in Japan after World War II and stressed the need for leaders to arrive at suitable methods to drive out fear from within their organizations. One of the possible methods is to structure the primary organization with care with attention to minute details as regards the functional abilities of the hired or chosen people, and to put in place a system of reward and punishment that is attitude based rather than incentive based. Team working and collective consciousness also help to minimize and eliminate fear progressively.

Point 9: Break down barriers between staff areas.Academic and research activities are often slow due to several barriers that exist within a group. While some are necessary and healthy, others are simply laborious and energy sapping and are better removed than allowed to exist undetected. In the modern information age, intellectual property rights have assumed greater relevance than ever before and appear to govern conscious and unconscious thinking to a large extent. Nevertheless, it is mandatory for decision makers to be alert to new opportunities in their primary or related disciplines, and one way to do this successfully is to have highly trained and trustworthy team members to function uninhibitedly and spontaneously at all times.

Point 10: Eliminate slogans, exhortations, and targets for the workforce. The workforce looks at patient care as a divine activity and is prepared to go the extra mile. The attitude of the doctors and nurses is crucial in the affairs of a hospital. They are the pillars of strength of any hospital, and active participation at all levels of the workforce is the key to success. This is determined by the nature of the relationship that exists between top management and the lower levels of professional and nonprofessional staff in a hospital. Charter Point 10 is probably the most vexatious issue in any organization and it is true for hospitals also. A practical approach to minimize this problem is to provide the ownership of smaller satellite hospitals and clinics to teams of doctors and nurses and encourage them to independently manage and produce results. The structure of the parent organization is critical to enable such a relationship to be developed with the workforce, and this reminds us of the statement of Raymond Miles: "The greatest barrier to success will be outmoded views of what an 'organization' must look like and how it must be managed."

Points 11, 12, and 13 are a cohesive interlinked movement of earlier thought processes toward the strong-willed decisive action of the transformation and implementation of a process that has proven benefits in global healthcare. Action at the end will serve to demonstrate the validity of the expressed scientific thinking and stimulate others to follow similar lines of thinking, paving the way for the Internet revolution to make a rapid foray into the domain of life sciences in a convincing and incisive manner.

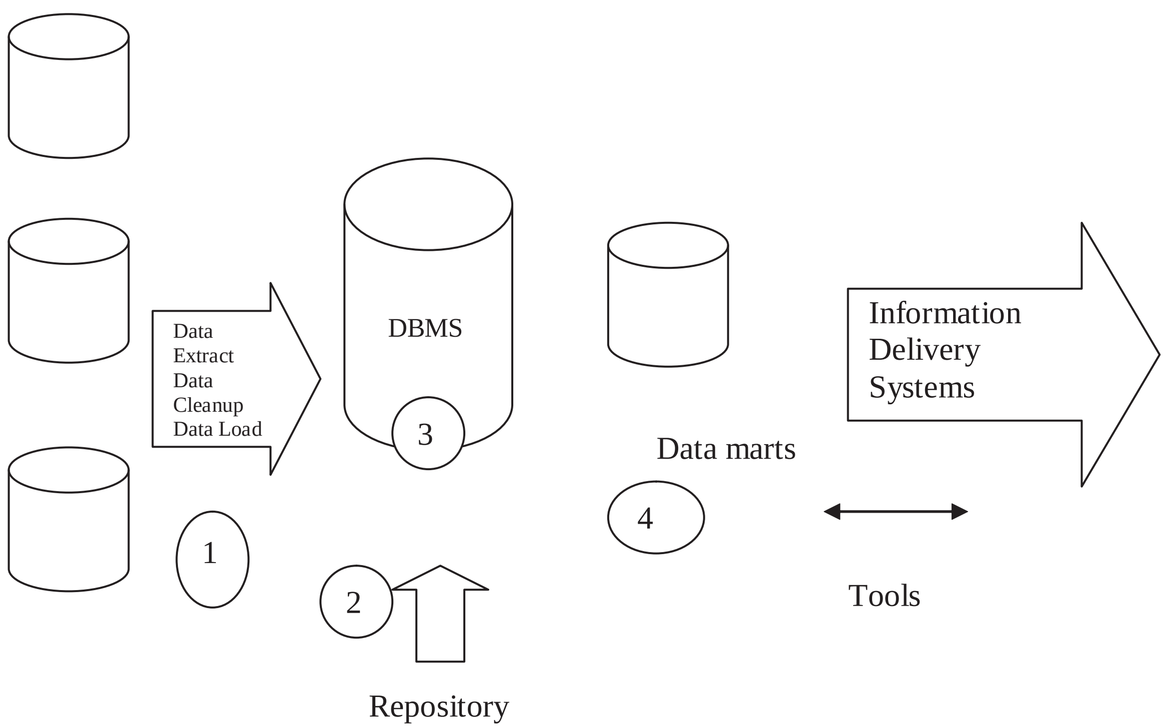
Point 14: Take action to accomplish the transformation.

Data-Warehouse Architecture for a Data-Mining Project in Life Sciences

Operational and External Data

See Figure 1. Example outputs from a data warehouse include the following:

Figure 1.



1. Homeopathic history to maintain transactions
2. Analysis of homeopathic histories to identify patterns
3. Identifying progressive disease patterns to initiate critical treatment measures
4. Mobilizing work-flow processes for emergency and critical situations like natural disasters
5. Recording the evolution of cancers from many patients within a nation and from many nations to create a data background for the comparison and prediction of outcomes of treatment plans, for the study and analysis of demographic patterns, and so forth
6. Creating self-help treatment processes for widespread ailments like chronic nasal allergies
7. Creating products and services for homeopathic students in training
8. To initiate global action against widespread epidemics like gastroenteritis, malnutrition, tuberculosis, and so forth

Relevance of Data Mining to Cancer Research

Models of Human Breast Cancer

The lack of absolute knowledge of the development and progression of cancer has resulted in many empirical and hypothetical treatment models. The number and type of questions that can be answered by controlled trials are limited by logistical and ethical considerations, and it is for this reason that models of human cancer are sought. Cancer is neither a single disease nor a group of diseases. It is a phenomenon of uncontrolled and unrestrained biological activity that alters the basic human functions and eventually kills the host. Hitherto, animal models were employed to understand the biology of cancer and extrapolate the results to humans. The animal model has failed to make us fully aware of the origins of human cancer.

Several models of breast cancer are currently in use, each of which embodies some accepted criterion. However, a universal model does not exist simply because the criterion adopted varies enormously from center to center, and also because the nature of the criterion selected is difficult to determine all over the world. Therefore, it is necessary to establish a set of criteria that is fairly universal and fundamental in order to proceed with a meaningful research program involving large numbers of people and many breast-cancer research centers.

Types of Models Available

The following models are commonly employed in many research centers. They are the canine model, rodent model, and human model. Models are necessary to formulate a scheme for obtaining, analyzing, and testing data in appropriate environments in order to apply the results to a larger population.

The Canine Model

Breast tumors occur commonly in dogs, and these tumors represent a close model of human breast cancer in morphology, clinical behavior, and incidence. However, by virtue of its closeness to the human situation, this model includes all the variables encountered clinically and necessitates the same staging of tumors and randomization of subjects as applied in human clinical trials. In addition, the time required for the evaluation of treatment modalities is long, and together these factors make the cost of using the model to obtain statistically significant results too great.

The Rodent Model

Aside from using different methods to study cancer in rodents, the overall results are not significantly different from the canine model and hence are not suitable for incorporating into a data warehouse.

The Human Model

While it is reasonable to assume that the basic mechanisms of hormone action and metastasis may be similar in human and rat breast cancers, it is less probable that they should show similar sensitivities to chemotherapeutic agents. It is for this reason that a model system that enables human material to be used for experimentation would be of value. Significant developments in this direction are taking place in many centers across the world, and a large amount of scattered data is available for incorporating into a central data warehouse.

The nature of experimental data is different from either epidemiological or clinical data. Epidemiological data is easy to collect and should be drawn from many nations to provide a definite and conclusive base to expand on seamlessly. The attributes of this database are a combination of general and peculiar characteristics spread across several age groups. The peculiar characteristics determine how an injurious agent produces its effect over time. Contrary to the traditional allopathic model of cancer causation, in which there is not much emphasis on a continuous cause operating in the background, the holistic integrated model of cancer causation believes in the existence of smaller cause-effect changes occurring all the time, albeit imperceptible to normal human senses. This resembles a chain of events that occurs in all the links of a computer network when the main switch is turned on.

A. M. Neville (1981) has some insights into the developments in research with relevance to human breast cancer. One overriding conclusion is that we must try to escape from viewing breast disease in a conventional sense as this approach to date has failed. It seems more important to detect those factors that are involved intimately in the control of the growth of breast cells, both normal and neoplastic. An understanding of those factors, and how and where they act will allow us to gain a greater appreciation of the progression of this disease and how it may be modulated to the patients' advantage. Growth factors and their receptors draw attention once more to the properties of the cell surface. Increased appreciation of this aspect of cell biology and biochemistry may well have value in the diagnosis and monitoring of the disease. Without such knowledge, it is unlikely that we will be able to devise meaningful and rational approaches to therapy in the coming decade.

Hopefully, with the advent of RAD tools, research time can be reduced and results made more meaningful and of a uniform quality in all the participating centers in a multination clinical trial. There is reason to believe that light can be shed on perplexing and controversial aspects of breast-cancer treatment within 3 years of beginning an accurately designed study.

SOME ISSUES ADDRESSED AT THE TELEMEDICINE RESEARCH LABORATORY

1. Infrastructure development for e-business and e-health
2. Research into health information systems and the development of prototypes
3. Data warehousing and data mining in life sciences
4. E-publishing
5. E-learning
6. E-communications
7. Mobile technologies and healthcare

CONCLUSION

The last few years have seen a growing recognition of information as a key business tool. Those who successfully gather, analyze, understand, and act upon the information are among the winners in this new information age. Translating this to the domain of life sciences, biological organisms obtain information through sensory and extrasensory means and methodically unravel the continuous flow of information for purposeful behavior. With behavior ranging from simple survival to a life of uninhibited and spontaneous activities, human beings are a different class of biological organisms. This is reflected in one's choice of behavior when faced with many conflicting choices. Of all the physical and mental activities we can perform, there is no other activity as important as decision making in our daily lives. The varied and complex process of decision making is at the soul of all activities in life sciences.

Data mining in life sciences with emphasis on cancer and AIDS will prove to be a profitable e-business opportunity for the current millennium. One of the many interesting business aspects of this opportunity is the profound transformation it can bring about in personal and business relationships, replacing old and worn out ideas with fresh and revolutionary thinking, and paving the way for a new practical approach to the economics of Web businesses. E-business economy will alter the lifestyles of many people, and the only attribute that may leave behind some losers in the bargain is the relative apathy and lethargy of some organizations and an unwillingness to adapt speedily to rapidly changing business processes. "The future allows unlimited and infinite opportunities to those who can discern in the present the mistakes of the past and clearly commit to themselves that they will never again repeat the same or other mistakes in the present or the future." Considering the global epidemic nature of cancer and AIDS, an international consortium for the research and development of telemedicine applications is a distinct reality in the not-too-distant future.

REFERENCES

Belbin, M. (2001). *Team roles at work*. Butter Worth-Heinemann.

Berson, A., Smith, S., & Thearling, K. (2000). *Building data mining applications for CRM*. India: Tata McGraw-Hill.

Creech, B. (1995). *The five pillars of TQM*. Truman Tally Books, Penguin Group.

Paraki, J. G. (2001). *Abstract: Telemedicine 2001, 6th International Conference on the Medical Aspects of Telemedicine*. *Technology and Health Care, 9*(4), 366.

Woodcock, J. (2002). *Step up to networking*. India: Prentice Hall.

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Chapter 5.14
Knowledge Management in Hospitals

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ABSTRACT

The medical field in recent years has been facing increasing pressures for lower cost and increased quality of healthcare. These two pressures are forcing dramatic changes throughout the industry. Managing knowledge in healthcare enterprises is hence crucial for optimal achievement of lowered cost of services with higher quality. The following chapter focuses on developing and fostering a knowledge management process model. We then look at key barriers for healthcare organizations to cross in order to fully manage knowledge.

INTRODUCTION

The healthcare industry is information intensive and recent trends in the industry have shown that this fact is being acknowledged (Morrissey, 1995; Desouza, 2001). For instance, doctors use about two million pieces of information to manage their patients (Pauker, Gorry, Kassirer & Schwartz, 1976; Smith, 1996). About a third of doctor's time is spent recording and combining information and a third of the costs of a healthcare provider are spent on personal and professional communication (Hersch & Lunin, 1995). There are new scientific findings and discoveries taking place every day. It is estimated that medical knowledge increases fourfold during a professional's lifetime (Heathfield & Louw, 1999), which inevitably means that one cannot practice high quality medicine without constantly updating his or her knowledge. The pressures toward specialization in healthcare are also strong. Unfortunately, the result is that clinicians know more and more about less and less. Hence it becomes difficult for them to manage the many patients whose conditions require skills that cross traditional specialties. To add to this, doctors also face greater demands from their patients. With the recent advances of e-health portals, patients actively search for medical knowledge. Such consumers are increasingly interested in treatment quality issues and are also more aware of the different treatment choices and care possibilities.

Managing knowledge in healthcare enterprises is hence crucial for optimal achievement of lowered cost of services with higher quality. The fact that the medical sector makes up a large proportion of a country's budget and gross domestic product (GDP), any improvements to help lower cost will lead to significant benefits. For instance, in 1998 the healthcare expenditure in the US was $1.160 billion, which represented 13.6% of the GDP (Sheng, 2000). In this chapter, we look at the knowledge management process and its intricacies in healthcare enterprises.

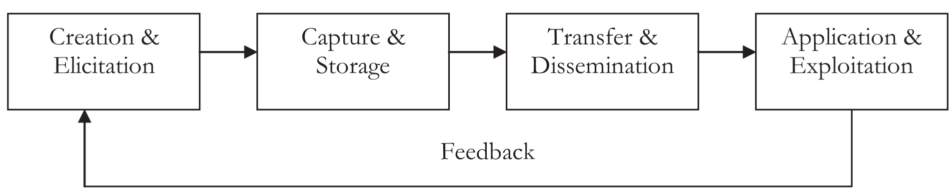
KNOWLEDGE MANAGEMENT PROCESS

Knowledge management from a process perspective is concerned with the creation, dissemination, and utilization of knowledge in the organization. Therefore, a well-structured process needs to be in place to manage knowledge successfully. The process can be divided into the following steps: beginning with knowledge creation or elicitation, followed by its capture or storage, then transfer or dissemination, and lastly its exploitation. We now elaborate on the various stages of the process:

Creation and Elicitation

Knowledge needs to be created and solicited from sources in order to serve as inputs to the knowledge management process. For the first scenario where knowledge has to be created, we begin at the root — data. Relevant data needs to be gathered from various sources such as transaction, sales, billing, and collection systems. Once relevant data is gathered, it needs to be processed to generate meaningful information. Transaction processing systems take care of this task in most businesses today. Just like data, information from various sources needs to be gathered. An important consideration to be aware of is that information can come from external sources in addition to internal sources. Government and industry publications, market surveys, laws and regulations, etc., all make up the external sources. Information once gathered needs to be integrated. Once all necessary information is at our disposal, we can begin analyzing it for patterns, associations, and trends — generating knowledge. The task of knowledge creation can be delegated to dedicated personnel, such as marketing or financial analysts. An alternative would be to employ artificial intelligence-based computing techniques for the task such as genetic algorithms, artificial neural networks, and intelligent agents (Desouza, 2002a). Data mining and knowledge discovery in data bases (KDD) relate to the process of extracting valid, previously unknown and potentially useful

Figure 1. Knowledge management process



patterns and information from raw data in large data bases. The analogy of mining suggests the sifting through of large amounts of low grade ore (data) to find something valuable. It is a multi-step, iterative inductive process. It includes such tasks as: problem analysis, data extraction, data preparation and cleaning, data reduction, rule development, output analysis and review. Because data mining involves retrospective analyses of data, experimental design is outside the scope of data mining. Generally, data mining and KDD are treated as synonyms and refer to the whole process in moving from data to knowledge. The objective of data mining is to extract valuable information from data with the ultimate objective of knowledge discovery.

Knowledge also resides in the minds of employees in the form of know-how. Much of the knowledge residing with employees is in tacit form. To enable for sharing across the organization, this knowledge needs to be transferred to explicit format. According to Nonaka and Takeuchi (1995), for tacit knowledge to be made explicit there is heavy reliance on figurative language and symbolism. An inviting organizational atmosphere is central for knowledge solicitation. Individuals must be willing to share their know-how with colleagues without fear of personal value loss and low job security. Knowledge management is about sharing. Employees are more likely to communicate freely in an informal atmosphere with peers than when mandated by management. Desouza (2003b) studied knowledge exchange in game rooms of a high-technology company and found significant project-based knowledge exchanged.

Capture and Storage

To enable distribution and storage, knowledge gathered must be codified in a machine-readable format. Codification of knowledge calls for transfer of explicit knowledge in the form of paper reports or manuals into electronic documents, and tacit knowledge into explicit form first and then to electronic representations. These documents need to have search capabilities to enable ease of knowledge retrieval. The codification strategy is based on the idea that the knowledge can be codified, stored and reused. This means that the knowledge is extracted from the person who developed it, is made independent of that person and reused for various purposes. This approach allows many people to search for and retrieve knowledge without having to contact the person who originally developed it. Codification of knowledge, while being beneficial for distribution purposes, does have associated costs. For instance, it is easier to transfer strategic know-how outside the organization for scrupulous purposes. It is also expensive to codify knowledge and create repositories. We may also witness information overload in which large directories of codified knowledge may never be used due to the overwhelming nature of the information. Codified knowledge has to be gathered from various sources and be made centrally available to all organizational members. Use of centralized repositories facilitates easy and quick retrieval of knowledge, eliminates duplication of efforts at the departmental or organizational levels and hence saves cost. Data warehouses are being employed extensively for storing organizational knowledge (Desouza, 2002a).

Transfer and Dissemination

One of the biggest barriers to organizational knowledge usage is a blocked channel between knowledge provider and seeker. Blockages arise from causes such as temporal location or the lack of incentives for knowledge sharing. Ruggles' (1998) study of 431 US and European companies shows that "creating networks of knowledge workers" and "mapping internal knowledge" are the two top missions for effective knowledge management.

Proper access and retrieval mechanisms need to be in place to facilitate easy access to knowledge repositories. Today almost all knowledge repositories are being web-enabled to provide for the widest dissemination via the Internet or intranets. Group Support Systems are also being employed to facilitate knowledge sharing, with two of the most prominent being IBM's Lotus Notes and Microsoft's Exchange. Security of data sources and user friendliness are important considerations that need to be considered while providing access to knowledge repositories. Use of passwords and secure servers is important when providing access to knowledge of a sensitive nature. Access mechanisms also need to be user-friendly in order to encourage use of knowledge repositories.

Exchange of explicit knowledge is relatively easy via electronic communities. However, exchange of tacit knowledge is easier when we have a shared context, co-location, and common language (verbal or non-verbal cues), as it enables high levels of understanding among organizational members (Brown & Duguid, 1991). Nonaka and Takeuchi (1995) identify the processes of socialization and externalization as means of transferring tacit knowledge. Socialization keeps the knowledge tacit during the transfer, whereas externalization changes the tacit knowledge into more explicit knowledge. Examples of socialization include on-the-job training and apprenticeships. Externalization includes the use of metaphors and analogies to trigger dialogue among individuals. Some of the knowledge is, however, lost in the transfer. To foster such knowledge sharing, organizations should allow for video and desktop conferencing as viable alternatives for knowledge dissemination.

Exploitation and Application

Employee usage of knowledge repositories for purposes of organizational performance is a key measure of the system's success. Knowledge will never turn into innovation unless people learn from it and learn to apply it. The enhanced ability to collect and process data or to communicate electronically does not — on its own — necessarily lead to improved human communication or action (Walsham, 2001). Recently the notion of communities of practice to foster knowledge sharing and exploitation has received widespread attention. Brown and Duguid (1991) argued that a key task for organizations is thus to detect and support existing or emergent communities. Much of knowledge exploitation and application happens in team settings and workgroups in organizations, hence support must be provided. Davis and Botkin (1994) summarize the six traits of a knowledge-based business as follows:

1. The more they (customers) use knowledge-based offerings, the smarter they get.
2. The more you use knowledge-based offerings, the smarter you get.
3. Knowledge-based products and services adjust to changing circumstances.
4. Knowledge-based businesses can customize their offerings.
5. Knowledge-based products and services have relatively short life cycles.
6. Knowledge-based businesses react to customers in real time.

KNOWLEDGE MANAGEMENT IN HOSPITALS

We now apply the generic discussion of knowledge, knowledge management, and the process in the context of healthcare enterprises. For purposes of this chapter, we focus our attention on hospitals, although much of the discussion can be applied to other healthcare enterprises, such as pharmaceutical companies, insurance providers, etc.

Knowledge in Hospitals

In healthcare, we have the presence of both explicit and tacit forms of knowledge. Explicit knowledge is available in medical journals, research reports, and industry publications. Explicit knowledge can be classified under: internal and external. Internal are those that are relevant to the practice of medicine, such as medical journals and research reports. External are legal, governmental, and other publications that do not directly affect patient treatment methodology but govern general medical practices. Three dimensions in health information outlined by Sorthon, Braithewaite and Lorenzi (1997) include management information, professional information, and patient information. Overlap and commonalties are identified, but fundamental differences exist in the types of information required for each dimension, the way the information is used, and the way standards are maintained. The achievement of a comprehensive and integrated data structure that can serve the multiple needs of each of these three dimensions is the ultimate goal in most healthcare information system development. Tacit knowledge is found in the minds of highly specialized practitioners, such as neurosurgeons or cardiac arrest specialists. Much of tacit knowledge resides in the minds of individuals. Seldom does efficient knowledge sharing take place. One exception to this is where practitioners exchange know-how at industry or academic conferences. This, however, happens on an all-too-infrequent basis.

Knowledge Management in Hospitals

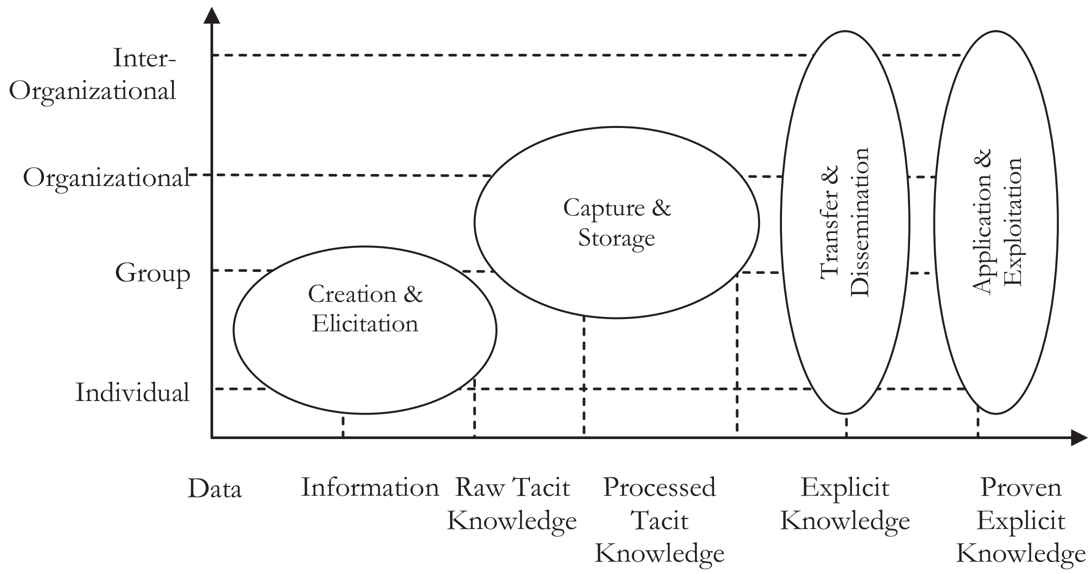
In the following section we step through the various stages of the knowledge management process.

Knowledge Creation and Elicitation

Creation and elicitation of knowledge can be handled in one of two modes: controlled or free form. In the controlled scenario, we can have an individual department responsible for overseeing knowledge gathering from the various functional areas. This department can be in lieu of the current medical records department in most hospitals, which are responsible for centrally storing patient information. We can also have a variation in which control is divested to each department. In this method, each department will be responsible for coordinating knowledge-sharing efforts from their constituents. For instance, a person in the pharmaceutical department will be responsible for gathering all knowledge on drugs administered to patients. In the second approach, i.e., free form, each individual is responsible for contributing to the organization's knowledge resource. A strong locus of control is absent. Individuals as end users of organizational resources share equal burden to contribute into the asset. A variation of the free-form strategy can be one in which each group, rather than individuals, are responsible for knowledge creation and sharing. An example would be a group of neurosurgeons that research new knowledge on surgical practices. Each of the above-mentioned strategies has associated pros and cons. For instance, with a controlled strategy, we need to have dedicated individuals responsible for knowledge creation and elicitation from group members. In the free-form strategy, while we do not have the overhead of a dedicated person, we lose a structured knowledge-creation process. Choosing a given strategy is a function of the hospital's resources. Along with soliciting internal knowledge, a hospital should also acquire relevant knowledge from external entities such as government, regulatory bodies, and research organizations. Gathering of external knowledge is crucial for hospitals due to the high nature of external pressures and their involvement in day-to-day operations.

As portrayed in Figure 2, knowledge creation and elicitation takes place at the individual and group level. Much of the elements gathered at this stage might be raw data, which after processing, becomes information. Information is then applied on experiences, learned associations, and training of employees to generate knowledge. This knowledge remains in tacit form until it is called upon for sharing with peers. Tacit knowledge

Figure 2. Staged look at knowledge management



stored with employees is raw to a large degree, as it is has not been checked for quality or validated against standards.

The other option in the healthcare industry is to generate knowledge through discovery. Data mining and other statistical techniques can be used to sift through large sets of data, and discover hidden patterns, trends, and associations. For instance, in the medical domain all resources are not only very expensive but also scarce. Optimal planning and usage of them is, hence, not a luxury but a requirement. To illustrate this let us take the case of simple blood units. Annually well over 12 million units of blood are transferred to patients (Clare et al., 1995; Goodnough, Soegiarso, Birkmeyer & Welch, 1993) with a cost-per-unit ranging from $48 to $110 with a national average of $78 (Sheng, 2000; Forbes et al., 1991; Hasley, Lave & Kapoor, 1994). Ordering of excess units of blood for operations is the primary cause of waste and corresponding increases in transfusion costs (Jaffray, King & Gillon, 1991). Blood ordered that is not used takes it out of supply for at least 48 hours (Murphy et al., 1995). Even though blood can be returned, it needs to be tested and routed which costs on average $33. In recent years, supply of blood has been decreasing in recent years due to an aging population and increased complexity of screening procedures (Welch, Meehan & Goodnough, 1992). Given these circumstances, any improvements in blood-need prediction can realize significant benefits. Data mining techniques such as artificial neural networks have been employed to sift through large medical databases and generate predictive models which can better forecast blood transfusion requirements. Kraft, Desouza and Androwich (2002a, 2002b, 2003a, 2003b) examine the discovery of knowledge for patient length-of-stay prediction in the Veterans Administration Hospitals. Once such knowledge is generated, it can be made available to external sources.

Knowledge Capture and Storage

Once gathered, knowledge needs to be captured and stored to allow for dissemination and transfer. Two strategies are common for capture and storage: codification and personalization. The codification strategy is based on the idea that knowledge can be codified, stored and reused. This means that the knowledge is extracted from the person who developed it, is made independent of that person and reused for various purposes. This approach allows many people to search for and retrieve knowledge without having to contact the person who originally developed it (Hansen et al., 1999). Organizations that apply the personalization strategy focus on dialogue between individuals, not knowledge objects in a database. To make the personalization strategies work, organizations invest heavily in building networks or communities of people. Knowledge is shared not only face-to-face, but also by e-mail, over the phone and via videoconferences. In the medical domain, the codification strategy is often emphasized, because clinical knowledge is fundamentally the same from doctor to doctor. For instance, the treatment of an ankle sprain is the same in London as in New York or Tokyo. Hence it is easy for clinical knowledge to be captured via codification and to be reused throughout the organization.

Knowledge capture has been one of the most cumbersome tasks for hospitals. Until rather recently much of the patient knowledge was stored in the form of paper reports and charts. Moreover, the knowledge was dispersed throughout the hospital without any order or structure. Knowledge was also recorded in different formats, which made summarization and storage difficult.

Recently we have seen advancements in the technology of Electronic Medical Records (EMRs). EMRs are an attempt to translate information from paper records into a computerized format. Research is also underway for EMRs to include online imagery and video feeds. At the present time they contain patients' histories, family histories, risk factors, vital signs, test results, etc. (Committee on Maintaining Privacy and Security in Healthcare Applications of the National Information Infrastructure, 1997). EMRs offer several advantages over paper-based records, such as ease of capture and storage. Once in electronic format, the documents seldom need to be put through additional transformations prior to their storage.

Tacit knowledge also needs to be captured and stored at this stage. This takes place in multiple stages. First, individuals must share their tacit know-how with members of a group. During this period, discussions and dialogue take place in which members of a group validate raw tacit knowledge and new perspectives are sought. Once validated, tacit knowledge is then made explicit through capture in electronic documents such as reports, meeting minutes, etc., and is then stored in the knowledge repositories. Use of data warehouses is common for knowledge storage. Most data warehouses do have web-enabled front-ends to allow for optimal access.

Knowledge Transfer and Dissemination

Knowledge in the hospital once stored centrally needs to be made available for access by the various organizational members. In this manner knowledge assets are leveraged via diffusion throughout the organization. One of the biggest considerations here is security. Only authorized personnel should be able to view authorized knowledge. Techniques such as the use of multiple levels of passwords and other security mechanisms are common. However, organizational security measures also need to be in place. Once the authorized users get hold of the knowledge, care should be taken while using such knowledge, to avoid unscrupulous practices. Moreover, employees need to be encouraged to follow basic security practices, such as changing passwords on a frequent basis, destroying sensitive information once used, etc. Ensuring security is a multi-step process. First, the individual attempting to access information needs to be authenticated. This can be handled through use of passwords, pins, etc. Once authenticated, proper access controls need to be in place. These ensure that a user views only information for which he or she has permission. Moreover, physical security should also be ensured for computer equipment such as servers and printers to prevent unauthorized access and theft.

Disseminating healthcare information and knowledge to members outside the organization also needs to be handled with care. Primarily physicians, clinics, and hospitals that provide optimal care to the patients use health information. Secondary users include insurance companies, managed care providers, pharmaceutical companies, marketing firms, academic researchers, etc. Currently no universal standard is in place to govern exchange of healthcare knowledge among industry partners. Hence, free flow of healthcare knowledge can be assumed to a large degree. From a security perspective, encryption technologies should be used while exchanging knowledge over digital networks. Various forms are available such as public and private key encryptions, digital certificates, virtual private networks, etc. These ensure that only the desired recipient has access to the knowledge. An important consideration while exchanging knowledge with external entities is to ensure that patient identifying information is removed or disguised. One common mechanism is to scramble sensitive information such as social security numbers, last and first names. Another consideration is to ensure proper use by partners. Knowledge transferred outside the organization (i.e., the hospital) can be considered to be of highest quality as it is validated multiple times prior to transmittal.

Medical data needs to be readily accessible and should be used instantaneously (Schaff, Wasserman, Englebrecht & Scholz, 1987). The importance of knowledge management cannot be stressed enough. One aspect of medical knowledge is that different people need different views of the data. Let us take the case of a nurse, for instance. He or she may not be concerned with the intricacies of the patient's condition, while the surgeon performing the operation will. A pharmacist may only need to know the history of medicine usage and any allergic reactions, in comparison to a radiologist who cares about which area needs to be x-rayed. Hence, the knowledge management system must be flexible to provide different data views to the various users. The use of intelligent agents can play an important role here through customization of user views. Each specialist can deploy customized intelligent agents to go into the knowledge repository and pull out information that concerns them, thus avoiding the information overload syndrome. This will help the various specialists attend to problems more efficiently instead of being drowned with a lot of unnecessary data. Another dimension of knowledge management is the burden put on specialists. A neurosurgeon is paid twice as much, if not more, than a nurse. Hence, we should utilize their skills carefully to get the most productivity. Expert systems play a crucial role here in codifying expertise/knowledge. When a patient comes for treatment, preliminary test and diagnosis should be handled at the front level. Expert systems help by providing a consultation environment whereby nurses and other support staff can diagnose illness and handle basic care, instead of involving senior-level doctors and specialists. This allows for the patients that need the care of experts to receive it and also improves employee morale through less stress.

Knowledge Application and Exploitation

The last stage, and the most important, is the application and exploitation of knowledge resources. Only when knowledge stored is used for clinical decision-making does the asset provide value. As illustrated in Figure 3, knowledge application and exploitation should take place at all levels from the individual to inter-organizational efforts. We draw a distinction here between application and exploitation. Applications are predefined routines for which knowledge needs are well defined and can be programmed. For instance, basic diagnosis when a patient first enters the hospitals, these efforts include calculation on blood pressure, pulse rates, etc. Knowledge needed at this level is well defined and to a large extent is repetitive. On the other hand, exploitation calls for using knowledge resources on an ad-hoc basis for random decision-making scenarios. For instance, if a hospital wants to devise an optimal nurse scheduling plan, use of current scheduling routines, plus knowledge on each individual's skill sets can be exploited for devising the optimal schedule. Decisions like these, once handled, seldom repeat themselves on a frequent basis.

With knowledge management being made easy and effective, quality of service can only increase. A nurse, when performing preliminary tests on a patient, can provide them with better information on health issues through consultation with an expert system. Primary care doctors normally refer patients for hospital care. Some of the primary care doctors may work for the hospital (Network) and the rest are independent of the hospital (Out-of-Network). Today there are a lot of inefficiencies associated with referring patients to hospitals. If a patient is referred, he or she has to contact the hospital personnel who then first take in all patient information and then schedule an appointment. The normal wait time can be any where from one to four weeks depending on seriousness. With the Internet revolution today, all patients, doctors, and hospitals can improve the process tremendously through the deployment of dedicated intelligent agents. Each doctor can be provided with a log-on and password to the hospital's web site. Upon entry to the web site, the doctor can use search agents to browse through appointment schedules, availability of medical resources, etc. These agents can then schedule appointments directly and electronically receive all documentation needed. Hospitals within a certain location can set up independent networks monitored by agents whereby exchange of medical knowledge and resources can take place. Patients can use search agents to browse through hospital web sites, request prescriptions, learn about medical treatments, view frequently asked questions, etc. Intelligent agents can also be trained to learn patient characteristics. Once this takes place, they can be deployed to monitor various medical web sites and send relevant information to the patient in the form of e-mails. Expert systems can be deployed to help the user navigate through the various knowledge bases through recommendations. If a user chooses the main category of "common cold," the expert system can ask for symptoms, suggest medications, etc. Patients can then use these notifications to improve the quality of their health. Intelligent agents also help in improving quality of service through providing only relevant decision-making information. Personnel can then act quickly and reduce time lags. An added benefit of a successful knowledge management system is less burden and stress on personnel. Hospitals are characterized for being highly stressful and always "on pins and needles" when it comes to employees. Through artificial intelligence, much of the routine details can be automated. This reduces the burden on personnel. Also, specialists and highly valued personnel can concentrate efforts on selected matters, the rest can be handled by junior level staff and intelligent systems. This makes for a more welcoming atmosphere.

IMPENDING BARRIERS TO KNOWLEDGE MANAGEMENT

The medical field has to overcome a few hurdles in order to realize the potential benefits of open connectivity for knowledge sharing among the partners of the supply chain and internal personnel such as doctors, surgeons, nurses, etc. We now highlight three of the most prominent issues:

Unified Medical Vocabulary

The first barrier is the development of a unified medical vocabulary. Without a unified vocabulary, knowledge sharing becomes close to impossible. There is diversity of vocabulary used by medical professionals, which is a problem for information retrieval (Lindberg, Humphreys & McCray, 1993). There are also differences in terminology used by various biomedical specialties, researchers, academics, and variations in information accessing systems, etc. (Houston, 2000). To make matters more complex, expertise among users of medical information also varies significantly. A researcher in neuroscience may use precise terminology from the field, whereas a general practitioner may not. Medical information also must be classified differently based on tasks. Researchers may need information summarized according to categories, while a practitioner or doctor may need patient-specific details that are accurate (Forman, 1995).

To help bridge some of the gap in terminology, we have two main medical thesauri in use. Medical Subject Headings (MeSH) and Unified Medical Language System (UMLS) are meta-thesauri developed by the National Library of Medicine (NLM) (Desouza, 2001). UMLS was developed in 1986 and has four main components: meta-thesaurus, specialist lexicon, semantic net, and information sources map. The meta-thesaurus is the largest and most complex component incorporating 589,000 names for 235,000 concepts from more than 30 vocabularies, thesauri, etc. (Lindberg et al., 1993). Approaches to organizing terms include human indexing and keyword search, statistical and semantic approaches. Human indexing is ineffective as different experts use varying concepts to classify documents, plus it is time-consuming for large volumes of data. The probability of two people using the same term to classify a document is less than 20% (Furnas, Landauer, Gomez & Dumais, 1987). Also different users use different terms when searching for documents. Artificial Intelligence-based techniques are making headway in the field of information retrieval. Houston et al. (2000) used a Hopfield network to help in designing retrieval mechanism for the CANCERLIT study. The issue of standardization of terminology continues to be a great debate. The Healthcare Financing Association (HCFA) is adopting some Electronic Data Interchange (EDI) standards to bring conformity to data (Moynihan, 1996). We can expect more standards to be released in the next few years to enable sharing of data.

Security and Privacy Concerns

With sharing of data comes the inherent risk of manipulation and security issues. Security of patients' data and preventing it from entering the wrong hands are big concerns in the field (Pretzer, 1996). Strict controls need to be put in place before open connectivity can take place. Patients' data are truly personal and any manipulation or unauthorized dissemination has grave consequences. Sharing of patient-identifiable data between members of the healthcare supply chain members is receiving serious scrutiny currently. Government and other regulatory bodies will need to set up proper laws to help administer data transmission and security (Palmer et al., 1986). The recent Health Insurance Portability and Accountability (HIPPA) Act can be seen as one of many governmental interventions into the healthcare industry for the protection of consumer privacy rights. Enterprises will have to go to the basics of ethics and operate carefully.

Organizational Culture

In every organization we can see the application of the 20/80 rule. Knowledge providers make up 20% of the workforce, as they possess experiences and insights that are beneficial to the organization. The remaining 80% are consumers of this knowledge (Desouza, 2002a). The providers are often reluctant to share and transfer knowledge as they fear doing so will make them less powerful or less valuable to the organization (Desouza, 2003a, 2003b). Between departments we also find knowledge barriers, in which one group may not want to share insights collected with the other. To help alleviate some of these issues, management should strive to provide incentives and rewards for knowledge-sharing practices. A highly successful approach is to tie a portion of one's compensation to group and company performance, thus motivating employees to share knowledge to ensure better overall company performance. Additionally, Foucault (1977) noted the inseparability of knowledge and power, in the sense that what we know affects how influential we are, and vice versa our status affects whether what we know is considered important. Hence, to alleviate this concern, an enterprise-wide initiative should be carried out making any knowledge repository accessible to all employees without regard to which department or group generated it.

A key dimension of organizational culture is leadership. A study conducted by Andersen and APQC revealed that one crucial reason why organizations are unable to effectively leverage knowledge is because of a lack of commitment of top leadership to sharing organizational knowledge or there are too few role models who exhibit the desired behavior (Hiebeler, 1996). Studies have shown that knowledge management responsibilities normally fall with middle managers, as they have to prove its worth to top-level executives. This is a good and bad thing. It is a good thing because normally middle-level managers act as liaisons between employees and top-level management, hence they are best suited to lead the revolution due to their experience with both frontline, as well as higher-level authorities. On the other hand it is negative, as top-level management does not consider it important to devote higher-level personnel for the task. This is changing, however. Some large companies are beginning to create the position of chief knowledge officer, which in time will become a necessity for all organizations. A successful knowledge officer must have a broad understanding of the company's operation and be able to energize the organization to embrace the knowledge revolution (Desouza & Raider, 2003). Some of the responsibilities must include setting up knowledge management strategies and tactics, gaining senior management support, fostering organizational learning, and hiring required personnel.

It is quite conceivable that healthcare enterprises will start creating the positions of chief knowledge officers and knowledge champions. Top management involvement and support for knowledge management initiatives cannot be underestimated. This is of pivotal importance in hospitals, as their key competitive asset is medical knowledge.

CONCLUSIONS

Some researchers and practitioners have expressed concern about knowledge management being a mere fad (Desouza, 2003b). To deliver promised values, knowledge management must address strategic issues and provide for competitive advantages in enterprises. McDermott (1999) noted that companies soon find that solely relying on the use of information technology to leverage organizational knowledge seldom works. The following chapter has introduced knowledge management and its process. We have also applied it to healthcare enterprises focusing on hospitals. Finally, we justified the knowledge management process by looking through two main strategic frameworks.

Knowledge management initiatives are well underway in most healthcare enterprises, and we can expect the number and significance of such efforts to increase over the next few years. Areas of future and continued research include: automated search and retrieval techniques for healthcare information, intelligent patient monitoring systems, and optimal knowledge representation semantics.

REFERENCES

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Towards a unified view of working learning and innovation. *Organization Science, 2*(1), 40-57.

Clare, M., Sargent, D., Moxley, R., & Forthman, T. (1995). Reducing health care delivery costs using clinical paths: A case study on improving hospital profitability. *Journal of Health Care Finance, 21*(3), 48-58.

Committee on Maintaining Privacy and Security in Health Care Applications of the National Information Infrastructure. (1997). *For the record: Protecting electronic health information.* Washington, DC: National Academy of Sciences.

Davis, S., & Botkin, J. (1994). The coming of knowledge-based business. *Harvard Business Review,* 165-70.

Desouza, K. C. (2001). Artificial intelligence for health care management. *Proceedings of the First International Conference on Management of Health care and Medical Technology.* Enschede, The Netherlands.

Desouza, K. C. (2002a). *Managing knowledge with artificial intelligence: An introduction with guidelines for non-Specialists.* Westport, CT: Quorum Books.

Desouza, K. C. (2002b). Knowledge management in hospitals: A process oriented view and staged look at managerial issues. *International Journal of Health Care Technology Management, 4*(6).

Desouza, K. C. (2003a). Barriers to effective use of knowledge management systems in software engineering. *Communications of the ACM, 46*(1), 99-101.

Desouza, K. C. (2003b). Facilitating tacit knowledge exchange. *Communications of the ACM, 46*(6), 85-88.

Desouza, K. C., & Raider, J. J. (2003). Cutting corners: CKO & knowledge management, *Business Process Management Journal.* (Forthcoming).

Forbes, J. M., et al. (1991). Blood transfusion costs: A multicenter study. *Transfusion, 31*(4), 318-323.

Forman, P. N. (1995). Information needs of physicians. *Journal of the American Society of Information Sciences, 46*(10), 729-736.

Foucault, M. (1977). Two lectures. In C. Gordon (Ed.), *Power/knowledge: Selected interviews and other writings.* New York: Pantheon Books.

Furnas, G. W., Landauer, T. K., Gomez, L. M., & Dumais, S. T. (1987). The vocabulary problem in human-system communication. *Communication of the ACM, 30*(11), 964-971.

Goodnough, L. T., Soegiarso, R. W., Birkmeyer, J. D., & Welch, H. G. (1993). Economic impact of inappropriate blood transfusions in coronary artery bypass graft surgery. *The American Journal of Medicine, 94*(5), 509-514.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Hasley, P. B., Lave, J. R., & Kapoor, W. N. (1994). The necessary and the unnecessary transfusion: A critical review of reported appropriateness rates and criteria for red cell transfusions. *Transfusion, 34*(2), 110-115.

Heathfield, H., & Louw, G. (1999). New challenges for clinical informatics: Knowledge management tools. *Health Informatics Journal, 5,* 67-73.

Hersch W. R., & Lunin L. F. (1995). Perspectives on medical informatics: Information technology in health care — Introduction and overview.

Journal of American Social Infrastructure Science, 46, 726-727.

Hiebeler, R. (1996). Benchmarking knowledge management. *Strategy and Leadership, 24*(2).

Houston, A. L., et al. (2000). Exploring the use of concept spaces to improve medical information retrieval. *Decision Support Systems, 30*(2), 171-186.

Jaffray, B., King, P. M., & Gillon, J. (1991). Efficiency of blood use and prospects of autologous transfusion in general surgery. *Annals of the Royal College of Surgeons of England, 73*(4), 235-238.

Kraft, M., Desouza, K. C., & Androwich, I. (2002a). Knowledge discovery in clinical databases: issues and process. In M. Khosrow-Pour (Ed.), *Issues & Trends of Information Technology Management in Contemporary Organizations - 2002 Information Resource Management Association Conference* (Vol. 1, pp. 168-171). Hershey, PA: Idea Group Publishing.

Kraft, M., Desouza, K. C., & Androwich, I. (2002b, July 28-30). Length of stay predictions for spinal cord injury patients using neural networks and nursing diagnoses data: methodological issues, results and applicability. *Proceedings of the Second International Conference on Management of Health Care and Medical Technology,* Chicago.

Kraft, M., Desouza, K. C., & Androwich, I. (2003a, January 6-9). Data mining in health care information systems: Case study of a veterans administration spinal cord injury population. *Proceedings of the Thirty-Sixth Hawaii International Conference on System Sciences* (HICSS-36), Los Alamos, CA: IEEE Press, Big Island.

Kraft, M., Desouza, K. C., & Androwich, I. (2003b). Health care information: From administrative to practice databases, In G. Grant (Ed.), *ERP & data warehousing: Issues and challenges.* Hershey, PA: Idea Group Publications.

Lindberg, D. A. B., Humphreys, B. L., & McCray, A. T. (1993). The unified medical language system. *Methods of Information in Medicine, 32,* 281-291.

McDermott, R. (1999). Why information technology inspired but cannot deliver knowledge management. *California Management Review, 41*(4), 103-117.

Morrissey, J. (1995). Managed care steers information systems. *Modern Health Care, 25*(8).

Moynihan, J. J. (1996). A milestone for paperless claims processing. *Health Care Financial Management, 50*(1), 68-69.

Murphy, W. G., et al. (1995). Blood use for surgical patients: A study of Scottish hospitals transfusion practices. *Journal of Royal College of Surgeons of Edinburgh, 40*(1), 10-13.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* New York: Oxford University Press.

Palmer, R. H., Kane, J. G., Churchill, W. H., Goldman, L., & Komaroff, A. L. (1986). Cost and quality in the use of blood bank services for normal deliveries, cesarean sections, and hysterectomies. *Journal of the American Medical Association, 256*(2), 219-223.

Pauker, S. D., Gorry, G., Kassirer, J., & Schwartz, W. (1976). Towards the simulation of clinical cognition: Taking a present illness by computer. *American Journal on Medicine, 65,* 981-996.

Pretzer, M. (1996). Why should you have a health lawyer's convention? Medical Economics, 73(16), 160-168.

Ruggles, R. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Schaff, R., Wasserman, G., Englebrecht, R., & Scholz, W. (1987). Medical treatment assistance with an interactive drug information system. *Medical Expert Systems Using Personal Computers*, 45-51.

Sheng, O. R. (2000). Decision support for health care in a new information age. *Decision Support Systems, 30*(2), 101-103.

Smith, R. (1996). What clinical information do doctors need? *British Medical Journal, 313,* 1062-1068.

Sorthon, F., Braithwaite, J., & Lorenzi, N. (n.d.). Strategic constraints in health informatics: Are expectations realistic? *International Journal of Health Planning and Management, 12*, 3-13.

Walsham, G. (2001). *Making a world of difference: IT in a global context.* Chichester, UK: Wiley.

Welch, H. G., Meehan, K. R., & Goodnough, L. T. (1992). Prudent strategies for elective red blood cell transfusions. *Annals of Internal Medicine, 116*(5), 393-402.

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Chapter 5.15
Knowledge Management in Medicine

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ABSTRACT

In the last decades, the amount of information has risen because of the technology revolution. The need for organizing information, in a way that the staff and the managers of a hospital require, lead to the generation of a new value, the knowledge management. Its benefits are sensible, not only for the staff, but also for the hospital as an entity. Many techniques are applied to solve all the daily problems in the health sector.

INTRODUCTION

During the last three decades of the previous century, there was a revolution in technology and its applications in medicine and the field of information. The promotion of knowledge and its communicability certainly have profited all the scientific sectors, both in the increase of efficiency and productivity, and in the growth of innovations.

Knowledge management is a notion that is difficult to define. A lot of definitions have been formulated, one of which is that knowledge management is an organism that is constituted of small parts that aim to collect, assess, unify, improve, and produce value from intellectual and information-based resources (Association of State and Territorial Health Officials [ASTHO], 2005).

Progress in medicine is essential; there has always been the mass production of knowledge, and those who are related to this science should take it into account, develop it, and apply it. Traditional sources of information are available, but they usually fail to provide answers whenever and wherever they are needed. Thus, roughly two thirds of problems in clinical practice remain unsolved (Gale Group, 2001). Unfortunately, the information and knowledge that are available to doctors nowadays are poorly organized and old.

In the healthcare field, doctors and patients need help with the choice of better actions for a given situation. The rate of growth and change in worldwide biomedical knowledge leads to the fact that no one is able to know the current practices in a sector without any kind of support (Purves & Robinson, 2003). A partial solution to this problem can perhaps be brought by medical knowledge management. Its aim is the regrouping, incorporation, and connection of any medical knowledge that was produced in the past in order for one to reach a reasonable decision in the present and useful study in the future (Quantum Enterprises, Inc., 2003).

Generally, knowledge management in the medical field can ensure the effective growth and dissemination of better practices, and a continuous assessment aiming at their improvement. Knowledge is created within time. All the data that constitute its base become information when they can be summarized and organized under reasonable models. Information becomes knowledge when it can be managed for active decision making, and knowledge can be turned into perspicacity when it is well developed within regular periods of time (Lobodzinski & Criley, n.d.).

USE AND VALUE OF KNOWLEDGE MANAGEMENT

The continuous effort toward efficiency and economic effectiveness creates a balance among the quality of provided services, and it includes costs that lead to the more effective management of medical knowledge that is derived from biomedical research. The need for a clinical process in the providing of medical care is rather obvious (Stefanelli, 2002). Thus, knowledge management in the field of medicine focuses on the knowledge of technologies used in clinical, administrative, and demographic activity. Today, the pressure of cost also influences the sector of health. The adoption of information technology is considered one of the basic mechanisms for the reduction of cost ("Data and Knowledge Management in Healthcare," 2005).

The society of public health is continuously focused on digital communication for the fulfillment of different kinds of tasks. Although technology has improved for the possibility of the collection, analysis, and dissemination of data, there are still obstacles in the use of information, such as the existence of information that is not well organized and systems that are not complete. The continuous improvement of technology, the lack of resources, the failure to confirm the requirements of data, and complicated data have led experts to the use and exploitation of existing knowledge for the promotion of health (Data and Knowledge Management for Public Health, 2005).

Through knowledge management we can certainly reduce the gap between the lack of data and the lack of systems that develop those data. Starting with the presumption that every problem has a solution, the effective management of knowledge in the health sector can constitute the base of knowledge, which is essential for the presentation of its innovations and distribution in a dynamically regenerative process (Bailey, 2003). Generally, there is a framework in hospitals that can be used as a driver for the management of knowledge. This is a methodology that helps with the designing of a strategy and its processes, and that enriches the transmission of knowledge and tools that support the collection and analysis of knowledge, and the storage and search of information. All these occur in collaboration with the personnel, the economic resources, suitable systems that allow communication in all kinds of situations, and the infrastructure so that the maximum effectiveness, efficiency, and creativity are ensured (Managing Knowledge to Improve Reproductive Health Programs, 2004).

BENEFITS OF KNOWLEDGE MANAGEMENT

In a hospital, even more than in any other organization, knowledge management becomes a necessity since a vast number of research by global organizations, both in Europe and the USA, has proven that a lot of people have died and a great part of the government budget was spent due to errors, which would probably have been avoided with the use of knowledge management. Even though there has been major technological and scientific growth, which has been observed during the last few decades in all the scientific sectors, the medical errors, and, generally speaking, all kinds of errors, that occur in hospitals remain frequent and rather expensive. In the year 2000, the Medical Institute reported that medical errors cost the medical industry and the pharmaceutical industry $37 billion annually, and 100,000 people lose their lives each year because of these errors (Detmer, 2001).

Table 1 presents the basic reasons that led to medical errors.

Table 2 presents the types of errors that occur most frequently.

Table 3 presents errors due to the medical personnel.

Table 1. Causes of errors (Institute of Medicine [IOM], 2000)

✓	Technical errors	44%
✓	Incorrect diagnosis	17%
✓	Failure in damage prevention	12%
✓	Errors in pharmaceutical contact ion	10%

Table 2. Most frequent errors (IOM, 2000)

✓	Incorrect diagnosis	40%
✓	Incorrect issuing of medicines	28%
✓	Errors in medical protocols	22%
✓	Administrative errors	4%
✓	Communication errors	2%

Table 3. Errors due to medical personnel (IOM, 2000)

✓ Negligence / carelessness	29%
✓ Inexperienced / uneducated personnel	14%
✓ Communication	12%
✓ Incorrect diagnosis	8%
✓ Tiredness of personnel	8%
✓ Illegible recipe or incorrect issuing of medicines	6%
✓ Other errors	14%

It is obvious that there are plenty of medical errors, they cost the state a lot of money, they can be dangerous for the lives of patients, and they basically occur due to human factors. About 70% of these errors could have been avoided or even prevented. According to the Medical Company of the USA, in the year 2000, 250,000 deaths were caused due to medical factors (JAMA, 2000). Even though the number seems rather small compared to the entire population of the USA (about the 0.07% of the population), it is very important and should have called to action all experts in the health sector. Knowledge management basically aims to reduce expenses and costs, as well as to increase productivity and efficiency, which will lead indirectly to the reduction of human losses. Each employee should consider his or her knowledge so we can trust him or her when it comes to the resolution of problems, the avoiding of errors, and the assuring of positive results and practices.

OBJECTIVES OF KNOWLEDGE MANAGEMENT: PROBLEM SOLVING

Knowledge management has a very positive impact on all sciences. Its aim is to serve each science separately and minimize the errors derived from the lack of knowledge. Generally, we should choose which information is essential in an organization, such as a hospital, and how we can facilitate the transport of knowledge to it. It is crucial to improve the perception of all the factors involved in the field of health and to support the new methods and technologies, which are not always accepted easily by the personnel of hospitals.

The main objective of knowledge management is to help in the briefing of our knowledge, and to aid its enrichment and exploitation. Today there are systems that aim at improving and promoting knowledge. This can be achieved through the review of practical progress in order to find, develop, disseminate, and use the knowledge for

Table 4. Examples of techniques in knowledge management

- ✓ The best practices on the management of special medical situations
- ✓ Analysis of indications for those situations
- ✓ Report on the existing and new medicines
- ✓ Development of direct and explicit information regarding complicated medical subjects
- ✓ Use of special vocabulary with common language for names of medicines, illnesses etc
- ✓ Determination of the available sources
- ✓ Analysis of data taking into consideration the danger factors
- ✓ Ability for direct access to the data anytime, anyplace
- ✓ Information regarding actions that should be done in case of emergency
- ✓ Creation of protocols under which people in the health field should work
- ✓ Research and better practices for settlement of medical subjects
- ✓ Research for new diseases which appear to the society
- ✓ Finding of information related to the health conditions of the population in a given geographical zone
- ✓ Thorough interconnection of information out of multiple choices e.g. handbooks and depictions
- ✓ Access to descriptions of diseases, ability to practice and research reports
- ✓ Knowledge regarding treatments that can be applied
- ✓ Access to informative pages of the hospital and more important to other hospitals for the acquisition of data and comparison of situations
- ✓ Unified communication and informative sending –receiving data systems

(ASTHO, 2005)

the profit of doctors and patients. Furthermore, these systems achieve an approach among the experts in different kinds of sciences facilitating exchange between the existing and the new techniques in the field of health (Advances in Clinical Knowledge Management Workshops, n.d.).

Table 4 presents examples of techniques in knowledge management in the medical field.

From Table 4 comes the conclusion that the main objectives of knowledge management are the isolation and later development of the structures of knowledge, the production of its gradual structures for the description of a future connection, the proposal to create functional systems for the development of medical knowledge, better comprehension of problems and decision making, and the application of knowledge management in medical information technology in all clinical departments and health systems.

SAFETY OF KNOWLEDGE MANAGEMENT

The information conveyed to doctors is turned later into knowledge, either through the development of computer-based systems or through the development of tools that will be used by experts in the field of information in collaboration with clinical groups. The knowledge and information by themselves are not in a position to improve clinical practices. The organized and professional management of information is required by all professionals (Sozou, 1998).

Knowledge is undefined, is precious in its acquisition, and can be easily lost or stolen in order to be converted or erased afterward. In the world of technologies nowadays, where everything tends to function digitally, a lot of mechanisms as well as structures are used for the protection of knowledge. A model that can ensure knowledge management should ensure its protection as well. In other words, it is essential in an informative

Table 5. Advantages of knowledge management for hospital personnel

- ✓ To avoid errors which happened in the past
- ✓ To reduce the time needed for detection of information, mainly for urgent incidents
- ✓ To assure the best clinical decisions by inexperienced employees
- ✓ To find alternative ways in the care of emergency situations
- ✓ To identify lack of information, which can lead to errors
- ✓ To encourage the flow of ideas, which leads to innovations
- ✓ To avoid unnecessary procedures and increase of cohesion and collaboration among the employees
- ✓ To increase productivity and efficiency

Table 6. Advantages of knowledge management in a hospital

- ✓ Improvement of quality of sanitary care through the increase of efficiency and productivity of personnel
- ✓ Facilitation of communication between medical personnel
- ✓ Reduction of expenses mainly from the pointless use of medicines and unnecessary insertion of patients in the hospital
- ✓ Creation of strategies for a vast number of data
- ✓ Contribution of hospital profits and better use of money, which would be unavailable without knowledge management

system to ensure the authenticity of knowledge; the safety of data from any kind of involuntary or voluntary modification, destruction, or revelation of its elements; the integrity of data; and the general application of political safety to information (Mundy & Chadwick, n.d.).

ADVANTAGES IN THE USE OF KNOWLEDGE MANAGEMENT

Knowledge management has a lot to offer to a hospital, and even more to its personnel. A technical and organizational infrastructure can be achieved. Table 5 presents its advantages for the personnel of a hospital.

Table 6 presents the major advantages of knowledge management in a hospital.

DISADVANTAGES IN THE USE OF KNOWLEDGE MANAGEMENT

Knowledge management has a lot of advantages, but also presents a lot of disadvantages. If there is not an explicit determination of knowledge and we do not recognize its importance, then we will not be able to achieve its appropriate management. In some cases, we focus on the past and the present and care less about the future, giving emphasis on counting knowledge and not on its results.

Generally, despite the increasing power of information technology, knowledge management in the form of supporting decisions and information concerning doctors has minimum impact on the results of healthcare. This occurs due to the fact that knowledge management addresses the relationship between patients and personnel; it does not provide harmony between the complexity of individuals and their regular actions that form special practices (Purves & Robinson, 2003).

Usually the efforts toward the medical management of knowledge are underestimated. As far as the systems are concerned, an uncontrolled increase of medical knowledge can lead to disaster (Quantum Enterprises, Inc., 2003). Table 7 presents some of the reasons why knowledge management is not efficient and presents disadvantages.

THE FUTURE OF KNOWLEDGE MANAGEMENT

Through the practices and techniques, doctors can have easier access to new information concerning

Table 7. Disadvantages presented by knowledge management due to certain reasons

- ✓ Knowledge in medicine is incomplete, vague, inaccurate and requires many years for its acquisition
- ✓ Continuous alteration of knowledge as technology develops
- ✓ Excessive emphasis to the reserve of knowledge and not to its flux
- ✓ Doctors usually forget the aim of knowledge management and do not realize the complexity of knowledge which is distributed

medicine and their applications, diagnostic tests, and the way diseases are treated, as well as established policies and processes. This access will decrease the possibility of costly medical errors and will promote healthcare for patients in the hospital (Detmer, 2001).

It is very important to create a network aiming at collaboration among experts and at the improvement of methods for the collection and analysis of data both for the present needs and the forthcoming ones. The future of medical knowledge management is in the present. We should take advantage of the revolution of technologies and information that has begun during the last decades (Gale Group, 2001). In the future, in order to reach the use and application of knowledge, we should analyze the existing aims, the types of knowledge, the users and their sources, the processes, and the technologies (Bouthillier & Shearer, 2002).

CONCLUSION

Knowledge management is a basic tool for all those working in the health field and for hospitals. It helps in sending the right information to the right person at the right time so that the right decisions can be made depending on the existing problems. It is certain that with the help of knowledge management, effectiveness in the health field will be increased through unified systems, processes, and methods; the cultivation of exchanging knowledge; and the promotion of the effective use of available information.

REFERENCES

Advances in clinical knowledge management workshops. (n.d.). Retrieved from http://www.ucl.ac.uk

Association of State and Territorial Health Officials (ASTHO). (2005). *Knowledge management for public health professionals.*

Baily, C. (2003). *Bulleting of the World Health Organization, 81*(11).

Bouthillier, F., & Shearer, K. (2002). Understanding knowledge management and information management: The need for an empirical perspective. *Information Research, 8*(1). Retrieved from http://Information.net/ir/8-1/paper14

Data and knowledge management in healthcare. (2005). *Proceedings of the 38th International Conference on System Sciences.*

Detmer, W. M. (2001). *Medical knowledge management solutions: Revolutionizing the delivery of medical information to the point of need.* Retrieved from http://www.unboundmedicine.com/healthcarereview.htm

Gale Group. (2001). Healthcare review. Retrieved April 2005, from http://www.findarticles.com

Institute of Medicine (IOM). (2000). *To err is human: Building a safer health system.* Retrieved from http://www.iom.edu./object.file/Masater/4/117/ToErr-8paper.pdf

Lobodzinski, S. M., & Criley, M. (n.d.). *Medical knowledge management.* Torrance: California State University Long Beach & Harbor UCLA Medical Center.

Managing knowledge to improve reproductive health programs (MAQ Paper No. 5). (2004).

Mercola. (2000). *Journal of the American Medical Association (JAMA), 284*(4), 483-485.

Mundy, D., & Chadwick, D. W. (n.d.). *Secure knowledge management for health care organizations.* Retrieved from http://sec.isi.salford.ac.uk/download/SecureKM.pdf

Purves, I., & Robinson, P. (2003). Knowledge management for health. *Medical Education, 37,* 429-433.

Purves, I., & Robinson, P. (2004). Knowledge management for health programs. *Medinfo,* 678-682.

Quantum Enterprises, Inc. (2003). *Knowledge integration and management.* Retrieved from http://www.quantument.com

Sozou, P. (1998). *Advances in clinical knowledge management.* London: University College.

Steffanelli, M. (2002). Knowledge management to support performance-based medicine. *Methods of Information in Medicine, 41*(1), 36-43.

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Chapter 5.16
Knowledge Management in Indian Companies:
Benchmarking the Pharmaceutical Industry

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ABSTRACT

In this chapter we look at knowledge management in India with particular regard to the pharmaceutical industry. In India, changes in government policy linked to global factors are bringing about increased pressures to strategically manage knowledge effectively. At the same time, significant knowledge management initiatives are already underway in other industry sectors. We outline some of the changes affecting the pharmaceutical industry globally, and consider India on some relevant activities. The development of IT solutions is seen as enabling effective knowledge management. We look at a range of knowledge management technologies and their existing or planned use in industry. The IT however merely underpins the knowledge management philosophy, which must be incorporated into processes, strategies and organisational culture for successful adoption. India and its indigenous organisations may be characterised by some specific cultural factors.

Effective implementation of KM will depend on a conducive cultural climate, both organisationally and nationally. We also therefore examine the extent of the perceived benefits, that shape the cultural shift from understanding knowledge management as simply an IT problem to recognition of knowledge management as a strategic process as seen by CEOs and top managers in indigenous Indian Fortune 100 companies. We look at how the pharmaceutical industry compares to other organizations of significant size in India across a range of factors concerned with knowledge management activity, using survey and interview techniques. We conclude that while only a few significant sectoral differences are evident, there is generally a heavy orientation towards IT-based conceptions of KM, which may be incompatible with the requirements for future success in the pharmaceutical industry globally.

INTRODUCTION

In this chapter we consider knowledge management initiatives with particular regard to the example of the Indian pharmaceutical industry. This industry exemplifies a knowledge-intensive industry area with an uncertain future due to a required change in practices in the context of international developments. Regulatory compliance, new knowledge creation, patent application and protection, sharing knowledge in partnerships and alliances, and widespread and timely access to information are all indicated areas of knowledge-based activity. The management of these processes entails their embedding into cultural and organisational practice, and this moderates the effectiveness of knowledge management tools. Many organisations face analogous issues of implementing KM strategies, despite sectoral differences, and we contextualise the Indian pharmaceutical industry both in its Indian and in its industry context. Lessons learned by benchmarking it in these contexts allow insights applicable to other healthcare industries. The chapter is organised as follows: first we review the global state of play in KM in large industries, concentrating on their strategic directions in KM, and highlight some issues applicable in specific countries and industries of concern here. Then we examine the particular industry environment surrounding pharmaceuticals, with particular reference to those factors applicable in India and noting the general importance of R+D. We then consider aspects of the Indian culture, at national and organisational levels, which distinguish it from competitor nations but which also potentially impact on the success of KM strategies. Finally we survey how KM is currently being undertaken in major Indian companies and especially compare pharmaceutical companies against other major organisations in relation to their knowledge management capabilities and strategic choices.

Knowledge Management and Industry

Knowledge management (KM) remains a central issue for large organisations. Having moved beyond being seen as a short-term fad, it is now widely recognised as critical to the success of knowledge-intensive industries, such as pharmaceuticals. Such industries, where the key organisational resource is knowledge, and which are often characterised by a focus on innovation and high research and development activity, are seen as taking on increased importance in the future economy (OECD, 1999). This has led to significant commercial and academic activity in information systems, in human resource management, accounting, economics and other disciplines. Surveys of CEO priorities, and numerous consultancy reports, dedicated journals, conferences and professional seminars indicate its continuing importance, as does the increased availability of vendor “solutions” and corporate appointments and internal KM initiatives. An indicative Google search uncovered (February,

2003) about 1,150,000 web pages. In this flurry of recent activity, definitions and understandings have been contested and, while work has separately focussed on IT, economic and human capital aspects, a more sophisticated understanding is emerging of its integrating potential. Earl (2001) has distinguished several schools that emphasise one or another of these various aspects and other frameworks and taxonomies have been proposed to integrate the extensive research underway.

KM, however, is not merely an academic exercise. Major companies have been quick to realise the importance of the assets implied by their data resources, the knowledge of their employees, and the communication of that knowledge in the work context. IT has allowed documents to be electronically preserved, emails to be archived, data to be warehoused, and computer activity to be logged, with management systems placed around those to search, discover patterns and organise for reuse or repurposing. These all, however, require explicated knowledge: the ability to form an intelligent query, to recognise a significant pattern, to relate ideas and to recognise a colleague's worth. In short, to make use of information in documents and databases is a human ability. And humans may not be able to express what they know, may not be willing to share it, and may not have had an opportunity to articulate information of relevance, such as a key connection between something of current organisational interest and something they have learned elsewhere. The concept of tacit knowledge, due originally to Polanyi (1958) and modified, elaborated and reinterpreted by later writers, has come to refer to that aspect in which unarticulated skills, intuitions and personal connections can be brought to bear in useful processes of knowing. According to Polanyi (1958), we know more than we are able to express in words. At the same time we rely on our awareness of what we cannot articulate. "While tacit knowledge can be possessed by itself, explicit knowledge must rely on being tacitly understood and applied. Hence all knowledge is either tacit or rooted in tacit knowledge. A wholly explicit knowledge is unthinkable" (Polanyi, 1969). Knowledge, therefore, can be formalized only in a limited way and any formal system will by necessity be incomplete. "The legitimate purpose of formalization lies in the reduction of the tacit coefficient to more limited and obvious informal operations, but it is nonsensical to aim at the total elimination of our personal participation" (Polanyi, 1958). However, many knowledge management initiatives rely on codification and formalization of knowledge and "tacit knowing is the fundamental power of the mind, which creates explicit knowledge, lends meaning to it and controls its uses" (Polanyi, 1969). Organisations dread losing employees with the ability to mobilise their knowledge in the organisation's service, hence the attempts to make it explicit and codified in transferable forms. The literature, unnecessary to rehearse further here, is replete with considerations of these issues, methods and "solutions" and with critiques of their philosophy. A clear distinction between tacit and explicit knowledge, which seems to underpin many knowledge management strategies does therefore not exist. Although the focus on explicit knowledge, particularly of technology-driven approaches to knowledge management, has significant implications for their success and usefulness.

Practically, there are many activities that have been conducted in an attempt to manage a particular organisation's knowledge, as we will see later. Many of these have been adopted piecemeal in a project context, in addressing a particular problem, or as pilot studies at the business-unit level. Maier and Remus (2002) propose contextualising KM activity centrally within a process-oriented strategy and enumerate eight sets of "strategies" identified from the literature. These include: (1) mapping sources of internal expertise (e.g., expert directories); (2) establishing new knowledge roles (e.g., create a new unit or position for knowledge-related tasks); (3) creating a virtual work environment (e.g., networked knowledge workers); (4) supporting knowledge flows (e.g., communication tools adapted for knowledge seekers and providers); (5) creating innovation and new knowledge (e.g., research and development focused on these). The other three strategic activity sets aim at managing customer information, intellectual assets, and integration with other business strategies.

Maier and Remus (2002) surveyed the top 500 German companies, as well as the 50 major banks and insurance companies in relation to their use of KM systems, and found a lack of process orientation in KM strategy. These authors also considered the numerous KM activities identified in the literature as confounding strategy, supporting activities and instruments. Reframing these activities within a process-oriented KM strategy, relating the activities to business processes, is seen by these authors as advantageous compared to other extant approaches. This is because of the value of an integrated approach, based on business processes.

Integration, focused around IT, has been understood by the Indian company Wipro, which recently achieved recognition for their leadership in knowledge management (Wipro, 2002). The international KM reality award recognises "implementation of knowledge management practices and processes by realizing measurable business benefits." The unified framework developed by Wipro cuts "across the boundaries of Culture, Content, Communities and Business Processes" and has resulted in a widely accessible knowledge base. "All of Wipro's initiatives like Six Sigma, PCMM, CMMi feed into the central knowledge management repository on a continuous basis" (Wipro, 2002).

Recent developments in information technology have inspired many Indian companies to imagine a new way for staff to share knowledge and insights. Instead of storing documents in personal files and sharing insights within a small circle of colleagues, they can store documents in a common information base and use electronic networks to share insights with their entire community. Most companies soon discover that leveraging knowledge is actually very hard and involves more community building than information technology (Gunnerson, Lindroth, Magnusson, Rasmusson and Snis, 2000). This is not because people are reluctant to use information technology, but due to the fact that they often need to share knowledge that is neither obvious, nor easy to document, and typically requires a human relationship to think about, understand and share (Swan, Newell and Robertson, 1999). However, with the growth in information technology capabilities, a clear operational distinction can be drawn between knowledge management as a technology and knowledge management as a strategy. The former can be captured, stored and transmitted as explicit knowledge in digital form (Marwick, 2001). The latter can only exist in an intelligent system (people) and uses information technology as a medium to create and share knowledge (Marwick, 2001). It is vital therefore to identify the interaction between knowledge and information technology and the appropriate balance between them.

The IT infrastructure in these approaches is seen as a key mediating component for explicit knowledge management. This is because information systems, enabling data or knowledge intensive processes operate in large, centralised or distributed organisations and typically require underpinning technologies specifically relevant to the nature of the knowledge work. IT-underpinned strategies have been implemented in several pharmaceutical companies with success.

Snis (2000) for example has described ways in which explicit knowledge in a Danish pharmaceutical company has been managed through, inter alia, IT support mechanisms such as intranet and "narrow-casting" of emails based on user profile matching. Such profiles identify processes and functions of specific concern to that group. Document management systems are also in use, with time-related status codes and access controls on operational documents, and this mechanism, with associated meta-information, allows relevant filtering of effective documents to applicable organisational groups or functional levels. User-owned and designed templates are also at work in functional areas allowing procedures and "better practices" to be shared. These are subject to internal quality controls before acceptance as a local way of working, and are framed by the legislative requirements of the external environment. Although the IT tools reported in her study certainly enabled effective knowledge management to occur, their success is surely dependent on the positive attitudes to knowledge management of those using them and Snis stresses that the IT should be seen in its mediating function. We return to this aspect of organisational culture later.

Knowledge Management and Healthcare

The consulting group KPMG describe various successful healthcare KM systems in their report, "The Knowledge Journey: Pathways to Growth" (KPMG, 2000). These include: Eli Lilly's globally spread intranet providing current information to the field sales force; NovaCare's system for providing regulatory and good practice knowledge as well as other information throughout the company; and Hoffman LaRoche's acceleration of new drug development through making information and knowledge available at every stage.

Eli Lilly, in particular, has led in the area of knowledge sharing by its strategic decision to emphasise alliances, e.g., with universities and biotechnology firms. They have developed tools which identified gaps in knowledge sharing and allowed effective remedial action to take place, in this case a discussion database that overcame geographical dispersion of partners (Futtrell et al., 2001). NovaCare's system is described in Quinn, Anderson and Finkelstein (1996), emphasizing its organisation around the frontline therapists' professional knowledge, in which detailed information on therapeutic care is recorded for use by a range of stakeholders. The (best practice) knowledge the company builds up over time is thus available to its professionals. Like Eli Lilly, Hoffman-La Roche's development of a new drug in conjunction with a range of strategic partners was another catalyst for a KM solution (Davenport and Prusak, 1997). In this case, collaboration tools and the development of a culture of sharing led to success (Vincente, 2002). Sharing knowledge is common to the above examples, and clearly addresses the human activities involved, with the technologies acting as effective supporting mechanisms.

Apart from the Roche example, Vincente (2002) recently summarised some other current KM initiatives of big pharmaceutical players and best practices identified by research. These included successful document management and collaboration at Amgen, and a portal and search solution to manage "overwhelming" unstructured information at AstraZeneca. He notes that the focus to date had been on document management and regulatory compliance, but portals and collaboration technologies are growing. As these latter technologies gain hold, the cultural factors affecting their usage will become significant. Indeed the field has for some time recognised the limits of equating KM with IT-based capture of existing knowledge, moving toward processes that enable new knowledge creation through tacit knowledge sharing, fostering communities and contexts in which this activity can thrive. These activities are more in the domain of human resource management, and processes of knowledge enabling are detailed in Von Krogh et al. (2000). Such a migration of focus will increasingly entail managerial initiatives addressing organisational cultures, not merely adopting IT "solutions." This will thus look to address the human processes of knowledge creation, and what can work culturally.

These examples show some of the current activities in organisations of relevance here, and resonate with the typical range of KM initiatives in knowledge intensive companies, including those that Skyrme (1997) identifies:

- Creation of knowledge databases: best practices, expert directories, market intelligence, etc.;
- Active process management: of knowledge gathering, classifying, storing, etc.;
- Development of knowledge centres: focal points for knowledge skills and facilitating knowledge flow;
- Introduction of collaborative technologies: intranets or groupware for rapid information access;
- Knowledge webs: networks of experts who collaborate across and beyond an organisation's functional and geographic boundaries.

It is clear that while these can be enabled by IT, strategically integrating them with processes that will work within the culture are required (Davenport and Prusak, 1997). This entails assessment of those processes, the available technologies and the perceived benefits and threats related to a KM strategy.

THE PHARMACEUTICAL INDUSTRY

Pharmaceutical companies have an aspirational mission — introducing innovative products to serve the market as quickly as possible followed by enhancing their commercial potential. Four traditional core processes involved include: discovery, development, manufacturing and marketing, and these are closely interrelated. The creation and direction of knowledge, however, is now seen as the newest or fifth process by which a pharmaceutical company creates competitive advantage: it is this that is recognised as "knowledge management" in the Indian pharmaceutical sector.

The inaugural issue of the Pfizer journal (Pfizer, 1997) provided a useful assessment of the global pharmaceutical industry at the start of the new century. Challenges identified in its suite of articles include: market pressure to reduce costs, the R+D impact of biotechnology advances and mergers occurring among significant players, generic competition and "patent pirates," and changing societal demographics and expectations.

These challenges translate into pressures to continue effective innovation, to streamline processes and to establish alliances (e.g., with biotechnology companies) to share findings as Pfizer, for example, has done (Pfizer, 1997, p. 19), and other major players likewise. All of these challenges are clearly critical knowledge-based activities. Innovation is recognised as a required continuing activity in the industry and to support this, growing larger, through mergers and alliances, has been a constant of pharma companies' strategies in recent times (Rasmussen, 2002). The value of scale has been stressed in a McKinsey study (Garg, Berggren and Holcombe, 2001) which notes that greater size "increases the number of bets a company can place on new technologies," as well as allowing faster completion of clinical trials, providing an advantage in launching blockbuster drugs, and increasing "its desirability as a licensing partner." Beyond a certain size, however, communities of practice begin to lose effectiveness and simply increasing size as a strategy is insufficient. Garg et al.'s analysis goes on to suggest that, with respect to new knowledge creation, a restructuring entailing smaller, federated specialist units is likely to be more productive and indicates that some major companies are already moving in this direction.

In addition to industry level challenges, the international and national legislative frameworks shape what is politically possible. For many countries, healthcare is a significant part of the national budget, and one that straddles public and private sector organisations. Although our focus here is primarily on pharmaceutical companies, it is to be noted that healthcare in general is a vastly larger concern, affecting these companies.

In India for example, a new national policy (the first in almost two decades) has been announced in which health sector expenditure is targeted to reach 6% of GDP by 2010 (PTI, 2002). The majority of this, however, is not centrally funded, with the policy aiming to decentralise services to district level and to achieve "gradual convergence of all health programmes under a single field administration" (Sharma, 2002). Currently India has a three-tier public health system, with central responsibility for major disease control (for example) and state governments funding the other two tiers. A convergence in which the responsibility devolves to the district level, and the central government's role becomes reduced to monitoring and funding of essential drug supplies, clearly implies knowledge management activity. Other aspects of the policy therefore indirectly address knowledge management issues, in which an integrated disease control network crossing the tiers of public healthcare can bring the goal of evidence-based policy-making closer. Interconnectivity, training and data integrity issues are indicated here (PTI, 2002), implicating both IT and human resource initiatives. There is a tight link between legislation for healthcare generally and pharma specifically. With respect to our focus on the pharmaceutical industry the policy notes the following two relevant points. Firstly, to avoid dependence on imports at least half of required vaccines or sera would be sourced from public sector institutions, and secondly, production and sale of irrational (understood here as not being science-driven) combinations of drugs would be prohibited (PTI, 2002).

It is not just national policies that impact on the pharmaceutical sector, however. Kuemmerle (1999) has shown that foreign firms invest in R&D sites abroad in order to augment their knowledge base or in order to exploit it. He states that foreign direct investment in Asia is expected to continue growth, with "more firms expected to carry out home-base-exploiting investments in China and India because of the future attractiveness of these countries' markets." The analysis by Atul (2002), however, qualifies this by noting specific relative advantages China has currently secured compared to India and shows how specific national policies have obtained these current advantages. Ganguli (1999) also expects a "sea-change in the pharmaceutical sector in India vis-a-vis business processes and intellectual property rights" due to changes in the patent laws occasioned by required compliance with the provisions of the Trade Related Intellectual Property Rights (TRIPS) following the GATT Uruguay. These particularly concern patent applications and marketing rights but also impact on research and development investments, and on foreign direct investment in R+D.

Policy settings will naturally impact on the strategic initiatives within the industry. With a market of about US$2.5 billion, the Indian pharmaceutical industry is the 12th largest in the world (Ramani, 2002) and other figures suggest a growth rate of 10% annually (Atul, 2002). The Indian pharmaceutical industry has traditionally thrived on rapidly copying Western drugs, often within four to five years of their first appearance in the global market The reverse engineering time includes a lag while likely market success is ascertained, but is much more rapid: both Zantac's and Viagra's marketers respectively met Indian competitors at the Indian and the global launches (Lanjouw and Cockburn, 2001).

Noting that India will implement the WTO-GATT agreement in 2005 (which will bar Indian firms from replicating innovations patented in Western countries), Ramani (2002) discusses approaches to research and development strategy and expenditure in this sector. In the Indian biopharmaceutical sector, this is linked not to firm size, but to research orientation, described in terms of the acquisition, disclosure, and internal creation of knowledge with market performance strongly correlated with a firm's (human) knowledge stocks. Examining a number of biotechnology firms on data from the mid-1990s, they found the counterintuitive result that patents, publications and academic collaborations all correlated negatively with R+D qualification intensity. The explanation provided recognizes the extent of tacit knowledge in biotechnology companies: literature is cited showing that because much of the knowledge created is tacit, residing in individuals or groups, it is hard to explicate, leading to a disincentive to patent. Although the imminent changes in the Indian patent law have led to a slight increase in patents recently (Desai and Agarwal, 2002), patent application processes and infrastructure were also reportedly inefficient at the time of writing, providing further disincentive. Publications and collaborations however do not have this latter problem, so managerial orientation is considered a more likely reason. Ramani (2002) concludes that since increased knowledge stocks impact positively with market performance of large firms, they might wish to reconsider whether increasing the knowledge disclosure parameters through publications and academic collaborations would increase longer term competitive advantage. Managing the intellectual property involved is thus likely to become vital.

It is the ability to create, generate or source knowledge that will provide sustainable advantage, but Kummerle (1999) has suggested that there are only a few outstanding academic clusters generating knowledge in the pharmaceutical industry and therefore, "foreign direct investment in R&D might be geographically more concentrated in only a few countries and regions than is the case in other industries." A WTO consultant (Prakash, 1998) interviewed the director of the Indian Drug Manufacturer's Association. His view was that the big foreign companies had never, and would not in future, conduct R+D outside their own countries, and there was little new internal investment and only a small overall amount in R+D. Without change there would be no indigenous innovation and the industry would be "stagnant." A study by Mansfield (1994) cited in Lanjouw (1999) confirms that the prevailing intellectual property laws in India were seen as so weak as to preclude it from being an acceptable location for basic R+D by multinationals, although there have been a small number of exceptions. The Indian government (2002) has recently announced its upgraded position on patents to comply with the Trade Related IPR agreements of its entry to WTO. The announcement also notes the related Doha declaration's (WTO, n.d.) stress on the affordability and availability of medicines for all. Pharma is not only big business: there are basic humanitarian issues in healthcare at issue. The debates and documents involved in relating IP rights to access to essential medicines are beyond the scope of this paper to review but one relevant source of further information is the Consumer Project on Technology website (http://www.cptech.org/).

Atul (2002) describes the comparative state of the pharmaceutical industries in China and India, and suggests China poses a threat to the Indian industry post 2005. He observes that foreign direct investment in the Chinese pharmaceutical industry is currently 18 times more than in India: a gap that is expected to increase "if India delays implementation of product patents and IPR laws." It is worth noting though that Chomsky (1994) has drawn parallels between the destruction of the French chemical industry when product patents were introduced and the likely impact of GATT on the Indian pharmaceutical industry. Lanjouw (1999) has considered this in some detail and suggested that there are signs that R+D will increase in India and that some companies will emerge as more innovative. But clearly in a sector that is having to change its model from reverse engineering of existing products towards indigenous innovation, the ability to create and share knowledge will be vital. This ability however, rests ultimately within the people making up an organisational and a national culture, and simply having enabling technologies is not sufficient to ensure success.

CULTURAL FACTORS IN RELATION TO KM STRATEGY AND IMPLEMENTATION

Knowledge sharing is essential for the effective implementation of knowledge management. The coupling between behaviour and technology is two-way: the introduction of technology may influence the way individuals work. People can and do adapt their way of working to take advantage of new tools as they become available, and this adaptation can produce new and more effective communication within teams. The history of information systems however is full of examples of user resistance to imposed developments that were "not invented here" or which did not fit the organisational culture or established way of working.

Staples and Jarvenpaa (2000), in a study of collaborative technology use in a Canadian and an Australian university, found that although task and technology factors were salient, indeed organisational culture factors did influence collaborative technology use for information sharing. Issues of trust and power are central here, and in an industry increasingly characterised by strategic partnering, the development of shared trust and a broad base of power is essential for generating a creative environment (Lendrum 1995). Although culture is learned, and ultimately plastic, both national culture and organisational culture have deeply held characteristics that may help or inhibit particular behaviours. Effective knowledge creation is critically dependent on willing workers within the organisation, and their propensity to share their knowledge. It is recognised that although local factors may override any particular predominant stereotype (Maruyama, 1994), such as a hierarchical and bureaucratic culture, entrenched national as well as organisational cultures are likely to play a significant role in determining this propensity.

Cultural factors at the national level, for example, have been shown to apply in a recent study of KM practice and understanding in Hong Kong (Poon Kam Kai Institute, 2000) whose summary of key findings notes the "paternalistic management style of Chinese companies" as being in evidence. Such factors translate into the typical practices of organisations in specific countries — Japan has had economic success in manufacturing through Kaizen (Imai, 1986), an ingrained philosophy to which it is culturally suited. But, when western manufacturers adopted integrated production "their divisions appear to lack the level of liaison and trust that exists between a Japanese manufacturer and its suppliers" (Imai, 1986). Again, the success of any particular organisational process must be attuned to what will work culturally.

The classic work-identifying dimensions by which national cultures are constructed and thereby differ is Hofstede (1980). A statistical analysis of two surveys was conducted in 1968 and 1972 totaling over 116 000 responses from employees of a large multinational firm (IBM was the empirical source). His book shows how his findings correlate to other extant studies and indicators. Considerable research has followed, including the introduction of a fifth dimension (short vs. long-term orientation), more countries and methodological critiques, which are addressed in a later book, revisiting the study and extending its implications (Hofstede, 1991; 1997). Although national culture and organisational culture are not "identical phenomena" (Hofstede, 1997), and the study of national differences has only been partly useful for understanding organisational cultures, organisational practices are shown to be culturally dependent. In the case of Indian companies, Hofstede (1997) suggests that the implicit model of organisation is the extended family, in which authority is concentrated along lines of seniority. In the original work, culture is characterised as "collective programming of the mind." Hofstede scored each of 40 countries on the following dimensions: power-distance, individualism, uncertainty-avoidance and masculinity. These dimensions are generally held to be stable, culturally entrenched and descriptively useful in illuminating cross-cultural differences. Two of these are particularly relevant here.

The first of these dimensions, power-distance, in organisational terms relates to the unequal distribution of power in a hierarchy, accounting for phenomena in which deference, sycophancy and servility are normal organisational behaviours. Hofstede's (1980) original definition is as follows:

"the power distance between a boss B and a subordinate S in a hierarchy is the difference between the extent to which B can determine the behaviour of S and the extent to which S can determine the behaviour of B."

India's score on this index is the fourth highest of all the countries, 77, where the mean is 51. This index has been theoretically related to trust and organisational innovation. It is worth noting that Hofstede (1980) reports other studies where a high score on this index correlates with relatively lower interpersonal trust. In other countries with high scores on power distance, low cooperativeness among employees and a relative lack of identification with cohesive work groups have also been shown. Such a climate would not be conducive to knowledge sharing. In contrast, Denmark has one of the lowest scores (18) on the power-distance dimension. The study reported earlier by Snis (2000) considered the issue of power, and found that in that (Danish) pharmaceutical organisation knowledge sharing was viewed as important and not seen as jeopardising an employee's position of expertise.

The second dimension in which cultures differ is uncertainty-avoidance, defined as "the extent to which members of a culture feel threatened by uncertain or unknown situations" and entails concepts such as the need for security and dependence upon experts and rules. On this index India scores 40, (seventh lowest overall) and well below the mean of 64. Some connotations of a lower value include more risk taking, acceptance of foreigners as managers, and a view that conflict in organisations is natural (Hofstede, 1980). It is also notable that those countries with lower values are held to be "more likely to stimulate basic innovations (but are) at a disadvantage in developing these to full-scale implementation" (Hofstede, 1997). The Australian Financial Review (Mills, 1994) published an assessment of Asian economies in which it viewed India as a "country of great creativity with a deep scientific and mathematical base" despite its commercial markets being "a haven of plagiarism and intellectual piracy." It also considered, however, that India was "a country of competing self-interest, and little concern for the common good." If the culture and incentive schemes are oriented towards knowledge hoarding, rather than sharing, innovation is likely to stall.

India's scores on Hofstede's other two dimensions are around the mean values and are not considered further here. The scores of particular organisations on the dimensions will also be moderated by local factors: Hofstede (1980) reports one study showing differences in structure and control systems between indigenous Indian and U.S. subsidiaries based in India. Although in the Indian pharma industry, the big players are mostly multinationals, Hofstede's original study was with IBM employees and the differences identified could thus be attributed to national factors. Since the employees in Indian pharma companies are predominantly Indian, whilst naturally remaining cautious in making attributions, the values learned in a particular culture can be expected to apply.

Puhlman and Gouy (1999) examined internal barriers to innovation in the international pharmaceutical industry, and noted that sharing knowledge is a major factor in successful companies, defined as those in the top 20% based on product introductions and sales. A lack of knowledge management leading to repeated mistakes was one of the five most common problems in innovation. Success was also seen to be enhanced by innovation in business systems, with information exchanged and disseminated faster, but also targeting the acquisition of new skills and information. Puhlman and Gouy's study showed that companies that use innovation tools and support knowledge management have considerably higher success rates, and note America's comparative advantages in process and strategy definition. They conclude with ten key self-assessment questions pertaining to innovation, addressing, inter alia, the gathering and systematic assessment of new ideas, the dissemination of knowledge, and the conduciveness of the company's culture.

SURVEY

Having covered the cultural issues that may impact on KM strategy success, we now look at some specific approaches to KM strategy in India through a 2002 survey of Indian Fortune 100 companies1, which include leading indigenous companies in the pharma and healthcare sector. In particular the survey, which had 17 respondents, looked beyond a conception of KM as being purely IT-based and emphasised its relation to corporate strategy. However India, which has a recognised strength in IT, has often tended to equate KM activity with IT capabilities and solutions. The following summarises the key points gleaned from the survey.

To determine the technological infrastructure for implementing knowledge management within an organization, respondents were asked the following question:

Has your organization implemented or is it planning to implement the following technologies?

Figure 1 shows the responses.

In the context of technology, respondents were looking at implementing both Internet and Intranet to develop a strong external and internal flow. In the context of the current scenario, developing a strong internal information backbone is of primary interest. This resulted in "document management systems" being the third most effective technology helping respondents in managing information. It is important to note though that technology in itself does not constitute a knowledge management programme; rather it facilitates one, especially in large, geographically dispersed organizations, typical of the participants in this survey. Another important aspect recognized was that, unlike such previous initiatives as Total Quality Management (TQM) and Business Process Reengineering (BPR), the cost of implementation was not budgeted by the IT function, suggesting a whole business strategic perspective.

The state of knowledge management implementation was also addressed, and respondents were asked the following question:

When, if at all, do you intend to do any of the following, or has your organization done them already?

Figure 2 shows that facets of knowledge management practice such as implementing enterprise resource planning, creating a knowledge management strategy and benchmarking the current situation score more than establishing knowledge policies, incentives for knowledge working, creating a knowledge map or measuring intellectual capital. The majority of those interviewed were planning to use these measure to ensure success, but their preliminary focus was on having sound IT systems to facilitate knowledge within the organization. This confirms that less attention had been paid to the non-IT aspects.

The survey questions on strategy began by asking Does your company have a Knowledge

Figure 1. Technologies used for knowledge management

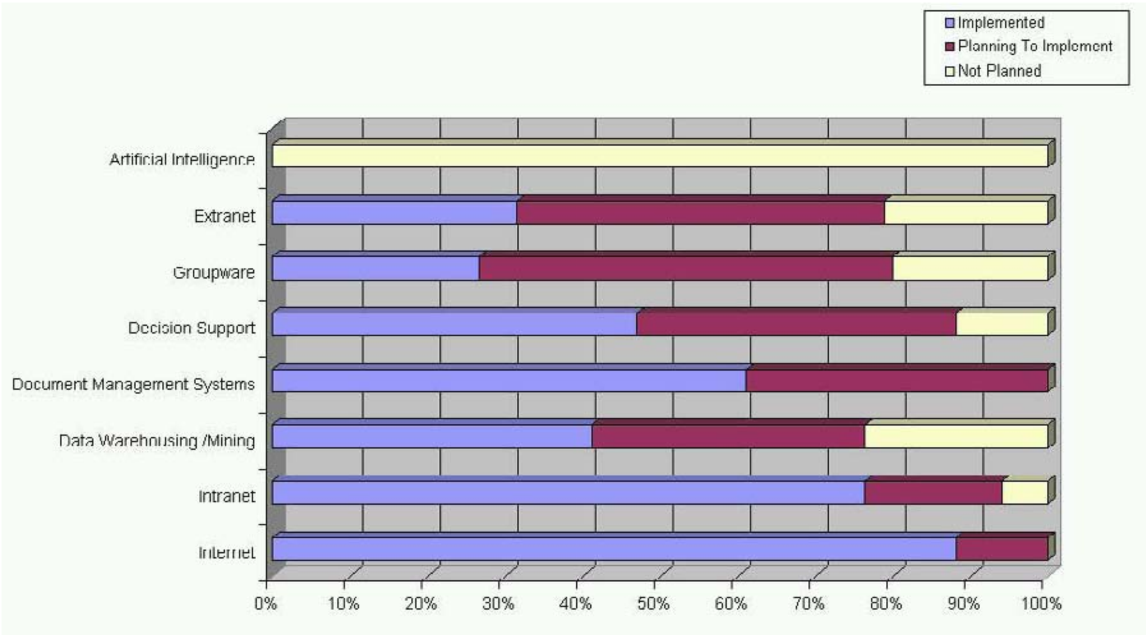
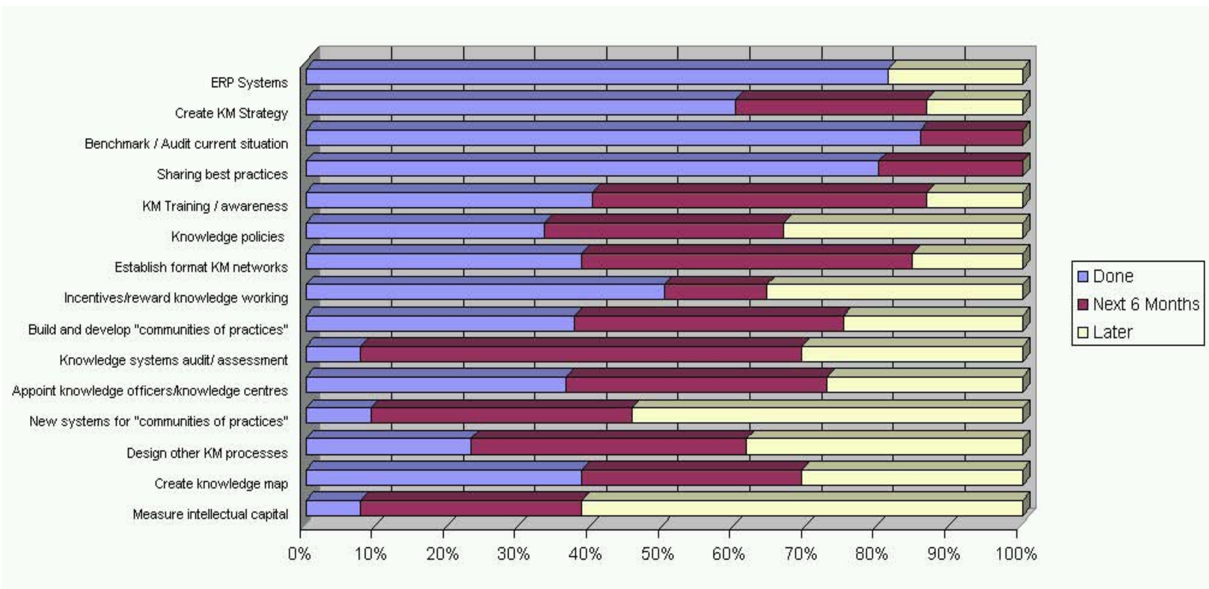


Figure 2. Knowledge management processes



Management Strategy? Seventy-five percent of respondents said that their organization had a knowledge management strategy in place, 19% stated there was no usage of any KM strategy, while 6% were completely unfamiliar with the term knowledge management. The above results demonstrate that most large organizations, including a major pharma, are not only informed about knowledge management but also are making efforts to successfully implement this strategy. However one company, which develops health-care systems, had no internal KM strategy at the time of the survey despite an otherwise strong emphasis on information management solutions in the sector.

To examine the current position of knowledge management programmes within the 75% of organizations with a knowledge management strategy in place, a set of statements was presented and participants were asked: How accurately does each statement reflect your organization? Results revealed that 50% of companies have initiated knowledge in a nonuniform manner with pilot approaches in place. This is a fairly typical "entry-level" approach to KM. Only 12.5% of respondents said their organization had knowledge management as an integral part of their business process where the value of organizational knowledge is reported to their stakeholders.

Most participating organizations in the survey have, however, prioritised knowledge management initiatives on their business agenda. To identify the level at which these organizations have planned to initiate knowledge management activities, the respondents were asked the following question:

Which according to you is the most appropriate level in your organization to initiate knowledge management?

Reflecting an understanding of KM's organisational centrality, 50% of initiators of knowledge management are preparing to initiate knowledge management at all levels, and foresee implementing knowledge management organization-wide. This indicates that at least some drivers of the concept visualize knowledge management activities to spread across the organization. However, 12.5% of respondents plan to initiate knowledge management activities at the business unit or division-level and 37.5% identify the departmental level to be the most suitable, although no pharma companies were in these latter groups.

Another set of questions identified the general issues businesses foresee to encounter within the next five years, beginning with an importance rating on previously identified KM issues. The major issues selected as being important for pharmaceutical companies included responsiveness, in terms of time-to-market, adaptability and quality with, to a lesser extent in the case of pharma, cost-productivity, alliance-networking and outsourcing all seen as relatively important. However, this was generally true across all companies survey, not just pharma, though it is a bit surprising that alliances were not seen as more important than they were. In view of the 1997 (East Asian) recession, which caused a downturn in turnover in the majority of the companies, the biggest threat identified by the respondents was the ability to reduce the time to market to realize competitive advantage. Cost reduction and improved productivity follow this issue. Quality of the product was one of the major concerns but was not identified as an immediate threat to business sustainability.

Respondents were also asked to make a selection from the list of benefits on basis of short-term and long-term gains, through the following question:

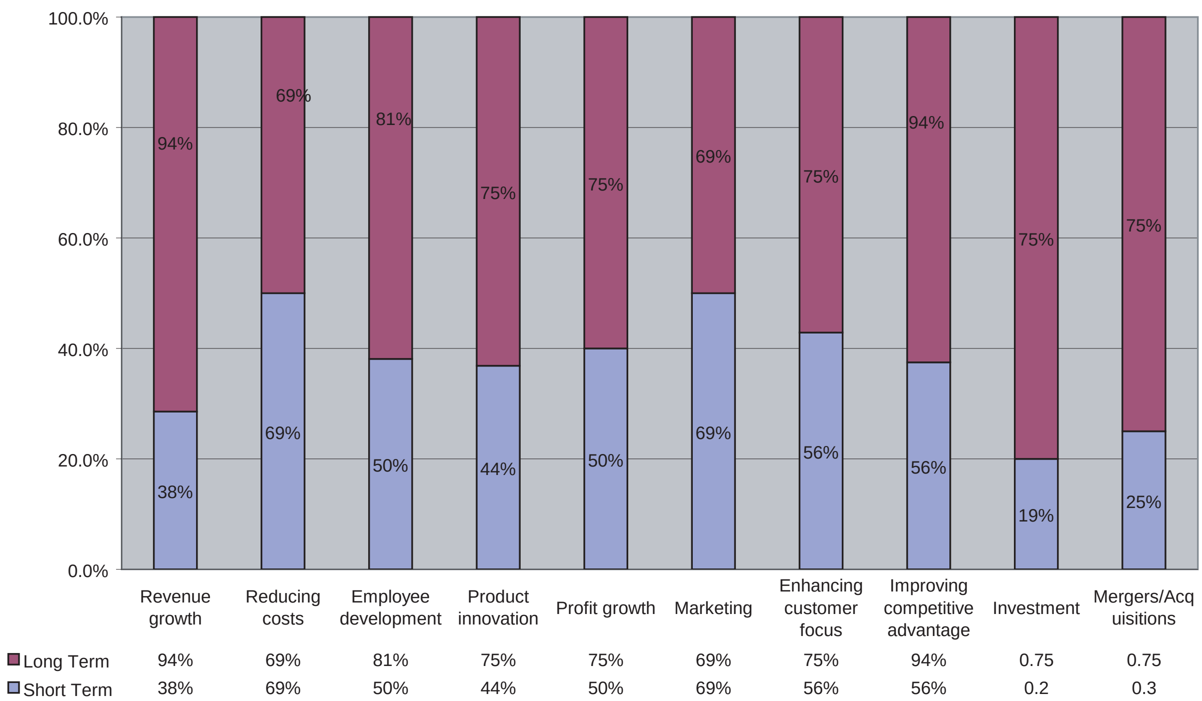
Out of the following, what are the short-term and/or long-term benefits of implementing a knowledge management strategy?

The responses indicated in Figure 3 reveal that the potential benefits on a long-term basis would be in context of improving "revenue growth" and further enhancing competitive advantage. Another potential long-term benefit identified was "employee development" and "product innovation," which are very critical parameters in measuring the success of a knowledge management implementation.

Key short-term benefits expected by respondents would be "reducing costs," "improving marketing strategies," "enhancing customer focus" and "facilitating profit growth." The results indicate that knowledge management is not focused at enhancing a particular business process, but is implemented to achieve all-round benefits for the organization. It reflects more of a traditional conception of companies than a knowledge-centric view and innovation, acquisitions and investment are all seen as of more benefit in the relatively longer term, with less than half of respondents in each case seeing primarily a short-term value. For all categories one major pharma company saw all the benefits as long-term only, at odds with a range of companies in other sectors, the majority of whom also saw short-term benefits in a number of categories.

To measure the success of a knowledge management implementation, it is important also to ascertain the potential threats. Respondents who had a knowledge management strategy in place or were planning to implement a sound knowledge management strategy were thus asked to select the most likely threats from the list provided led by the question: Of the following, what are the most likely threats towards achieving the benefits mentioned in the previous section? The results are shown in Figure 3.

Figure 3. Long-term and short-benefits of knowledge management

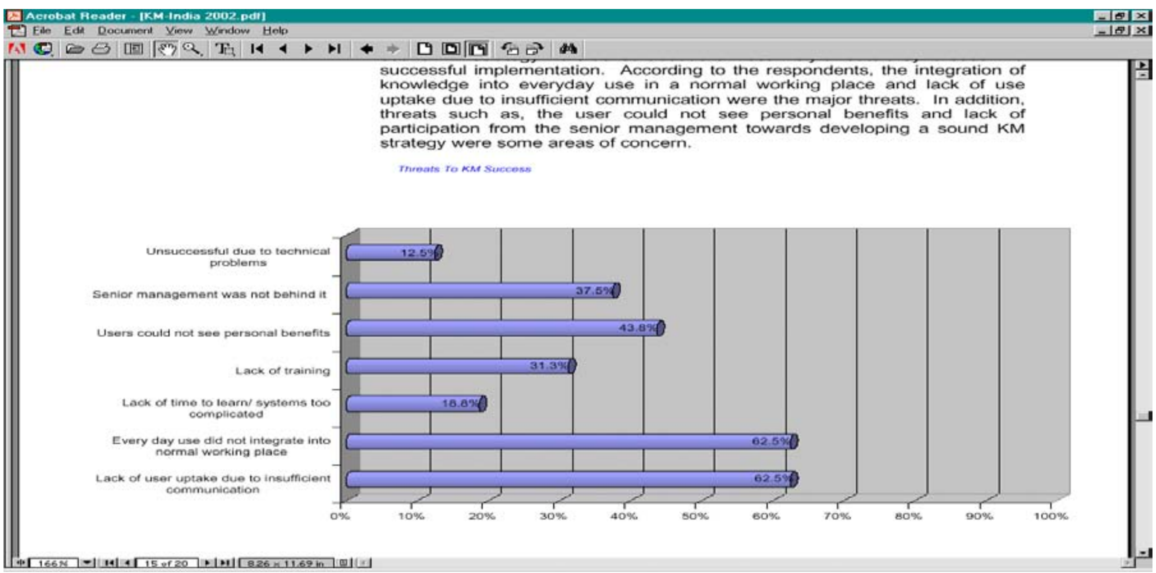


According to the respondents, as indicated in Figure 4, the integration of knowledge into everyday use in a normal work place and the lack of use or uptake due to insufficient communication were seen as the major threats. In addition, threats such as users not being able to perceive personal benefits and lack of participation from the senior management toward developing a sound knowledge management strategy were the prime areas of concern. The responses confirmed the fundamental flaw, i.e., viewing knowledge management only as a technology issue. We may assume from this that it is not the technology that is holding organizations back but a failure to initiate knowledge management into the organization's day-to-day operations and its culture. The communication issues identified as relevant barriers to KM comport with the low cooperativeness found in cultures with high power distance. Lack of senior support is also a substantial barrier for any culture formed along hierarchical authority lines.

CONCLUSIONS

In this concluding section we attempt to identify the current status and implications of knowledge management in organizations currently initiating knowledge management. Characteristics of national culture may at least in part be responsible for the anticipated and actual problems firms encounter in their knowledge management initiatives. They could also explain the focus on technology-driven approaches, as well as the failure to make knowledge management strategies an integral part of organizational life. Understanding of national and organizational culture and selecting a strategy that takes these factors into account seems a necessary prerequisite for successful knowledge management. In particular, barriers due to a prevalent cultural reluctance to share information mitigate against successful KM strategy implementations. Yet the nature of the industry environment in pharma requires effective knowledge sharing processes.

Figure 4. Threats for knowledge management



KM was primarily seen as having long-term, not short-term, benefits in pharma, yet the industry itself is having to change its model rapidly toward one based on innovation. In the survey data, in general however, there were few areas in which a particular sector (in particular pharmaceutical) was significantly divergent from norms in other sectors of Indian industry. The "knowledge management" projects within most of the respondents' organizations are just getting initiated and seem more heavily IT-oriented than HR and process-focused. It is vital to understand how indigenous organizations make an attempt to move beyond this concept and what measures they take to successfully initiate knowledge management. The big challenge, according to comments made by the senior executives who participated in this survey, will be to integrate the "pie in the sky" theories with actual use of "tools and technologies." A narrowly technical focus is likely to limit the potential for knowledge sharing unless coupled with effective human processes, and seeing knowledge as constructed through processes of social interaction among communities of practices means that issues of social networking, power and social inclusion/exclusion come to the forefront. In other cases information technology may actually undermine knowledge sharing and creation by reducing opportunities for informal contact or strengthening electronically the existing organizational walls, based on functional or geographical differentiation. Such issues may be at odds with the prevailing culture. However, although the pharma industry has several large multinational players located in India, our study is primarily concerned with the cultural capability of indigenous players to compete in knowledge intensive industries. Thus careful attention is needed to the potential impact of information technology on knowledge management for businesses in relation to existing social networks and communities within organizations.

REFERENCES

Atul, C. (2002). *Threat of China to Indian pharmaceutical industry*. Retrieved from http://www.indiainfoline.com/bisc/thre.html

Davenport, T., & Prusak, L. (1997). *Working knowledge: How organizations manage what they know*. Harvard Business School Press.

Desai, P., & Sandhu, K. (2002). *Knowledge management in India 2002*. Retrieved from http://www.knowledgepoint.com.au/knowledge_management/index.htm

Chomsky, N. (1994). *Noam Chomsky on India, GATT and pharmaceutical patents, and 3rd world. Lumpen*. Retrieved from http://www.cptech.org/pharm/noam.html

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-33.

Futrell, D., Slugay, M., & Stephens, C. H. (2001). Becoming a premier partner: Measuring, managing and changing partnering capabilities at Eli Lilly and Company. *Journal of Commercial Biotechnology, 8*(1), 5-13.

Ganguli, P. (1999). Towards TRIPs compliance in India: The patents amendment Act 1999 and implications. *World Patent Information, 21,* 279-287.

Garg, R., Berggren, R., & Holcombe, M. (2001). The value of scale in pharma's future. *Vivo, 19*(8), 2-7. Retrieved from http://www.mckinsey.de/_downloads/kompetenz/healthcare/INVIVO_value_of_scale901.PDF

Government of India. (2002). Press Information Bureau, Ministry of Law & Justice (press release), India Upgrades Legal System For Patent Related Litigation. Retrieved from http://pib.nic.in/archieve/lreleng/lyr2002/rdec2002/23122002/r231220021.html

Gunnerson, M., Lindroth, T., Magnusson, M., Rasmusson, P., & Snis, U. (2000). Less is more when IT comes to KM. *Proceedings of IRIS 23*. Retrieved from http://iris23.htu.se/proceedings/PDF/110final.PDF

Hofstede, G. (1980). *Culture's consequences: International differences in work-related values*. Newbury Park, CA: Sage.

Hofstede, G. (1991/1997). *Cultures and organizations: Software of the mind*. London: McGraw-Hill.

Imai, M. (1986). *Kaizen*. New York: Random House.

KPMG. (2000). *The knowledge journey*. Retrieved from http://www.kpmgconsulting.co.uk/research/othermedia/wf2_kbase.pdf

Kuemmerle, W. (1999). Foreign direct investment in industrial research in the pharmaceutical and electronics industries—results from a survey of multinational firms. *Research Policy, 28*, 179-193.

Lanjouw, J. O. (1999). *The introduction of pharmaceutical product patents in India: Heartless exploitation of the poor and suffering?* NBER working paper No. 6366. Retrieved from http://www.oiprc.ox.ac.uk/JLWP0799.pdf

Lanjouw, J. O., & Cockburn, I. M. (2001). New pills for poor people? Empirical evidence after GATT. *World Development, 29*(2), 265-289.

Lendrum, T. (1995). *The strategic partnering handbook*. Australia: McGraw Hill.

Maier, R., & Remus, U. (2002). Defining process-oriented knowledge management strategies. *Knowledge and Process Management, 9*(2), 103-118.

Mansfield, E. (1994). *Intellectual property protection, foreign direct investment and technology transfer*. IFC Discussion Paper, 19. The World Bank.

Maruyama, M. (1994). *Mindscapes and management*. Dartmouth: Aldershot.

Marwick, A. D. (2001). Knowledge management technology. *IBM Systems Journal, 40*(4), 814-830.

Mills, S. (Ed.). (1994). *Asian business insight. Fairfax:* Australian Financial Review Library.

OECD. (1999). *The knowledge-based economy: A set of facts and figures*. Paris: OECD.

Pfizer. (1997). The pharmaceutical industry at the start of a new century. *The Pfizer Journal, 1*. Retrieved from http://www.thepfizerjournal.com/TPJ01.pdf

Polanyi, M. (1958). *Personal knowledge: Towards a post-critical philosophy*. London: Routledge and Kegan Paul.

Polanyi, M. (1969). *Knowing and being*. London: Routledge & Kegan Paul.

Poon Kam Kai Institute. (2000). *Pilot survey on knowledge management in Hong Kong*. Retrieved May 2000 from http://www.pkki.business.hku.hk/pilot.htm

Prakash, S. (1998). *Trade and development case studies - country studies: India*. Retrieved from http://www.itd.org/issues/india5a.htm

PTI. (2002). *Two-year rural posting must for new docs according to new NHP clearing*. Express Healthcare Management. Retrieved from http://www.expresshealthcaremgmt.com/20020515/hospinews1.shtml

Puhlmann, M., & Gouy, M. (1999, June). Internal barriers to innovation: An international investigation. *Pharmaceutical Executive, 19*(6), 85-95.

Quinn, J. B., Anderson, P., & Finkelstein, S. (1996, March/April). Managing professional intellect. *HBR*, 71-80.

Ramani, S. V. (2002). Who is interested in biotech? R&D strategies, knowledge base and market sales of Indian biopharmaceutical firms. *Research Policy, 31*, 381-398.

Rao, M. (2002). *What do KM and cricket have in common?* Retrieved from http://www.destinationkm.com/articles/default.asp?ArticleID=982

Rasmussen, B. (2002). *Implications of the business strategies of pharmaceutical companies for industry developments in Australia*. Centre for Strategic Economic Studies, Working paper. Retrieved from http://www.cfses. com/pharma/documents/01-Business_Strategy.PDF

Sharma, D. C. (2002, May). India's new health policy aims to increase public investments. *The Lancet, 359*, 1587.

Skyrme, D. (1997, September). Knowledge management: Oxymoron or dynamic duo. *Managing Information, 4*(7), 16-18. Retrieved from http://www.skyrme.com/pubs/kmoxy.htm

Snis, U. (2000). Knowledge is acknowledged? A field study about people, processes, documents and technologies. *Proceedings of the 33rd Hawaii International Conference on System Sciences* (vol. 3, p. 3023).

Staples, D. S., & Jarvenpaa, S. L. (2000). Using electronic media for information sharing activities: A replication and extension. *Proceedings of the 21st International Conference on Information Systems*, Brisbane, Australia (pp. 117-133).

Swan, J., Newell, S., & Robertson, M. (2000). Limits of IT-driven knowledge management initiatives for interactive innovation processes: Towards a community-based approach. *Proceedings of the 33rd Annual Hawaii International Conference on System Sciences*, Maui, January. IEEE Computer Society Press.

Vincente, S. (2002). Retrieved from http://www.novonordisk-it.com/resources/km+conference+nice+-+stefano+vincenti+v1.pdf

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. Oxford University Press.

Wipro. (2002). *Wipro recognised for global leadership in corporate-wide knowledge management*. Retrieved from http://www.wipro.com/newsroom/newsitem2001/newstory219.htm

WTO. (n.d.). *The Doha declaration explained*. Retrieved from http://www.wto.org/english/tratop_e/dda_e/dohaexplained_e.htm

ENDNOTE

1 The questions (please contact authors for a copy of survey if required) were derived from a similar European study in 2000 by consulting group KPMG (http://www.kpmg.nl/das).

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Chapter 5.17
Goals and Benefits of Knowledge Management in Healthcare

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ABSTRACT

The aim of this chapter is to explain the role of knowledge management and how it can be successfully applied in the area of healthcare in order to improve health services and to increase patients' satisfaction. The first part of this chapter is about explaining the theories beyond knowledge management as "what is knowledge" and how it can be transformed and captured across people and organizations. The second part consists of the theory of knowledge management and the benefits of it in the area of healthcare in comparison with the old traditional systems. Knowledge management systems can be used to index and at the same time to spread all that information across people, libraries, and hospitals.

INTRODUCTION

During the last 10 to 15 years, knowledge management (KM) has become more popular day by day. There is a lot of interest in the concept of capturing and sharing knowledge with technology as the enabler. This requires the existence of a knowledge-sharing culture. The KM system stores historical knowledge and knowledge created during exchanges of information among people who are interested in learning. Knowledge management allows everyone to reuse the knowledge (best practice) or to create new ideas (innovation).

According to Syed Sibte Raza Abidi (2001, p. 1), "Knowledge Management (KM) in healthcare can be regarded as the confluence of formal methodologies and techniques to facilitate the creation, identification, acquisition, development, preservation, dissemination and finally the utilisation of the various facets of a healthcare enterprise's knowledge assets."

People in their everyday practice collect massive amounts of data and information that are knowledge poor, a fact that makes their decision about patients' cures more complicated. Knowledge in healthcare is deemed a high-value form of information that is necessary for healthcare professionals to act. For that matter, with the emergence of KM, the raw empirical data can be changed into empirical knowledge and provide professionals with a decision-support tool (Syed Sibte Raza Abidi, 2001).

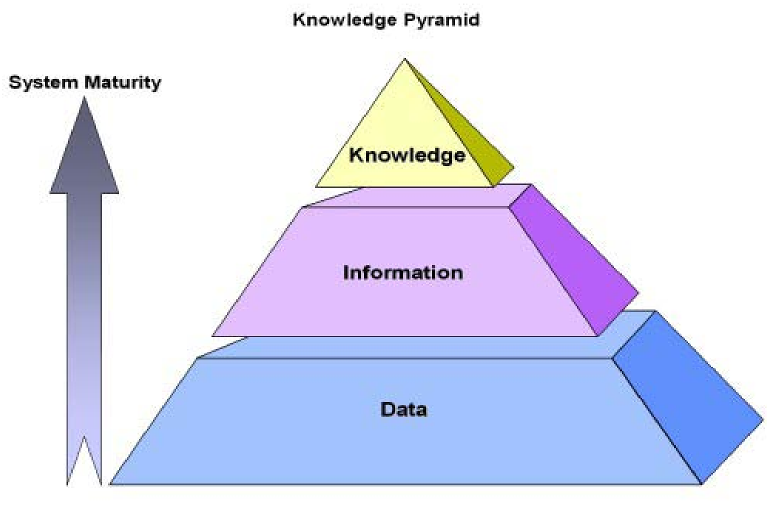
KM in healthcare presents further interest for all those who are involved in the delivery of health services. KM allows rapid access to a knowledge treasure. The KM model goes beyond the need to manage data or information overload. It satisfies the requirements for implementing best practice and supplying high-quality health services, which increase patient satisfaction. The model aims at greater efficiency, coordination, and cost reduction. It is a portfolio of knowledge that increases ealth-care professionals' effectiveness and productivity. A KM system offers them the opportunity to learn how other colleagues successfully carried out similar problems (De Lusignan, Pritchard, & Chan, 2002).

WHAT IS KNOWLEDGE?

According to ITIL People (http://www.itilpeople.com/Glossary/Glossary_k.htm), "Knowledge is part of the hierarchy made up of data, information and knowledge. Data are raw facts. Information is data with context and perspective. Knowledge is information with guidance for action based upon insight and experience."

Knowledge is very difficult to define; it is not just a simple document or something that someone told us. In order for a person to gain knowledge, there are three stages to progress through as the pyramid (see Figure 1) indicates. The actual con-

Figure 1. Knowledge pyramid (Marco, 2003)



tent in each stage becomes smaller, starting with data and finishing with knowledge.

1. Data: Documents, unorganized and unprocessed (raw material)
2. Information: Selected data ➔ Interpretation of the data (processed data)
3. Knowledge: Selected information ➔ Interpretation of the information

Example: In order to complete an academic assignment, some steps need to be taken:

1. Research at libraries and on the Internet; Collect some documents ➔ Data
2. Interpretation of that data ➔ Information
3. Interpretation and evaluation of the information ➔ Knowledge

TYPES OF KNOWLEDGE

Two types of knowledge exist in an organization.

1. Explicit ("Know that"): Something that is written down (informative texts) and can be easily understood if read, for example, technical reports and books
2. Tacit ("Know how"): Something that is written in the mind and cannot be easily expressed, for example, experience gained from a job

Knowledge management refers to the knowledge of a company as an asset, the same as land, for example (Ahmad, 2001).

TRANSFORMATION OF KNOWLEDGE

The transformation of knowledge is very important. The following explains Nonaka and Takeuchi's (1995) model of the four methods of knowledge conversion:

1. Socialization: Convert tacit knowledge into tacit knowledge; share experiences (tacit knowledge)
   Example: Two people discussing
2. Externalization: Convert tacit knowledge into explicit knowledge; write it down
   Example: Writing a report
3. Combination: Convert explicit knowledge into explicit knowledge; combine explicit knowledge
   Example: Reading two theories and from them creating a new one
4. Internalization: Convert explicit knowledge into tacit knowledge; gain experience
   Example: Learning from a book

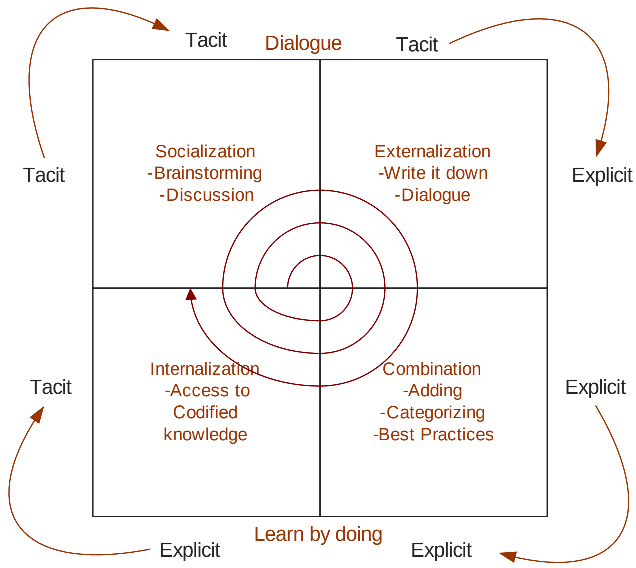
Figure 2 demonstrates the conversion of knowledge according to Nonaka and Takeuchi's model.

KNOWLEDGE MANAGEMENT

Peter Drucker first introduced the terms knowledge work and knowledge worker in the 1960s. Knowledge management as a term was coined back in the 1990s due to the fact that Japanese companies were at the top compared to other companies globally. Knowledge management is about organizing and managing the knowledge of workers.

To begin with, in order for a company to introduce knowledge management, it should first develop a culture of knowledge sharing within the organization. However, in order to develop a culture of sharing in a company, the employees need to trust each other and the company in advance. After the preparation of the ground, the IT part can take place. Workers then must take a training course on the KM software. Additionally, good management of the knowledge database is

Figure 2. Nonaka and Takeuchi's model



vital. This can be achieved by categorizing the knowledge database by subjects and dates, and by means of a search engine (Ahmad, 2003).

Imagine a library (physical) with a list of books that can be traced via computer software that indicates each bookshelf's column code and book details in order for a person to locate and borrow a book. Additionally, there are people (librarians) that make sure that the right book is in the right location. A knowledge-management system without knowledge sharing is like a virtual library that needs librarians to take care of it.

Knowledge management is completely based on a knowledge-sharing culture inside a company or between companies. People, by interacting with each other, create communities of practice. These people have common interests and aims; so, by cooperation, they develop their own kind of communication and rules.

People must share and exchange knowledge in order to find the best practice for a subject orto innovate knowledge. Once the knowledge is in the knowledge base, the knowledge analysts can begin seeking, studying, and analyzing the information in order to pull the quality knowledge. Afterward, the workers or professionals can go through the information, and pull and reuse the knowledge. This avoids the duplication of effort and dramatically reduces decision-making time. Knowledge management supports the requirement that successes and failures have to be recorded. The knowledge can then be accessed by the use of technology (Ahmad, 2003).

Knowledge management refers to knowledge as an asset that the company owns, like, for example, land and machinery. KM supports the fact that the most important resource in an organization is the people's knowledge. As a popular song says, "people have the power…"

A McKinsey survey outlined in the article "Creating a Knowledge Culture" illustrates the importance to create a need for knowledge:

Less successful companies tend to take a top-down approach: pushing knowledge to where it is needed. Successful companies, by contrast, reward employees for seeking, sharing and creating knowledge. It requires effort to develop what we call "knowledge pull"—a grassroots desire among employees to tap into their company's intellectual resources. (Knowledge Portal, http://www.knowledge-portal.com/people.htm)

KM aims at keeping knowledge up to date and correct, providing knowledge in the right location, applying knowledge of the most suitable type, and providing knowledge at the time at which it is needed.

In other words, KM allows for securing and distributing knowledge in order to assure and optimise its availability (Montani & Bellazzi, 2002).

KNOWLEDGE MANAGEMENT IN HEALTHCARE

According to the Royal College of Surgeons in Ireland (http://www.rcsi.ie), there are 10,000 different diseases and syndromes, 3,000 types of drugs, 1,100 different types of laboratory tests, and finally 400,000 articles added per annum to the biomedical literature.

Furthermore, internal medicine includes 2 million facts (Wyatt, 2003). The growth rate in biomedical literature doubles every 19 years (Wyatt, 1991).

Doctors' decisions determine three quarters of healthcare costs and depend critically on medical knowledge (Tierney, Miller, Overhage, & McDonald, 1993). Once knowledge has been captured in some form such as a guideline, it can be managed (Wyatt, 2001).

Knowledge in medicine arrives from reports, libraries, experience, guidelines, laboratory experiments, protocols, practice, group meetings, and so forth. By adding interaction between these forces, then the outcome can be superior.

Because of the above reasons, the use of knowledge management is critical in the healthcare sector. By having a sharing culture with a common aim—the best possible patient care—and by using an information system, not for data warehousing but instead for interpretation and annotation to create knowledge, then the healthcare sector can be dramatically improved.

Healthcare organizations need to improve the quality of patients' treatment. This includes a decision-support system (best practice) and the reduction of errors in patients' diagnoses and treatment.

Two kinds of healthcare information exist: information about patients and information about cases. In order for professionals to be accurate, both kinds of information are needed. By combining these two kinds of information, professionals are able to come up with the right solution (UCL, http://www.ucl.ac.uk/kmc/resources/top_tips.html).

By using a successful knowledge-management system tool, professionals are able to make conclusions by interpreting and understanding patients' data and by carrying out a successful diagnosis in order for the right actions to be applied.

Furthermore, by using a KM system, professionals are able to access the right information and advice at the right time. However, if there is a difference between a theory in the knowledge base and the related practice, professionals can add comments for later improvement.

By implementing knowledge management, professionals can have access to best practices, and if they are able to understand the importance of a knowledge-sharing culture, then there is also some space for development and innovation. Furthermore, a KM system can improve the decision-making time and so also reduce the costs of a hospital (as a famous slogan says, "time is money").

Professionals can explore and learn faster by going through the knowledge database and studying the cases of other patients and the specific treatments that were applied to them. Furthermore, professionals can apply to evidence-based clinical guidelines.

Besides this, each hospital may be positioned in different places globally, which makes it difficult for a person to access another hospital's knowledge. With KM, research (healthcare) departments that are carrying out experiments can provide other hospitals with knowledge by using a KM system.

Imagine that a conference on a new infection is to take place, but not all doctors across the country are able to attend. By using a knowledge-management system, the doctors that were absent could log in and see a video or a tape on a specific subject and contribute later to that problem by using the KM system.

Moreover, other problems based on the management of the hospital's staff and strategies could be discussed between managers or doctors in order to improve the quality of services offered. Afterward, the amount of information could be written down (explicit) for future reuse by other hospitals.

According to Wyatt (2001, p. 8):

The future of knowledge management in health is bright. We already have adequate technology in the shape of the Internet and a good intellectual framework in evidence-based health, which are being used to improve each other. We also have many health librarians who are knowledge management professionals.

The importance of knowledge management can also be justified by presenting Table 1, which illustrates the differences between the old and the new healthcare elements.

Example: Alerts or recommendations described in literature (McDonald, 1976)

If treatment includes cardiac glycoside
and last premature ventricular systoles/minute > 2
then "Consider cardiac glycoside as cause of arrhythmia"

Result: When data matches events, a recommendation is printed out for the doctor.

Impact: The frequency with which doctors responded to target events doubled from 22% to 51%.

Table 1. Old and new health-care paradigms (Olson, 2004)

Old Healthcare Paradigm	New Healthcare Paradigm
• HIS System • Operations-Oriented • Hierarchical Database • Programmer-Centric • Silo-Based • Character-Based • Fragmented Decision Support	• Enterprise-Wide Knowledge Management System • Analysis-Oriented • Relational Database • End user-Centric • Process-Based • GUI/WEB-Based • Holistic Decision Support

GOALS AND BENEFITS OF KNOWLEDGE MANAGEMENT IN HEALTHCARE

- Support in decision making about patients, interference, and the evaluation of research
- Enhanced healthcare system by improving communication between professionals in the decision-making process
- Improved patient healthcare
- Improved quality, access time, and portability of healthcare
- Increased communication between professionals and hospitals
- Improved cost management by reducing the time of patients' hospital treatment
- Reduced time of decision making by using a knowledge database and consequently the reduction of the time of patients' residence in hospitals
- Reduced error rate (defects) in decision making
- Reduced inconvenience
- Increased patient satisfaction

CONCLUSION

Without doubt, the KM model constitutes a hopeful innovation in the health sector with more possibilities and uses. It is about time for a qualitative upgrade of health-services provision to take place. It is obvious that the direct access o all healthcare professionals in KM will minimise medical errors, decrease the medium duration of hospitalisation, reduce the cost of hospitalisation, increase the patient's satisfaction, and have a positive contribution to the relation of cost and effectiveness.

People have to bear in mind that the health-services sector has a specific particularity: Patients are human beings with particular needs, special characters, and different interactions in therapeutic interventions. KM is a tool that helps healthcare professionals to implement the best practices while considering the special needs of each patient, and sometimes to innovate. IT in knowledge management is just the enabler; the idea is for people to start sharing experiences and ideas with a common aim. Finally, healthcare remains a human science with a strong scientific basis; its consultations have such high levels of complexity that they probably can never be completely computerised and automated.

REFERENCES

Abidi, S. S. R. (2001). Knowledge management in healthcare: Towards "knowledge-driven" decision-support services. *International Journal of Medical Informatics, 63,* 5-18.

Ahmad, K. (2001). *The knowledge of organisations and the organisation of knowledge.* UK: University of Surrey.

De Lusignan, S., Pritchard, K., & Chan, T. (2002). A knowledge-management model for clinical practice. *J Postgrad Med, 48*, 297-303.

Godbolt, S. (n.d.). *Moving into knowledge management in the NHS, issue 3.* London: London Library.

Marco, D. (2003). *A meta-data repository is the key to knowledge management.* Brookfiled: Enterprise Warehousing Solutions.

McDonald, C. J. (1976). Protocol-based computer reminders: The quality of care and the non-perfectability of man. *New England Journal of Medicine, 295,* 1351-1355.

Montani, S., & Bellazzi, R. (2002). Supporting decisions in medical applications: The knowledge management perspective. *International Journal of Medical Informatics, 68,* 79-90.

Myers, F. (2003). *Knowledge management in healthcare: Succeeding in spite of technology.* FL: AFSM International.

Nanaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Olson, E. (2004). *Knowledge management & business intelligence in healthcare.* Coppell: The Shams Group.

Tierney, W. M., Miller, M. E., Overhage, J. M., & McDonald, C. J. (1993). Physician order writing on microcomputer workstations. *JAMA, 269,* 379-383.

Wyatt, J. (1991). Use and sources of medical knowledge. *Lancet, 338,* 1368-1373.

Wyatt, J. (2001). *Clinical knowledge and practice in the information age: A handbook for health professionals.* London: RSM Press.

Wyatt, J. (2003). *When do we need support systems?* London: National Institute for Clinical Excellence.

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Chapter 5.18
Effects of Knowledge Management Implementations in Hospitals:
An Exploratory Study in Taiwan

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ABSTRACT

From the knowledge management point of view, the fundamental mission of hospital management is the delivery of quality medical services, utilizing highly specialized knowledge to solve healthcare problems within various resource constraints. Similar to other knowledge-intensive industries operating in highly challenging business environments, hospitals of all sizes must view the creation, organization, distribution, and application of knowledge as a critical aspect of their management activities. Knowledge management represents a viable strategy as hospitals strive simultaneously to provide quality medical services, improve operational efficiency, and conform to the government's documentation and reporting regulations. This study examines the correlation as well as the causal relationships among knowledge characteristics, knowledge acquisition strategy, implementation measures, and performance of knowledge management implementations in the context of hospital management. Using primary data collected in Taiwan, our analyses show that the characteristics of knowledge affect the ways in which knowledge management is implemented,

and the implementation measures, in turn, have a significant impact on the results of knowledge management implementations.

INTRODUCTION

Hospitals of all sizes currently are faced with a multitude of management pressures, including industry competition, customer satisfaction, shortage of specialized personnel, compliance with government regulations, cost reduction, and the ever-increasing demand for more effective cures (Camilleri & O'Callaghan, 1998; Porter & Teisberg, 2004). In coping with these challenges, hospitals actively are experimenting with various management initiatives and programs, such as total quality management and knowledge management, with varying performance results. Emerging as a new multidisciplinary management field, knowledge management (KM) promises to enhance competitive advantage in the highly dynamic knowledge economy by treating valuable and scarce knowledge as a critical organizational asset and by managing it in a systematic manner (Sharkie, 2003; Ulrich & Smallwood, 2004). From the knowledge management point of view, many hospital services involve knowledge-intensive processes that are carried out to solve patient health-related problems. Because of the knowledge-intensive nature of healthcare services, much of a hospital's success depends on effective and efficient creation, organization, validation, dissemination, and application of its highly specialized medical knowledge.

Traditional knowledge management mechanisms in most hospitals typically include morning meetings, apprenticeships, internships, professional seminars, research partnerships with outside research institutions, and other forms of human interaction. Sophisticated information technologies also are being deployed in some hospitals in order to manage medical images and to capture scarce expertise (e.g., medical expert systems) (Davenport & Glaser, 2002). The addition of Internet technologies to the portfolio of information processing technologies offers a new set of powerful tools in order for hospitals to implement knowledge management programs.

In light of the strategic value of professional knowledge, hospitals increasingly recognize a need to manage more actively their intellectual capitals. The field of knowledge management provides the frameworks and techniques that are required to transform a hospital into a learning organization (Adams & Lamont, 2003; Awad & Ghaziri, 2004; Becera-Fernandes, Gonzales & Sabherwal, 2004; Gupta & Govindarajan, 2000; Hansen et al., 1999; Leonard-Barton, 1995). These frameworks and techniques emerge from the inquiries conducted and the experiences acquired in a variety of contexts, including manufacturing (Kim, Hwang & Suh, 2003), customer relationship management (Gebert, Geib, Kolbe & Brenner, 2003), consulting (Sarvary, 1999), retail chain (Tsai, Yu & Lee, 2005), and health care (Powers, 2004). Much of the literature, however, has been either case studies or conceptual discussions. Empirical studies based on the primary data collected in the field, however, are important for advancing the field of knowledge management toward maturity.

Motivated by the dearth of empirical inquiries in knowledge management that address issues in hospital management, we conduct this study to identify the relationship between some factors that play a significant role in successful knowledge management implementations in the healthcare environment. Our purpose is to understand how knowledge management is practiced and the result of implementation in this knowledge-intensive sector. We also seek to contribute to hospital management by offering empirical evidence for the value of knowledge management in coping with the multi-faceted management challenges faced by today's hospitals.

The remainder of the article is structured as follows. The next section describes an interview process conducted with hospital executives and medical doctors for the purpose of selecting the constructs for our research model. We review some of the existing knowledge management literature that relates to our research constructs. We also discuss our research hypotheses that are formulated as a result of field interviews and literature reviews. The section on research methodology describes the research framework, data collection approaches, and data analysis techniques. This is followed by the results of data analysis. The last section discusses some implications of the research findings for hospital knowledge management in particular and knowledge management in general. Suggestions for future research in knowledge management also are presented.

Identification of Research Constructs

Knowledge management increasingly has received attention as an important multidisciplinary field in both the academic and corporate arenas over the past years (Adams & Lamont, 2003; Becera-Fernandez et al., 2004; Davenport, De Long & Beers, 1998; Gloet & Berrell, 2003; Sharkie, 2003). A common denominator among knowledge management researchers is the belief that in the knowledge economy, which is characterized by rapid change and fierce competition, knowledge should be viewed as a valuable and manageable resource, just like tangible assets such as capital and factory facility (Davenport & Prusak, 2000; Leonard-Barton, 1995; Liebowitz & Wilcox, 1997; Soo, Devinney, Midgley & Deering, 2002). Various conceptual frameworks for effective implementation of knowledge management programs or projects have been proposed in order to facilitate knowledge sharing and to stimulate continuous innovation both within and across organizational boundaries (Awad & Ghaziri, 2004; Davenport & Glaser, 2002; Lee & Hong, 2002; Soo et al., 2002; Tiwana, 2000; Wang, 2002; Wiig, 1994). Due to the knowledge-intensive nature of healthcare delivery processes, there has been a call for implementation of knowledge management in the context of hospital management in the pursuit of sustainable competitive advantage (Davenport & Glaser, 2002; Powers, 2004; Van Beveren, 2003).

In order to better understand the unique features of hospital management as related to knowledge management, we conducted hour-long interviews with two hospital executives and three medical doctors in a regional medical center. A structured questionnaire was used in the interviews, supplemented by open-ended questions, to help us to identify the research constructs for our inquiry. Several points stood out to provide a direction for the study. First of all, medical services (esp. clinical care) are very context-sensitive. A specific clinical care problem may be attributed to the patient's personal condition, disease specifics, disease history, family background, treatment history, medication history, and so forth. Effective treatment collectively must consider a wide variety of factors. The complexity of clinical care knowledge, in other words, often comes from a great number of factors and the subtle relationships among these factors that need to be considered in the treatment decision. The ability to distinguish between the relevant and irrelevant factors and to identify the relationships among these factors is a core competence of a true expert. Also, although theoretical knowledge distributed by such published avenues as books and articles is valuable in developing a medical expertise, ultimately, it is the practical experience in dealing with specific cases that truly builds up a medical doctor's professional expertise and the hospital's knowledge repository. In addition, most medical knowledge accumulated over the years is practical knowledge that is not preserved in any printed media. These findings lead to the selection of knowledge characteristics as a research construct.

We also found from the field interviews that specific implementation measures, such as the availability of information infrastructure that facilitates KM activities, incentive programs, and other people-related factors, play a key role in the success (or failure) of the KM implementation program. Information technologies are used to digitize and to store knowledge content. Once kept in the systems, valuable knowledge content easily can be disseminated, integrated, and deployed. Each specialization unit in a hospital usually represents an organizational silo separated from other specialization units. A well-designed information system enables the sharing of related information and knowledge by baking the system capabilities in the daily business processes (Davenport & Glaser, 2002). Furthermore, the interviews identified two preferred indicators for assessing the performance of the KM implementation: improvement of internal process and overall organizational performance. Two research constructs—KM implementation measures and KM performance—are identified as a result. Finally, the research construct Knowledge Acquisition Strategy is included in the research model in order to evaluate the strategic role of knowledge source in hospital management. Based on the findings of our preliminary inquiry, the scope of this study is limited to four research constructs: the characteristics of medical knowledge, the strategy used to acquire valuable knowledge, how KM concepts are implemented, and the result of KM implementations. The following section reviews the literature relating to these four constructs.

Knowledge Characteristics

As a service-oriented and knowledge-intensive organization, a hospital typically deals with knowledge in a variety of categories: customer (patient) knowledge, service (treatment) knowledge, process knowledge, and account management, to name just a few. In generic terms, knowledge can be characterized in many ways: shallow vs. deep, procedural vs. declarative, explicit vs. tacit, domain-independent vs. domain-specific, common sense vs. professional, static vs. dynamic, and proprietary vs. nonproprietary, for example (Awad & Ghaziri, 2004; Davenport & Glaser, 2002; Gloet & Berrell, 2003; Gupta & Govindarajan, 2000; Howells, 1996; Nonaka & Takeuchi, 1995; Polanyi, 1996; Ulrich & Smallwood, 2004). A recent list of knowledge attributes proposed by Holsapple (2003) consists of 23 items. According to the healthcare practitioners that we interviewed, for the medical and healthcare service industry, four knowledge characteristics are deemed most relevant: knowledge mode (explicit vs. implicit), knowledge complexity, strength knowledge appropriability (ease of replication and transferring), and knowledge volatility (dynamic vs. static). These four characteristics were identified using a rating questions list, augmented by open-ended elaborative discussions.

Explicit knowledge is represented in the form of recorded products, such as printed documents, formulas, software, system manuals, and hardware equipment, while implicit knowledge primarily is undocumented and retained as memory (Howells, 1996; Nonaka & Takeuchi, 1995; Polanyi, 1996; Zack, 1999). Hospitals vary in their perceptions of and relative emphasis on the explicitness—implicitness continuum of their valuable healthcare knowledge. Different perceptions and preferences may lead to different strategies being adopted for knowledge acquisition and other important aspects of knowledge management implementation measures. Explicit knowledge is more amenable to technologically oriented solutions, such as a document base and a knowledge map, whereas implicit knowledge is handled primarily through social networks.

Complex knowledge is difficult for organizations to acquire. Once acquired, however, it can become a valuable source of competitive advantage (Holsapple, 2003; Teece, 1998). Knowledge complexity is determined by the abstract nature of knowledge, the number of knowledge components, and the interaction of these components (Soo et al, 2002). In the healthcare domain, both the great amount and the intricate interactive effect of professional medical knowledge pose a substantial challenge for hospitals that are striving to provide quality healthcare services.

Knowledge that is nonproprietary in nature easily can be transferred across organizational boundaries. The proprietary nature of knowledge usually is determined by the extent to which the knowledge is tightly tied to the specific organization (Teece, 2003; Soo et al., 2002). From the system development point of view, proprietary knowledge usually is domain-specific. Both domain-specific and domain-independent knowledge are important in solving complex problems. However, past successes of expert system technology applications demonstrate that domain-specific knowledge usually contributes more than domain-independent knowledge in solving difficult problems. This notion of organizational specificity associated with knowledge management is illustrated well by Gupta and Govindarajan (2000) in a case study of the Nucor Steel Corporation. The consistently superior performance of Nucor Steel demonstrates that, once knowledge creation and sharing are embedded in the management practice and the daily operational routines, the resultant proprietary knowledge can establish a solid foundation for a truly sustainable competitive advantage (Adams & Lamont, 2003). The value of proprietary knowledge is obvious in hospital management, especially in dealing with challenging healthcare problems.

Currency of knowledge can be an important issue at times when new knowledge renders old knowledge useless. In these cases, knowledge must be subject to frequent updating in order to stay valuable. The optimal updating frequency is determined by the dynamic (or static) nature of the knowledge. The issue of knowledge updating has been addressed in expert systems development (Liebowitz & Wilcox, 1997). In fact, one of the criteria in the selection of knowledge-based expert system application domains is that the domain knowledge must be relatively static. The complexity involved in knowledge updating and validation poses a significant challenge for keeping a knowledge base current and for having the system accessible at the same time. In the broader context of medical care service delivery, updating of the knowledge repository may affect the strategy for knowledge acquisition as well as knowledge management implementation measures.

Knowledge Strategy

A knowledge strategy, as defined by Zack (1999), "describes the overall approach an organization intends to take to align its knowledge resources and capabilities to the intellectual requirements of its strategy" (p. 135). Zack's (1999) knowledge strategy framework consists of two dimensions: exploitation vs. exploration and internal vs. external. While the exploitation vs. exploration dimension distinguishes a creator from a user of knowledge, the internal vs. external dimension describes the organization's primary sources of knowledge. Internal knowledge is characterized as being "resident within people's heads; embedded in behaviors, procedures, software and equipment; recorded in various documents; or stored in databases and online repositories" (Zack, 1999, p. 138). External sources of knowledge include publications, university alliances, government agencies, professional associations, personal relations, consultants, vendors, knowledge brokers, and interorganizational alliances. Using Nucor Steel's experience, Gupta and Govindarajan (2000) argued that internally created knowledge tended to contribute more to an organization's competitive advantage than did external approaches.

Another useful KM strategy framework is represented by a codification vs. personalization dichotomy. According to Hansen, et al. (1999), the codification-oriented KM strategy is suitable for explicit, recordable, formal, and replicable knowledge, and the personalization-oriented strategy works better for implicit knowledge. Whereas information technology plays a central role within the codification strategy, it primarily provides tool support for the personalization strategy. The choice of primary knowledge acquisition strategy usually is determined by a variety of factors, among which is the characteristics of knowledge (Awad, 2004; Davenport & Prusak, 2000; Tiwana, 2000; Wiig, 1994).

Knowledge Management Implementation Measures

Knowledge management generally is viewed as a collection of management practices consisting of knowledge accumulation, knowledge organization, knowledge dissemination, and knowledge application (Awad & Ghaziri, 2004; Davenport & Prusak, 2000). The implementation of organizational KM projects typically involves technical as well as non-technical measures. A flexible and efficient information technology infrastructure is an essential requirement. The subsequent distribution and application of the organizational knowledge depends on digital representation, computerized storage, dissemination of the knowledge content, and the application context. Additionally, properly designed incentive programs must be in place in order to discourage knowledge hoarding and to promote knowledge sharing (Davenport & Prusak, 2000; Soo et al., 2002). Sufficient resources must be committed to encourage active learning and perpetual updating of the professional staff's knowledge base.

Knowledge Management Performance Measurement Issues

Measuring the results of KM projects is a challenging task. The subjective nature of the benefit measurement and the lengthy lead time required in order for the benefit to become quantitatively measurable usually are cited as the main sources of difficulty (Abeysekera, 2003; Stone & Warsono, 2003). Although the organizational benefit resulting from KM project implementation eventually must be expressible in financial terms, a significant portion of the benefit is qualitative and only can be measured subjectively. Most literature, therefore, suggests a portfolio approach to measuring the result of KM implementation, such as innovative capability, which would include both financial and non-financial data (Chourides, Longbottom & Murphy, 2002; Darroch, 2003; Soo et al., 2002). Furthermore, it is recognized increasingly that in order for KM to achieve its greatest success, KM functions must be integrated tightly with major business processes. For example, Davenport and Glaser (2002) indicate that, based on their experience at a major medical center in Boston, medication knowledge must be embedded into a doctor's prescription writing process in order to make knowledge application a natural part of daily work practice. The tight integration of knowledge management process and other business processes contributes at least partially to a straightforward measurement of the result of KM implementation (Darroch, 2003).

The input from the practitioners also suggests the following relationships to be examined in the study:

1. The primary knowledge acquisition strategy is affected significantly by knowledge characteristics (knowledge characteristics → knowledge acquisition strategy).
   Rationale: Knowledge either is created from within the organization or collected from external sources. Each knowledge acquisition strategy has its pros and cons, depending on the nature of business, the available resource, and other factors. Knowledge that is created internally tends to fit the organizational needs better and to and contributes more to the competitiveness, for example. Although both internal and external sources can be used, an organization usually has a primary knowledge acquisition strategy regarding how to build up its knowledge stock. Everything else being equal, the perceived

knowledge characteristics may determine the primary knowledge acquisition strategy that is adopted by the organization.

2. Knowledge management implementation measures are affected significantly by knowledge characteristics (knowledge characteristics → KM implementation measures).

   Rationale: When valuable knowledge is perceived to be primarily tacit, it is less likely that a significant amount of resource will be invested in building sophisticated information systems to support knowledge management activities. Rather, most of the KM implementation measures will be people-oriented. Further, in an effort to cope with knowledge complexity and volatility and to encourage the development of proprietary knowledge, an organization may pay more attention to its incentive program, expertise development, and human resource planning. Therefore, it is reasonable to assume that the way a hospital chooses to implement KM programs is influenced significantly by its perception of knowledge characteristics.

3. Knowledge implementation measures are affected significantly by the primary knowledge acquisition strategy (primary knowledge acquisition strategy → KM implementation measures).

   Rationale: Creating knowledge internally often requires knowledge workers to share knowledge with the rest of the organization. Knowledge sharing usually is not a natural component of organizational culture in most Taiwanese hospitals, where high work pressure and departmental silos tend to encourage knowledge hoarding. In order to encourage internal creation of knowledge through knowledge sharing, hospitals must implement a portfolio of facilitating measures, such as incentive programs, expertise development, human resource planning, and technological infrastructure. Therefore, we postulate that KM implementation measures are affected by the primary knowledge acquisition strategy.

4. KM performance is affected significantly by the primary knowledge acquisition strategy (primary knowledge acquisition strategy → KM implementation performance).

5. KM performance is affected significantly by KM implementation measures (KM implementation measures → KM performance).

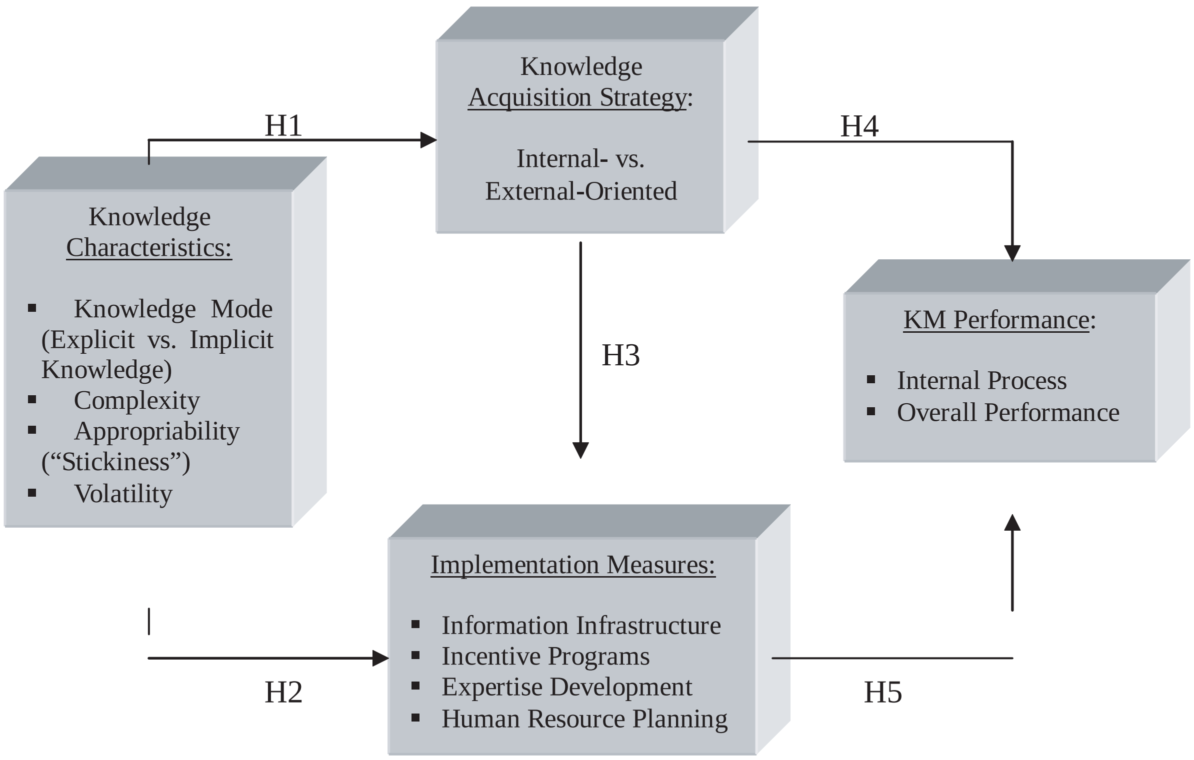
   Rationale: O'Dell, Elliott, and Hubert (2003) identified three general categories of value propositions for KM program implementation—customer intimacy, product-to-market excellence, and operational excellence—as a result of APQC's first benchmarking study on best practices in KM. Operational excellence is the most relevant to the context of hospital management. The value proposition defines the goal for KM implementation. Since the degree to which the goal is achieved can be affected significantly by the approach (strategy) and the specific actions (implementation measures) taken to pursue the goal, we set up these two hypotheses to validate our presumptions.

RESEARCH DESIGN

Research Framework, Variables, and Hypotheses

For the purpose of this research, KM was defined as a management function responsible for the acquisition, organization, evaluation, sharing, distribution, and application of both tacit and explicit knowledge for an organization. In order to gather data to analyze how KM was practiced in Taiwanese hospitals, we postulated that the hospital management professionals' perceptions of knowledge characteristics would affect the primary strategy adopted to acquire knowledge and also would affect the hospitals' KM imple-

Figure 1. Research framework



mentation measures. We further assumed that these latter two sets of variables, in turn, would affect the result of KM implementation. These hypothesized relationships between the research variables were derived from the result of literature and our field interviews with healthcare professionals in Taiwanese hospitals. The diagrammatic depiction of our research model is shown in Figure 1. The five research hypotheses established to validate our presumption also are indicated in the diagram.

Operational Definition of Research Variables

The characteristics of knowledge were represented by four important dimensions of medical and hospital management knowledge that we identified in our preliminary interview with medical professionals: knowledge mode (explicit vs. tacit nature of knowledge), complexity, strength of knowledge appropriability, and knowledge volatility.

The primary strategy adopted to acquire knowledge in this study was dichotomized into internally oriented acquisition and externally oriented acquisition. Internal sources included apprenticeships, intranet, internal documentation, morning meetings, internal medical databases, and department meetings. External sources included collaboration with universities, external consultants, internships in other hospitals, seminars, and professional conferences.

The knowledge management implementation measures were represented by activities in four areas: information infrastructure, incentive programs for knowledge sharing, expertise development, and human resource planning. The first three items corresponded to three basic entities involved in knowledge management programs: people (incentive programs), knowledge (expertise development), and technological tools (information infrastructure). The fourth item (human resource planning) corresponded to both people and knowledge.

Two categories of variables were used to represent the performance measure of knowledge management implementation in hospitals: internal process improvement and overall organizational performance enhancement. Internal process improvements consisted of communications and efficiency improvement measures, such as problem-solving time, employee participation, decision-making cycle time, and employee interaction. Overall organizational performance measures covered such items as service quality, customer focus, absenteeism, and customer (patient) satisfaction. With these definitions of the research variables, the research hypotheses were formulated as follows:

Hypothesis 1 (H1): The primary knowledge acquisition strategy is affected significantly by knowledge characteristics.

Hypothesis 2 (H2): KM implementation measures are affected significantly by knowledge characteristics.

Hypothesis 3 (H3): KM implementation measures are affected significantly by the primary strategy adopted for knowledge acquisition.

Hypothesis 4 (H4): KM implementation performance is affected significantly by the primary knowledge acquisition strategy.

Hypothesis 5 (H5): KM implementation measures affected significantly KM performance.

Questionnaire Design and Data Collection

All research variables except knowledge acquisition strategy were represented by multiple questions using five-point Likert scales, with 1 indicating very poor or highly disagree and 5 indicating very good or highly agree. A checklist was devised for knowledge acquisition strategies. A questionnaire was sent to 20 head physicians in four medical centers. This first version of the questionnaire was tested using results from the 12 respondents. Based on feedback from the pilot test, the questionnaire was revised by removing the questions with low reliability coefficients and by modifying the ones lacking semantic clarity. The revised version consisted of 44 Likert scale questions. There were 15 questions for knowledge characteristics, 18 questions for KM implementation measures, and 11 questions for performance measures. A copy of the questionnaire was mailed to the president of each of the 126 hospitals on the list that was compiled by the Department of Health of Taiwan. Hospital presidents were targeted on the assumption that they were familiar with the issues under study.

Due to the exploratory and empirical nature of the study, the questionnaire was limited in the criterion validity and the construct validity. Both the content validity and the discriminant validity were assumed to be proper, since the questions were based on the literature and the input from the practicing professionals. The reliability measures, as represented by Cronbach, if all research variables are above 0.70, an indication of acceptable reliability (Nunnally, 1978). Table 1 summarizes the reliability measures of all research variables. Note that two questions were removed from the original set of 46 questions as a result of this analysis.

Table 1. Reliability of research variables

Variables	Sub-dimensions	Question Items	Cronbach α
Knowledge Characteristics	Explicitness	1, 2, 3, 4	0.8239
	Complexity	5, 6, 7, 8	0.7605
	Appropriability	9, 10, 11, 12*	0.7187
	Volatility	13, 14, 15, 16	0.7905
Implementation Measures	Information Infrastructure	17, 18,19, 20, 21	0.8827
	Incentive Program	22, 23, 24, 25	0.8191
	Expertise Development	26, 27, 28, 29, 30*, 31	0.8063
	Human Resource Planning	32, 33, 34, 35	0.7674
Performance Measures	Internal Process	36, 37, 38, 39, 40, 41	0.9115
	Overall Preformance	42, 43, 44, 45, 46	0.8374

*: *Questions are subsequently removed due to insufficient reliability measures.*

Data Analysis Method

In order to test the previous hypotheses, several statistical analysis techniques were employed to analyze the data. In particular, t-test was conducted to evaluate the effect of knowledge characteristics on the primary acquisition strategy and the effect of the knowledge acquisition strategy on the KM implementation measures. Canonical correlation analysis was conducted to determine the correlation relationship between knowledge characteristics and implementation measures, both of which are multiple variables. Finally, stepwise regression analysis was used to determine the impact of the KM implementation measures on both of the performance measures.

RESEARCH FINDINGS

The questionnaire was mailed to 126 hospitals in Taiwan, from which 50 questionnaires were returned. The questionnaire was addressed to the person who was most familiar with knowledge management practices in the hospital. Three questionnaires were removed due to incomplete answers. The remaining 47 accounted for an effective response rate of 37.3%. Ten questionnaires were filled out by hospital presidents, seven by vice presidents, one by a physician, and 29 by hospital management staff. The Kolmogorov-Smirnov statistics for knowledge characteristics, implementation measures, and performance measures all exhibited normal distribution at the 0.001 significance level.

Hypothesis 1 stated that the primary knowledge acquisition strategy is affected significantly by knowledge characteristics. The frequency distribution of knowledge acquisition strategies summarized in Table 2 showed that the most common internal source of knowledge was morning meetings, and the most widely used external knowledge source was outside meetings. Table 3 showed the means and standard deviations of each of the four dimensions of knowledge characteristics. The measures of knowledge characteristics were dichotomized, using averages as the thresholds, into two distinct levels: high and low. A t-test was performed to determine the correlation relationship between knowledge acquisition

Table 2. Distribution of primary knowledge acquisition strategy

Types of KA Strategy		Freq.		Freq. Total	
Internal-Oriented	Manual and Instruction Management	1	2.1	20	42.6
	Morning Meeting	12	25.5		
	Group Discussion within Department	6	12.8		
	Hospital-wide Medical Database	1	2.1		
External-Oriented	Collaboration with University	3	6.4	27	57.4
	Consultant	2	4.3		
	Internship with other Hospitals	2	4.3		
	Outside Meeting	20	42.6		

Table 3. Means (μ) and standard deviations (σ) of knowledge characteristics

Knowledge Characteristics	μ	σ
Knowledge Mode	3.7872	0.5874
Complexity	2.9043	0.4056
Appropriability	3.4752	0.5462
Volatility	3.0691	0.6567

strategy and knowledge characteristics. Table 4 shows that the adoption of internal-oriented strategy was affected significantly by the level of knowledge explicitness (t = 1.152, p-value = 0.012), and the use of external-oriented knowledge was affected significantly by knowledge complexity (t = 1.224, p-value = 0.000). In other words, the internal-oriented strategy was used more to acquire knowledge with high explicit levels, whereas the external-oriented strategy was used more for knowledge with high complexity levels. These were indications that, in general, hospitals in Taiwan tended to rely on external sources to update and upgrade their knowledge bases. The lack of resources and the competitive pressure from the environment were keeping most of them from actively investing in internal research and development in order to create valuable knowledge from within the organization. With a few exceptions (e.g., Chang-Hua Christian Hospital), only the medical centers that are affiliated with research universities had the capabilities and resources with

Table 4. Relationship between knowledge characteristics and KA strategy

Knowledge Characteristics	Knowledge Acquisition Strategy			
	Internal-Oriented	External-Oriented	t-value	p-value
Explicitness	3.8241	3.4825	1.152	0.012*
Complexity	3.2167	2.7621	1.224	0.000**
Appropriability	3.5667	3.4074	0.998	0.328
Volatility	3.1375	3.0185	0.610	0.545

Table 5. Canonical correlation analysis between knowledge characteristics and implementation measures

Knowledge Characteristics	Canonical Variate	Implementation Measures	Canonical Variate
	χ_1		η_1
Knowledge Explicitness	0.688*	Information Infrastructure	0.71*
Complexity	-0.005	Incentive Program	0.708*
Appropriability	0.854*	Expertise Development	-0.128
Volatility	0.918*	Human Resource Planning	0.921*
Extracted Variance	51.16%	Extracted Variance	46.76%
Wilks Λ	0.465	Redundancy	0.174
F-value	2.13	Canonical Correlation (ρ)	0.61
p-value	0.011	ρ^2	0.37

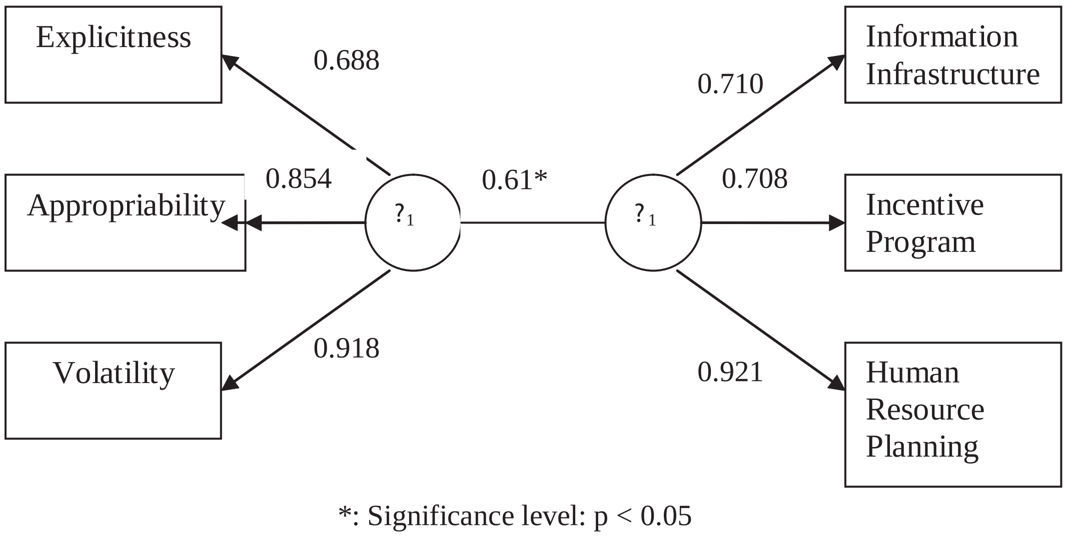
*:*Absolute value of canonical loading > 0.6*

which to carry out knowledge creation activities in a systematic manner.

Hypothesis 2 states that KM implementation measures are affected significantly by knowledge characteristics. Since both knowledge characteristics and implementation measures consist of four variables, canonical correlation analysis was employed in order to determine the correlation relationship. As summarized in Table 5 and as graphically presented in Figure 2, the result of canonical analysis identified that the linear composition of three knowledge characteristics—knowledge explicitness, appropriability, and volatility—were correlated significantly with the linear composition of three implementation measures: information infrastructure, incentive program, and human resource planning. The correlation coefficient (ρ) was 0.61 at the significance level 0.05.

Hypothesis 3 states that KM implementation measures are affected significantly by the primary strategy adopted for knowledge acquisition. The result of the t-test indicated that two implementation measures were affected significantly by the knowledge acquisition strategies. Internal-oriented strategy adopters scored higher in informa-

Figure 2. Path diagram of canonical correlation analysis between knowledge characteristics and implementation measures



tion infrastructure than external-oriented strategy adopters, whereas external-oriented adopters scored higher in incentive measures.

Hypothesis 4 states that the performance of KM implementation is affected significantly by the primary knowledge acquisition strategy. The result of the t-test (Table 6) showed that different knowledge acquisition strategies did not cause significant differences in either dimension (internal process and overall organizational performance) of the performance of KM implementation. Hypothesis 4 was rejected. Since internally created knowledge usually is considered more likely to contribute to an organization's competitive advantage (Gupta & Govindarajan, 2000), this finding indicated that the hospitals in Taiwan still lacked a proper understanding of the strategic value of locally created knowledge.

Hypothesis 5 states that knowledge management performance is affected significantly by implementation measures. Three stepwise regression analyses were conducted to test this hypothesis. The first test was a simple regression analysis, in which both the performance measures and the implementation measures were treated as single, composite variables. The second test treated the performance measures as one variable and the four dimensions of the implementation measures as four variables. The third test treated each of the two dimensions of the performance measures as a dependent variable. The first test resulted in a regression equation:

KM Performance = 1.086 + 0.684 * KM Implementation Measures
F-value = 15.517, ($p < 0.1$ for the intercept and $p < 0.001$ for the regression coefficient), Adjusted $R^2 = 0.24$

Table 6. Effect of knowledge acquisition strategy on knowledge management performance

KM Performance	KA Strategy (μ)		t-value	p-value
	Internal-Oriented	External-Oriented		
Internal Process	3.2583	3.5123	-1.028	0.310
Overall Organizational Performance	3.4500	3.5852	-0.645	0.522

Table 7. Impact of implementation measures on KM performance (stepwise regression analysis)

Implementation Measures	Standardized Regression Coefficient	Correlation Coefficient (R)	R^2	F-value	p-value
Human Resource Planning	0.506	0.638	0.407	30.851	0.000*
Incentive Program	0.305	0.695	0.482	20.510	0.000*
Standardize Regression Equation: KM Performance = 0.506 x Human Resource Planning + 0.305 x Incentive Program					

**: Level of Significance $p < 0.001$*

Table 8. Impact of implementation measures on KM performance

	Internal Process		Overall Organizational Performance	
	Regression Coefficient	p-value	Regression Coefficient	p-value
Intercept	-0.225	0.731	0.615	0.333
Information Infrastructure	-0.231	0.170	0.083	0.602
Incentive Program	0.380	0.019*	0.260	0.016*
Expertise Development	0.046	0.530	0.051	0.469
Human Resource Planning	0.850	0.000**	0.437	0.015*
F-value	11.487		6.258	
p-value	0.000		0.000	
Adjusted R^2	0.522		0.373	

**: $p < 0.05$; **: $p < 0.001$*

This result showed that the implementation measures did exhibit significant influence on the performance measures. The second and the third regression analyses were conducted to further investigate this relationship.

In the second regression analysis, each of the four dimensions of the KM implementation measures was treated as an independent variable, with the performance measures as a single composite variable. The third regression analysis related the four dimensions of the KM implementation measures with the two dimensions of the performance measures. Table 7 shows that only human resource planning and the incentive measures significantly affected the performance of KM efforts. Between the two dimensions of the performance measures, human resource planning and incentive measures contributed significantly to both the internal process and the overall performance, as shown in Table 8. The second and third regression analyses essentially confirmed the result of the first regression analysis and also provided a greater understanding of the importance of people factors in effective KM.

CONCLUSION AND DISCUSSION

This study investigated the practice and the effect of KM in hospital management. It examined the effect of knowledge characteristics on knowledge acquisition strategy and KM implementation measures, the effect of knowledge acquisition strategy on implementation approaches and performance measures, and the effect of implementation approaches on KM performance. Using primary data gathered in Taiwanese hospitals, the study found that knowledge characteristics significantly affected implementation measures, and implementation measures, in turn, had a significant effect on the result of KM implementation. More specifically, the level of explicitness of knowledge (knowledge mode) was found to have a significant effect on the adoption of the internal-oriented knowledge acquisition strategy. The complexity of knowledge was related significantly to the external-oriented knowledge acquisition strategy. In general, people factors, such as incentive programs and human resource planning, appeared to have more impact on the result of KM than technology factors, confirming a popular belief regarding the importance of non-technological factors in KM, as reported in the existing literature.

The correlation relationship between knowledge characteristics and implementation measures is worth noting. In addition to incentive programs and human resource planning, information infrastructure was found to be affected significantly by three knowledge characteristics: explicitness, proprietary nature, and variation. The enabling capability of information technology for knowledge storage, dissemination, and application allows for integration of specialized knowledge with routine business processes, such as disease diagnosis and medicine prescription in the healthcare domain (Davenport & Glaser, 2002). Increasingly, hospitals are relying on technological measures as a strategic vehicle to cope with both professional and managerial challenges. The emphasis of information technology applications can be attributed to the collaboration between major hospitals and universities. Information technology development and applications have been a major thrust in Taiwan. Many universities set up research centers to function as an interface between information system researchers and the regional hospitals. Some technologies resulting from these collaborations either are adopted by or are shared with smaller hospitals. The maximal benefit of information technology deployment has yet to be realized, however. The value of technological tools is maximized when they become integral parts of truly integrated business processes.

This study contributed to the field of KM in several ways. For practicing KM professionals and business functional managers, the study demonstrates the importance of matching KM implementation measures with knowledge characteristics. Understanding characteristics of valuable knowledge in an organization is a prerequisite for effective management of its organizational knowledge. Similarly, knowledge-driven organizations consciously must evaluate and adopt their implementation measures. When properly implemented, KM programs may produce visible benefits, including those associated with operationally oriented goals and those associated with long-term financial outcomes.

For KM research, this study empirically revealed the correlation between knowledge characteristics and KM implementation measures. The performance impact of implementation measures, especially those associated with people elements, also was confirmed. The lack of the knowledge acquisition strategy's influence on performance measures suggested that hospitals may have acknowledged the value of both internal and external sources of knowledge and indiscriminately adopted both strategies in order to enrich their knowledge repositories.

Because of several limitations of the study, however, due caution must be exercised in interpreting and applying the results of this study. For example, since the data were gathered in the hospitals in Taiwan, cultural and other environmental differences may limit one's ability to generalize the research findings. Similar researches must be conducted in a variety of cultural and societal settings in order to establish the external validity in a more general fashion.

Another research limitation was that some questionnaires were filled out by the targeted respondents' delegates, including medical doctors and information technology managers. Although the delegates possessed proper understanding of knowledge characteristics or implementation measures, they might not be the best people to answer the questions about overall organizational performance resulting from KM implementation. Additionally, the subjective nature of the questionnaire responses based on the Likert scale constituted a limitation that might discount the validity of the research results.

Healthcare organizations in the United States use information technology extensively to automate important processes and support other aspects of operations. An industry expert estimated that spending in healthcare information technology will increase about 9% per year for the next three years and will reach $30 million in 2006 (Powers, 2004). In light of the important role played by healthcare organizations in our daily lives, more research is needed to provide knowledge about how to improve the quality of hospital management. Based on the findings of this research, two directions may be suggested for future research in this particular domain. First, in-depth case studies may be conducted to verify the validity of our research findings in specific contexts and to assess how contextual factors impact the linkages among knowledge characteristics, KM implementation measures, knowledge acquisition strategy, and KM performance measures. Second, our research model may be replicated in different societies to allow for cross-cultural comparison. Such comparison is necessary in order for the research model to become better established in the KM literature.

REFERENCES

Abeysekera, I. (2003). Intellectual accounting scorecard—Measuring and reporting intellectual capital. *Journal of American Academy of Business, 3*(1/2), 422-440.

Adams, G.., & Lamont, B.T. (2003). Knowledge management systems and developing sustainable competitive advantage. *Journal of Knowledge Management, 7*(2), 142-154.

Awad, E.M., & Ghaziri, H.M. (2004). *Knowledge management.* Upper Saddle River, NJ: Pearson Prentice Hall.

Becera-Fernandez, I., Gonzales, A., & Sabherwal, R. (2004). *Knowledge management: Challenges, solutions, and technologies*. Upper Saddle River, NJ: Pearson Prentice Hall.

Camilleri, D., & O'Callaghan, M. (1998). Comparing public and private hospital care service quality. *International Journal of Health Care Quality Assurance, 11*(4), 127.

Chourides, P., Longbottom, D.L., & Murphy, W. (2002). Excellence in knowledge management: An empirical study to identify critical factors and performance measures. *Measuring Business Excellence, 7*(2), 29-46.

Darroch, J. (2003). Developing a measure of knowledge management behaviors and practices. *Journal of Knowledge Management, 7*(5), 41-54.

Davenport, T.H., & Glaser, J. (2002). Just-in-time delivery comes to knowledge management. *Harvard Business Review, 80*(7), 107-111.

Davenport, T.H., De long, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review*, 443-57.

Davenport, T.H., & Prusak, L. (2000). *Working knowledge: How organizations know what they know*. Harvard Business School Press.

Gebert, H., Geib, M., Kolbe, L., & Brenner, W. (2003). Knowledge-enabled customer relationship management: Integrating customer relationship management and knowledge management concepts. *Journal of Knowledge Management, 7*(5), 107-123.

Gloet, M., & Berrell, M. (2003). The dual paradign nature of knowledge management: Implications for achieving quality outcomes in human resource management. *Journal of Knowledge Management, 7*(1), 78-89.

Gupta, A.K., & Govindarajan, V. (2000). Knowledge management's social dimension: Lessons from Nucor Steel. *Sloan Management Review, 42*(1), 71-80.

Hansen, M.T., et al. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Holsapple, C.W. (2003). Knowledge and its attributes. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (Vol. 1, pp. 166-188). Springer.

Howells, J. (1996). Tacit knowledge, innovation and technology transfer. *Technology Analysis & Strategic Management, 8*(2), 106-116.

Kim, S., Hwang, H., & Suh, E. (2003). A process-based approach to knowledge flow analysis: A case study of a manufacturing firm. *Knowledge and Process Management, 10*(4), 260-276.

Lee, S.M., & Hong, S. (2002). An enterprise-wide knowledge management system infrastructure. *Industrial Management + Data Systems, 102*(1/2), 17-25.

Leonard-Barton, D. (1995). Wellsprings of knowledge. *Harvard Business Review, 71*(2), 75-84.

Liebowitz, J., & Wilcox, L.C. (1997). *Knowledge management*. Ft. Lauderdale, FL: CRC Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. London: Oxford University Press.

Nunnally, J.C. (1978). *Psychometric theory* (2nd ed.). McGraw-Hill.

O'Dell, C., Elliott, S., & Hubert, C. (2003). Achieving knowledge management outcomes. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (pp. 253-287).

Polanyi, M. (1996). *The tacit dimension*. London: Routledge & Kegan Paul.

Porter, M., & Teisberg, E.O. (2004). Redefining competition in health care. *Harvard Business Review, 82*(6), 65-72.

Powers, V. (2004). Improving IT wellness—Health-care organizations adopt knowledge-enabled technology. *KM World, 10*, 11, 26.

Sarvary, M. (1999). Knowledge management and competition in the consulting industry. *California Management Review, 41*(2), 95-107.

Sharkie, R. (2003). Knowledge creation and its place in the development of sustainable competitive advantage. *Journal of Knowledge Management, 7*(1), 20-31.

Soo, C., Devinney, T., Midgley, D., & Deering, A. (2002). KM: Philosophy, process, and pitfall. *California Management Review, 44*(4), 129-150.

Stone, D.N., & Warsono, S. (2003). Does accounting account for knowledge? In C.W. Holsapple (Ed.), *Handbook on knowledge management* (Vol. 1). Springer.

Teece, D.J. (1998). Research directions for knowledge management. *California Management Review, 40*(3), 289-292.

Teece, D.J. (2003). Knowledge and competence as strategic assets. In C.W. Holsapple (Ed.), *Handbook on knowledge management* (Vol. 1, pp. 129-188). Springer.

Tiwana, A. (2000). *The knowledge management toolkit*. Upper Saddle River, NJ: Prentice-Hall.

Tsai, M.-T., Yu, M.-C., & Lee, K.-W. (2005). Developing e-business systems based on KM process perspective: A case study of Seven-Eleven Japan. *Journal of American Academy of Business, 6*(1), 285-289.

Ulrich, D., & Smallwood, N. (2004). Capitalizing on capabilities. *Harvard Business Review, 82*(6), 119-128.

Van Beveren, J. (2003). Does health care for knowledge management? *Journal of Knowledge Management, 7*(1) 90-95.

Wang, S. (2002). Knowledge maps for managing Web-based business. *Industrial Management + Data Systems, 102*(7), 357-364.

Wiig, K.M. (1994). *Knowledge management: The central management focus for intelligent-acting organizations*. Arlington, TX: Schema Press.

Zack, H.M. (1999). Developing a knowledge strategy. *California Management Review, 41*(3), 125-145.

APPENDIX 1: SUMMARY OF HYPOTHESIS TESTING RESULTS

H1	The primary knowledge acquisition strategy is significantly affected by knowledge characteristics.	Partially Accepted
H1.1	The primary knowledge acquisition strategy is significantly affected by knowledge mode.	Accepted
H1.2	The primary knowledge acquisition strategy is significantly affected by knowledge complexity.	Accepted
H1.3	The primary knowledge acquisition strategy is significantly affected by the proprietary nature of knowledge.	Rejected
H1.4	The primary knowledge acquisition strategy is significantly affected by knowledge volatility.	Rejected
H2	Knowledge management implementation measures are significantly affected by knowledge characteristics.	Accepted
H3	Knowledge management implementation measures in the hospitals are significantly affected by the primary strategy adopted for knowledge acquisition.	Partially Accepted
H4	Knowledge management performance is significantly affected by the primary knowledge acquisition strategy.	Rejected
H5	Knowledge management performance is significantly affected by knowledge management implementation measures.	Accepted
H5.1	Internal processes are significantly improved by information infrastructure	Rejected
H5.2	Internal processes are significantly improved by incentive measures for KM implementations.	Accepted
H5.3	Internal processes are significantly improved by expertise development measures.	Rejected
H5.4	Internal processes are significantly improved by human resource planning.	Accepted
H5.5	Overall performance is significantly improved by information infrastructure.	Rejected
H5.6	Overall performance is significantly affected by incentive measures for KM implementations.	Accepted
H5.7	Overall performance is significantly affected by expertise development.	Rejected
H5.8	Overall performance is significantly affected by human resource planning.	Accepted

APPENDIX II: SURVEY QUESTIONNAIRE

(Measurement Scale: 1 = Highly Disagree, 5 = Highly Agree)

Questions About Knowledge Characteristics

1. Documentation has been created for all medical expertise.
2. Medical service delivery processes have formal specifications.
3. Doctor's practice experience may be documented in writing.
4. Doctors can share their professional expertise without any obstacles.
5. Major surgical operations are accomplished by task force teams.
6. Significant differences of expertise exist among the doctors in the same specialty.
7. Outside experts often are called upon to assist with major surgery operations.
8. Mutual support among doctors within the same specialty usually is difficult to come by.
9. Medical expertise is integrated tightly with hospital management and organizational culture.
10. Outsourcing often is used due to inadequacy of medical expertise.
11. Innovations of medical practices are difficult to be obtained by competition.
12. Doctors are expected to remain up-to-date with data in their expertises.
13. The frequency of rare case treatment experience is higher than the competition.
14. New and innovative medical knowledge and technology are adopted faster than competition.
15. Knowledge used around here advances fast.

Knowledge Management Implementation Measures:

16. Information systems are developed aggressively to enable organization, dissemination, and application of knowledge.
17. Doctors are strongly encouraged to access document bases and to systematically construct medical databases.
18. Operation automations through information technology are pursued actively to support doctors' work.
19. Substantial amounts of financial resources are invested in information technology.
20. Doctors are encouraged to use the Internet to enhance medical expertise exchange and diffusion.
21. Knowledge sharing is an important criterion in performance evaluation.
22. Proposals for creative ideas are rewarded, even when the ideas prove to be wrong.
23. Knowledge creation and sharing often are rewarded with salary increases and bonuses.
24. Knowledge creation and sharing are rewarded with promotions.
25. Doctors always are willing to accept training and work assignments that are tougher than the competition.
26. The hospital is not hesitant to increase head counts of supporting technical specialists.
27. Doctors are willing to accept the challenges to enhance their professional expertises.
28. Doctors often explicitly reject the idea of being evaluated by personnel from other fields.
29. Competition among doctors in the same field often hinders knowledge sharing.
30. Doctors are strongly encouraged to learn and to innovate.
31. Open and smooth channels of communication exist in the hospital.

32. Doctors frequently are encouraged to engage themselves in experience and expertise exchange.
33. One-on-one mentor and apprentice-style training of resident doctors is common here.

Knowledge Management Performance

(5 = Much Better, 3 = About the Same, and 1 = Much Worse)

34. Doctors' expertise and experience exchange
35. Handling of doctors' suggestions with regard to medical operations
36. Doctors' sense of participation
37. Decision-making speed
38. Proposal preparation cycle time
39. Overall efficiency improvement
40. Overall quality of service
41. Patient satisfaction
42. Decrease of number of administrative personnel
43. Reduction of impact caused by turnover
44. Handling of medical service improvement projects

Primary Strategy for Knowledge Acquisition

(Check only one of the following)

___ University
___ Mentor and Apprentice System
___ Consultant
___ Internship with other hospitals

___ Morning Meetings
___ Intranet
___ Departmental meetings
___ Outside Seminars and Conferences
___ Medical Databases in the Hospital
___ Documentation Management (including operational manuals and instructions)
___ Others

Chapter 5.19
Organizing for Knowledge Management:
The Cancer Information Service as an Exemplar

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ABSTRACT

The Cancer Information Service is a knowledge management organization, charged with delivering information to the public concerning cancer. This chapter describes how societal trends in consumer/client information behavior impact clinical knowledge management. It then details how the CIS is organized to serve clients and how it can interface with clinical practice by providing referral, by enhancing health literacy, by providing a second opinion, and by giving crucial background, assurance to clients from neutral third party. The CIS serves as a critical knowledge broker, synthesizing and translating information for clients before, during, and after their interactions with clinical practices; thus enabling health professionals to focus on their unique functions.

INTRODUCTION

The Cancer Information Service (CIS) is essentially a knowledge management (KM) organization, manifestly charged with delivering up-to-date information to the public related to scientific advances concerning cancer. Its latent purpose, increasingly important in a consumer driven medical environment, is to insure the rapid diffusion of state-of-the-art medical care. It is an award-winning national information and education network, which has been the voice of the National Cancer Institute (NCI) for more than 30 years in the US. While the CIS has extensive outreach programs dedicated to reaching the medically underserved, it is probably best known for its telephone service that has a widely available 800 number (1-800-4-CANCER). We will use the CIS as an exemplar in this chapter of issues related to a national information infrastructure that supports clinical knowledge management.

Because of the critical role of broader societal trends we will turn to a discussion of them before describing in more detail the basic services and organizational structure of the CIS and its potential interfaces with clinical KM. Many health organizations have realized that there are strategic advantages, especially in enhancing quality, maintaining market share, and developing innovations, in promoting information technologies. Improving information management, associated analytic skills, and knowledge utilization should be a top priority of clinical practice (Johnson, 1997). It has become commonplace for almost all hospitals and managed care providers to have very active information programs for their clients allowing those in clinical settings to concentrate on their central, unique missions. Government information providers can also act as information services providing knowledge before, during, and after client interactions with clinical organizations. Health professionals can partner with KM services that recognize the public's demand for information and the various difficulties involved in reaching the people who need information. Indeed, the CIS focuses on the classic KM functions of retrieving and applying knowledge, combining it, and finally distributing/selling it.

This chapter's objectives are to answer the following questions:

1. How do societal trends in consumer/client information behavior impact clinical KM?
2. How the CIS is organized to serve clients?
3. How it can interface with clinical practice?
   a. By providing referral
   b. By enhancing health literacy
   c. By providing a second opinion
   d. By giving crucial background, assurance to clients from neutral third party
4. How can the CIS serve as an answer to information explosion?
   a. For client it acts as synthesizer, translator who can relieve clinical settings of this task
   b. Through client it directly acts to disseminate information to improve practice

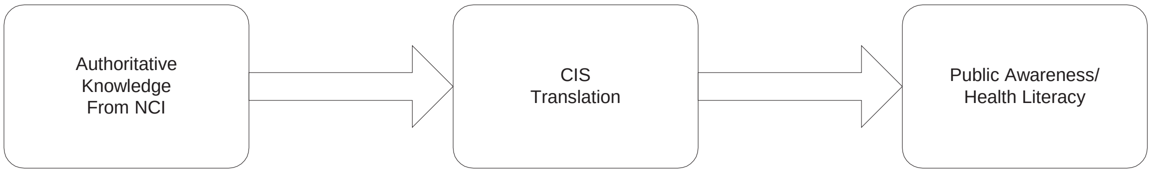
BACKGROUND

Knowledge Management

KM has been loosely defined as a collection of organizational practices related to generating, capturing, storing, disseminating, and applying knowledge (MacMorrow, 2001; Nonaka & Takeuchi, 1995). It is strongly related to information technology, organizational learning, intellectual capital, adaptive change, identification of information needs, development of information products, and decision support (Choo, 1998; Fouche, 1999). They are so intimately related, in fact, that it is often difficult to say where one approach stops and another begins. We will primarily view KM as a system for processing information. This is certainly the organizing thrust of the CIS. The CIS obtains the knowledge it translates to the public from the NCI (Figure 1). It is organized to provide consistent, quality information translated in a manner that can result in meaningful responses on the part of callers (e.g., course of treatment) that transforms basic information into knowledge (and perhaps in some cases even into wisdom and ultimately action). Thus, the KM service the CIS provides makes information purposeful and relevant to individuals that need it, who are often in dire circumstances.

Knowledge itself runs the gamut from data, to information, to wisdom, with a variety of distinctions made in the literature between these terms (e.g., Boahene & Ditsa, 2003). Special weight

Figure 1. Knowledge flow



in the context of the CIS is given to a consensus surrounding refereed scientific findings that can be translated to the public to improve cancer prevention, detection, and treatment. What is knowledge is often a matter of intense negotiation between various stakeholders as evidenced by the recent controversy over the most appropriate ages for screening mammography (HHS, 2002). Accordingly, the KM structure of the CIS is fundamentally a responsive one, very dependent on changes in the larger biomedical environment. It does not have the luxury of operating in a command environment, it must respond to the diversity, complexity, and sense-making abilities (health literacy) of its audience, placing it clearly in more post modern conceptions of KM (Dervin, 1998). So, the CIS must respond to the information environment of an information seeking public, with information specialists acting as the public's human interface in transforming information to knowledge.

PUBLIC INFORMATION SEEKING AND CLINICAL PRACTICE

Information seekers are often frustrated in their attempts to seek information, especially from doctors in clinical settings. A major focus of health communication in recent years has been on the long-standing problems with patient-doctor communication (Thompson, 2003). The amount of information physicians give to patients is correlated with patient satisfaction with healthcare and with compliance (Street, 1990). People are more likely to follow behavioral recommendations when their understanding is high. Lack of communication between doctor and patient has been found to relate to decreased ability to recall information given by the caregiver, patient dissatisfaction, decreased adherence to prescribed regimens, and other forms of non-compliance (Brown, Stewart, & Ryan, 2003).

Cancer-related information seeking is often a great challenge to individuals. They have to overcome their tendency to deny the possibility of bad news and the distasteful problems associated with cancer. They also have to be willing to believe that their individual actions can make a difference, that by seeking information they gain some control and mastery over their problems. They also have to overcome the limits of their education and prior experience. They have to possess skills as information seekers, An awareness of databases, familiarity with the Internet, an ability to weigh conflicting sources of information and to make judgments about their credibility. In short, any one of the factors in this long-linked chain could severely impede, if not halt, the information seeking process. Recognizing this, individuals are increasingly relying on knowledge brokers, such as the CIS, as intermediaries to conduct their searches for them (Johnson, 1997).

There are a number of ways that use of knowledge brokers can complement clinical practice. First, individuals who want to be fully prepared before they visit the doctor often consult the Internet (Fox & Rainie, 2002; Taylor & Leitman, 2002). Indeed, Lowrey and Anderson (2002) suggest prior web use impacts respondent's perception of physicians. Second, there appears to be an interesting split among Internet users, with as many as 60 percent of users reporting that while they look for information, they only rely on it if their doctors tell them to (Taylor & Leitman, 2002). While the Internet makes a wealth of information available for particular purposes, it is often difficult for the novitiate to weigh the credibility of the information, a critical service that a knowledge broker, such as a clinical professional, can provide. This suggests that a precursor to a better patient-doctor dialogue would be to increase the public's knowledge base and to provide alternative, but complementary information sources, by shaping client's information fields. By shaping and influencing the external sources a patient will consult both before and after visits, clinical practices can at one in the same time reduce their own burden for explaining (or defending) their approach and increase the likelihood of client compliance.

Why is Cancer-Related Information Seeking Important?

Information is an important first step in health behavior change (Freimuth, Stein, & Kean, 1989). The consequents of information carrier exposure and seeking are many, including information gain, affective support, emotional adjustment, social adjustment, attitude change, knowledge change, behavior maintenance, a feeling of greater control over events, reduction of uncertainty, and compliance with medical advice (Johnson, 1997). Information seeking can be defined simply as the purposive acquisition of information from selected information carriers. Cancer-related information seeking has become increasingly important over the last decade. Not too long ago, information related to cancer was the exclusive preserve of doctors and other health professionals. Today in the U.S., not only is the diagnosis shared, but individuals have free access to an often bewildering wealth of information. With this access has come an increasing shift of responsibility (some might say burden) to the individual to convert information into knowledge, in the process making decisions concerning his/her treatment and adjustment to cancer (Johnson, Andrews, Case, & Allard, in press).

Individual Responsibility/Client/Consumer Movement

Increasingly the responsibility for health-related matters is passing to the individual, partly because of legal decisions that have entitled patients to full information (Johnson, 1997). The consumer movement in health is in part actively encouraged by hospitals, insurance providers, and employing organizations (Duncan, 1994) who want to encourage health consumers to 'shop' for the best product at the most affordable price (Hibbard & Weeks, 1987). Facilitating and enhancing this consumer movement have been explosive developments in information technologies, which make more specialized media sources available, permitting increased choice in information carriers, and increased connectivity with other interested parties (Case, Johnson, Andrews, Allard, & Kelly, 2004; Duncan, 1994).

Large numbers of patients do not receive state of the art treatments (Freimuth et al., 1989), partly because physicians cannot keep up with the information explosion (Duncan, 1994; NCI, 2003). The overload of information on health professionals today forces decentralization of responsibilities, with increasing responsibility passing to individuals if they are going to receive up-to-date treatment. The physician is no longer the exclusive source of medical knowledge; they must be cognizant of the welter of information available and their role in this complex system (Parrott, 2003). Recognition of the limits of health professionals also requires individuals to be able to confirm and corroborate information by using multiple sources. In fact, patients often call the CIS to verify information they receive elsewhere (Freimuth et al., 1989).

Cancer patients tend to want much more information than healthcare providers can give to them, even if willing (Johnson, 1997). Information that to a client is necessary for coping with cancer, may be seen by doctors as an intrusion into their prerogatives. Exacerbating this problem is the fact that doctors and patients may not share similar outcome goals. Traditionally, doctors have viewed the ideal patient as one who came to them recognizing their authority and who were willing to comply totally (with enthusiasm) with recommended therapies (Hibbard & Weeks, 1987).

Perhaps the most threatening aspect of enhanced information seeking for health professionals is their loss of control. Many doctors have legitimate concerns about self-diagnosis and patients possessing just enough information to be dangerous (Broadway & Christensen, 1993) and the general preferences of consumers may cause them to avoid unpopular, albeit effective, invasive procedures (Greer, 1994). Still, the more control that health professionals have, the less effective they may ultimately be, especially in terms of insuring that clients act according to consensus views of treatment (Johnson, 1997).

SOLUTIONS AND RECOMMENDATIONS

One approach to managing these problems is for those in clinical practice to either create or to partner with KM services that recognize the public's demand for information and the various difficulties involved in reaching the people who need information in the most timely fashion. There are a number of indications that programmatically the best channels for providing cancer-related knowledge are those channels that constitute a hybrid of the positive properties of both mediated and interpersonal channels.

Information and referral centers can take many forms, such as hotlines, switchboards, and units within organizations (e.g., nurse's medical help lines) where individuals can go to get answers to pressing concerns from knowledge brokers. They serve three primary functions: educating and assisting people in making wise choices in sources and topics for searches; making information acquisition less costly; and being adaptable to a range of users (Doctor, 1992). These services have been found to offer considerable help and assistance to callers (Marcus, Woodworth, & Strickland, 1993).

Telephone information and referral services like the CIS represent a unique hybrid of mediated and interpersonal channels, since they disseminate authoritative written information, as well as verbal responses to personal queries (Freimuth et al., 1989). The hybrid nature of telephone services is important, since it can overcome some of the weaknesses of other channels. They have the additional advantage of homophily of source, a crucial factor in effective communication (see Rogers, 2003), since the calls are handled by individuals of closer status and background to potential callers than are physicians. It has been suggested that the CIS provides an important link between symptomatic people and health services, since a substantial proportion of callers follow up with more information seeking, passing on information to others, or consultations with health professionals (Altman, 1985).

The advantages of telephone services as a channel include they: are free, are available without appointment and forms, offer a high level of empathic understanding, offer greater client control, permit anonymity for both parties, bridge geographic barriers, provide immediate responses, the client can take greater risks in expressing feelings, convenience, cost effectiveness, and personalized attention (Johnson, 1997). All these factors are reflected in respondents rating CIS as the highest quality source of cancer information (Mettlin et al., 1980) and the extremely high rate of user satisfaction in subsequent surveys (Morra, Bettinghaus, Marcus, Mazan, Nealon, & Van Nevel, 1993; Thomson & Maat, 1998; Ward, Duffy, Sciandra, & Karlins, 1988).

Knowledge Management Services of CIS

We need every weapon against cancer, and information can be a powerful, lifesaving tool. ... A call is made, a question is answered. NCI reaches out through the CIS, and the CIS is the voice of the NCI (Broder, 1993, pp. vii).

... one phone call, one conversation, can save a life. This is the true essence of the service and the most rewarding aspect of the program (Morra, Van Nevel, O'D.Nealon, Mazan, & Thomsen, 1993, p. 7)

In broad sweep (see Figure 1), the CIS has traditionally been the disseminator/translator of consensus based scientific information from NCI to broader segments of the public, responding to demand characteristics of an increasingly knowledgeable, responsible public. We can easily organize a description of the CIS around the major functions of KM organizations: transforming information into knowledge; identifying and verifying knowledge, capture/securing knowledge; organizing knowledge; retrieving and applying knowledge, combining it, creating it, and finally distributing/selling it (Liebowitz, 2000).

The CIS is one section of the Health Communication and Informatics Research Branch (HCIRB) of the Behavioral Research Program (BRP) of the Division of Cancer Control and Population Services (DCCPS). The DCCPS is a major research division of NCI that also has research programs focusing on Epidemiology and Genetics, Applied Research, and Surveillance Research. The BRP contains additional branches relating to Applied Cancer Screening, Basic BioBehavioral Research, Health Promotion, and Tobacco Control. (For more information see http://dccps.nci.nih.gov). The "HCIRB seeks to advance communication and information science across the cancer continuum-prevention, detection, treatment, control, survivorship, and end of life" (http://dccps.nci.nih.gov/hcirb).

The CIS was implemented in 1975 by the NCI to disseminate accurate, up-to-date information about cancer to the American public, primarily by telephone (Ward et al., 1988; Morra, Van Nevel et al., 1993) and is currently governed by the principles of "responsiveness, tailoring information to audience needs, and proactively sharing information" (http://cis.nci.nih.gov/about/orgprof.html). The CIS was one of the first federally-funded health-related telephone information systems in the US (Marcus et al., 1993).

Information is available, free of charge, in both English and Spanish to anyone who calls 1-800-4- CANCER. In recent years the CIS has added a special telephone service to promotion smoking cessation (1-877-44U-QUIT), as well as services for the hearing impaired, and has instituted a range of web-based services. The CIS responds to nearly 400,000 calls annually and many more requests for assistance on its LiveHelp website feature (http://cis.nci.nih.gov/about/underserved.html). In total, in 2002 the CIS handled over 1.4 million requests for service (NCI, 2003). The impetus underlying the creation of the CIS was the assumption that all cancer patients should receive the best care. To accomplish that end it was felt that free and easy access of consumers to credible information was critical (Morra, Van Nevel et al., 1993).

KM Roles in the CIS

To accomplish its KM work the CIS has developed several specialized, functional roles in its 14 Regional Offices (ROs). The major roles in each of the RO's include, Project Directors (PD), Telephone Service Managers (TSM), and Partnership Program Managers (PPM) and subordinate Partnership Coordinators. These roles differ both in their position requirements and in their organizational status level, with PDs the day-to-day managers for the regional CIS offices (Morra et al., 1993).

TSMs are in charge of managing the Information Specialists (IS) and the referral resources. The IS within the CIS, who serve as knowledge brokers, have a unique cluster of skills: though the CIS is not a help/counseling "hotline," callers are often very anxious; information specialists must be able to communicate highly technical information clearly to callers who come from all demographic groups and who differ considerably in their levels of knowledge (Davis & Fleisher, 1998; Morra, 1998). Performance standards for telephone calls are set nationally and are monitored by an extensive formal evaluation effort unique for telephone services (Kessler, Fintor, Muha, Wun, Annett, & Mazan,1993; Morra, 1998). IS are clearly constrained to be information providers within strict protocols, to not interfere with existing medical relationships, to refrain from counseling, and to provide callers with quality assurances of information they provide (e.g., "this is consensus scientific information") (NCI, 1996).

The CIS Partnership Program is designed to reach out to people, especially the medically underserved and minority communities, who do not traditionally seek health information, providing equal access to cancer information from a trusted source (http://cis.nci.nih.gov/about/orgprof.html). PPMs are responsible for disseminating health messages through networking with other organizations such as local American Cancer Societies, state health departments, and so on. In doing this they serve a strategic multiplier function for the CIS, increasing the health literacy of clients.

Designing for KM

The traditional CIS telephone service is literally the tip of the iceberg of a very sophisticated KM system that has considerable strategic advantages because of its commitment to translating the highest quality, consensus based scientific information to the public. Enhanced information seeking possibilities for the public are created by new technologies, representing an information architecture, in three areas: data storage, data transport, and data transformation (Cash, Eccles, Nohria, & Nolan, 1994). While we will discuss these components separately, increasingly it is their blending and integration that is creating exciting new opportunities for information seeking (Case et al., 2004). Networks, like the Internet, usually combine enhanced telecommunication capabilities with software that allows linkage and exchange of information between users (one of which is often a database). In the health arena these benefits and possibilities are captured under the heading of health informatics. Consumer health information is perhaps the fastest growing area of this specialty (MacDougall & Brittain, 1994).

Telecommunication systems such as fiber optic cables and satellite systems provide the hardware that links individuals and provides enhanced access to systems. Telecommunication systems maintain communication channels (e.g., e-mail) through which information is accessed and reported. They can specifically enhance the information seeking of patients by creating new channels for sending and receiving information (e.g., Live Aid feature on CIS's Web site), helping them in filtering information, reducing their dependence on others, leveraging their times to concentrate on the most important tasks, and enhancing their ability for dealing with complexity. One example of enhanced data transport lies in the benefits of telemedicine: increased access to information, increased consistency in medical decision making, matching diagnostic and management options to patient needs, increased quality of care, more interpretable outcomes, increased efficiency, increased efficacy, decreased costs, and a more uniform structure for healthcare (Turner, 2003).

Essentially databases provide a means for storing, organizing, and retrieving information. Modern conceptions of storage have broadened this function considerably to include verification and quality control of information entering a storage system. Doctors have historically mistrusted medical information systems because they may not capture the subtlety and nuance that only their long experience and training can bring to a situation (Shuman, 1988). They also do not provide much assistance to health professionals in areas where there is low consensus knowledge (Brittain, 1985). Unfortunately, a number of scientific controversies in well established areas have emerged in recent years that even peer review may not successfully address.

To their credit, the authoritativeness of the information they provide has always been a paramount concern for government databases. In the cancer area the NCI's Physician Data Query (PDQ) has been paying systematic attention to these issues for two decades (Hibbard, Martin, & Thurin, 1995). PDQ was originally designed to address the knowledge gap between primary care physicians and specialists. In a 1989 survey of primary care practitioners two-thirds felt that the volume of the medical literature was unmanageable and 78 percent reported that they had difficulty screening out irrelevant information from it (Hibbard et al., 1995). "This knowledge gap is responsible for the prolonged use of outmoded forms of cancer treatment resulting in unnecessarily high rates of cancer morbidity and mortality" (Kreps, Hibbard, & DeVita, 1988, pp. 362).

Fundamental to PDQ is the recognition that the rapid dissemination of health information is critical to successful treatment, since at the time it was created in the early 1980's approximately 85 percent of cancer patients were treated by primary care doctors (Kreps et al., 1988). In its early days one-third of the PDQ usage came from the CIS (Kreps et al., 1988), reflecting a high level of usage by the lay public that has continued to this day.

PDQ seeks to provide a current peer-reviewed synthesis of the state-of-the-art clinical information related to cancer (Hibbard et al., 1995). PDQ contains several components. Cancer information summaries in both health professional and patient versions on adult treatment, pediatric treatment, supportive care, screening and prevention, genetics, and supportive care. A registry of clinical trials and directories of physicians, professionals who provide genetic services, and organizations that provide cancer care is also available.

A critical issue facing all databases is how old, irrelevant information is culled from any storage system. A not so apparent problem of public databases, like many of those available on the Internet, is the potential lack of timeliness of the information. The cancer information file of PDQ is reviewed and updated monthly by six Editorial Boards of cancer experts in different areas. These Editorial Boards have clear guidelines on levels of evidence for information to be considered for the database. CIS IS receive extensive training on cancer-related issues and the use of PDQ (Davis & Fleisher, 1998; Fleisher, Woodworth, Morra, Baum, Darrow, Davis, Slevin-Perocchia, Stengle, & Ward, 1998).

More generally, HHS through the NIH's National Library of Medicine and the Office of Disease Prevention and Health Promotion's National Health Information Center, have devoted considerable resources and given thought to building a national information infrastructure in the U.S. The integration of data storage and transport with sophisticated software offers unique opportunities for solutions that transcend the limits of individual information processing, especially that of novices. Combining databases and telecommunications with software creates telematics that allows for the possibility of increasingly sophisticated searches for information and analysis/interpretation of it once it is compiled. The CIS IS, acting as a knowledge broker, serves a critical function in translating information into knowledge for increasingly literate health consumers.

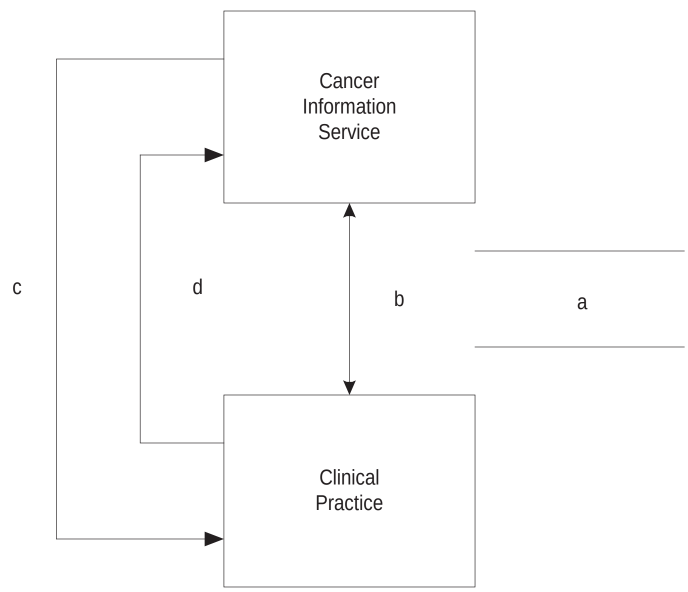
FUTURE TRENDS

Consortia and Clinical Knowledge Management

The future of KM in clinical settings is likely to be a turbulent one. It is clear, however, that those in clinical settings will be asked to do more with less. Thus, increasingly organizations will be looking for partners to provide services they cannot provide—in this role the CIS can be a key strategic partner for clinical practice allowing those in clinical settings to concentrate on their central, unique missions. Government information providers can act as central repositories for information services that would be provided before, during, and after client interactions with clinical organizations. They can do this in the ad hoc, random basis currently characteristic of a client's information environment (pattern a in Figure 2), or they can form explicit partnerships (paths b, c, and d) with clinical practice in consortia.

Consortia are particularly interesting settings in which to examine these issues because of the voluntary nature of relationships within them, which often creates a situation that is a mix of system/altruism and market/self-interest. A consortium can be defined simply as a collection of entities (e.g., companies, occupational specialties, community members) brought together by their interest in working collaboratively to accomplish

Figure 2. Relationships between CIS and clinical practice



something of mutual value that is beyond the resources of any one member (Fleisher et al., 1998; Johnson, 2004).

Organizations often find that they are either strapped for resources or are pursuing projects of such magnitude that they must pool their resources to pursue innovations (Hakansson & Sharma, 1996); developing cooperative relationships with other entities promotes the possibility of resource sharing and greater efficiencies, especially in community (Dearing, 2003) and governmental settings (Dorsey, 2003; Parrott & Steiner, 2003). Fundamentally, consortiums are formed so that their members can accomplish more than they could do on their own. Given the interest in new organizational forms, heightened competition, fractured communities, and declining resources available to any one group, this topic has captured the attention of researchers in a wide range of disciplines (Hakansson & Sharma, 1996; Johnson, 2004).

The focus of these consortiums should be on providing consistent health-related messages and information (resulting from relationships described by b, c, and d in Figure 2) that through their repetition from multiple trustworthy institutions increases the probabilities that clients will comply with the best medical advice. The CIS's existing PPM provides the critical foundations for the development of such consortia (Thomsen & Maat, 1998). Indeed, increasing health literacy by encouraging autonomous information seekers should be a goal of our healthcare system (Parrott, 2003). While it is well known that individuals often consult a variety of others before presenting themselves in clinical settings (Johnson, 1997), outside of HMO and organizational contexts, there have been few systematic attempts to shape the nature of these prior consultations.

If these prior information searches happen in a relatively uncontrolled, random, parallel manner (pattern a), expectations (e.g., treatment options, diagnosis, drug regimens) may be established that will be unfulfilled in the clinical encounter. The emergence of the Internet as an omnibus source for information has apparently changed the nature of opinion leadership; both more authoritative (e.g., medical journals) and more interpersonal (e.g., cancer support groups) sources are readily available and accessible online (Case et al., 2004). This is a part of a broader trend that Shapiro and Shapiro (1999) refer to as "disintermediation"—the capability of the Internet to allow the general public to bypass experts in their quest for information, products and services.

Contemporary views of health communication are more likely to stress a dialogic view of interaction, with both parties initiating and attending to messages in turn (paths b, c, and d). Health professionals' most important role in these more contemporary perspectives is as stimulus or cue to action, defining the agenda of the most important issues that an audience needs to face (path d). For those clients who have had no prior contact with a clinical organization, the CIS can provide referral services (path c in Figure 2) for clients predisposed to act. About 20 percent of callers to Midwest Regional Office of the CIS last year asked for referrals to health professionals, treatment facilities, and/or community services (http://www.karmonos.org/cis/telephone.html). Clinical entities should be familiar with this referral process and the kinds of information provided to insure a smooth encounter with referred clients.

Proactive prior referral and/or exposure to an information source such as the CIS can ease the burden on clinicians by transmitting basic information to clients that then does not have to be repeated in an office visit (path c). Increasingly the focus of health communication campaigns is on getting people to seek more information on health topics (Parrott, 2003; Salmon & Atkin, 2003). Creating rich information fields through such practices as 'self-serving' to information from data bases, for example, should make for a more informed consumer, who is likely to consume less time of health professionals "being brought up to speed" on the basics of his/her disease and its treatment. As we have seen, this enhanced level of health literacy can result in various improved outcomes for clients.

Similarly, as part of a visit clinicians can encourage individuals to use services like the CIS to secure a second, complementary opinion (path d). These services can provide crucial background, support, and assurance to clients from neutral third party. For clients the CIS IS act as a knowledge broker synthesizing and translating information, thus relieving clinical settings of this task. The CIS can perform many of the same functions that call centers and customer relations staff can provide for information technology services. Similarly, it has taken on the increasingly critical role of referral to clinical trials for new and/or experimental treatments (http://cancer.gov/cancerinfo/pdq/cancerdatabase), something that should be done in concert with clinical practice (path b).

While the CIS, and similar government services, have often been viewed as competitors or interlopers into clinical practice, its access to NCI's research infrastructure, the development of authoritative guidelines (PDQ), and its role in translating this information to the public, demonstrate it can be a key contributor to a more effective healthcare delivery system (NCI, 2003). In the past, through clients, it has directly acted to disseminate information to improve practice. The ultimate outcome of effective KM is the rapid adoption or creation of appropriate innovations that can be successfully implemented within a particular organization's context. In the case of the CIS there was an even broader mandate, a latent purpose to insure the rapid diffusion of state-of-the-art medical care to the public. By explicitly recognizing, managing, and supporting this role, clinical entities can more effectively manage their limited resources to insure that consonant information is provided to clients that is more likely to result in positive healthcare outcomes. While often services like the CIS have been viewed as a competitor, it may be better to view it as a complementary/supportive service, especially for government driven healthcare systems.

CONCLUSIONS

In broad sweep (see Figure 1), the CIS has traditionally been the disseminator/translator of consensus based scientific information from NCI to broader segments of the public. Societal trends in consumer/client information behavior make this a critical role in today's broadly envisioned clinical practice environment. While the CIS is organized to serve clients directly, it can also interface with clinical practice by providing referrals, enhancing health literacy, providing second opinions and crucial background, assurance to clients from neutral third party. Thus, the CIS is a partial answer to information explosion: for client it acts as synthesizer, translator who can relieve clinical settings of this task and through clients it directly acts to disseminate information to improve clinical practice.

This chapter highlights how information providers can interface with clinical practice to form a strategic partnership that advances health outcomes for the public. All this suggests the increasing importance of information as a strategic asset that should be systematically incorporated in the planning of health professionals. Health institutions need to recognize the potential benefit of marketing unique corporate knowledge and expertise to other information seekers and to consider their unique role in a complex information seeking environment. Health professionals also need to lobby the government to maintain critical information infrastructures.

While more and more information can be produced more efficiently, there is a concomitant increase in the costs of consuming (e.g., interpreting, analyzing) this information (More, 1990). Thus, proactively working to shape a client's information fields by insuring concordant information is provided may forestall increasing problems for clinical practice in the rapidly growing information jungle.

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REFERENCES

Altman, D.G. (1985). Utilization of a telephone cancer information program by symptomatic people. *Journal of Community Health, 10,* 156-171.

Boahene, M., & Ditsa, G. (2003). Conceptual confusions in knowledge management and knowledge management systems: Clarifications for better KMS development. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges* (pp. 12-24). Hershey, PA: IRM Press.

Brittain, J.M. (1985). Introduction. In J. M. Brittain (Ed.), *Consensus and penalties for ignorance in the medical sciences: Implications for information transfer* (pp. 5-10). London: British Library Board.

Broadway, M.D., & Christensen, S. B. (1993). Medical and health information needs in a small community. *Public Libraries, September/October,* 253-256.

Broder, S. (1993). Foreward. *Journal of the National Cancer Institute, Monograph 14,* vii.

Brown, J.B., Stewart, M., & Ryan, B.L. (2003). Outcomes of patient-provider interaction. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 141-161). Mahwah, NJ: Lawrence Erlbaum.

Case, D., Johnson, J.D., Andrews, J.E., Allard, S., & Kelly, K.M. (2004). From two-step flow to the Internet: The changing array of sources for genetics information seeking. *Journal of the American Society for Information Science and Technology, 55*, 660-669.

Cash, J.I., Jr., Eccles, R.G., Nohria, N. & Nolan, R.L. (1994). *Building the information-age organization: Structure, control, and information technologies.* Boston: Irwin.

Choo, W.C. (1998). *The knowing organization: How organizations use information to construct meaning, create knowledge, and make decisions.* New York: Oxford University Press.

Davis, S.E., & Fleisher, L. (1998). Treatment and clinical trials decision making: The impact of the Cancer Information Service, Part 5. *Journal of Health Communication, 3,* 71-86.

Dearing, J.W. (2003). The state of the art and the state of the science in community organizing. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 207-220). Mahwah, NJ: Lawrence Erlbaum.

Dervin, B. (1998). Sense-making theory and practice: An overview of user interests in knowledge seeking and use. *Journal of Knowledge Management, 2*, 36-46.

Doctor, R.D. (1992). Social equity and information technologies: Moving toward information democracy. In M. E. Williams (Ed.), *Annual review of information science and technology* (pp. 44-96). Medford, NJ: Learned Information.

Dorsey, A.M. (2003). Lessons and challenges from the field. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 607-608). Mahwah, NJ: Lawrence Erlbaum.

Duncan, K.A. (1994). *Health information and health reform: Understanding the need for a national health information system*. San Francisco: Jossey-Bass.

Fleisher, L., Woodworth, M., Morra, M., Baum, S. Darrow, S. Davis, S., Slevin-Perocchia, R., Stengle, W., & Ward, J.A. (1998). Balancing research and service: The experience of the Cancer Information Service. *Preventive Medicine, 27,* S84-92.

Fouche, B. (1999). Knowledge networks: Emerging knowledge work infrastructures to support innovation and knowledge management. *ICSTI Forum, 32.*

Fox, S., & Rainie, L. (2002). *How internet users decide what information to trust when they or their loved ones are sick*. Retrieved from the Pew Research Center Web site http://www.pewinternet.org/

Freimuth, V.S., Stein, J.A., & Kean, T.J. (1989). *Searching for health information: The Cancer Information Service Model*. Philadelphia: University of Pennsylvania Press.

Greer, A. L. (1994). You can always tell a doctor ... . In L. Sechrest, T.E. Backer, E.M. Rogers, T.F. Campbell & M.L. Grady (Eds.), *Effective dissemination of clinical and health information* (pp. 9-18). Rockville, MD: Agency for Health Care Policy Research, AHCPR Pub. No. 95-0015.

Hakansson, H., & Sharma, D. D. (1996). Strategic alliances in a network perspective. In D. Iacobucci (Ed.), *Networks in marketing* (pp. 108-124). Thousand Oaks, CA: SAGE.

HHS (February 21, 2002). *Press release: HHS affirms value of mammography for detecting cancer.*

Hibbard, J.H., & Weeks, E.C. (1987). Consumerism in health care. *Medical Care, 25,* 1019-1032.

Hibbard, S.M., Martin, N.B., & Thurn, A.L. (1995). NCI's Cancer Information Systems: Bringing medical knowledge to clinicians. *Oncology, 9,* 302-306.

Johnson, J.D. (1997). *Cancer-related information seeking.* Cresskill, NJ: Hampton Press.

Johnson, J.D. (2004). The emergence, maintenance, and dissolution of structural hole brokerage within consortia. Communication Theory, 14, 212-236.

Johnson, J.D., Andrews, J.A., Case, D.O., & Allard, S. (in press). Genomics-The perfect information seeking research problem. *Journal of Health Communication.*

Kessler, L., Fintor, L., Muha, C., Wun, L., Annett, D., & Mazan, K.D. (1993). The Cancer Information Service Telephone Evaluation and Reporting System (CISTERS): A new tool for assessing quality assurance. *Journal of the National Cancer Institute, Monograph, 14*, 617-65.

Kreps, G. L., Hibbard, S. M., & DeVita, V. T. (1988). The role of the physician data query on-line cancer system in health information dissemination. In B. D. Ruben (Ed.), *Information and behavior* (Vol. 2, pp. 1,6-7). New Brunswick, NJ: Transaction Books.

Liebowitz, J. (2000). *Building organizational intelligence: A knowledge management primer.* New York: CRC Press.

Lowery, W., & Anderson, W.B. (2002). *The impact of Web use on the public perception of physicians.* Paper presented to the annual convention of the Association for Education in Journalism and Mass Communication, Miami Beach, FL.

MacDougall, J., & Brittain, J.M. (1994). Health informatics. *Annual Review of Information Science and Technology, 29,* 183-217.

MacMorrow, N. (2001). Knowledge management: An introduction. *Annual Review of Information Science and Technology, 35*, 381-422.

Marcus, A.C., Woodworth, M.A., & Strickland, C.J. (1993). The Cancer Information Service as a laboratory for research: The first 15 years. *Journal of the National Cancer Institute, Monograph 14,* 67-79.

More, E. (1990). Information systems: People issues. *Journal of Information Science, 16,* 311-320.

Morra, M., Bettinghaus, E.P., Marcus, A.C., Mazan, K.D., Nealon, E., & Van Nevel, J.P. (1993). The first 15 years: What has been learned about the Cancer Information Service and the implications for the future. *Journal of the National Cancer Institute, Monograph, 14,* 177-185.

Morra, M.E. (1998). Editorial. Journal of Health Communication, 3, V-IX.

Morra, M.E., Van Nevel, J.P., O'D.Nealon, E., Mazan, K.D., & Thomsen, C. (1993). History of the Cancer Information Service. *Journal of the National Cancer Institute, Monograph 14*, 7-34.

NCI (1996). *CIS policy and procedures manual.* Bethesda, MD: National Cancer Institute.

NCI (2003). *The nation's investment in cancer research.* Rockville, MD: NIH.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

Parrott, R. (2003). Media issues. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 445-448). Mahwah, NJ: Lawrence Erlbaum.

Parrott, R., & Steiner, C. (2003). Lessons learned about academic and public health collaborations in the conduct of community-based research. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 637-649). Mahwah, NJ: Lawrence Erlbaum.

Rogers, E.M. (2003). *Diffusion of innovations* (5th ed.). New York: Free Press.

Salmon, C.T., & Atkin, C. (2003). Using media campaigns for health promotion. In T. L. Thompson, A. M. Dorsey, K. I. Miller & R. Parrott (Eds.), *Handbook of health communication* (pp. 449-472). Mahwah, NJ: Lawrence Erlbaum.

Schuman, T.M. (1988). Hospital computerization and the politics of medical decision-making. *Research in the sociology of work, 4*, 261-287.

Shapiro, A.L., & Shapiro, R.C. (1999). *The control revolution: How the Internet is putting individuals in charge and changing the world we know.* New York: Public Affairs.

Street, R. L., Jr. (1990). Communication in medical consultations: A review essay. *Quarterly Journal of Speech, 76,* 315-332.

Taylor, H., & Leitman, R. (May, 2002). *Four-nation survey shows widespread but different levels of Internet use for health purposes.* Health Care News, 2. Retrieved from http://www.harrisinteractive.com/newsletters_healthcare.asp

Thomsen, C.A., & Maat, J. T. (1998). Evaluating the Cancer Information Service: A model for health communications. Part 1. *Journal of Health Communication, 3,* 1-14.

Thompson, T.L. (2003). Provider-patient interaction issues. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 91-93). Mahwah, NJ: Lawrence Erlbaum.

Turner, J.W. (2003). Telemedicine: Expanding health care into virtual environments. In T. L. Thompson, A. M. Dorsey, K. I. Miller, & R. Parrott (Eds.), *Handbook of health communication* (pp. 515-535). Mahwah, NJ: Lawrence Erlbaum.

Ward, J.A.D., Duffy, K., Sciandra, R., & Karlins, S. (1988). What the public wants to know about cancer: The Cancer Information Service. *The Cancer Bulletin, 40,* 384-389.

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Chapter 5.20
Knowledge Management Governance

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INTRODUCTION

There are many barriers to the implementation of knowledge management (KM) strategies. These include the lack of time and financial resources allocated to sharing knowledge, a lack of organizational understanding of the philosophy and the benefits of KM, and a lack of skills in KM. However, survey data show that the greatest acknowledged obstacle to the implementation of a KM strategy is the management culture of the organization (Chase, 1997; Zyngier, 2001). These obstacles reveal a problem in the implementation of an organizational KM strategy. The problem lies not in the implementation of a given strategy per se, but in the lack of governance of that strategy.

The governance process is a framework of authority that ensures the delivery of anticipated or predicted benefits of a service or process (Farrar, 2001). The operationalization of that strategy is therefore executed in an authorized and regulated manner. Governance mechanisms must be invoked to guide both the initial implementation and the ongoing control and authority over KM strategies. A governance framework will provide the management of risk, review mechanisms and fiscal accountability in leveraging tacit knowledge, and the sharing of explicit knowledge within an organization. Knowledge is not simply a series of artefacts to be managed. This article identifies the processes in KM that are subject to governance. KM governance centres the decision-making authority as an executive framework to deliver the expected benefits of the strategy and for these benefits to be delivered in a controlled manner. This is achieved by the establishment of checks and balances in the implementation of the strategy. It ensures that evaluation measures feedback that enables deliberate adjustment of the delivery of the strategy, and that needs and expectations are being met. If the needs and expectations of the organization cannot be met, then the governance process should then be able to establish and manage the cause.

The first part of this article discusses KM strategy development and shows the origins of KM governance in the concept of the use of governance principles and practices. The second part will discuss the central issues in KM governance, being authority, evaluation, measurement, and risk management. The third part will suggest a structure or model for KM governance explaining how this operates in an organizational context, and suggests future trends for this research.

BACKGROUND

The Role of Leadership

Executive management leads and establishes the culture and consequent ability of an organization to capture, share, and manage its knowledge. In the past, leaders in organizations were empowered to order changes, and then all that was required of the organization was to implement the plan (Bridges & Mitchell, 2000). The culture of an organization is developed by the structure, attitude, and example of management. Krogh, Ichijo, and Nonaka (2000) describe how effective management and the support of knowledge creation depends on the physical, virtual, and emotional context in which they are manifested. Where there is a strong commitment at the level of executive management to change organizational culture, an organization is able to begin to create the values that lead to knowledge sharing across boundaries (Hackett, 2000; O'Dell, Grayson, & Essaides, 1998). Currently, interpretations of knowledge management leadership (Rumizen, 2002; Tiwana, 2002) endow the leader with the responsibility to direct, conduct, or guide functions in the implementation of such a strategy.

The terms knowledge champion, leader, and sponsor are used interchangeably in the knowledge management literature. The terms variously indicate a person who initiates a KM strategy, or one who supports and promotes the initiation of such a strategy. Therefore, the person or persons responsible for the implementation of a KM strategy may have the sole responsibility for the development and implementation of a KM strategy. This cannot ensure buy in from the organization as a whole. These risks are revealed as found in Australian and international surveys that have disclosed some of the obstacles to KM strategies (Chase, 1997; Davis, McAdams, Dixon, Orlikowski, & Leonard, 1998; DeLong & Fahey, 2000; Ewyk, 1998; Fang, Lin, Hsiao, Huang, & Fang, 2002; Hackett, 2000; IC2 Institute at the University of Texas at Austin, 2001; McAdam & Reid, 2001; Zyngier, 2001).

KM Strategy Development

KM literature describes many approaches to the development of a strategy or plan to be implemented as a means of achieving the organizational objectives of sharing tacit and explicit knowledge within the organization. Strategies are usually grounded in a theoretical methodology that will provide the greatest leverage in implementation (Zack, 1999), with each meeting perceived needs in the organization. There are two categories of strategies: deliberate and emergent strategies. Deliberate strategies must be articulated in a plan that must then be implemented. Emergent strategies are those that emerge in the organization as part of the process of learning what works well and what does not. Mintzberg (1994) suggests that strategic planning processes fail when they are not constructed to understand, internalise, and synthesise, that is, to learn from the successes or failures of the strategic process as it is implemented. In this sense, strategic planning would be a static and inviolate process. This is where the concepts of strategic approaches to KM are vulnerable unless the strategy is conceived of as a learning or evolutionary process. This being so, a KM strategy or plan is not rigid, but is an operational process that will enable learning and can evolve to take into account new and emerging environments within and outside the organization. KM obstacles lie not in the plan, but in the processes of control or regulation that surround the planning, implementation, feedback, and ongoing development of the plan. These processes are governance processes.

Governance Principles and Practice

There are a number of current contending uses of the term governance. In this article, governance refers to the governance processes of control or regulation within companies, interpreted as the implementation of authority through a framework that ensures the delivery of anticipated or predicted benefits of a service or process in an authorized and regulated manner (Weill & Woodham, 2003). This approach forms a context for analysis, management, risk management, and the ongoing development of strategies to manage organizational knowledge. It is also a means of developing measures of the effectiveness of those strategies. Governance will be affected by the composition of the membership of the governing body, the personal characteristics and history of the individuals involved, and the visions and principles enshrined in organizational structures and processes.

There are two main theories in the governance literature that relate to the purpose of the corporation and whose interests it should serve (Farrar, 2001; Van den Berghe & De Ridder, 1999). These are:

1. the shareholder model where the primacy focus of serving shareholder interest and value is the underlying philosophy or driver of governance, and cost minimisation and profit maximisation are paramount, and
2. the stakeholders model where the primary interest is on all stakeholders including the organization's owners or shareholders, creditors, employees, and the local communities in which the firm exists.

The stakeholders or consultative model may be considered a less managerially neat option due to the need to consult and reconcile conflicting interests; however, where decisions are made and endorsed by the majority of stakeholders, there is greater acceptance of decisions and activity around those decisions (Vinten, 2000).

In the stakeholder model, a greater contribution of decision making is expected at all levels. Internal stakeholder governance processes are not merely good management processes, but can also be viewed in terms of ensuring that a wide range of organizational needs are represented and being met. While to-date governance principles have rarely been applied to other managerial strategies, this approach is seen in the work of the IT Governance Institute (2001), the IT Governance Institute and COBIT Steering Committee (2000), and the British Standards Institution and Technical Committee (2002). The notion of IS and IT governance activity is already apparent as a subset of governance. This framework similarly facilitates the provision of feedback mechanisms within other managerial strategies to serve as a model of continuous improvement in organizational structures. Responsiveness to stakeholder interests enhances the capacity of the organization to identify and analyse a greater range of risks and to better deliverservices or products.

Governance is at the centre of the decision-making authority. It is a framework to deliver the expected benefits of investments in a controlled manner through the establishment of checks and balances in the mode of service delivery. It ensures that evaluation feeds back into the service delivery strategy, and that stakeholder needs and expectations are being met. This approach is echoed by Galliers' (1999) sociotechnical approach to business and IS strategy formations, and the management of organizational transformation that takes into account the organizational environment, business strategies and processes, and required infrastructure. He sees that implementation requires the allocation of responsibilities with clearly defined objectives, timescales, and performance measures. This is paralleled by ongoing evaluation and review, including long-term planning and perspective, and the recognition and accounting for consequential or emergent strategies.

Weill and Woodham (2002) propose that the design of governance mechanisms is constructed in the context of the competing operational, structural, and infrastructural forces that operate within a business in harmony with organizational objectives. A governance framework must understand how decisions are made in key domains. These domains are principles, infrastructure strategies, architecture and investment, and prioritisation. Thus, governance will concentrate on the relationships and processes that develop and maintain control over the infrastructure, and human resources utilized in order to deliver the service to the organization. It provides check and balance mechanisms that enable the decision-making processes and results in IT contributing as a value-adding function in service of the enterprise.

An emphasis on strategy, risk management, the delivering of financial value, and performance measurement indicates the ongoing management of best practice. Applied to organizational IT, it is suggested that "at the heart of the governance responsibilities of setting strategy, managing risks, delivering value and measuring performance, are the stakeholders values, which drive the enterprise and IT strategy" (IT Governance Institute, 2001, p. 10). This is not a linear mechanism, but it is intended to feed back both the positive and negative aspects of performance. These response mechanisms will in turn moderate and improve practice in addition to responding to the internal and external effects in the organizational environment.

FOCUS ON KM GOVERNANCE

The delivery of a KM strategy in an organization exists and provides services to meet the needs for the creation, dissemination, and utilization of tacit and explicit knowledge to fulfill organizational objectives. How this function is fulfilled is reflected in the timeliness of service delivery and the satisfaction levels of internal and also, potentially, external clients. The processes and principles that act as a framework for the examination, regulation, supervision, and revision of KM strategies are termed KM governance. Wiig (1997) described governance functions as those of the monitoring and facilitation of knowledge-related activities within the implementation process. There is little in the literature that separates descriptions of strategy implementation from the authority framework that governance provides. Knowledge management governance processes determine organizational knowledge-access conditions, quality maintenance, decision-making processes, and means for resolving KM obstacles.

Authority

KM governance can meet process objectives through the development of an effective understanding of the potential of KM within the organization, an effective understanding of the role of KM within the organization, and the alignment of KM with the value proposition and strategy of the organization. Finally, it also meets process objects through the regular review, approval, and monitoring of KM investments in infrastructure and in human resources. KM governance centres on the decision-making authority, an executive framework to deliver the expected benefits of the strategy. This can then be delivered in a controlled manner through the establishment of evaluation, measurement, and risk management in service delivery. It ensures that these processes feed back into the service delivery strategy, and that all stakeholder needs and expectations are being met. If they cannot be met, then the governance process will be able to establish the reason and resolution.

Risk Management

Governance processes manage the risks of KM to acknowledge and challenge the cultural issues, structural obstacles, and other relevant issues as they arise during the implementation and ongoing operation of the strategy. The management of these risks assists in their resolution and strengthens strategies to manage knowledge within the organization. The need for risk management in KM was formally indicated in 2001 (Standards Australia) with the need to identify the assets, risks, and controls associated with the implementation of strategy. Obstacles to the effective management of organizational knowledge include a management culture in the organisation that hinders KM with concomitant change-management issues. Additionally, the philosophy of knowledge management is often inadequately understood in the organisation, and conflicts of organizational priorities are problematic for the development and initiation of a KM strategy. For many organizations, the development of criteria for knowledge collection is difficult (Chase, 1997; Zyngier, 2001).

Risk management is a proactive strategy of analysis and aids in the anticipation of risks to the KM strategy before they arise (Standards Australia, 2003). By engaging with the risks, it becomes possible to develop a means of risk resolution. The resolution may require organizational change management, the provision of additional financial or infrastructural support, or a realignment of the original strategy in light of unforeseen or emergent activity within the organization. Risk management requires regular evaluation of the strategy and the organization that it serves.

Evaluation and Measurement

Governance in KM implies and demands deliberate consideration of the strategies in place in the long and medium term. KM governance processes incorporate evaluation and measurement in order to prove the value of practices, and to progress and develop existing practices. Governance mechanisms must maintain a collective knowledge of trends in industry, technology, and the corporate structural and social environment.

Evaluation looks at both successes of and obstacles to the implementation of a KM strategy. The evaluation of successes must take into account the contribution made to the aims and objectives of the organization. When the successes make a contribution, they should be continued. When they do not make a contribution, consideration should be given to their continuance. The evaluation of obstacles to the KM strategy implies the capacity to question why the risk may not have been foreseen and therefore managed. The evaluation of obstacles must take into account the barriers they create for the aims and objectives of the organization. When this is the case, can these ends be achieved utilizing an alternative solution or method?

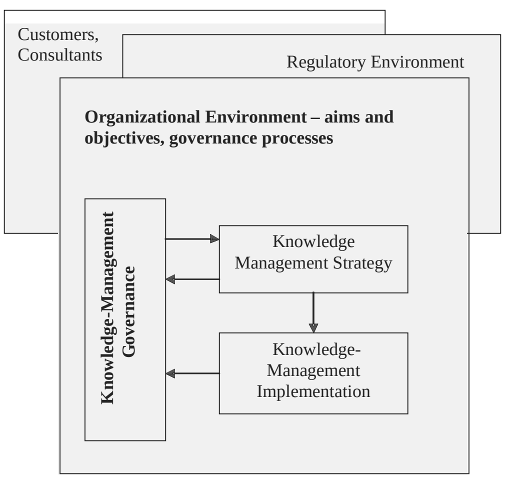
There are a number of criteria currently used to establish the return on investment (ROI) for KM strategies: Liebowitz and Wright (1999) look at human capital growth, Sveiby (1997) uses intangible assets, and some use the balanced scorecard (Kaplan & Norton, 1996) with a number of measures including financial, growth, customer, and internal business processes. Probst, Raub, and Romhardt (2000) look at the normative, operational, and strategic goals of the strategy to see if they are being met. Other common techniques include simple measures of staff retention or an improvement in the product-to-market delivery time, both in quantity, and in quality. If these are evident and are the only variance from usual practice, then the strategy is seen as successful.

A KM Governance Framework

KM literature deals with the need for the alignment of strategy with organizational aims and objectives, and for leadership of that strategy. This process is supported by information and communications technology and operates in the organizational context of the corporate governance principles. There is an explicit link between the market and the organization in its aims and objectives that lead to governance processes.

The governance framework presents the functions of KM as supporting the aims, objectives, and governance processes of the organization in the context of the broader environment of its external stakeholders, which includes its customers and consultants and the regulatory environment. The KM strategy is developed by KM leaders in the planning of a process of the identification, acquisition, development, sharing and distribution, utilization, and finally retention of knowledge (Probst et al., 2000; Tiwana, 2002). The practice of KM implementation follows with the execution of a course of action that is intended to fulfill the aims and objectives of the plan in order to support the aims and objectives of the organization as a whole. The relationship between the KM strategy and the KM implementation is in theory a unidirectional one where implementation is merely the following through of the strategic plan. In practice, this relationship may be more interactive as those responsible for the implementation may also have a level of responsibility for the development of the strategic plan. KM governance is the layer exercising the authority processes and principles that act as a framework for the examination, regulation, supervision, and revision of KM strategies.

Figure 1. Framework for KM governance



The KM strategy is developed by KM practitioners. The interaction between the development of strategy and governance is twofold. The governance process develops the principles and rationale for the impetus and momentum of the strategy, the management of risks, the financial control, and the accountability for stakeholder response. The governance process also evaluates KM activity according to previously defined and articulated performance measures.

The KM strategy is implemented or operationalized by KM staff, and supported and promoted by champions in the organization. The implementation of the strategy is evaluated according to the criteria established by the governance body. Evaluation will also take into account changes in product and customers, changes in the regulatory environment, and inputs from consultants or industry partners. It reflects the aims and objectives of the organization that it serves. The KM strategy is planned and may be revised as the need arises. The evaluation data flows from the KM implementation to the governance body, which then feeds its decision(s) back to the redevelopment of the strategy.

Companies that rely on or utilize KM for the transfer of strategic knowledge should work to establish KM governance committees including one for stakeholder representation. There are two fundamental objectives in this governance process. These are as follow:

- to ensure that KM delivers value to the identified stakeholders. This value is derived from the value proposition of the organization and the organizational strategies put in place to achieve those ends.
- to control and to minimise the risk to the KM strategy. The strategy must be capable of adjustments required in response to perceived flaws in its capacity to effectively transfer knowledge. A KM strategy is not a single prescribed formula that can fit all organizations or even fit organizations within a particular industry segment.

KM governance can meet the previous objectives through:

- the sponsorship of an effective understanding of the role and potential of KM within the organization,
- the alignment of KM with the value proposition and strategy of the organization,
- the regular evaluation review, approval, and monitoring of KM investments in infrastructure and in human resources, and
- the management of the risks of KM.

In acknowledging knowledge as the organization's strategic asset and differentiator, it can be seen that the ultimate responsibility of the KM governance process is to ensure the governance of KM as a means of pursuing success in the implementation of a KM strategy in the organization.

FUTURE TRENDS

KM governance is currently a subject of extensive research that has built the model described. Future research possibilities may lie in looking in depth at the interrelationships between governance and stakeholders, in evaluation and measurement, in risk-management techniques, and in authority over infrastructure and investments.

The governance model described was developed from research undertaken with Australian and global organizations (Zyngier, Burstein, & McKay, 2005). Future research possibilities may lie in testing this model and developing others in other operating environments.

CONCLUSION

Governance processes operate to manage the risks of KM to acknowledge and contend with the cultural issues, structural obstacles, and other relevant issues as they arise during the implementation and ongoing operation of a strategy. The management of these risks will assist in the resolution of such issues and in turn strengthen the strategies to manage knowledge that are employed within the organization. Acknowledging knowledge as the organization's strategic asset and competitive differentiator is not the ultimate responsibility of the governance process. The effective governance of KM may be a means of pursuing success. However, the governance of KM implies more than this. It implies and demands strategic thinking about the strategies in place for long-term and medium-term planning. Such strategies should not be regarded as linear in direction, but they should incorporate feedback both in the positive and negative aspects of the KM strategy that will in turn modify, progress, and develop existing plans and practices.

This article has outlined the theoretical framework of internal organizational governance and its application in strategies to manage organizational knowledge for the implementation of those strategies. Governance functions operate to ensure that KM delivers value to the identified stakeholders and provides a control mechanism to minimise risks to the successful implementation of a KM strategy. The governance framework given for these processes and practices may better enable an effective and coordinated outcome for KM strategies that ensures the delivery of anticipated benefits in an authorized and regulated manner.

REFERENCES

Bridges, W., & Mitchell, S. (2000). Leading transition: A new model for change. *Leader to Leader, 16*.

British Standards Institution & Technical Committee BDD/3. (2002). *BS 15000-1:2002 IT service management, Part 1: Specification for service management.* London: British Standards Institution.

Chase, R. L. (1997). The knowledge-based organisation: An international survey. *Journal of Knowledge Management, 1*(1), 38-49.

Davis, S., McAdams, A., Dixon, N., Orlikowski, W., & Leonard, D. (1998). *Twenty questions on knowledge in the organisation*. Business Intelligence and Ernst & Young Center for Business Innovation. Retrieved from *http://webarchive.org/web/20001212102500/www.businessinnovation.ey.com/research/researchf.htm*

DeLong, D. W., & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *The Academy of Management Executive: Ada, 14*(4), 113-127.

Denning, S. (2001). *The springboard: How storytelling ignites action in knowledge-era organizations*. Woburn, MA: Butterworth-Heinemann.

Earl, M. J., & Scott, I. A. (1999). What is a chief knowledge officer? *Sloan Management Review, 40*(2), 29.

Ewyk, O. v. (1998). *MIS98 Mindshare conference knowledge management survey results*. Retrieved September 22, 2000, from *www.hci.com.au/hcisite/articles/mis98srvy.htm*

Fang, S.-C., Lin, J. L., Hsiao, L. Y. C., Huang, C.-M., & Fang, S.-R. (2002). The relationship of foreign R&D units in Taiwan and the Taiwanese knowledge-flow system. *Technovation, 22*, 371-383.

Farrar, J. (2001). *Corporate governance in Australia and New Zealand*. South Melbourne, Australia: Oxford University Press.

Galliers, B. (1999). Editorial: Towards the integration of ebusiness, knowledge management and policy considerations within an information systems strategy framework. *Journal of Strategic Information Systems, 8*, 229-234.

Hackett, B. (2000). *Beyond knowledge management: New ways to work and learn* (Research Rep. No. 1261-00-RR). New York: The Conference Board.

IC2 Institute at the University of Texas at Austin. (2001). *The information and knowledge management audit*. Retrieved January 10, 2001, from *www.glis.utexas.edu/~coast/audit/*

IT Governance Institute. (2001). *Board briefing on IT governance*. Rolling Meadows, IL: Information Systems Audit and Control Foundation.

IT Governance Institute & COBIT Steering Committee. (2000). *COBIT framework* (3rd ed.). Rolling Meadows, IL: IT Governance Institute.

Kaplan, R., & Norton, D. (1996). *The balanced scorecard*. Boston: Harvard Business School Press.

Krogh, G. V., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. Oxford: Oxford University Press.

Liebowitz, J., & Wright, K. (1999). A look toward valuating human capital. In J. Liebowitz (Ed.), *Knowledge management handbook* (pp. 5.1-5.13). Boca Raton, FL: CRC Press.

McAdam, R., & Reid, R. (2001). SME and large organisation perceptions of knowledge management: Comparison and contrasts. *Journal of Knowledge Management, 5*(3), 231-241.

Mintzberg, H. (1994). The fall and rise of strategic planning. *Harvard Business Review*, 107-114.

O'Dell, C., Hasanali, F., Hubert, C., Lopez, K., Odem, P., & Raybourn, C. (2000). Successful KM implementation: A study of best-practice organizations. In C.

Holsapple (Ed.), *Handbook on knowledge management: Vol. 2. Knowledge directions* (pp. 411-443). Berlin, Germany: Springer-Verlag.

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing knowledge: Building blocks for success.* Chichester, UK: John Wiley & Sons.

Rumizen, M. C. (2002). *The complete idiot's guide to knowledge management.* Indianapolis, IN: Alpha A Pearson Education Company.

Standards Australia. (2001). *HB 275-2001 knowledge management: A framework for succeeding in the knowledge era.* Sydney, Australia: Standards Australia International Limited.

Standards Australia. (2003). *AS 5037-(Int)2003 knowledge management interim Australian standard.* Sydney, Australia: Author.

Sveiby, K. E. (1997). *The new organizational wealth: Managing and measuring knowledge-based assets.* San Francisco: Berrett-Koehler Publishers, Inc.

Tiwana, A. (2002). *The knowledge management toolkit Orchestrating IT, strategy, and knowledge platforms* (2nd ed.). Upper Saddle River, NJ: Prentice Hall PTR.

Van den Berghe, L., & De Ridder, L. (1999). *International standardisation of good corporate governance: Best practices for the board of directors.* Boston: Kluwer Academic Publishers.

Vinten, G. (2000). The stakeholder manager. *Management Decision.*

Weill, P., & Woodham, R. (2002). *Don't just lead, govern: Implementing effective IT governance* (White Paper No. 326). Boston: CISR.

Wiig, K. M. (1997). Knowledge management: An introduction and perspective. *The Journal of Knowledge Management,1*(1), 6-14.

Zack, M. H. (1999). Managing codified knowledge. *MIT Sloan Management Review, 40*(4), 45.

Zyngier, S. (2001). *Knowledge management strategies in Australia: Preliminary results of the survey of the knowledge management uptake in Australian companies* (Research Rep. No. 1/2001). Caulfield East, Australia: Monash University.

Zyngier, S., Burstein, F., & McKay, J. (2005). Governance of strategies to manage organizational knowledge—A mechanism to oversee knowledge needs. In M. Jennex (Ed.), *Knowledge management case book*. Hershey, PA.: Idea Group Publishing.

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Chapter 5.21
Human Resources and Knowledge Management Based on E-Democracy

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ONLINE RESEARCH AND E-DEMOCRACY

Correspondence between everyday and scientific life is a blessing (Warren & Jahoda, 1966). Although virtual communities are nowadays widely expanded, research online is not fully developed yet, as methodological approaches are not designed specifically for online research. In addition, the results from the evaluation and the reports do not find an immediate space of use. As such, the researchers use methodologies that deal with online situations borrowing methods and techniques from the "real" ones. Although the adaptations have the same principles, there are limitations due to the virtual nature of the research. In addition, multi-disciplinary approaches characterize virtual communities as different fields interact, such as learning approaches, psychology of the individual and the masses, sociology, linguistics, communication studies, management, human computer interaction and information systems. As a result, there is no methodology that, solely used, could bring results for adequate evaluation and implementation of the results in the community. Due to this complexity, we suggest Real Time Research Methodology based on Time-Series Design to study process-based activities; Focus Groups Methodology and Forum Messages Discourse Analysis as two of the most vital parts in the use of a multi-method. The other parts will depend on the nature and culture of the selected virtual community. Both focus groups (FG) and Forum Messages Discourse Analysis are referred as Extraction Group Research Methodology, or X-Groups. The reason for using X-Groups is the actual implementation of members' suggestions into their environment as an interaction into an immediate space of use.

X-GROUPS METHODOLOGY

The individualistic bias of the researcher can be partially overcome by research methods that either engage with people in the social contexts of their lives (such as participant observation) or by questioning them collectively (as in discussion groups of various kinds) (Livingston, 2000). We suggest the wide use of FG of experts as the first approach that has the potential to deliver useful results from the users for the users in virtual communities. FG spring from the active members identifying the important actors based on social network Analysis. FG are contrived settings, bringing together a specific sector to discuss a particular theme or topic, where the interaction within the group leads to data and outcomes (Cohen, Manion, & Morrison, 2000). The reliance is on interaction within the group who discuss a topic (Morgan, 1988), and it is from the interaction of the group that the data emerge. In virtual communities' research-contrived nature, which, according to Cohen et al. (2000), is a limitation, is not so here because the nature of the group is completely natural. As such, FG discussions could be economical in time, yield insights for the discussion topic, have practical and organizational advantages, and bring people together with different opinions or different collectives. In addition, they produce a large amount of data; develop, generate and evaluate the produced data; and gather feedback simultaneously. A strategic plan is needed to identify the actors, the common context and the shared vision to result in a successful intervention. The actors are the individuals who meet the objectives for virtual communities and are able to recognize, deliver new ideas and contribute to the community development and evolution. Extraction of both individuals and data gave the name to the methodology as X-Groups. Following the same democratic principle in X-Groups methodology, patterns recognition, tags and codes are suggested to derive members' suggestions from a pilot study before the main study. The pilot will give the basic tree of tags in order to code the main study towards the ultimate goal of construction of reports based on FG suggestions. X-Groups head toward articulation of a collective reality that encompasses individual views, problems and underlying causes of the problems and solutions, as suggested by the members of the studied community.

X-Groups use Real Time software that has the potential to provide valuable help and economy of time for both the identification of actors and their suggestions. The systemization of the results and the construction of a skeleton could be conducted supporting both the inductive (looking for patterns and associations) and deductive (propositions reached hypothetically) extractions. Research methods borrowed from sociology and software such as "netminer" for Social Network Analysis (SNA) can give the map with the actors and their activities. "ATLAS.ti" for Discourse Analysis (DA) could assist with the identification of tags and code-trees as well as the identification, extraction, indexation and categorization of members' suggestions. Unfortunately, nowadays software for knowledge management is still in a primitive stage, with limited semantic search and automatic indexation. As such, there are two levels of identification and assessment:

1. SNA and DA on the virtual communities level for FG identification and all members suggestions
2. SNA and DA on the FG level for FG suggestions.

The results would portray the souls of the organization and common visions.

IDENTIFICATION OF ACTORS VIA SNA

Following Shneinderman's (1998) concept on information visualization, the decision was made on the use of SNA as it depicts social relationships between a set of actors (Baroudi, Olson, & Ives, 1986). One of the goals of SNA is to visualize communication and relationships between members through diagrams. Following Zaphiris, Zacharia and Rajasekaran (2003), SNA is backed up by social sciences and strong mathematical theories such as graph theory and matrix algebra, which makes it applicable to analytical approaches and empirical methods. SNA uses two approaches; namely, ego-centered analysis and whole-network analysis. In ego-centered analysis, the focus is on the individual rather than on the whole. SNA uses various concepts to evaluate different network properties (Baroudi et al., 1986), such as centrality, the assessment of the power of an actor based on the number of alters that actor is directly connected to, connectivity and cliques. A clique is a subset of actors in a network who are more closely tied to each other than to the other actors who are not part of the subset. Comparison of the graphs illuminates members' roles in the communities in order to identify their interests and their areas of best practice. We used a GUI-based SNA tool called Netminer for Windows. Cyram NetMiner II is an innovative software tool for exploratory network data analysis and visualization. It provides visualization of the social network structures and positions of actors within the network using sociograms, which are graphs with nodes and lines for actors and ties respectively (Netminer, 2003). An example is provided from a study on an online community of online community managers. The degree in Figure 1 (Freeman, 1979) refers to the number of ties to others in an adjacency matrix. There were 47 nodes from 26 participants. Cindy, Rebecca, Chris and Ewan seemed to receive more responses in both Figures 1 and 2. Chris sent only one message, but this message created lots of objections and suggestions.

Centrality in SNA is a structural attribute of nodes in a network and their structural position in the network. It is a measure of the contribution of network position to the importance, influence and prominence of an actor in a social network.

Figure 1. Discussion network nodes

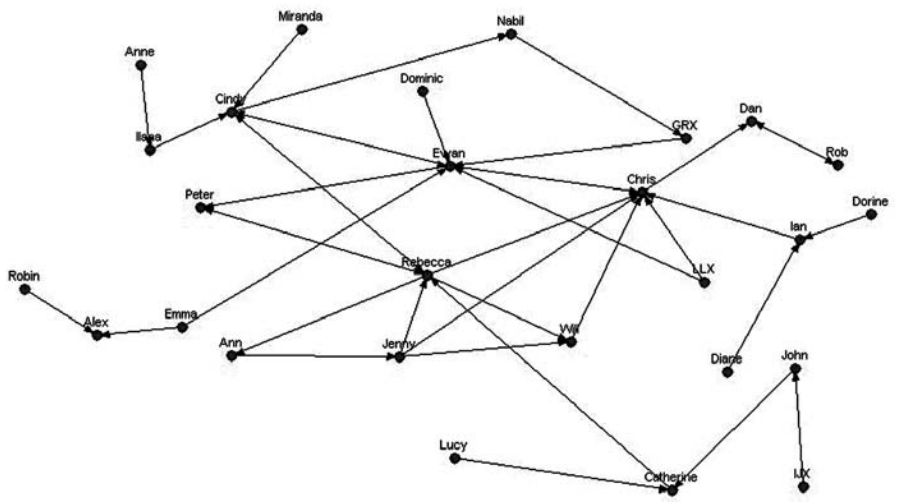
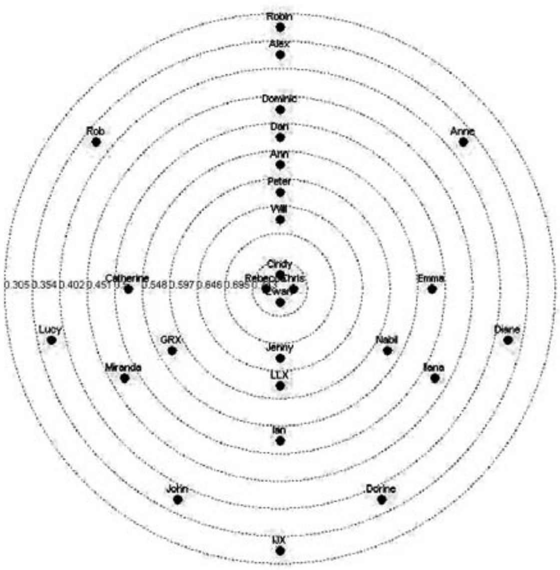


Figure 2. Information centrality



Centralization refers to the extent to which a network revolves around a single node.

The previous four members appear in the center of the activity. Comparisons between graphs could maintain the reliability degree for the selection of actors based on their input in the community. In this study, FG members were selected up to the 5th circle in Figure 2. The number of members is defined by their input in the community and could be limited to the 1st or 2nd circle. Then FG discuss critical issues for a specific period of time (e.g., one week). The next section is mainly centered on Focus Groups Discourse Analysis, as the second stage of the Centrifugal Design for knowledge management and human resources.

IDENTIFICATION OF SUGGESTIONS VIA FORUM DA (DISCOURSE ANALYSIS)

After FG identification and FG discussion, DA for content analysis can be used to identify meaningful material. FG discussions' extractions on critical issues are highly dependent on the context, taking into consideration that "the conventional meaning of an utterance was but a stage of its interpretation" (Sinclair, 1992, p. 79). DA using innovative software based on semantic text extraction and information indexation could provide a basic structure of descriptions, problems, suggestions and ideas. With the advent of such a tool, organizations will be able to automatically educe metadata, contextual meaning and relationships between data. ATLAS.ti software for qualitative analysis handles large bodies of textual, graphical, audio and video data, and offers a variety of tools for accomplishing the tasks associated with any systematic approach to unstructured data; for example, data that cannot be comprehensively analyzed by formal, statistical approaches. The role of the researcher is crucial, so in order to limit subjectivity and due to the absence of suitable software, more than one researcher could work on the same data and compare their findings (Oriogun & Cook, 2003).

DA refers to the analysis of all forms of spoken interaction and all written texts, is concerned with the function of language and its uses for a variety of consequences, considers the way in which language is both constructed and constructive, and recognizes that the same phenomena can be described in different ways (Potter & Wetherell, 1987). Potter and Wetherell insist that DA cannot be readily contained within a fixed methodology. Similarly, Burr (1995) refers to DA as an approach rather than a method. Computer-Mediated Discourse Analysis approach (CMDA) (Herring 1999) is drawing theoretical assumptions from linguistic discourse analysis. “At its core is the analysis of logs of verbal interaction (characters, words, utterances, messages, exchanges, threads, archives, etc.)” (Herring, 2004). It is based on four levels of language interchange: (a) structure: structural phenomena include the use of special typography or orthography, novel word formations and sentence structure, (b) meaning: meanings of words, utterances (e.g., speech acts) and larger functional units, (c) interaction: turn-taking, topic development and other means of negotiating interactive exchanges, and (d) social behavior: participation patterns (as measured by frequency and length of messages posted and responses received).

Turn-taking and time lag in spoken communication is absolutely linear, whereas CMC exhibits numerous violations of both the “no gap, no overlap” principle and the principle of orderly turn alternation (Herring, 1999). As such, Figure 3 is mostly based on Herring et al. (2004), who draw on Bauer’s (2000) useful distinction in content analysis between “syntactic” (structural) and “semantic” phenomena. This maps the content analysis framework (Figure 3).

Extraction of both structural and, in particular, semantic issues could be investigated, recorded and used towards Centrifugal Decision Making and e-democracy by specifying both employee and knowledge updates. Having in mind the limitations of DA, it is an attempt to reveal useful insights to what is presented as fact or common sense and be restricted to the internal working of the text.

Figure 3

DISCOURSE ANALYSIS SEARCH
Keywords and Themes (recurrent terms, concepts)
Compare and contrast Identify ideas and representations (associations, mobility, implications)
Variation in text
Brakes, hesitations, inconsistencies, contradictions
Consistency with and between texts
Intertextuality (repetition of keywords and phrases)
Emphasis and detail
Rhetorical devises used Alliteration Metaphors Taking for granted notions
Deixis
The use of words that make reference to the situation (now, we this etc)
Modality
Judgement (might, regret, correct, right etc)
Online text indications
Use of specific online symbols such as emoticons, stress of text using capital letters, incomplete sentences, dots and dashes, nick names etc
Expression of Feelings
Use of text, symbols, phrases etc for expression of feelings

As a result, reports can be written and proposals could be taken into account from the directors and managers. In our study, the online community managers FG provided specific structures, mechanisms and suggested tools for community organization and online groupz-ware.

CONCLUSION

X-Groups methodology—together with other methodological approaches or solely used—has the potential to provide human potential recognition, skills profiles, staff assessments and training requirements, as well as identify common problems, needs and visions, gaps in communities' policy and updates directly to the knowledge base. Innovative software that will be able to implement X-Groups philosophy could limit subjectivity. We cannot be responsible citizens unless we make our voices heard. Science and technology can enhance e-democracy and help us shout out loud at this crucial moment for humanity. Then, the question that arises is, "Can we survive the process, recognise our own potential and take the responsibility to add our brick on the wall?"

REFERENCES

Baroudi, J.J., Olson, M.H., & Ives, B. (1986). An empirical study of the impact of user involvement on system usage and information satisfaction. *Communication of the ACM, 29*(3), 232-238.

Bauer, M. (2000). Classical content analysis: A review. In M. Bauer & G. Gaskell (Eds.), *Qualitative researching with text, image and sound* (pp. 131-151). Thousand Oaks: Sage.

Burr, V. (1995). *An invitation to social constructionism*. London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education*. London: Routledge Falmer.

Herring, S.C. (1999). Interactional coherence in CMC. (2004, July 7). *Journal of Computer-Mediated Communication, 4*(4). Retrieved from www.ascusc.org/jcmc/vol4/issue4/

Herring, S.C. (2004, May). Computer-mediated discourse analysis: An approach to researching online behavior. In S.A. Barab, R. Kling, & J.H. Gray (Eds.), *Designing for virtual communities in the service of learning.* New York: Cambridge University Press.

Lambropoulos, N., & Birmpas, A. (2004). Teachers' CoP participation in governmental decision making: Centrifugal decision making in education. *Proceedings of the 6th KEDEK Conference,* University of Patras.

Livingstone, D.W. (2000). Exploring the icebergs of adult learning: Findings of the first Canadian survey of informal learning practices'. NALL working paper (10)2000. The Research Network on New Approaches to Lifelong Learning Ontario Institute for Studies in Education of the University of Toronto (OISE/UT).

Morgan, D.L. (1988) *Focus groups as qualitative research.* Beverly Hills, CA: Sage Publications.

Netminer. (2003). *Netminer for Windows manual.* (2004, July 17) Retrieved from www.netminer.com

Oriogun, K.P., & Cook, J. (2003). Transcript reliability cleaning percentage: An alternative interrater reliability measure of message transcripts in online learning. *American Journal of Distance Education. 17*(4), 221-234.

Potter, J., & Wetherell, M. (1994). Analysis discourse. In M. Bryman & R. Burgess (Eds.), *Analysis qualitative data.* London: Routledge.

Shneiderman, B. (1998). *Designing the user interface: Strategies for effective human-computer interaction* (3rd edition). Reading: Addison-Wesley.

Sinclair, J. (2002). Priorities in discourse analysis. In M. Coulthard, (Ed.), *Advances in spoken discourse analysis* (3rd edition). London: Routledge.

Warren, N., & Jahoda, M. (Eds.). (1966). *Attitudes.* Middlesex: Penguin Books.

Zaphiris, P., Zacharia, G., & Rajasekaran, M.S. (2003) Distributed constructionism through participatory design. In C. Ghaoudi (Ed.), *Usability evaluation of online learning programs.* Hershey, PA: Idea Group Publishing.

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Chapter 5.22
Integration of Knowledge Management and E-Learning

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INTRODUCTION

Knowledge management (KM) and e-learning are two concepts that address the requirements of lifelong learning. Over the past several years, there has been an increasing focus on the integration of knowledge management and e-learning systems. By 2003, 70% of organizations implementing knowledge management were linking it with e-learning technically and organizationally (Gartner, 2000). The integration of knowledge management and e-learning enables the creation of great synergies in organizations and business applications. In this article, these two concepts will be presented and their integration will be discussed in detail.

BACKGROUND

E-learning has its historical roots in more than 30 years of development of computer-supported education. The past decade, in particular, has witnessed a dramatic increase in the development of technology-based teaching and learning (Alavi & Leidner, 2001a). E-learning is an instructional process that gives online learners access to a wide range of resources—instructors, learners, and content such as readings and exercises—independently of place and time (Zhang & Nunamaker, 2003). It represents the conscious learning process where objectives and domains are clearly defined, and the focus is set to individual online learner perspectives and demands. Effective and efficient e-learning methods are generally required to ensure that online learners are equipped with the latest knowledge in a timely manner. The previous research has proposed a framework in which e-learning effectiveness is affected by two major components: the human dimension and the design dimension in virtual learning environments (Piccoli, Ahmad, & Ives, 2001). The technology in this framework is geared toward providing effective e-learning. For example, content management is one of the factors in the design dimension, which includes factual knowledge, procedural knowledge, and conceptual knowledge, that has a positive relationship with e-learning effectiveness. The design of interaction enhances the knowledge sharing among learners, and between learners and the instructor.

In contrast to traditional classroom learning, e-learning has several advantages for learners, such as time and location flexibility, relatively cost and time savings, learner-controlled instruction, unlimited access to electronic learning materials, and flexible collaboration between instructors and learners. The previous research has shown that learners benefit from using a variety of e-learning systems. Many e-learning systems present instructional material in a static, passive, and unstructured manner, and give learners little control over the learning content and process. The adaptive e-learning systems integrate knowledge management activities into their e-learning architectures and provide online learners with tailored instruction.

Individuals and groups learn by understanding and then acting, or by acting and then interpreting (Crossan et al., 1999). The process of change in individual and shared thought and action, which is affected by and embedded in the institutions of the organization, is called organization learning (Vera & Crossan, 2003, pp. 122-141). When individual and group learning becomes institutionalized, organizational learning occurs, and knowledge is embedded and created in non-human repositories such as routines, systems, structures, culture, and strategy (Hardaker & Smith, 2002; Crossan et al., 1999).

Knowledge management (KM), on the other hand, has been developed within the business context. The recent interest in organizational knowledge has prompted the use of knowledge management in order to process and manage the knowledge to the organization's benefit (Alavi & Leidner, 2001b). Knowledge management outcomes fall into three main categories: knowledge creation, retention, and transfer (Argote et al., 2003). Knowledge creation occurs when new knowledge is generated in an organization. Knowledge retention involves embedding knowledge in a repository so that it exhibits some persistence over time. Knowledge transfer is evident when experience acquired in one unit affects another. These three categories are closely related.

Lee and Choi (2003) proposed a research framework for studying knowledge management such that the synergy of information technologies, as one of the knowledge management enablers, is positively related to the knowledge management process. Information technology affects knowledge creation in a variety of ways, such as in knowledge sharing, storage, and knowledge flow. Therefore, knowledge management systems are used to rapidly capture, share, organize, and deliver large amounts of corporate knowledge. Knowledge management systems refer to a class of information systems applied to management of organizational knowledge. They are developed to support knowledge management processes in terms of knowledge creation, storage/retrieval, transfer, and application (Alavi & Leidner, 2001b).

Knowledge management processes, also called knowledge management activities—form a structured, coordinated system for managing knowledge effectively (Becerra-Fernandez & Sabherwal, 2001). Table 1 illustrates knowledge management processes and the potential roles of information technology (IT). For instance, knowledge creation can be achieved through learning tools, such as e-learning systems. Knowledge can be stored/retrieved in/from e-learning sys-

Table 1. Knowledge management processes and the potential roles of IT (Alavi & Leidner, 2001b)

Knowledge Management Process	Knowledge Creation	Knowledge Storage/ Retrieval	Knowledge Transfer	Knowledge Application
Supporting Information Technologies	Data mining Learning tools	Electronic bulletin boards Knowledge repositories Database	Electronic bulletin boards Discussion forums Knowledge directories	Expert systems Workflow management
IT Enablers	Combining new sources of knowledge Just-in-time learning	Support of individual and organizational memory inter-group knowledge access	More extensive internal network More communication channels available Faster access to knowledge sources	Knowledge can be applied in many locations More rapid application of new knowledge through workflow automation
Platform Technology	Groupware and communication technologies			
	INTRANETS			

tem repositories and electronic bulletin boards. Discussion forums and electronic bulletin boards provide knowledge transfer between learners, and course management and content management can be viewed as knowledge application in e-learning environments. Schwartz et al. (2000) stated that knowledge acquisition, distribution, and storage are highly correlated and can fruitfully influence each other. Knowledge acquisition deals with the issues that surround knowledge extraction in its various forms; knowledge distribution tackles the problem of getting the right knowledge to the right place at the right time (Schwartz & Te'eni, 2000), and knowledge storage undertakes the knowledge repository. Knowledge management is a learning process than requires a continuous re-evaluation of the way knowledge is acquired, organized, and delivered (van der Spek & Spijkervet, 1997).

KNOWLEDGE MANAGEMENT ENABLERS AND KNOWLEDGE MANAGEMENT PROCESSES IN E-LEARNING

The integration of knowledge management and e-learning is an elaboration of knowledge management systems and e-learning systems. Knowledge management could be a cornerstone of e-learning. Effective e-learning leverages traditional e-learning technology such as computing, communication, and multimedia technologies, and knowledge management to create learning environments that can be richer and more flexible, scalable, and cost effective than the standard classroom or lecture hall (Piccoli et al., 2001; Becerra-Fernandez & Sabherwal, 2001). Therefore, e-learning systems integrating with knowledge management are designed to support the rapid capture, delivery, and measurement of knowledge in a Web-based fashion. They are designed to consider online learners' attributes and instructional strategies to provide adaptive, learner control and collaborative e-learning environments, and to thereby maximize e-learning effectiveness.

Recent knowledge management developments enable the education community to provide high-quality multimedia content via the Internet, keep track of online learner activities, or support long-distance communication and cooperation. These developments cover the complete cycle of teaching and learning and its many functional aspects. Based on Lee and Choi's (2003) research framework, an e-learning system is considered to be one knowledge management enabler that provides the infrastructure necessary for the e-learning organization to increase the efficiency of knowledge processes. However, from a broader point of view, the knowledge management enablers and the knowledge management processes in e-learning are correlated at different levels. Knowledge storage and retrieval are classified in one knowledge management process in the previous research (Alavi & Leidner, 2001b). In this article, knowledge storage and knowledge retrieval are divided into two separate processes due to the sequence of the knowledge management process. The knowledge storage process normally

Table 2. Relationship between KM enablers/techniques and KM processes in e-learning

		Knowledge Management Processes in E-Learning				
		Knowledge Creation	Knowledge Storage	Knowledge Retrieval	Knowledge Transfer	E-Learning Application
Knowledge Management Enablers/Techniques in E-Learning	Content Management	+	++	–	–	++
	Course Management	+	+	–	+	++
	Administration and Operation	–	+	++	++	+
	Evaluation Management	+	+	+	+	++
	Interaction/Collaboration	++	+	+	++	+

Note: - less related; + correlated; ++ highly correlated.

occurs at an earlier stage, while the knowledge retrieval process occurs at a later knowledge management stage.

An e-learning environment includes the following five knowledge management enablers: content management, course management, administration/operation, evaluation management, and interaction/collaboration. They are correlated with the knowledge management process in different ways and at different levels, summarized in Table 2. For instance, knowledge creation is highly correlated to interaction/collaboration, but less correlated to the administration and operation functions. This indicates that interaction/collaboration as a knowledge management enabler has a very positive impact on the knowledge creation process, but the administration/operation function has little or no impact on knowledge creation. One may also conclude that these five enablers have positive effects on e-learning applications of different magnitudes.

The classification and definitions of these five knowledge management enablers in e-learning are described below.

- Content Management: The American Productivity & Quality Center (APQC, 2001) defines content management as "a system to provide meaningful and timely information to end users by creating processes that identify, collect, categorize, and refresh content using a common taxonomy across the organization." Content management covers pedagogical, psychological, and didactic issues, as well as technical questions. It is a major component of knowledge management. Nearly all relevant e-learning environments offer rich content management functionality. Content management enables the knowledge storage process and the e-learning application process.
- Course Management: This includes the ability to share materials and modules across e-learning systems; the ability to edit, comment, and track changes on learners' documents; and the ability to monitor and access learners' e-learning performance. In short, course management offers instructors the ability to electronically maintain and manage class rosters, distribute course materials, administer online exams, and communicate with learners. Course management enables the knowledge creation process.
- Administration and Operation: Administration includes user management, administration of access rights, and all aspects of operation. Administration and operation enable the knowledge retrieval and knowledge transfer in e-learning.
- Evaluation Management: Self-evaluation can foster effective learning and implement a high degree of learning control. Evaluation management is used to guide learners' e-learning and build their knowledge, and to verify if the information is successfully turned into knowledge. In order for e-learning to be proven effective, learners need to verify that they have succeeded in gaining new knowledge or skills. During this phase, the relationship between information and knowledge becomes visible with respect to e-learning.
- Interaction/Collaboration: This supports communicating and collaborating between learner, the systems and organizations, as well as among learners as a pedagogical technique. Interaction and collaboration provide rich functionalities for knowledge sharing, creation, and transfer.

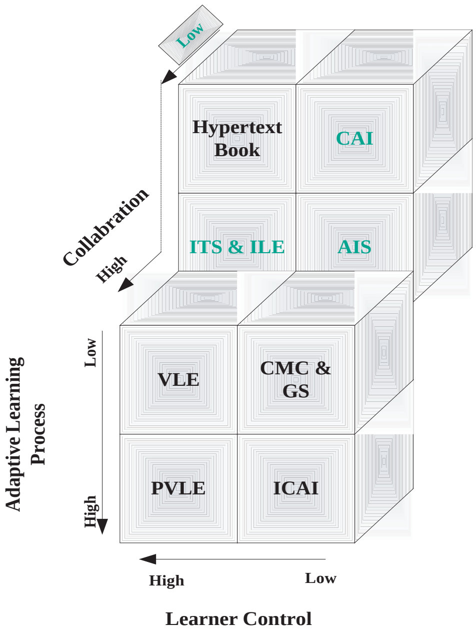
FUTURE TRENDS: INTEGRATING KNOWLEDGE MANAGEMENT AND E-LEARNING

Over the past several years, there has been an increasing focus on the integration of knowledge management and e-learning systems. Both e-learning and knowledge management share a similar focus: how to enhance human knowledge and its use within organizations. Professionals in both fields are increasingly looking for ways to integrate them in order to manage knowledge. The practice of knowledge management has adopted a number of different technologies, from low-tech e-mail to sophisticated, intelligent searches and extended enterprise analytical tools. Whatever the technology, the objective of such adoption is the same: to capture, store, retrieve, and distribute knowledge from internal and external sources, and build upon the intellectual knowledge wealth inherent in the organization. Knowledge management, in general, addresses more of the unintentional, indirect, but continuous learning process. The integrating of e-learning and knowledge management presents exciting opportunities for e-learning systems development and targeted learning based on lifelong learning needs.

Different terminologies have been used for e-learning (Sloman, 2002). Therefore, e-learning environments will be analyzed and classified further. The analysis is based on three main functional dimensions of e-learning systems—collaboration, adaptivity, and learner's control level from low to high—for a particular e-learning system. Combinations of these three dimensions generate eight different scenarios, which show the evolution of e-learning historically, as shown in Figure 1.

In the early days of e-learning, Hypertext Books, Computer-Assisted Instruction (CAI) systems, Communications (CMC), and Group Systems (GSs) were introduced to online learners. These e-learning environments provided online learners with access to up-to-date, relevant learning materials, and the ability to communicate with experts in the field in which they were studying in a very rigid manner. Along with the continuing evolution of information and communication

Figure 1. Evolution of e-learning



AVLE: Adaptive Virtual Learning Environment

VLE: Virtual Learning Environment

ITS: Intelligent Tutoring System

CMC: Computer-Mediated Communication

CAI: Computer-Assisted Instruction System

ICAI: Intelligent Computer-Assisted Instruction System

AIS: Adaptive Instructional System

ILE: Interactive Learning Environment

GS: Group System

technologies, Virtual Learning Environments (VLEs), Intelligent Tutoring Systems (ITSs), Intelligent Computer-Assistant Instruction (ICAI) systems, Adaptive Instructional Systems (AISs), Interactive Learning Environments (ILEs), and Adaptive Virtual Learning Environments (AVLEs) are developed, Those e-learning environments are making improvements to give online learners more flexibility in their e-learning in terms of collaboration, adaptivity, and learner control to overcome one-size-fits-all instruction, and to provide contextual and adaptive supports for e-learning.

This e-learning evolution framework is proposed based on the analysis of eight scenarios integrating increasing amounts of knowledge management into an e-learning environment (Figure 1). Levels of collaboration, the adaptive learning process, and learner control are measurements used to classify these eight scenarios. As an example, the Hypertext Book-based e-learning systems correspond to a low degree of collaboration, a low degree of adaptivity, and a low degree learner control. On the other hand, the Adaptive Virtual Learning Environments (AVLEs) correspond to a high degree of collaboration, a high degree of adaptivity, and a high degree of learner control. The higher level of collaboration provides better knowledge management processes in terms of knowledge creation, storage, and transfer. Higher levels of the adaptive learning process also have greater impact on the knowledge management process, and higher learner control gives the learner more power to engage in knowledge creation and sharing. Therefore, with the evolution of knowledge management integrated into e-learning environments, AVLE illustrates the future trend of e-learning, which provides adaptive components to personalize learning instruction and match with each learner's individual cognitive capability in order for knowledge construction to occur.

Table 3 presents the integration relationship among knowledge management processes in e-learning within eight scenarios of e-learning environments. It has been clearly identified

Table 3. The integration relationships between KM processes and e-learning systems

		Hypertext Book	CAI	ITS & IEL	AIS	CMC & GS	ICAI	VLE	AVLE
Knowledge Management Process in E-Learning	Knowledge Creation	–	–	+	+	+	+	+	++
	Knowledge Storage	–	+	+	+	–	+	+	+
	Knowledge Retrieval	–	+	+	+	–	+	+	+
	Knowledge Transfer	–	–	+	+	+	+	+	+
	Application	–	+	+	+	+	+	+	++

Note: - less related; + correlated; ++ highly correlated.

that Hypertext Book systems involve very few knowledge management processes. In contrast, the knowledge management processes are well integrated in Adaptive Virtual Learning Environments. Firstly, the knowledge creation process is highly integrated with the AVLEs. Most AVLEs have a "Just-In-Time" e-learning facility, which is an important IT enabler in the knowledge creation process. Some advanced AVLEs have data mining and reasoning capabilities, which are used to help learners analyze their learning performance. Also, the knowledge retrieval process plays an important role in AVLEs, where the contents are retrieved adaptively, based on different individual learners' dynamic situations. Another important knowledge process in AVLEs is knowledge transfer. The communication channels in AVLEs allow learners to publish their opinions and ideas, to access knowledge resources, and to discuss their opinions. For this reason, AVLEs have been attracting more and more attention from educational professionals and development professionals due to their advanced knowledge management facilities and its e-learning effectiveness. In general, the more an e-learning system is integrated with knowledge management processes, the better the learning effectiveness is that can be achieved.

CONCLUSION

E-learning and knowledge management are of increasing importance in this "knowledge economy," and lifelong learning issues will be of continuing significance. Although the integration of e-learning and knowledge management is in its early stage, there are numerous signs of the coming integration that will provide online learners with adaptive e-learning environments. This article has addressed the integration of knowledge management and e-learning to improve the capture, organization, and delivery of corporate knowledge in e-learning. Based on the analysis of knowledge management enablers and knowledge management processes in e-learning, the relationships of these two dimensions are shown in Table 2.

Furthermore, the evolution of e-learning systems has been examined, and eight scenarios have been identified, as shown in Figure 1. Analysis of these eight scenarios helps us to better understand the integration of knowledge management, and to predict the future trends of e-learning systems.

Finally, the integration relationship between knowledge management processes in e-learning and the eight scenarios of e-learning environments is presented in Table 3. The conclusion may be drawn that an e-learning system designed to have a higher level of collaboration, adaptive learning processes, and learner control should better integrate the knowledge management processes. With a higher level of knowledge management integration,, e-learning systems will have more opportunities to achieve e-learning effectiveness.

The proposed relationships in this article between knowledge management enablers and knowledge management processes in e-learning, and between knowledge management processes and e-learning systems, can be viewed as a framework for the integration between knowledge management and e-learning. Such a framework could be very useful for further research, as well as for practitioners in real-world application development.

REFERENCES

Alavi, M., & Leidner, D.E. (2001a). Research commentary: Technology-mediated learning: A call for greater depth and breadth of research. *Information Systems Research, 12*(1), 1-10.

Alavi, M., & Leidner, D.E. (2001b). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

American Productivity & Quality Center. (2001). *Is your content out of control?* Retrieved from http://www.apqc.org/portal/apqc/site/generic2?path=/site/km/resources.jhtml

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), 571-582.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Crossan, M., Lane, H., & White, R. (1999). An organizational learning framework: Dimensions for a theory. *The International Journal of Organizational Analysis, 3*(3), 37-60.

Davenport, T.H., Long, D., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

Hardaker, G., & Smith, D. (2002). E-learning communities, virtual markets and knowledge creation. *European Business Review, 14*(5), 342-350.

Lee, H., & Choi, B. (2003). Knowledge management enablers, processes, and organizational performance: An integrative view and empirical examination. *Journal of Management Information Systems, 20*(1), 179-228.

Piccoli, G., Ahmad, R., & Ives, B. (2001). Web-based virtual learning environments: A research framework and a preliminary assessment of effectiveness in basic IT skills training. *MIS Quarterly, 25*(4), 401-425.

Schwartz, D.G., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D. Schwartz & Brasethvik (Eds.), *Internet-based knowledge management and organizational memory* (pp. 1-23). Hershey, PA: Idea Group Publishing.

Schwartz, D.G., & Te'eni, D. (2000). Tying knowledge to action with k-mail. *IEEE Intelligent Systems, 15*(3), 33-39.

Sloman, M. (2002). *The e-learning revolution: How technology is driving a new training paradigm* (p. 222). New York: AMACOM.

Van der Spek, B.R., & Spijkervetr, A.L. (1997). *Knowledge management: Dealing intelligently with knowledge*. Kenniscertrum CIBIT.

Vera, D., & Crossan, M. (2003). Organizational learning and knowledge management: Toward an integrative framework. In Easterby-Smith and Lyles (Eds.), *The Blackwell handbook of organizational learning and knowledge management* (pp. 122-141). Blackwell Publishing.

Zhang, D., & Nunamaker, J.K. (2003). Powering e-learning in the new millennium: An overview of e-learning and enabling technology. *Information Systems Frontiers, 5*(2), 207-218.

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Chapter 5.23
The Political Economy of Knowledge Management in Higher Education

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ABSTRACT

In this chapter, I discuss the economic and political implications of knowledge management in higher education. First, I examine the linkages between KM and capitalism, with the help of theoretical frameworks that connect increasing managerialism in higher education with the promises of profit-making in the New (Knowledge) Economy. Next, I discuss the politics of information and the ways in which knowledge is stratified in postsecondary institutions. Third, the social dynamics of information and communications technologies (ICT) are explored in the context of higher education institutions. These perspectives provide a counter-balance to the decidedly functionalist views of much of the knowledge management literature. The intent of the chapter is to provide a foundation for the rest of the volume and the more specific studies of KM in higher education to follow.

INTRODUCTION

As the external environment increased pressure upon institutions of higher education to become more productive and business-like, it is not surprising that business management techniques are promoted as the best vehicles for change (Ewell, 1999). In the Information Age, the management techniques that have been the most popular in the private sector pertain to e-business, the art of combining the marketplace with high technology and opportunities provided by the Internet. E-business initiatives are also becoming common in higher education, with Web-based portals linking academic units to shared databases and common business rules (Katz et al., 2000). Distance education courses are hosted on the World Wide Web, and "e-learning" has become standard jargon in the field. Academic managers have embraced information technology since the age of the mainframe computer, which has resulted in the development of techno-centric institutional infrastructures, electronically-driver business cores, and wired classrooms in colleges and universities throughout the industrialized world.

Ushered into academe on the heels of information technology and institutional restructuring, knowledge management promises to lead to better decision-making capabilities, improve academic services, and reduce costs (Kidwell, Vander Linde, & Johnson, 2001). KM is often loosely defined, but its central purpose is the action of "transforming information and intellectual assets into enduring value" (Kidwell et al., 2001, p. 3). Founded on the notion that "intellectual capital" is a hidden asset of many businesses, KM seeks to bring this essential knowledge to light in order to make organizations more competitive. In the arena of higher education, KM is being touted as a method that will increase institutional innovation (Lyman, 2000). Getz, Siegfried, and Anderson have stated that, "higher education occupies a strategic role in productivity growth, not only because it is an industry itself, but also because it is a source of new ideas and trains the managers that affect productivity throughout the economy" (Getz, Siegfried, & Anderson, 1997, p. 605). It is in this context that KM proponents have noted that the absence of KM principles in higher education is a striking oversight (Serban & Luan, 2002).

Colleges and universities are obvious sites to explore the implementation of knowledge management (KM) principles in the public sector, given the historic connections between academe and the production of knowledge. While the creation and dissemination of knowledge has long been the social role of colleges and universities, recent neoliberal shifts in the political climate have led to legislative and private sector demands for evidence of a return on investment for public expenditures to higher education. As state support for postsecondary education dwindles, more attention is paid to "productivity" measures and ways in which institutions are maximizing public and private investments. Institutional research offices have been at the core of the data collection efforts. An increase in the use of information technology has provided more opportunities to measure and codify the production capacities of higher education institutions, from the learning mission to research output. Data points such as graduation rates, expenditures per student, faculty/student ratios, the cost to raise a dollar, grant revenues received, patents granted, and other factoids are collected, contextualized, and distributed by academic institutions to their public and private constituents. Thus, the information gathered and evaluated is used to determine financial aid formulas, institutional rankings, state appropriations, and other important "knowledge-based" decisions that affect higher education.

Recently the principles of KM have been applied to academic settings to help in these efforts. As an outgrowth of the data-gathering opportunities afforded by the widespread adoption of information technology (IT), KM is wedded to the technological infrastructures of modern organizations. Therefore, issues of access to and control over IT systems and the social power differential between those who are the "monitored", those who are the "users", and those who are the "managers" of technology are inherent to KM implementation, regardless of the size and type of organization where it occurs. Academic labor and its products have been traditionally shaped by professional norms and peer-review, but a shift toward technocratic decision-making in an environment marked by academic capitalism (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004) has permitted new value systems to prevail. In such an organizational climate, the intellectual capital that was previously considered a public good is now a "knowledge asset" that has the potential to increase institutional legitimacy and to provide new revenue streams. Knowledge management, as it has been defined and shaped by the private sector, is thus being employed in the public sphere in order to "capture" these assets and codify them into tangible objects with market value. However, academic managers who employ KM techniques do not have to adopt business values that promote the commoditization of knowledge for profit. This book offers an alternative expression of ideas and case study evidence to encourage a more thorough exploration of the uses of KM in higher education.

In this chapter, I discuss the economic, political, and social implications of knowledge management in higher education. First, I examine the linkages between KM and capitalism, with the help of theoretical frameworks that connect increasing managerialism in higher education with the promises of profit-making in the New (Knowledge) Economy. Next, I discuss the politics of information and the ways in which knowledge is stratified in postsecondary institutions. Third, the social dynamics of information and communications technologies (ICT) are explored in the context of higher education institutions.These perspectives (economic, political, and social) provide a counter-balance to the decidedly functionalist views of much of the knowledge management literature. The intent of the chapter is to provide a foundation for the rest of the volume and the more specific studies of KM in higher education to follow.

THE ECONOMICS OF KNOWLEDGE MANAGEMENT

The ability to produce and consume information and knowledge products situates the field of knowledge management in a capitalist cycle, and therefore dimensions of power and inequality are inherent in the application of this (or any) managerial schema. From an economic standpoint, information and knowledge are commodities, either exchanged for free in the gift economy market (Lessig, 2001) or for a price in the consumer market. Thus, even when KM is used in non-profit settings, the ability to profit from the capture and diffusion of information and knowledge is embedded in the best-practices and technical infrastructures that were created for the business context. Further, as colleges and universities move closer to private-sector behaviors and values as described by acadmic capitalism theory (Slaughter & Leslie, 1997; Slaughter & Rhoades, 2004), opportunities for the influx of business strategies into higher education institutions increase. For these reasons, we must begin to understand how market principles affect the implementation of knowledge management in the public arena. In addition, I will introduce the theory or academic capitalism, describe the increase in managerialsim in academe, and explore the ways in which higher education institutions are intertwined with digital capitalism.

Academic Capitalism

Academic capitalism is a term used by Slaughter and Leslie (1997) to describe the market-like behaviors of higher education organizations. They noted that the production of human capital is one of the more important functions of higher education in modern society. They stated that:

Universities are the repositories of much of the most scarce and valuable human capital that nations possess, capital that is valuable because it is essential to the development of the high technology and technoscience necessary for competing successfully in the global economy. The human capital possessed by universities, of course, is vested in their academic staffs. Thus the specific commodity is academic capital, which is not more than the particular human capital possessed by academics. This final step in the logic is to say that when faculty implement their academic capital through engagement in production, they are engaging in academic capitalism. Their scarce and specialized knowledge and skills are being applied to productive work that yields a benefit to the individual academic, to the public university *they serve, to the corporations with which they work, and to the larger society. It is indeed academic capitalism that is involved, both technically and practically. (pp. 10-11)*

Central to their analysis was the use of resource dependency theory, as outlined by Pfeffer and Salancik (1978). Resource dependency theory describes the ways in which organizations become dependent upon other organizations through resource allocation. Pfeffer and Salancik list three factors used to determine the extent of dependence: the importance of the resource and its criticality to organizational survival, organizational discretion over the allocation of the resources in question, and the presence or absence of alternative resources (Pfeffer & Salancik, 1978, pp. 45-46). Slaughter and Leslie noted that "national and state/provincial restriction of discretionary resources created increased resource dependence at the institutional level, causing institutions and professors to look to alternative revenue sources to maintain institutional income" (Slaughter & Leslie, 1997, p. 64). While resource dependence largely defines organizational behavior as reactive to external forces, it has also been applied to help understand intraorganizational power relationships (Salancik & Pfeffer, 1974).

The theory of academic capitalism was further developed by Slaughter and Rhoades (2004), who posited that the shift toward market-like behaviors in academe is an outgrowth of the New Economy. Slaughter and Rhoades noted the linkages created among individuals working in academic settings and in industry, realizing that these relationships are far more complex and mutually supportive than resource dependency is able to describe. They conceptualized that:

The theory of academic capitalism focuses on networks—new circuits of knowledge, interstitial organizational emergence, networks that intermediate between public and private sectors, extended managerial capacity—that link institutions as well as faculty, administrators, academic professionals and students to the new economy. Together these mechanisms and behaviors constitute an academic capitalist knowledge/learning regime. (p. 15)

Interestingly, the interpersonal and interorganizational networks noted by Slaughter and Rhoades are enhanced by information and communications technologies. These ICT networks, which form the basis for the academic capitalist knowledge/learning regime, are sources of data for knowledge management. When the human capital of faculty, administrators, academic professionals, or students is transferred to a digital environment, it can be measured and commodified by the organization through the use of KM principles in order to achieve competitive advantage and increased revenue at the institutional level.

Academic Managerialism

While academic capitalism theory provides a lens through which to understand the changing relationship between academe and the marketplace, other perspectives can be utilized to better comprehend the shifts in the internal division of labor within higher education institutions. The changes brought about by the New Economy affect more than the production process, according to Castells. He stated:

…the economy is informational, not just information-based, because the cultural-institutional attributes of the whole social system must be included in the diffusion and implementation of the new technological paradigm, as the industrial economy was not merely based on the use of new sources of energy for manufacturing but on the emergence of an industrial culture, characterized by a new social and technical division of labor. (Castells, 2000, p. 100)

In the academic arena, the new social and technical division of labor described by Castells can be seen most readily in the instructional function, where information and communications technologies have had a profound impact on the cycle of production. This new social and technical division of academic labor is described by Rhoades (1998). He utilizes "enskilling" and "deskilling" labor theories to comment on the changing roles of faculty in relation to the instructional function of higher education. As the instructional paradigm has changed due to the use of ICTs in teaching and the massification of postsecondary education, the role of faculty is in flux. Faculty may either be retrained to utilize instructional technologies or be side-lined by technical experts who can perform the function for them. The decision to "opt out" of using instructional technologies poses career risks for faculty, especially those who are untenured and those who teach large undergraduate courses. Rhoades posited that when faculty shift their teaching to a digital environment they are subjected to increased managerial control and loss of autonomy. He stated that, "new technologies can pose a threat to that freedom, enabling detailed monitoring and/or surveillance of workers' activities" (Rhoades, 1998, p. 199).

Indeed, the instructional purview of faculty is undermined by the increase in the numbers of "managerial professionals," described by Rhoades and Sporn as "neither professors nor administrators," but individuals with "professional associations, conferences, journals and bodies of knowledge that inform their practice" (Rhoades & Sporn, 2002, p. 16). Rhoades and Sporn commented on the impact of managerial professionals on the instructional function of higher education by stating that, "most [universities] now have teaching centres and professional development centres staffed by full-time managerial professionals who directly and indirectly impact instructional delivery—for example, encouraging the use of instructional technology in classrooms" (Rhoades & Sporn, 2002, p. 16). The increase of managerial professionals creates a "matrix mode of production," meaning that the division of labor within academe is more distributed among various employment categories (Rhoades & Sporn, 2002). In other words, whereas the instructional function was previously performed by the lone faculty member with perhaps the aid of graduate teaching assistants, laboratory technicians, and secretaries, today faculty share the instructional function with instructional designers, multimedia specialists, courseware support analysts, library information specialists, and classroom technicians.

Although KM is seen as a rational (impartial) approach to asset valuation and strategic planning, it is critical for academic employees to recognize the ways in which professional self-preservation might affect the adoption and implementation of KM in the postsecondary environment. Knowledge management intersects this new production cycle often at the level of the managerial professional or upper-level administrator. As "management" is at the core of KM, it follows that those who manage will be the first to consider the use of KM in their workplaces, and the "problem-definition" phase of KM will be informed by their perspectives. Yet it is important for academic managers to fully comprehend the changes that have occurred in higher education with regard to the division of labor and production functions. For example, if one of the goals of KM is to optimize the quality/cost ratio, the increased expense of additional administrators and managerial professionals must be taken into account (Leslie & Rhoades, 1995). The cost of additional academic staff is particularly significant with regard to the instructional function, where expenditures for the technologies themselves are not likely to be fully recovered through increases in efficiency or by the implementation of new fees. Therefore, instructional expenditures per student must include the associated costs of instructional support staff and the technological infrastructure, not just faculty/student ratios.

Digital Capitalism

Digital capitalism frames the growth of the IT sector as an extension of the previous industrial economic cycle, with concessions to the thought that an observed "amplification" of capitalism might be a signal of the New Economy (or at least, a new economy). In Digital Capitalism: Networking the Global Market System (1999), Dan Schiller described the neoliberal transformation of electronic networks into a profit-generating system, where communications and data processing would eventually be deregulated in the United States. From military use to a federally funded inter-university research tool, what would become the Internet developed as a shared network using open-source software (Hafner, 1996). As the use of networks grew in U.S. business and finance, investment in computer equipment outpaced all other forms of capital from the late 1970s through the 1990s (Schiller, 1999). Schiller stated that "information technology investment, finally, and network applications in particular, comprised the pivot of a restructuring of big capital—both industrial and financial" (p. 17). The commercialization of the Internet led to a new production cycle, centered on the need for hardware and software to serve the growing number of (primarily American) business clients seeking to perform network transactions.

Although research universities were central to the early stages of the Internet, the role of such institutions since the 1970s is not fully explained by Schiller. Higher education's ties to digital capitalism are discussed in three ways in his book: the commoditization of education (through distance learning and electronic courseware), as a site of consumption of information technology, and as a partner with industry in research alliances. Schiller described the role of universities in research centers with strong ties to business, but only mentioned the use of information technology or production of software at these facilities in passing (Schiller, 1999, p. 164). Although listed by name as corporations with a large impact on worldwide markets for information technology throughout the book, Schiller provided just one sentence to say that "Netscape, Sun Microsystems, and Cisco comprise three leading Internet companies that were each direct spin-offs from academe" (p. 162). Instead of focusing on the development of information technologies on college campuses, Schiller centered on the consumption of technology in higher education, noting the speed at which schools were outfitted with high-speed networks, computers, and high-tech classrooms (p. 190). Yet, Schiller mentioned the for-profit provision of educational services through distance education and courseware production as a contribution to knowledge capital (pp. 185-202). Absent from his discussion of digital capitalism in academe is the growth of revenue-generating courseware and other instructional materials in the public education system, which Melissa Anderson describes as a form of "instructional capitalism" (Anderson, 2001). Further, it must be understood that information technology companies are active in the higher education sector and are becoming closely aligned with the business core of academic services (Metcalfe, 2004).

Thus, colleges and universities are closely tied to both production and consumption through their utilization and creation of information technology products. The framework of digital capitalism, also explored by McChesney, Wood, and Foster (1998), reminds us that the ubiquity of IT in our modern lives rivals that of ever-present capitalism. Not since the creation of the plastics industry have we been so transformed by a particular corporate sector, and just as we rarely object to the use of extruded petroleum byproducts in our lives these days, we rarely mind the ways in which IT has become a fixture of our work and leisure hours. Indeed it could be said that higher education is an environment that is at the forefront of the digital age, and that our campuses are places where it is difficult to labor or learn without high-technology. We might be lured, however, into the belief that academe is a hallowed grove more informed by the agrarian age than a post-industrial one, especially if we find ourselves in liberal arts institutions. Yet, Castells pointed us to the crux of working in a knowledge factory in a knowledge age when he stated that "in the new, informational mode of development the source of productivity lies in the technology of knowledge generation, information processing, and symbol communication" (Castells, 2000, p. 17). He further clarified this notion by stating that "what is specific to the informational mode of development is the action of knowledge upon knowledge itself as the main source of productivity" (Castells, 2000, p. 17).

THE POLITICS OF KNOWLEDGE MANAGEMENT

Although computer systems may seem inherently apolitical, the opposite is true as the digital environment is able to be shaped by nearly any political system or method of control (Loader, 1997). While most peope understand that organizations are rife with internecine struggles, few comprehend how these "turf battles" affect the informational culture and IT landscape. While power and control are at the heart of much of organizational strife, these battles may become most evident in political discussions of jurisdiction and territory. In this section, I discuss the connections between knowledge management and notions of digital democracy and the changes that globalization brings to the electronic environment in academe.

Digital Democracy

Since its introduction to society at large, networked computing has been considered in political terms. Jordan (2001) described early computer culture as anarchist and libertarian, citing organizations such as the Electronic Frontier Foundation and the Center for Democracy and Technology as influential in the formation of basic political values of the Internet and computing (see also Borsook, 2000). Jordan also noted the dominance of Anglo-American norms in cyberspace, including language preference (English) and the desire for self-governance. Other early proponents of the Internet imagined it to be an "electronic agora" (Rheingold, 1993), referencing the notions of egalitarianism and democracy thought to exist in ancient Greek marketplaces. This perspective saw the ancient agora as a place where free exchange of ideas and goods took place, and where equality was common. However, in the same manner that Jeffersonian Neoclassicists championed the characteristics of Greek society that best suited them (such as political representation solely for landowning male gentry), while ignoring considerable social injustices (slavery and the disenfranchisement of women, to name two examples), the application of false notions of ancient "democracy" to the Internet and computing environments only served to obfuscate the existence of digital power and inequality.

In fact, rather than having its roots in democratic ideals, the term "cyberspace" derives from another classical reference, the Greek word kubernetes, meaning helmsman or governor. Thus, at its very core, the digital environment is framed by administrative issues and governance structures (hence the job title "systems administrator"). Knowledge management, then, from a political perspective is as much about jurisdiction as it is about jurisprudence. This is readily understood when one considers the power of information and misinformation within a polarized or politicized organizational environment. Information technology networks are not just conduits for the flow of binary bits and bytes; computer systems are pathways between knowledge territories (Herbert, 2000).

In higher education institutions, this can be seen in the networked domains of separate colleges and departments, each with their own servers. Thus it can be said that higher education institutions exhibit characteristics of both provincial and federal systems of control. The languange of computing reinforces these territories by using words like "domain" to describe areas of administrative control. Knowledge management efforts rarely acknowledge these multi-layered organizational jurisdictions in a way that satisfies both the proponents of decentralization and the champions of central managerialism.

Campus environments can be both decentralized in their computing networks as well as bound together by a single "enterprise" system that serves as the business core of the organization. These campus-wide systems are today more often than not commercial products, sold to institutions by companies such as Sungard SCT, Datatel, and Campus Management. The enterprise software allows for integration of various campus units, such as student admissions, course registration, financial aid, and business services. In many cases, these units previously had their own computing systems and only minimal data sharing with other academic departments. As these units are linked by shared enterprise software and common datasets, information administration becomes more centralized. In circumstances where such campus-wide software is purchased, some degree of control over academic information management is ceded to the private sector. In fact, there are campuses where IT management is performed by employees of the vendors of enterprise software, with these "Outsourced CIOs" sitting on the president's cabinet (Metcalfe, 2004). The mix of public and private managers in these situations complicates the flow of information in higher education organizations, as work-processes themselves are seen as proprietary information and therefore subject to classification as "trade secrets" rather than open systems where anyone in the organization can track the flow of information from individual to individual.

Globalization

The term "globalization" is difficult to define, and even more difficult to determine where and if it exists. However complicated it may be to describe, most scholars agree that a restructuring is occurring on a global scale, affecting capital systems and social structures. In higher education, evidence of these changes are seen in the migration patterns of students and faculty, the development of cross-national education programs such as distance learning initiatives, and increasing internationalization of colleges and universities. Vaira (2004) noted the shifts in postsecondary education by stating:

> *…higher education is witnessing a process of deep institutional change that involves the deinstitutionalization of its rooted policy and values frameworks and the parallel institutionalization of new ones. These processes entail more or less strong resistances, conflicts, [and] tensions but also efforts to conciliate, adapt, translate, assemble the new with the old, the national features of higher education system with the new globalizing pressures, the single institutions structural and cultural features with the new imperatives and demands. (p. 485)*

The institutionalization of new policy and values frameworks, as informed by a globalized economic, social, and political reality, may be seen in the information systems of modern campuses. For knowledge management practitioners, it is important to note that as higher education is becoming more tied to global markets, the value of knowledge assets will be increasingly determined on a global stage. For example, if a university has an International Memorandum of Agreement with another university in a different country, intellectual capital built between the partners could be considered a shared commodity with different value for each contributing agency. What might have the most value to one of the partners might have the least value to the other partner, but the value is still there to be understood and recognized by both. This will be most important in terms of intellectual property policies and copyright laws, which may differ from institution to institution, country to country.

Furthermore, globalization affects the learning environment of higher education in such a way that KM practices should consider the various cultural and language systems embedded within information technology, especially courseware. In a multi-ethnic, multi-lingual learning environment, what values are conveyed by the course management systems given that many have been created in North America (e.g., WebCT and Blackboard)? Are there cultural forms of expression that cannot be conveyed online? Does this have a negative impact on teaching and learning? Perhaps most importantly, does the exportation of courseware reinforce economic, social, and political structures? For example, if Mexican higher education institutions purchase courseware developed in Canada or the United States, does this perpetuate the political and economic dominance that has already made North America an unbalanced trade region? What are the effects of the commercialization of academic IT on national identity? What forces prevent Mexican institutions from developing their own courseware, in Spanish? As globalization continues to become evident in higher education, questions such as these should guide information technology managers in the academic setting.

THE SOCIOLOGY OF KNOWLEDGE MANAGEMENT

The field of knowledge management can benefit from sociological perspectives for several reasons. First, the social study of science, including computer science, has led to a rich body of literature detailing the ways in which patterns of communication and interpersonal relations affect organizational systems. The scholarship, often under the heading of society, technology and society (STS) studies, provides much food for thought for those who attempt to shape "irrational" organizations through seemingly "rational" means. Also, sociological perspectives are important to knowledge management as it is people who are the most important assets of an organization. Understanding the motivations and influences of individual actors is critical to successful KM implementation. In addition, it is important for KM practitioners to understand that technology is not "neutral;" that it is instead created from a particular world-view, and as such performs as a proxy for specific individuals within an organization. In this section I briefly describe the social construction of technology.

Social Construction of Technology

The term "technological determinism" can be defined as the impact of technology on society and the way in which social processes and progress are fixed by the development of particular technological innovations (see Winner, 1977, 2001). While it is not impossible to imagine a world without computers, for example, it is difficult to conceptualize what our contemporary lives would be like without such a technological development. Yet it is more challenging to parse out how computers have determined particular social structures, functions or layers of social contact that would not exist without them. Ultimately, it is first a human that sets the technological "wheel" in motion, and the consequences of that action are either beneficial or harmful to society at large (Tenner, 1996).

A conceptual framework for research on the relationship between technology and society was presented by Pinch and Bijker in a chapter titled, "The Social Construction of Facts and Artifacts: Or How The Sociology of Science and The Sociology of Technology Might Benefit Each Other" (1987). They discussed the empirical approach to the social construction of technology (SCOT) as a three-stage process. First, they stated that the "interpretive flexibility" of the technology or technological artifact must be acknowledged. They elaborated by saying that, "By this we mean not only that there is flexibility in how people think of or interpret artifacts but also that there is flexibility in how artifacts are designed" (p. 40). In other words, technological artifacts are shaped by the inventor as much as they are shaped by the subsequent users. Second, they discuss a period of "stabilization and closure" that occurs with the development of technologies, where the artifact in question has "solved" a particular problem or the problem for which the artifact was originally intended is no longer relevant. This stage is an interesting one in that it highlights the ways that technology is used and repurposed by relevant social groups, rather than just the outcomes that were intended by the developer. Their final stage of analysis involves the "wider context" and how a particular technological innovation has affected the "sociopolitical milieu" (p. 46). This stage involves the development of values and social meanings around objects and their function. While this particular research method has its critics (see Klein and Kleinman, 2002), it nonetheless is an important process from which to consider the mutual shaping of technological artifacts and social systems.

For the field of KM, the research techniques outlined by Pinch and Bijker can be useful ways to understand how information and communications technologies are both created and utilized in an organizational setting. Pertinent questions can be asked by following the SCOT approach, including "What is the problem that is to be solved," and "Who is involved in the process of developing the system (the relevant social groups) to solve this problem?" Furthermore, the SCOT approach acknowledges that there are many possible solutions to any given problem, and the final product will be constructed by the "technological frames" or viewpoints and value-systems held by the developers.

Complimentary approaches to understanding the impact of technological innovations on society include Thomas's "power-process" model. In What Machines Can't Do: Politics and Technology in the Industrial Enterprise (1994), Thomas discussed his "power-process" model, which offers a new perspective on the forces behind the development and implementation of new technologies. Thomas argued that too often the study of technology focuses only on the implementation stage of technological change, and infrequently considers the social and political factors present within an organization that affect the choices made during the entire process. Thomas identifies three stages of change: (1) the identification of the problem that requires attention and the proposal for technological change, (2) the selection between presented technological alternatives, and (3) the implementation of the chosen innovation. Thomas also presented a set of methodological guidelines to use while studying the process of technological change. He promotes taking account of the organizational and decision-making history, paying greater attention to how dissimilar logics are coupled (e.g., technological determinism and social change theory), focusing on the process of choice, and assessing the role of power and worldview of the decision-makers and other organizational members.

Like the SCOT approach, the power-process model contextualized technological change within a social or organizational environment. It recognizes that many individuals are involved in the development of technological solutions, and also highlights the consequences of leaving key players out of the development process. A central element of the model that is critical for those who want to utilize KM techniques is the understanding of the role of power and authority within an organization. Who makes the final decisions in an organization is often more important than the many hours of preparation and planning that might occur around technological change.

Finally, it must be understood that the technology itself bears the imprint of the values and attitudes of its designers. This is made very clear in Forsythe's research as presented in her article, "New Bottles, Old Wine: Hidden Cultural Assumptions in a Computerized Explanation System for Migraine Sufferers" (1996). Forsythe describes the development and implementation of a digital solution to the problem of the tedium of taking patient histories during a doctor's visit in a medical office. Due to the exclusion of migraine sufferers from the design phase, the computerized system that was finally developed was "designed to persuade the patients that the physician's diagnosis of their headaches is correct" rather than truly discover the root causes of the patients' headaches (p. 566). Forsythe found the development of the system as an example of a "technological imperative." She stated that:

practitioners in medical informatics take for granted the benefits of automation, including computerizing the doctor-patient communication that might otherwise take place face to face. In medical informatics, intelligent systems technology is treated as a solution in search of a problem. (p. 570)

Forsythe's work reminds us that "innovation" is often in the eye of the beholder. For KM practitioners, it is important to recognize that personal zeal or affinity for a technological solution may not be in the best interest of the community that the solution is intended to serve.

CONCLUSION

In the Information Age, technological infrastructure is an instrument of power, "whether transparent or opaque." Star (1995, 1999) noted that "the ecology of the distributed high-tech workplace, home, or school is profoundly impacted by the relatively unstudied infrastructure that permeates all its functions" (p. 379). As such it is important for us to recognize the economic, political, and social motivations behind the development of technological "solutions" in organizational settings. In higher education in particular, the knowledge-intensive environment would seem especially ready for the variety of changes that can be brought by way of information technologies, but the "technological imperative" must not sway developers and users of these systems. The "build it and they will come" approach may result in costly development of an underutilized system if in fact the people involved in the implementation are not keen on the project or its intended effects.

Thus, the use of knowledge management principles should proceed only with the careful examination of the economic, political, and social implications of knowledge codification in higher education. Aspects of market-value, political power, and social stratification will impact the development of any technological solution. To counteract the potentially negative effects of technological change in higher education, critical questions must be asked. We must ask why the products of higher education are to be evaluated relative to market value rather than the social good. We should ask who will gain access to our common and individual intellectual property. Furthermore, we should insist that we are made aware of the ways in which our work will be monitored and by whom. Finally, we need to know exactly who will reap the reward when our knowledge is "captured."

REFERENCES

Anderson, M. S. (2001). The complex relations between the academy and industry: Views from the literature. *Journal of Higher Education, 72*(2), 226-246.

Bijker, W., Pinch, T., & Hughes, T. (Eds.). (1989). *The social construction of technological systems.* Cambridge, MA: MIT Press.

Borsook, P. (2000). *Cyberselfish: A critical romp through the terribly libertarian culture of high-tech.* New York: PublicAffairs Press.

Castells, M. (2000). *The rise of the network society* (2nd ed.). Oxford: Blackwell Publishers.

Ewell, P. T. (1999). Imitation as art: Borrowed management techniques in higher education. *Change, 31*(6), 10-15.

Forsythe, D. E. (1996). New bottles, old wine: Hidden cultural assumptions in a computerized explanation system for migraine sufferers. *Medical Anthropology Quarterly, 10*(4), 551-574.

Getz, M., Siegfried, J. J., & Anderson, K. H. (1997). Adoption of innovations in higher education. *Quarterly Review of Economics and Finance, 37*(3), 605-631.

Hafner, K. (1996). *Where wizards stay up late: The origins of the Internet.* New York: Simon and Schuster.

Herbert, S. (2000). Zoning cyberspace. *Studies in Law, Politics, and Society, 20*, 101-123.

Jordan, T. (2001). *Cyberpower: The culture and politics of cyberspace and the Internet.* New York: Routledge.

Katz, R. N., & Oblinger, D. G. (Eds.). (2000). *The "E" is for everything: E-commerce, e-Business, and e-Learning in the future of higher education.* San Francisco: Jossey Bass.

Kettinger, W. J. (1990). The decentralization of academic computing: Defining future roles. *CAUSE/EFFECT, 13*(3).

Kidwell, J. J., Vander Linde, K. M., & Johnson, S. (2001). Applying corporate knowledge management practices in higher education. In G. Bernbom (Ed.), *Information alchemy: The art and science of knowledge management* (pp.1-24). San Francisco: Jossey-Bass.

Klein, H. K. & Kleinman, D. L. (2002). The social construction of technology: Structural considerations. *Science, Technology, & Human Values, 27*(1), 28-52.

Leslie, L. L. & Rhoades, G. (1995). Rising administrative costs: On seeking explanations. *The Journal of Higher Education, 66*(2), 41-61.

Lessig, L. (2001). *The future of ideas: The fate of the commons in a connected world.* New York: Random House.

Loader, B. (Ed.) (1997). *The governance of cyberspace: Politics, technology and global restructuring.* New York: Routledge.

Lyman, P. (2001). Knowledge discovery in a networked world. In G. Bernbom (Ed.), *Information alchemy: The art and science of knowledge management* (pp.1-24). San Francisco: Jossey-Bass.

McChesney, R. W., Wood, E. M., & Foster, J. B. (1998). *Capitalism and the Information Age: The political economy of the global communication revolution.* New York: Monthly Review Press.

Metcalfe, A. S. (2004). *Intermediating associations and the university-industry relationship.* Unpublished doctoral dissertation, Center for the Study of Higher Education, The University of Arizona.

Pfeffer, J., & Salancik, G. R. (1978/2003). *The external control of organizations: A resource dependence perspective.* Stanford, CA: Stanford University Press (original work published 1978).

Pinch, T., & Bijker, W. (1987). The social construction of facts and artifacts: Or how the sociology of science and the sociology of technology might benefit each other. In W. Bijker, T. Hughes, & T. Pinch (Eds.), *The social construction of technological systems: New direction in the sociology and history of technology* (pp. 17-50). Cambridge, MA: MIT Press.

Reingold, H. (1993). *The virtual community: Homesteading on the electronic frontier.* Reading, MA: Addison-Wesley.

Rhoades, G. (1998). *Managed professionals: Unionized faculty and restructuring academic labor.* Albany: State University of New York Press.

Rhoades, G., & Sporn, B. (2002). New models of management and shifiting modes and costs of production: Europe and the United States. *Tertiary Education and Management, 8,* 3-28.

Salancik, G. R., & Pfeffer, J. (1974). The bases and use of power in organizational decision making: The case of a university. *Administrative Science Quarterly, 19*(4), 453-473.

Schiller, D. (1999). *Digital capitalism: Networking the global market system.* Cambridge, MA: MIT Press.

Serban, A. M., & Luan, J. (Eds.). (2002). Knowledge management: Building a competitive advantage in higher education. *New Directions for Institutional Research,* No. 113. San Francisco: Jossey-Bass.

Slaugher, S., & Leslie, L. (1997). *Academic capitalism: Politics, policies, and the entrepreneurial university.* Baltimore: Johns Hopkins Press.

Slaughter, S., & Rhoades, G. (2004). *Academic capitalism in the new economy: Markets, state, and higher education.* Baltimore: Johns Hopkins Press.

Star, S. L. (1995). *The cultures of computing.* Cambridge: Blackwell Publishers.

Star, S. L. (1999). The ethnography of infrastructure. *American Behavioral Scientist, 43*(3), 337-391.

Tenner, E. (1996). *Why things bite back: Technology and the revenge of unintended consequences.* New York: Alfred A. Knopf.

Thomas, R. J. (1994). *What machines can't do: Politics and technology in the industrial enterprise.* Berkeley: University of California Press.

Vaira, M. (2004). Globalization and higher education organizational change: A framework for analysis. *Higher Education, 48*(4), 483-510.

Winner, L. (1977). *Autonomous technology: Technics-out-of-control as a theme in political thought.* Cambridge, MA: MIT Press.

Winner, L. (2001). Where technological determinism went. In S. H. Cutcliffe & C. Mitcham (Eds.), *Visions of STS: Counterpoints in science, technology and society studies* (pp. 11-17). Albany: State University of New York Press.

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Chapter 5.24
Learning in Organizations

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INTRODUCTION

In work life, socially based learning occurs all the time. We learn from interactions between peers, genders, functional groups, and across hierarchies, and it happens in ways not normally recognized as learning (Jordan, 1993). Therefore, use of the term "social" learning reflects that organizations, organizational units, and work groups are social clusters, as are study groups and task groups, and thus learning occurs in a social context.

In this situation, social learning is defined as learning occurring within or by a group, an organization, or any cultural cluster and it includes:

- The procedures by which knowledge and practice are transmitted across posting cycles, across different work situations and across time;
- The procedures that facilitate generative learning—learning that enhances the enterprise's ability to adjust to dynamic and unexpected situations and to react creatively to them.

Social learning represents important processes that contribute to individuals' abilities to understand information, create knowledge from that information, and share what they know. Social learning is therefore intrinsic to knowledge management.

This article is based on research conducted by the Enterprise Social Learning Architectures (ESLA) team. The ESLA team was created in

1998 to carry out a research study into "social learning" and the organizational culture that supports such learning. The study, spanning a period of four years, took place in a number of different settings within the Australian Defence Organisation (ADO).

The findings of this research are of importance because the ADO, like other organizations, faces the problem that much of the organization's memory and knowledge is "walking out the door" in terms of the skills, experience, and the corporate knowledge of its ex-employees. In the current climate, the competitive edge lies in gaining the knowledge edge, and to do so requires an understanding of how new knowledge is generated within groups, what motivates people to share what they know, how it is shared between and managed amongst members of an organization, and to what extent organizational culture influences social learning. In this article, we explore some of the organizational factors that enhance social learning and as such, are instrinsically related to knowledge management, as there is a symbiotic relationship between the two concepts.

BACKGROUND

A key assumption underlying the study was that research aimed at explicating social learning requires a socio-technical approach. Many organizations invest heavily in implementing information technology in the hope of providing a seamless solution to managing information resources and organizational knowledge. Unfortunately, these initiatives are often implemented without much regard to how people in organizations go about creating, acquiring, sharing, and making use of information (Bednar, 2000; Davenport, 1994; Vandeville, 2000). The greatest knowledge base in the company does not reside in a computer database somewhere but in the heads of the individuals associated with that organization. These individual knowledge bases are continually changing and adapting to the real world in front of them. Therefore, these individual knowledge bases need to be connected together so that they can do whatever they do best in the shortest possible time. New communication technology will certainly support information sharing where physical proximity is not a possibility. However, the technology alone will not create the trust and interpersonal context necessary to achieve a true network. It is, therefore, necessary to prepare the cultural ground. Values cannot be shared electronically or via bits of paper. Organizations are not based on electronic networks, rather, relationships must be initially constructed through face-to-face interactions (Davenport, 1994). Thus, knowledge sharing will depend on the quality of conversations, formal or informal, that people have (Davenport & Prusak, 1998).

Research on the cultural aspects of those organizations that foster new knowledge and generative learning suggests that employee trust and open communication play an integral role. Higher levels of trust between managers and employees are correlated with more open communication (Ruppel & Harrington, 2000). Schein (1993) and Phillips (1997) suggest that information sharing promotes common identity, mutual trust, and organizational learning and is directly related to organizational cultures that foster generative learning. Schein (1993) also claims that opening up and sharing encourages integration between organizational subcultures and, in turn, organizational adaptation to change. Organizations have a responsibility to create a culture in which learning occurs and that culture will determine the quality of learning that takes place. Such a culture provides the opportunity for personal contact so that tacit knowledge, which cannot effectively be captured in procedures or represented in documents and databases, can be transferred (Davenport & Prusack, 1998; Webber, 1993). For this to occur, the focus has to be on increasing the ability of the individual, as it would be the collective result of many individual actions that would produce a result for the whole of the organization. In a culture that values knowledge, managers recognize not just that knowledge generation is important for business success but also that it should be nurtured.

The methodology of the study evolved over time and included qualitative and quantitative aspects. The research team used ethnographic techniques in the form of fieldwork, which entailed observing the work taking place in different settings, and using directed questioning to clarify issues. In addition to ethnographic observations, the ESLA team undertook extensive, semi-structured interviews with a stratified sample of staff to ensure that an adequate representation was achieved. More than 60 interviews were conducted, and all interviews and field notes were transcribed, coded, and analyzed using the qualitative software package N'Vivo.

The quantitative method involved a questionnaire consisting of Likert scale questions, some open-ended questions, as well as questions ranking listed attributes. In addition, the questionnaires were designed to collect some demographic data about study participants. The response rate for the questionnaires was more than 90%.

The combination of methods offered complementary perspectives of each of the settings. The observations and interviews provided data that offered the insiders' points of view and also shed light on unique aspects of the various social settings that were studied, adding richness to the data. On the other hand, the quantitative surveys enabled generalizations across the settings and answered "what if" types of questions.

SOCIAL LEARNING ENABLERS

A set of overarching organizational values will determine what type of learning culture and organizational communication climate prevails within any company. The ESLA research findings indicate that in organizational cultures characterized by trust, transparency of decision-making, empowerment and forgiveness of mistakes, sharing of information is widespread. It is difficult to determine whether the organizational cultural values are an organizational "property" adopted by its staff or whether these values are influenced by individuals and their belief system. However, within the same organization, different units were operating according to a different "cultural code". This seems to indicate that each individual staff member can mold their organizational culture within the spheres of their responsibility or influence and, as stated earlier, it is the collective sum of individual actions that results in learning at the organizational level.

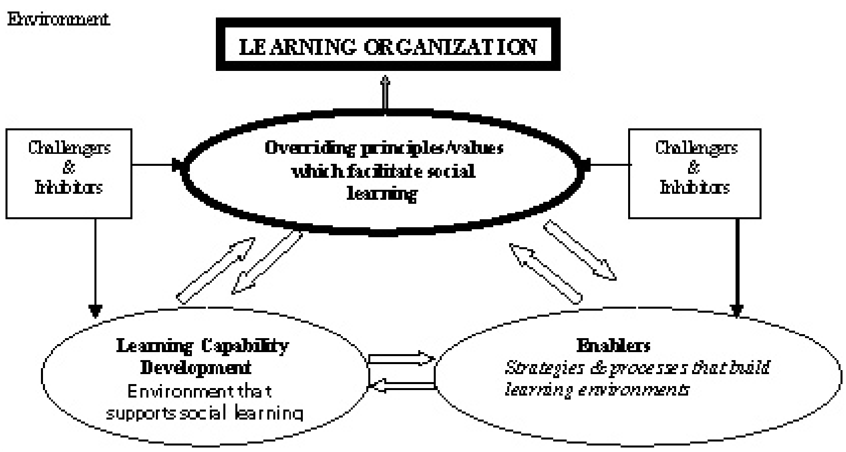
In addition to the overarching values, the research identified an additional set of factors that supports and enables effective social learning. These factors fall into two categories. The first, Learning Capability Development, refers to characteristics in the environment and provides a context in which the second category operates, such as organizational infrastructure. This second category is referred to as Enablers and represents processes and strategies that, if present and effectively applied in an enterprise, can facilitate social learning, such as Common Identity, Team Building, Access to Information, Development of Individual Expertise, and Induction and Enculturation.

As depicted in Figure 1, all of these social learning factors can, from time to time, be either inhibited or challenged by issues such as political and economic vagaries, budget uncertainty, organizational restructures, retrenchments, and so forth.

A graphical representation of the structured social learning architecture is shown in Figure 2.

A common finding through all the settings studied was the impact of trust and open communication on the enablers of generative and social learning. This is because of trust's impact on willingness to share knowledge and to voice ideas.

Figure 1. Factors impacting on social learning in organizations



Higher levels of risk-taking behavior have been found to result from increased trust in co-worker relationships (Mayer, Davis, & Schoorman, 1995) and from supervisors showing concern for employees' ideas and feelings (Oldham & Cummings, 1996). Additionally, greater risk-taking can result from increased trust for supervisors, in that co-workers' preparedness to act in innovative ways is a form of risk-taking, and it can be encouraged by supervisors' acceptance of mistakes as learning tools, which is a form of trust (Costigan, Itler, & Breman, 1998). Moreover, employees see themselves as more motivated and more likely to take initiative in professional development activities when they have higher levels of trust for their supervisors (Costigan et al., 1998).

The ESLA research findings point to a recursive relationship between trust and employees' sense of empowerment and self-esteem. Employees who are feeling good about themselves and their value to the organization are likely to be motivated, reliable, and have loyalty to the organization. This loyalty will precipitate higher productivity, higher staff retention rates, and the willingness to share knowledge and ideas with others, thus contributing to the knowledge base of the organization. These relationships are depicted in Figure 3.

The literature supports the findings that trust is pivotal in climates of organizational change and when environments are uncertain (Kramer & Tyler, 1995). The results of the ESLA quantitative surveys indicate that trust in leaders and their decision-making played an important part, with just over half (53%) of respondents saying that they trust decisions made by their leaders. It is interesting to note that the higher up the hierarchical chain, the greater the level of agreement with this statement. Nevertheless, the need for more transparency of organizational decision-making was often repeated. One of the interviewees put it very succinctly:

We need a far more open information network that actually allows us to see how the organization works.

Figure 2. Structured social learning architecture

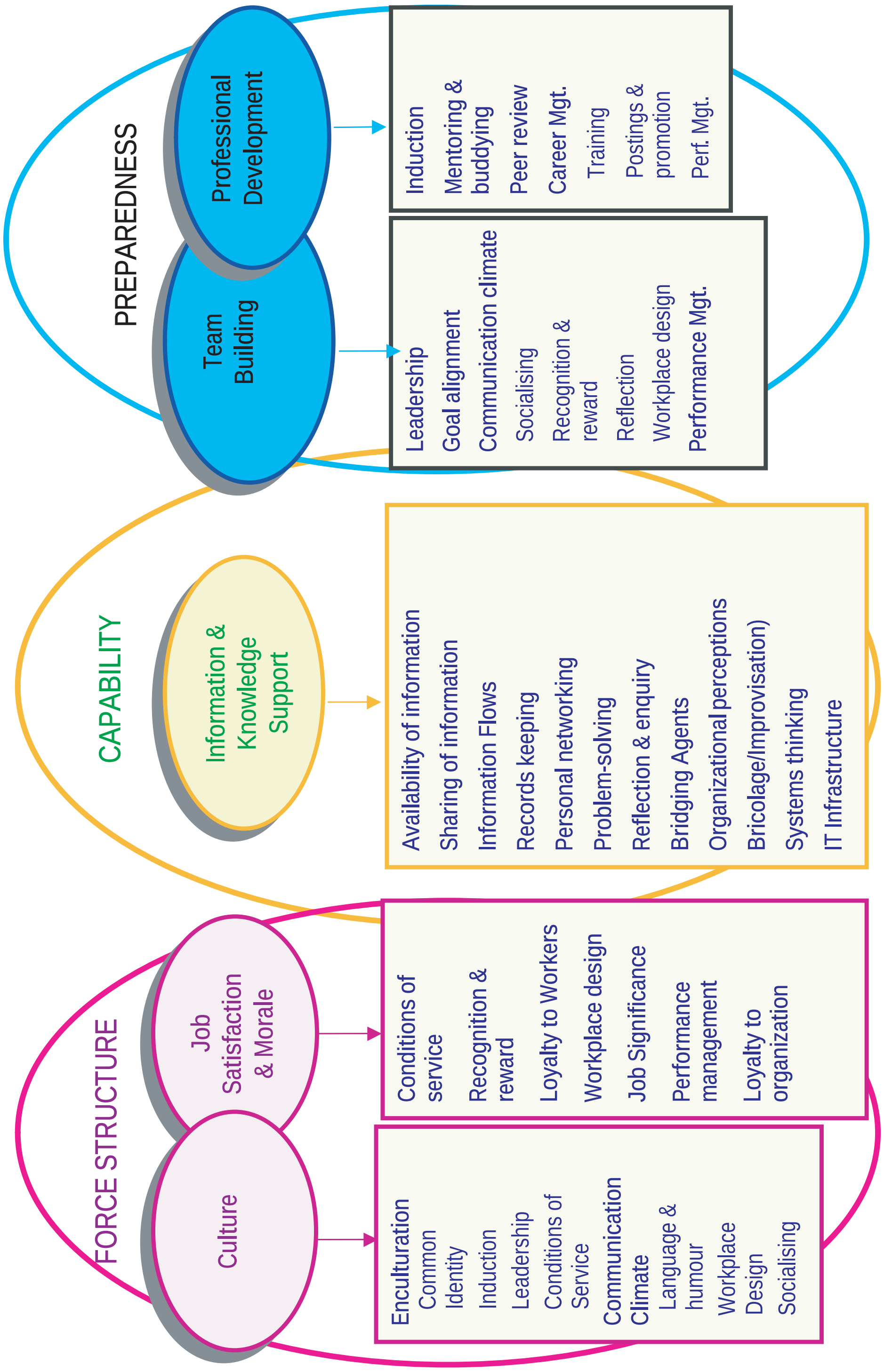
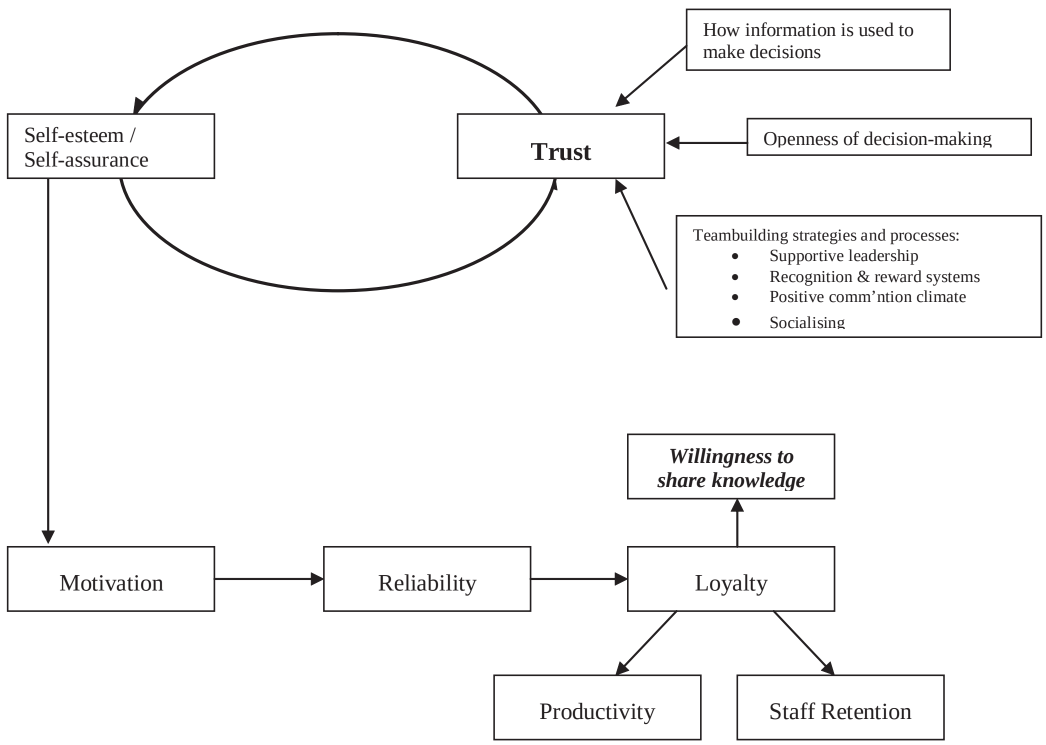


Figure 3. The role of trust in organizations



The ESLA research data clearly points out that the qualities of certain leaders and the team cultures these leaders create are associated with high levels of trust within those teams, and a generally positive attitude toward collaboration and teamwork. For instance, in teams characterized by cohesiveness and strong team spirit, leaders took on the role of a facilitator, rather than a traditional command-control role, thus allowing people to shape their work themselves. These leaders empowered people to go and seek out their own solutions rather than mandating actions, and they positioned people in ways so as to leverage their unique strengths, to make their own decisions, and have their own responsibilities. They encouraged a wide span of communication so that the individuals in need of information were able and free to consult not only their immediate work group but also the entire organization and beyond and any network that they needed to go to for information. This way these individuals were able to solve their problems quickly and to provide a rapid response to the customer. Moreover, these leaders used frequent two-way feedback to convey their expectations, as well as asking the staff to provide feedback on their own performance. The ESLA team was told that this type of leadership also gave the staff a tremendous opportunity to explore, improvise, and learn.

The ESLA researchers also were given examples of team leaders who motivated people and built trust by providing every opportunity for their personal and professional development. These leaders were able to motivate people in order to bring the best out of team members and to achieve results. Additional methods of team motivation that were observed included celebrating individual and team achievements, and always looking for something positive to say about each team member.

Leaders of successful teams were able to set realistic expectations of their team. Numerous staff interviewed said that knowing what their leaders are expecting of them is one of the most important factors for successful teamwork because it allowed the team to have achievable goals. Furthermore, staff were constantly kept informed and in the loop by e-mails, drop-ins, and meetings. In many cases, at the onset of a new posting, leaders were forthcoming with their vision and expectations of the team, as is indicated by the following:

…the first day he started, he sat us all down in a big meeting for about two and a half hours and he said this is what I expect of you and he had the white-board out and then we could let him know what we expected of him and it was a good way to start.

However, this practice was not prevalent throughout all the settings under study. The survey data points out that 58% of respondents in one of the settings felt that their supervisors did not communicate their expectations of day-to-day work requirements well. This breakdown in communications, along with a lack of transparency in decision-making processes, became a fertile breeding ground for organizational politics and low morale and subsequently diminished opportunities for social learning.

The interview data and the survey data clearly indicated that good communication skills were considered to be one of the most valued factors of effective leadership, as stated by one of the informants:

…if I pick on three things, I'd say communication skills, observation skills, you know your ability to observe and to take in data, and then also a bit of a brain on your head so you can make sensible decisions, on the basis of that.

In most instances, staff spoke very highly about their leaders, and 83% felt that in their team good leadership enhanced teamwork; however, the ESLA team was made aware that:

…some of the people we have in positions of authority don't have a schmick about manpower management, they really don't. Some are good, I mean it's not a manual skill, it's an emotional skill.

The power of positive feedback, recognition, and reward cannot be overemphasized, not only for building a team's performance but also for the building of trust. This recognition must apply not only to big tough jobs but equally to quiet, unassuming day-to-day tasks. Mitchell (2000) points out that making employees feel appreciated, focusing attention on their good ideas, inviting them to extend themselves, and saying "thank you, we know that you are a good employee, we value you and your work," is a big factor in motivation. A positive self-image and self-confidence is one of the early steps toward effective motivation. A person who feels motivated and feels good about himself or herself acts with confidence. Individuals empower themselves by receiving positive feedback and add to the empowerment of others when recognition is given freely (Katzenback & Smith, 1993).

A lack of day-to-day recognition of one's work came through very strongly as an issue. The research data indicated that recognition of one's achievements and good work was well established in some teams; however, this practice was not widespread throughout all the settings studied. In some units, the managers used recognition and praise as an empowering tool within their teams; however, the same managers were often not recognized themselves, by their own superiors.

[Recognition] it's something that your boss says to you each day, saying, 'Jeez, that piece of writing was really good, mate. You did a great job there.' It's that sort of mentality that we have to get through to our senior managers...

Most of the respondents (86%) indicated that recognition comes foremost from their immediate team members and 62% said that their supervisors always acknowledge their positive contributions at work. The researchers were told that in some teams there are special celebrations once an important piece of work is satisfactorily completed or milestones are reached. Such celebrations reinforce for workers that their efforts are valuable to the team's functions and products. It is clear that the benefits of recognition and reward flow in two directions, on one side there is a benefit for the individual and their willingness to share knowledge, and on the other, the supervisors are gaining respect and trust from their staff. The following quote depicts this:

…the flow on effect of that [recognition] is that the rest of the group say, 'Hey gees, you know, yeah she has done a good job. Yes and she's been recognized for it. Yeah. It's not such a bad group that we were working for.' And the flow on to me is they see that I care, as a supervisor, and I'm prepared to recognize good work. But culturally—culturally we don't put the importance on this, I think, that we should…

The research data strongly indicates that socializing plays an important role in trust building and social learning. The aspect of "feeling good" about work colleagues is an important motivating factor and a factor contributing to building trust amongst employees and, again, their willingness to share knowledge. Maslow's theory of motivation identifies a sense of belonging to a group and getting to know each other as a vital step in the life of a team and in achieving set goals. As they get to know each other, the team members derive satisfaction from belonging to a cohesive team, but more importantly, they become aware of each other's strengths and weaknesses, what they can or cannot do, their expertise and experience. This knowledge facilitates utilizing each team member to their full potential.

The respondents indicated that work-related social activities led to a greater sense of team spirit (85%). These social activities were not just frivolous functions; they were core activities that were ultimately task oriented. As one of the respondents put it:

…it is important and we do, we have time out where we go for coffee and to chat, it's team building and getting to know each other, and I think that's really important because you need to get to know the personalities on your team….We talk about work things when we're having coffee, but it's joking and fun.

Scholars use the term social capital to refer to human relationships that make organizations work effectively. Healthy social relationships in organizations build trust, make people learn faster and be more productive and creative (Prusak & Cohen, 2001). However, building successful social relationships in organizations during times of constant change, staff shortages, and pressure to deliver with fewer resources is extremely difficult.

...People in the headquarters need to let off steam, so if everybody was just working constantly five days a week with no let-up, you know, you'd start to get cracks in the organization. So people do appreciate it, [socializing] you know, when it happens...

The ESLA research data indicates that social activities lead to greater team cohesion and enhanced team morale. Informal social gatherings allow people to get to know each other, build trust and stronger relationships, and (more importantly) share knowledge. Many interviewees stated that during such informal social gatherings they learn more about what is happening in other units in the organization than through formal channels.

CONCLUSION

Social learning requires individuals to be willing to share their knowledge and to be willing to voice their ideas. In this way, shared knowledge empowers not only the individual, but also the team and the organization as a whole.

The ELSA research findings indicate that the requisite cohesion and commitment arises from effective leadership, transparency in decision-making and communication, appropriate reward and recognition, socializing, and commitment to a common goal. However, trust appears to be an overriding requirement, one that provides the glue that binds these processes and strategies for effective social learning and building of corporate knowledge. Knowledge sharing cannot be mandated, it must occur willingly. It is for this reason that trust must underpin the team building behaviors and attitudes that result in the confidence and cohesion needed to openly share knowledge, construct new knowledge, and build stronger organizations.

The implications of the research are that organizations seeking to improve information sharing and knowledge generation need to develop a greater awareness of the processes and strategies of organizational learning. Organizational knowledge is distributed across functional groups and its generation and continual existence is dependent on the overall organizational culture. This study indicates that information sharing and subsequent knowledge generation would be successful when interactive environments are cultivated before other solutions are implemented, particularly those based on technology alone.

REFERENCES

Ali, I., Pascoe, C., & Warne, L. (2002). Interactions of organizational culture and collaboration in working and learning. *Educational Technology and Society, 5*(2), 60-69.

Ali, I., Warne, L., Agostino, K., & Pascoe, C. (2001, June 19-22). *Working and learning together: Social learning in the Australian Defence Organization*. Informing Science Conference IS2001—Bridging Diverse Disciplines Proceedings (CD-ROM), Krakow, Krakow University of Economics, Poland.

Bednar, P. (2000). A contextual integration of individual and organizational learning perspectives as part of IS analysis. *Informing Science, 3*(3), 145-156.

Costigan, R.D., Itler, S.S., & Breman, J.J. (1998). A multi-dimensional study of trust in organizations. *Journal of Management Issue, 10*(3), 303-317.

Davenport, T.H. (1994). Saving IT's soul: Human-centered information management. *Harvard Business Review,* March-April.

Davenport, T.H., & Prusack, L. (1998). *Working knowledge: How organizations manage what they know.* MA: Harvard Business School Press.

Jordan, B. (1993). *Ethnographic workplace studies and computer supported co-operative work*. Interdisciplinary Workshop on Informatics and Psychology. Scharding, Austria.

Kazenback, J.R., & Smith, D.K. (1993). The discipline of teams. *Harvard Business Review,* March-April, 111-120.

Kramer, R.M., & Tyler, T.R. (1995). *Trust in organizations, frontiers of theory and research*. Sage Publications.

Mayer, R.C., Davis, J.H., & Schoorman E.D. (1995). An integrative model of organizational trust. *Academy of Management Journal, 20*(3), 709-734.

Mitchell, S. (2000). Be bold and discover the power of praise. East Roseville: Simon & Schuster.

Oldham, G.R., & Cummings, A. (1996). Employee creativity: Personal and contextual factors at work. *Academy of Management Journal, 39*(3), 607-635.

Phillips, R.A. (1997). A stakeholder theory and principle of fairness. *Business Ethics Journal, 7*(1), 51-66.

Prusak, L., & Cohen, D. (2001). How to invest in social capital. *Harvard Business Review, June*, 86-93.

Ruppel, P.C., & Harrington, S.J. (2000). The relationship of communication, ethical work climate, and trust to commitment and innovation. *Journal of Business Ethics, 25,* 313-328.

Schein, E.H. (1993). Organizational culture and leadership. *Organizational Dynamics, 22*(2), 40-51.

Vandeville, J. (2000). Organizational learning through the collection of 'Lessons Learned.' *Informing Science, 3*(3), 127-133.

Warne, L. Ali, I., & Pascoe, C. (2002). Sharing knowledge through effective team building: Trust vs. the information power dynamic. *Proceedings of the Australian Conference for Knowledge Management and Intelligent Decision Support,* In F. Burstein & H. Linger (Eds.), Melbourne, (pp. 73-85).

Warne, L., Ali, I., & Pascoe, C. (2003). *Social learning and knowledge management: A journey through the Australian Defence Organization*: The final report of the enterprise social learning architectures task, DSTO-RR-0257, AR 012-854, Defence Systems Analysis Division, DSTO Information Sciences Laboratories, South Australia.

Webber, A.M. (1993). What's so new about the new economy? *Harvard Business Review,* January/February, 24-42.

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Chapter 5.25
Mapping Group Knowledge

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INTRODUCTION

During group meetings it is often difficult for participants to effectively: share their knowledge to inform the outcome; acquire new knowledge from others to broaden and/or deepen their understanding; utilise all available knowledge to design an outcome; and record (to retain) the rationale behind the outcome to inform future activities. These are difficult because, for example: only one person can share knowledge at once which challenges effective sharing; information overload makes acquisition problematic and can marginalize important knowledge; and intense dialog of conflicting views makes recording more complex.

This article reports on the social process of mapping group knowledge which aims to better support the processes of sharing, acquiring, utilising and retaining, knowledge during group meetings. Mind mapping, causal mapping (Eden, forthcoming), concept maps (Gaines & Shaw, 1995a), and various mapping techniques reported in Huff and Jenkins (2002) have been used to structure and represent individual thinking and knowledge about an issue. Software now exist to support these mind-mappers (e.g., MindMap®, KMap, Decision Explorer). However, often individuals cannot solve problems themselves and instead need insight from a range of people who can collectively address the problem. For example, groups are often used where issues are so complex that they require the involvement of a number of diverse knowledge holders. Also groups are often used where political considerations suggest that the involvement of various key people would facilitate the implementation of actions.

Thus, the principles of mapping individual knowledge have been applied to small groups of people to support their collective structuring and thinking about an issue. Approaches such as Dialog Mapping (Conklin, 2003), concept mapping (Gaines & Shaw, 1995a), and Journey Making (Eden & Ackermann, 1998a) can all support the process of mapping group knowledge during meetings. While it is possible to deploy these approaches using flipchart paper and pens, software have been developed to support these particular approaches (i.e., Compendium, KMap, and Group Explorer, respectively). These software aim to capture, represent, and model the participants' knowledge in a more versatile manner than is possible on paper, enabling more effective navigation and consideration of the breadth and depth of issues.

This article begins with an introduction to the research on mapping knowledge. Then it reviews the benefits for knowledge management of engaging groups in mapping their collective knowledge. An example of a computer-based mapping methodology is briefly introduced—the Journey Making approach. Future research directions and implications for knowledge management conclude the article.

BACKGROUND TO RESEARCH ON MAPPING

Much work has been performed on the applications of cognitive and causal mapping, for example mapping for: negotiation (Bonham, 1993), strategic management (Carlsson & Walden, 1996), strategy (Fletcher & Huff, 1994; Bougon & Komocar, 1994), communication (Te'eni, Schwartz, & Boland, 1997), litigation (Ackermann, Eden, & Williams, 1997), IS requirements planning (McKay, 1998), consumer branding (Henderson, Iacobucci, & Calder, 1998), and knowledge management (Shaw, Edwards, Baker, & Collier, 2003b).

Also work has been conducted on other types of mapping, for example: knowledge networks, which represent the knowledge around a process (Gordon, 2000); mapping knowledge contained on an intranet (Eppler, 2001); and integrating concept maps with other applications to build the knowledge base (Gaines & Shaw, 1995b). With the exception of knowledge networks, that work differs to cognitive/causal mapping which concentrates more on the social process of generating knowledge through personal reflection and/or collaboration.

This article focuses on maps built by groups of knowledge holders during facilitated workshops. This body of literature is smaller, but includes: exploring how to facilitate the process of capturing knowledge from groups using mapping (Johnson & Johnson, 2002), group mapping using computers (Eden & Ackermann, 1998a; Shaw, 2003), using group mapping in a research study (Casu, Thanassoulis, & Shaw, 2002; Edwards, Collier, & Shaw, 2004), and using group mapping for knowledge management (Gaines, 2002). These studies tend to focus on improving the process of conducting a group mapping session and building group maps.

In terms of analysing the content of maps, research has focused on analysing the nature of individual cognitive maps, for example, analysing the themes in the maps (Jenkins & Johnson, 1997), and the number of concepts in the maps and the number of in/out arrows linking concepts (Eden, forthcoming). Some exploration of the properties of group maps (albeit sometimes group maps which have been generated by merging the cognitive maps of individuals) has also been performed (e.g., McKay, 1998; Eden & Ackermann, 1998b; Shaw, 2003). Shaw, Ackermann, and Eden (2003a) offer a typology for how managers access and share knowledge during group mapping activities.

The research on mapping concentrates on the deployment, evaluation, and improvement of the methods often leading to practical and theoretical advances of mapping techniques.

We now review the general benefits of mapping group knowledge.

MAPPING KNOWLEDGE FOR KNOWLEDGE MANAGEMENT

To structure the following discussion, we return to the sharing, acquisition, utilisation, and retention of knowledge to explore how mapping supports each of these. Below we assume that there are 5-12 people (participants) in a group who are mapping their knowledge. The knowledge is being captured in a map, and the process of mapping is being supported by a facilitator. This map is publicly displayed for all participants to see. This arrangement is characteristic of Dialog Mapping, concept mapping, and Journey Making (see Figure 1).

Sharing Knowledge

Sharing knowledge in a group meeting is not a straightforward activity. The group decision support systems experimental literature (see Fjermestad & Hiltz, 1998, for a review) has identified a range of factors which inhibit the sharing of knowledge, for example: "production blocking" when people cannot generate new ideas because they are trying to remember the ideas they want to share, and "evaluation apprehension" that your contributions will be negatively evaluated by the group.

When group mapping, one way of partially avoiding these inhibitors is through participants sharing knowledge by either writing it onto cards or typing it into a networked computer which is running a brainstorming software. These bring the advantage that many participants can share their knowledge simultaneously as they are not constrained to waiting for others to finish speaking before they can share their own opinion. Consequently lots of knowledge can be shared very quickly to the map, enabling the group to focus on discussing the knowledge that has been shared rather then trying to access the knowledge that each member holds. Furthermore, anonymity of who contributed the knowledge gives participants the freedom to share knowledge which they are not too sure of (or which is controversial)—allowing the group to evaluate its legitimacy.

Mapping also encourages creativity by providing stimuli (on the public display of knowledge) in the form of other peoples' ideas from which to gain inspiration. Also, facilitators can offer participants different types of sessions in which to share their knowledge, whether they share their knowledge whilst knowing/without knowing/partially knowing what other participants have shared (see Shaw, 2003, for more details). Finally, sharing knowledge directly into the map enables the participants to select/craft their own wording of contributions, without their knowledge being interpreted and reworded by a facilitator. For more details on these points, see Gaines and Shaw (1995c), Eden and Ackermann (1998a), and Shaw (2003).

Acquiring New Knowledge

Acquiring knowledge in group meetings can be problematic, as often the knowledge is poorly shared and poorly managed when shared, making identification of the key issues difficult. Information overload can also hinder the acquisition of new knowledge (Grise & Gallupe, 1999).

Through mapping, the facilitator will aim to capture the knowledge in a format where individuals can engage in a structured discussion of, what emerges through discussion to be, the key points. By communicating perspectives in only a few words, the public screen can display the breadth of issues. Through discussion, detail can be added to those issues, ensuring the requisite depth of knowledge is acquired and integrated into the group's consideration of the issues. Participating in this discussion is a key source of new information (acquiring knowledge) where people come to appreciate the legitimacy of competing perspectives—but not necessarily agree with that perspective.

Through mapping the participants share and discuss knowledge about the relationships between the issues. This enables them to enrich their appreciation of the issues with new knowledge about their causes and consequences. This is in contrast to a brainstorm where the issues are discussed, but not necessarily the relationship between the issues in a systematic, structured fashion.

In mapping, the acquisition of knowledge is a catalyst for synthesising knowledge across participants. The aim is often for the participants to build a shared understanding of what are the critical pieces of knowledge that must be incorporated into any decision or action plan. This shared understanding often does not extend to consensus on what should be done. Instead, the action plan should contain enough of what the different participants are interested in that they are willing to accept actions which they are less interested in.

Utilising Knowledge

Due to the problems of sharing and acquiring knowledge in group workshops, it is often difficult to gather appropriate knowledge to utilise. Furthermore, bounded rationality, decision-making heuristics, group thinking, and information overload can make the effective usage of shared and acquired knowledge problematic. However, in mapping workshops process support aims to take the group through the issues in a structured and transparent way, to overcome these problems and effectively utilise the knowledge in the group.

Mapping aims to support the utilisation of knowledge, primarily through helping participants to cope with the complexity of multiple perspectives that have been shared. By modelling the knowledge on a public screen, the participants do not need to retain the knowledge in their head or try themselves to integrate different pieces of knowledge from different people. The facilitator, using the model/map, will display the knowledge on the public screen and provide structure to reduce the cognitive demands on the recipients (i.e., manage its complexity). Thus the effects of information overload might be reduced, allowing participants to concentrate on utilising the knowledge for the purposes of the workshop.

For example, in strategy development workshops, the knowledge is utilised to identify and agree on a portfolio of actions which will progress the organisation/group in the required direction. Knowledge will be used to design appropriate actions by understanding drivers and pre-requisites for action, exploring consequences of action, identifying incompatibilities across actions, and appreciating issues of action implementation.

Retaining Knowledge

Knowledge retention can be problematic over the short and long term. At one extreme, people can forget what they heard less than 10 minutes ago as they are overwhelmed with a spiralling conversation that is continuous, offering them new knowledge. At the other extreme, organisations want to retain knowledge for future use, perhaps over years.

Mapping in group workshops assists in the short-term 'retention' of knowledge by publicly displaying the knowledge either on a flip-chart or via a projector. The display is used as a shared device through which the group communicates—that is, participants make reference to the publicly displayed model as they illustrate their reasoning for holding particular opinions. This prevents group members from having to retain the argument in their heads.

The maps can also act as a long-term record of what was agreed and the rationale behind this agreement. These can be circulated around the organisation, but might be difficult to interpret for those not in the workshop. Progress against actions can be logged with reference to the maps (Shaw et al., 2003b).

We now review one particular workshop approach that maps group knowledge—the Journey Making approach.

THE JOURNEY MAKING APPROACH

Journey Making has been selected for further description because it is supported by a mapping software that, like KMap, offers a group the functionality to share their knowledge through a networked computer directly into an electronic map.

Journey Making stands for the JOint Understanding, Reflection, and NEgotiation of strategY (Eden & Ackermann, 1998a). This facilitator-led approach arose from a need to support groups in their strategy making endeavours. Through jointly understanding the range of pertinent issues in a problem, it is believed that a group is in a better position to tackle that problem. Reflection on the range of potential causes of the problem, and consequences of taking action to address the problem, engage the whole group (individually and collectively) in critical thinking and discussion. The range of potential actions to address the problem are rigorously considered with the aim of participants accepting the legitimacy of competing actions (or rejecting actions) through social negotiation. The outcome is typically an action plan that contains a portfolio of strategic actions that when implemented, the group believes, will tackle the problem.

Underpinning Journey Making is an aim of providing participants with a process through which they:

- Surface their own views in a group as other people do the same, and then…
- Collectively explore (not just get told about) the commonality/differentiation between those views, in order to…
- Learn about the connections across these multiple views (i.e., identify how the issues affect/are affected by each other), enabling them to…
- Build their knowledge through developing a richer appreciation of these connections (i.e., thinking through the causes and consequences of issues), to…
- Expand their individual and collective knowledge of the topic beyond that which they held prior to the workshop, enabling them to…
- Select an appropriate combination of actions which are thought to have the desired impact when implemented.

Mapping is central to this process as the following discussion will show.

MAPPING KNOWLEDGE IN JOURNEY MAKING WORKSHOPS

In a computer-supported Journey Making workshop, computer technology assists in the sharing, capturing, and displaying of views, and the voting on options. Walking into a typical Journey Making room (Figure 1), the participant would often see: 8-10 laptop computers sitting in a horseshoe running a group decision support software (Group Explorer); a projector displaying causal mapping software (Decision Explorer) on a very large projection screen; and a facilitator facing the group with computers in front of him/her.

In a Journey Making workshop, normally between 5-16 participants share their knowledge to the causal map through computers. During the brainstorm (or ‘gathering’ in Journey Making terminology, as the process is designed to gather occupational views, not purely lateral thoughts), the participants type their knowledge, views, and opinions (in the form of ‘contributions’ of 4-10 words in length) into their own networked computer which is running Group Explorer software. All contributions are made anonymously, in that issues are not identified to the individuals who made them. For example, in response to a question about how to encourage learning and sharing of knowledge in the workplace, one manager might type: “utilise the existing expertise of existing people”; another might suggest that the company should address the issue that “individuals experience outside of the business is not capitalised.”

Figure 1. Participants in a journey making mapping workshop

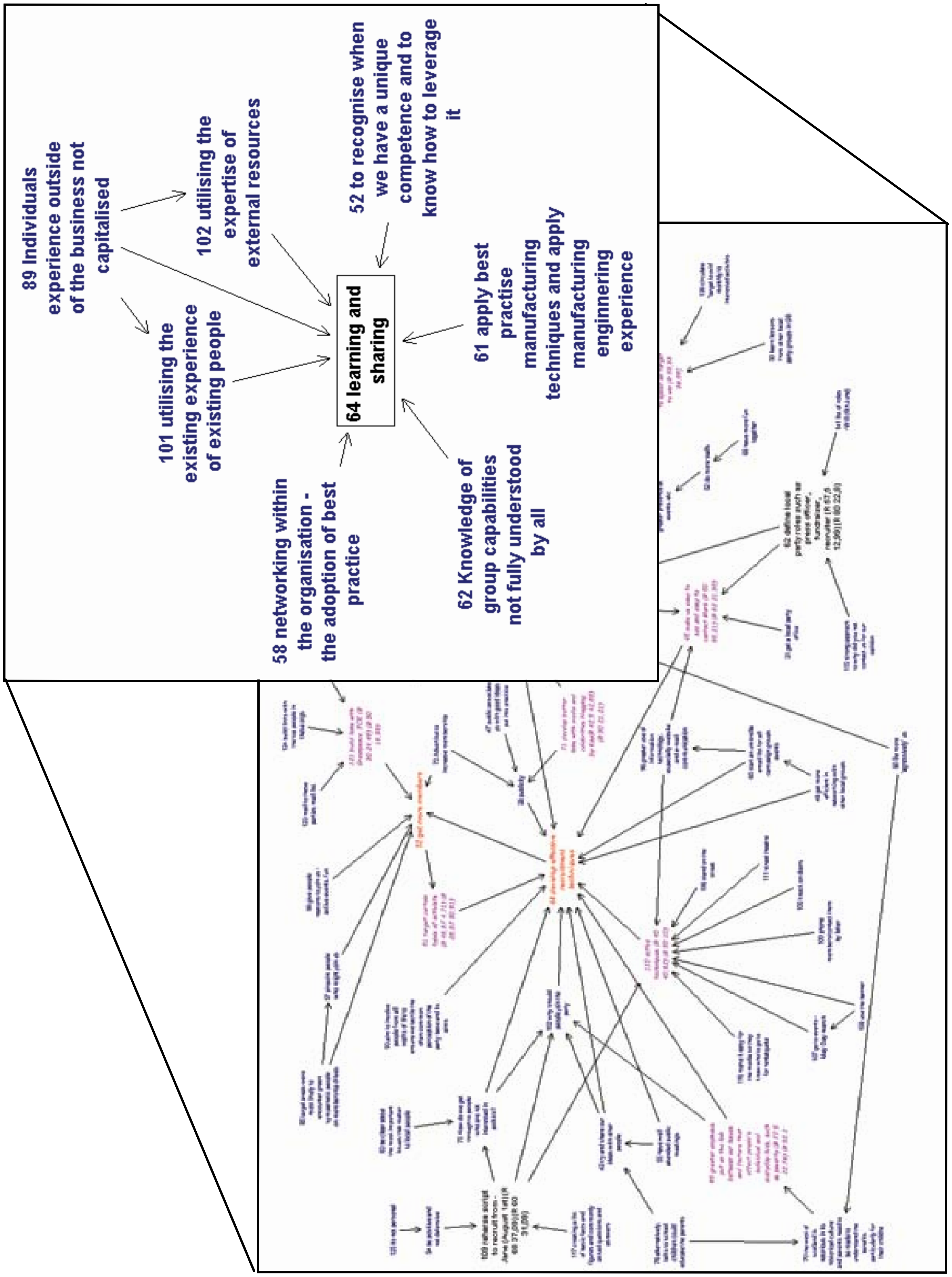
These would then be displayed on the map (see Figure 2).

The facilitator, on his/her own computer screen, will move all the participants' contributions into content-related clusters and display those clusters on a public screen (using a projector) for all the participants to read and be stimulated by. Participants can then type in more contributions in response to either the stimulus 'question' or after reading what others have contributed on the public screen.

Also, participants can share knowledge of the relationship between different contributions. When building group maps, these relationships (represented in the map as an arrow) are usually causal as the group is exploring the causes of problems and drivers that will cause/bring change. For example, the participants building the map in Figure 2 thought that "individuals' experience outside of the business is not capitalised," but if addressed, could be one way of "utilis[ing] the existing expertise of existing people."

Following the gathering, the facilitator will encourage a group discussion around the issues represented on the map. This discussion will aim to surface more contributions to be added to the

Figure 2. An extract from a group map



map, as well as further structure the contributions by identifying more causal relationships/links.

The product of this work will be a structured causal map which reflects the participants' knowledge of the situation and on which the participants can begin to consider which actions should be implemented in the organisation, and exploring the effects these actions might have if implemented. Through exerting effort in building and negotiating a feasible action plan (and understanding the benefits from implementing it), the facilitator will aim for group members to build commitment to implementing the actions. This commitment will help ensure that the implementation of actions is followed through to completion.

FUTURE TRENDS

As evident from earlier discussions, researchers are using the principles of mapping to gather and structure knowledge in a range of ways. For mapping in group workshops, much of this attention aims to evaluate the existing methods as a catalyst for their improvement. In terms of improving the mapping aspect of these workshops, researchers are continually reflecting on practice of mapping in groups (Johnson & Johnson, 2002), offering new ways of conducting workshops to collect knowledge with more breadth and/or depth (Shaw, 2003), offering methods for interrogating maps during workshops (Eden, forthcoming), and developing new software to support different types of group mapping.

In the Operational Research community, researchers are examining how the results from mapping activities can feed into other methods of analysis, for example, multi-criteria decision models (Belton, Ackermann, & Shepherd, 1997) and data envelopment analysis models (Casu et al., 2002). In this way mapping can be effective for multi-methodology applications (as shown in Mingers & Gill, 1998) where a combination of different methods are combined to better address the issues.

The use of computer technology gives new access to the way in which participants contribute knowledge to group maps during workshops. Being able to log the knowledge shared by participants in a computer database enables post-workshop analyses of what each person shared when, and how that was used by the group to inform the final outcome. Complementing this data with video recordings of group discussion and social negotiation would enable the entire workshop to be amenable to post-workshop analyses. A fruitful direction for research would be to use these data to better understand the way in which knowledge is shared and used during these meetings.

Another direction for research would be to explore the impact of a workshop on the organisation—taking a longitudinal perspective through to the implementation of actions and the role of mapping in this.

CONCLUSION

During meetings, the structured collection and representation of knowledge can support the participants' acquisition, utilisation, and retention of available knowledge. We suggest that mapping is able to support the participants when they share, reflect upon, synthesise, expand, record, and creatively employ knowledge to better achieve the aims of the meeting. Through formal mapping methodologies such as Dialog Mapping, concept mapping, and Journey Making, facilitators can better support groups in these endeavours. However, more research to evaluate mapping approaches is needed to inform the continuous development of the techniques and of the software that supports them.

REFERENCES

Ackermann, F., Eden, C., & Williams, T. (1997). Modelling for litigation: Mixing qualitative and quantitative approaches. *INTERFACES, 27*, 48-65.

Belton, V., Ackermann, F., & Shepherd, I. (1997). Integrated support from problem structuring through to alternative evaluation using COPE and VISA. *Journal of Multi-Criteria Decision Analysis, 6,* 115-130.

Bonham, G.M. (1993). Cognitive mapping as a technique for supporting international negotiation. *Theory and Decision, 34*, 255-273.

Bougon, M.G., & Komocar, J.M. (1994). Directing strategic change: A dynamic holistic approach. In A.S. Huff (Ed.), *Mapping strategic thought* (pp. 135-163). Chichester: John Wiley & Sons.

Carlsson, C., & Walden, P. (1996). Cognitive maps and a hyperknowledge support system in strategic management. *Group Decision and Negotiation, 6,* 7-36.

Casu, B., Thanassoulis, E., & Shaw, D. (2002). Using a group decision support system to aid input-output identification in data envelopment analysis. In A. Emrouznejad, R. Green, & V. Krivonozhko (Eds.), *Proceedings of the International Data Envelopment Analysis Symposium* (pp. 159-164). Moscow, Russia.

Conklin, J. (2003). *Wicked problems and social complexity. Working paper of the CogNexus Institute.* Retrieved from http://www.cognexus.org

Eden, C., & Ackermann, F. (1998a). *Making strategy: The journey of strategic management.* London: Sage Publications.

Eden, C., & Ackermann, F. (1998b). Analysing and comparing causal maps. In C. Eden & J.C. Spender (Eds.), *Managerial and organisational cognition* (pp. 192-209). London: Sage Publications.

Eden, C. (forthcoming). Analyzing cognitive maps to help structure issues or problems. *European Journal of Operational Research.*

Edwards, J.S., Collier, P.M., & Shaw, D. (2004). *Management accounting and knowledge management.* London: Chartered Institute of Management Accountants.

Eppler, M.J. (2001). Making knowledge visible through intranet knowledge maps: Concepts, elements, cases. *Proceedings of the 34th Annual Hawaii International Conference on Systems Sciences,* Los Alamitos, CA.

Fjermestad, J., & Hiltz, S.R. (1998). An assessment of group support systems experiment research: Methodology and results. *Journal of Management Information Systems, 15*(3), 7-149.

Fletcher, K.E., & Huff, A.S. (1994). Strategic argument mapping: A study of strategy reformulation at AT&T. In A.S. Huff (Ed.), *Mapping strategic thought* (pp. 135-194). Chichester: John Wiley & Sons.

Gaines, B.R. (2002). Organizational knowledge acquisition. In C.W. Holsapple (Ed.), *Handbook on knowledge management: Volume 1* (pp. 317-347). Berlin, Heidelberg: Springer-Verlag.

Gaines, B.R., & Shaw M.L.G. (1995a). Concept maps as hypermedia components. *International Journal of Human-Computer Studies, 43*(3), 323-361.

Gaines, B.R., & Shaw, M.L.G. (1995b). WebMap: Concept mapping on the Web. *World Wide Web Journal, 1*(1), 171-183.

Gaines, B.R., & Shaw, M.L.G. (1995c). Collaboration through concept maps. In J.L. Schnase & E.L. Cunnius (Eds.), *Proceedings of Computer Support for Collaborative Learning'94* (pp. 135-138). Mahwah, NJ.

Gordon, J.L. (2000). Creating knowledge maps by exploiting dependent relationships. *Knowledge-Based Systems, 13*(2-3), 71-79.

Grise, M.L., & Gallupe, R.B. (1999). Information overload in face-to-face electronic meetings: An integrative complexity approach. *Journal of Management Information Systems, 16,* 157-185.

Henderson, G.R., Iacobucci, D., & Calder, B.J. (1998). Brand diagnostics: Mapping brand effects using consumer associative networks. *European Journal of Operational Research, 11,* 306-327.

Huff, A.S., & Jenkins, M. (2002). *Mapping strategic knowledge.* London: Sage Publications.

Jenkins, M., & Johnson, G. (1997). Linking managerial cognition and organisational performance: A preliminary investigation using causal maps. *British Journal of Management, 8*, S77-S90.

Johnson, P., & Johnson, G. (2002). Facilitating group cognitive mapping of core competencies. In A.S. Huff & M. Jenkins (Eds.), *Mapping strategic knowledge* (pp. 220-236). London: Sage Publications.

McKay, J. (1998). Using cognitive mapping to achieve shared understanding in information requirements determination. *The Australian Computer Journal, 30*, 139-145.

Mingers, J., & Gill, A. (1998). *Multimethodology: Theory and practice of combining management science methodologies.* Chichester: John Wiley & Sons.

Shaw, D. (2003). Evaluating electronic workshops through analysing the 'brainstormed' ideas. *Journal of the Operational Research Society, 54*(7), 692-705.

Shaw, D., Ackermann, F., & Eden, C. (2003a). Sharing knowledge in group problem structuring. *Journal of the Operational Research Society, 54*(9), 936-948.

Shaw, D., Edwards, J.S., Baker, B., & Collier, P.M. (2003b). Achieving closure through knowledge management strategy. *Electronic Journal of Knowledge Management, 1*(2), 197-205.

Te'eni, D., Schwartz, D.G., & Boland, R.J., (1997). Cognitive maps for communication: Specifying functionality and usability. In J. Carey (Ed.), *Human factors in management information systems: The Relationship between user interface design and human performance* (pp. 83-100). Greenwhich, CT: Ablex.

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Chapter 5.26
Some Implementation Challenges of Knowledge Management Systems:
A CRM Case Study

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ABSTRACT

The promise of knowledge management systems is challenged by implementation problems. This CRM case illustrates that technology-driven approaches are not likely to succeed. It also indicates some limitations of top-down managerial interventions, arguing that we need a deeper understanding of learning processes to be able to implement KM systems successfully. A more experimental implementation strategy is suggested.

INTRODUCTION

The great expectations for knowledge management systems illustrate a phenomenon long acknowledged by IS research: A strong socio-economic trend (the growth of knowledge workers) fuses with a technological trend (knowledge supporting technologies like Lotus Notes and World Wide Web). In a global economy, knowledge may be the greatest competitive advantage for a company (Davenport, Prusak, 1998), with the support of KM technology to structure the knowledge and make it available in the company's learning process.

On the other hand there are continuing reports of disappointments, due to poor alignment between business and technology (Applegate et al., 1999) or the mismatches between the socio-technical potential and the old management practices (Ciborra, 1996). Implementing information systems has proved to be difficult (Markus, Benjamin, 1997), and the main challenge with KM systems also seems to be implementation (Ericsson, Avdic, 2002).

Implementation is mostly seen as an acceptance challenge (Kwon, Zmud, 1987). This view is probably valid also in the area of KM systems (Ericsson, Avdic, 2002), but there are two aspects which may deserve a closer examination. First, Leonard-Barton observed (1988) that company adoption does not necessarily imply user adaptation. The spread of the knowledge-based, less hierarchical organizations with both more powerful and knowledgable users (Nambisan et al., 1999) has accelerated this development: The knowledge user decides whether he or she will use the system, and in what way.

Secondly, the use of knowledge systems is quite different from the use of transaction systems. Since KM systems usually are set up to support organizational learning, they constitute part of a much more complex process. Argyris and Schön (1996) defines organizational learning in these terms:

Organizational learning occurs when individuals within an organization experience a problematic situation and inquire into it on the organization's behalf (..) In order to become organizational, the learning that results from the organizational enquiry must become embedded in the images of the organization held in its members' minds and/or in the epistemological artefacts (the maps, memories, and programs) embedded in the organizational environment (p. 16).

This process is coined organizational learning II or double-loop learning, in contrast to single-loop learning, i.e., problem-solving. Organizational learning concerns changing the theory-in-use, the underlying assumptions of how things are working, which heavily influence the patterns of actions. Argyris and Schön observe that there often is a mismatch between the official espoused theory and the theory-in-use. An important implication from this is that only real double-loop learning can change the theory-in-use.

Thus, the question posed in this chapter is the following: How should we implement KM systems in a way that supports organizational learning? To illustrate this we shall tell a story of a six-year CRM project - an important goal being knowledge synergies - trying to describe in some detail how a knowledge-based organization addressed the challenge.

The chapter is structured as follows: first, the chapter describes the case methodology. There is followed with a brief outline of the promise of CRM systems. Next, the chapter discusses two process perspectives on implementation are presented, and the case is described in some detail, focusing on the implementation process and actor behavior, told by the practitioner. The chapter then discusses solutions and recommendations, focusing on the interaction between learning and management. Finally, it briefly outlines future trends and finishes with a summary of the conclusions.

METHODOLOGY: A CASE STUDY

This chapter tells the story of a Norwegian knowledge-based organization, the Oslo-based National Institute of Technology (TI) that started implementing a CRM system in 1993. The focus is on the implementation process that lasted six years. The author was the IT manager at the institute during this period.

Using a qualitative and interpretive approach (Miles, Huberman, 1994), the study focuses on behavior as a practitioner experienced the project, using only very simple theoretical concepts. These concepts are part of the narrative, illustrating what we conceived was our methodological options at the time. The empirical evidence also includes company and project documents and user satisfaction surveys.

Being a single case study, there is no claim of validity for the KM systems field in general. Rather, the aim is to ask relevant questions, and discuss them in the light of existing theories.

THE PROMISE OF CRM SYSTEMS

Theories on relationship marketing were developed at the end of the 1980s, under the motto "from transaction to relation." Researchers showed that companies have both economic and social relations: In addition to economic transactions there is, usually, a development of trust. These relations may give benefits to both sides and among them are a higher degree of customer loyalty, lower marketing costs, mutual learning and other forms of strategic cooperation. Developing long-term customer relations is a part of the company's strategy development, and should involve every level of the company (Hakansson, 1995).

Since relationship marketing is heavily dependent on rich customer information, and also dependent on frequent communications with the customers, the pioneers were early aware of the IT potential. Today, CRM systems represent a large and growing part of the software industry (Tafti, 2002).

Ciborra and Failla describe CRM as an information infrastructure, consisting of processes, people and technology (Ciborra, Failla, 2000). CRM is linked to the BPR thinking, in the way that CRM is also process oriented and focused on dramatic and fundamental change. CRM structures and supports all activities that support a business transaction, from the first lead to fulfillment.

Assumptions about the effect of CRM system are simplified in Figure 1.

As Figure 1 illustrates, CRM is a long-term business strategy, where the CRM system is an important component. The reason for the high expectations is that the CRM systems seem to connect the two central resources of the modern, "flat" and decentralized company: The core competence of the knowledge workers, and the company's relations with its most important customers (Kay, 1993).

CRM systems have three promises:

- It gives each worker a tool to manage her personal contacts, activities, documents, etc. As Drucker has stated, "managing oneself" has become the management challenge for the knowledge worker (Drucker, 1999).
- It provides a tool for dialogue marketing, making the company able to individualize the marketing activities: The customer gets only the information he wants and needs (Hakansson, 1995).

Figure 1. The basic assumption of the effect of CRM systems

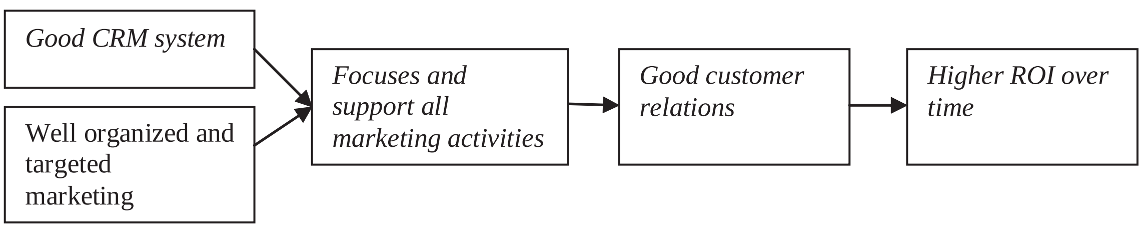
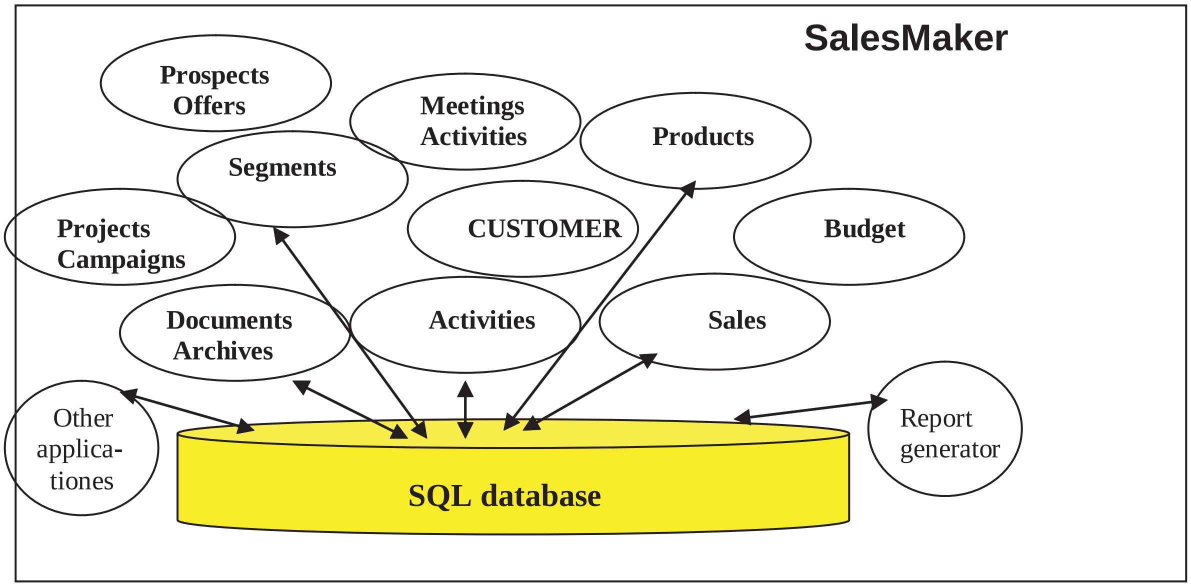


Figure 2. Features of Norwegian CRM system salesmaker



- It represents a synergic potential for the company: If all this information could be utilized in analysis and concept development, it might be a basis for new products and markets, transcending the barriers of business functions and locations.

This is not trivial. If successfully implemented, this implies that the CRM systems could be an important technology for the non-hierarchical, knowledge-based organization of the 21st century.

Figure 2 shows the rich functionality of a medium-sized Norwegian CRM system, SalesMaker, used in the TI case.

THE CASE: COULD A FORMER GOVERNMENTAL INSTITUTE BECOME A FLEXIBLE AND MARKET-DRIVEN COMPANY WITH THE HELP OF CRM?

The National Institute of Technology (TI) was made a private foundation in 1989. The main market was the small and medium-sized companies in Norway (being 95% of all the Norwegian companies) that are too small to do their own technology development and transfer. The services provided were technical consulting, practical courses in disciplines like welding, testing and calibration, and also ISO certification. There were branch offices in other cities in Norway, and an international component, the Norwegian Technology Attachés.

As a private organization TI had to earn its own income, and the governmental support was gradually reduced during the 1990s from 50% to 25%, while the total income increased from 125 mill NOK to 185 mill NOK.

The 260 employees were not used to marketing and selling services. After privatization all the managers were recruited from the private sector, while the technical consultants survived from the old organization. They were largely technically inclined, and regarded marketing as a, maybe necessary, but unwanted activity. The culture in the technical departments was practical and rather practical. The manager of the furniture department, with a lifelong experience with electrical sawing tools was proud to say about job applicants: "Well, it's OK that he has a Ph.D., but then at least he shouldn't have more than nine fingers left!"

TI's only real competitive advantage was the 8,000 small and medium sized customer companies, and thousands of personal contacts. Could this asset be capitalized and thus develop TI into a modern and market-driven company? And could CRM play an important role in this transformation? The director thought so, and in 1992 she commissioned a major project called, The Customer Project. The objectives were:

1994: Better financial control of the consulting projects (about 4,000 each year).
1995: More effective and efficient marketing by systematic dialogue marketing.
1996: Develop long-term relations with the most important customers.

It was easier said than done. In 1992 the institute did not even have a LAN, and the workforce was unfamiliar to the concept of CRM. How was this to be accomplished?

Methodology: Software Engineering — or Organization Development?

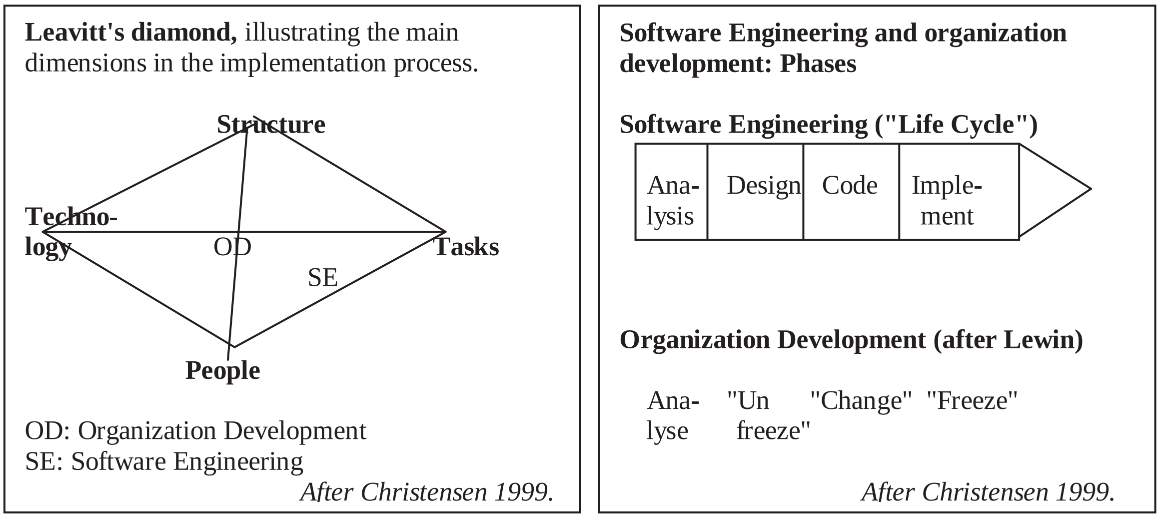
Around 1990 IS projects were usually analyzed in terms of success factors (Kwon, Zmud, 1987). The critical success factors (CSF) for the Customer System were assumed to be strategic alignment, cross-functional synergies (BPR inspired), workforce participation (Scandinavian school), technically competent implementers and a sound technical solution. This was rather by the books, and also the teaching of the TI staff.

The CSFs, however, do not give much guidance on how IS should be implemented. In practice there was a choice of two models, the Software Engineering model or the Organization Development model. The SE approach takes as a point of departure that an information system is developed and implemented into an organization (Sommerville, 2001). The mainstream of the IT industry - like Microsoft - has traditionally focused on the functional attributes of the system (advanced, user friendly, etc.). The Scandinavian school has focused more on the user participation and acceptance. For both schools, however, the starting point is the technology and the emphasis is on structure and rationality.

The Organization Development model comes from the behavioral sciences, and the point of departure is that organizations are stable organisms that change slowly and reluctantly (Argyris, Schön, 1996). To succeed, the organization should prepare for the change, then change slowly, and lastly institutionalize the changes ("freeze"). The OD discipline has traditionally not been very interested in IS, and has focused on the irrational aspects of change processes, and that a normal outcome is a gap between intentions and results. The reason for this is resistance to change.

Both traditions, the SE and the OD, should ideally be combined. Christensen (1999) makes an interesting attempt, where Leavitt's diamond

Figure 3. Two non-congruent frameworks: The organization development model and the software engineering model



is used to illustrate how the two perspectives could be integrated.

Figure 3 illustrates both the elegance and the problem in Christensen's synthesis (Christensen, 1999). Leavitt's diamond illustrates the need for an integrated approach, because the 4 variables are very integrated. The phases, however, show how incongruent these schools are. The main problem is not to gain acceptance for the integrated approach, but to implement it in real projects. The practitioner communities, being the IT consultants on one hand and the OD consultants on the other, represent different cultures, with different tools and terms, for different contexts.

At TI we chose the software engineering approach, following the recommendations of the vendor of the CRM system. This did not imply that the Customer Project was seen as a purely technical project. On the contrary, great effort was made to ensure user participation and organizational alignment. One of several measures was to merge the IT and marketing departments into one unit, with the responsibility for the CRM implementation.

The First Attempt in 1993/94: Crises

Chronology

Autumn 1991.
: IT strategy, concluding with the Customer Project, is approved.

Winter 1992.
: A projects group and a steering group are established. Requirements document is made after interviewing all departments.

Spring 1992.
: Agreement with Software Innovation purchasing SalesMaker (first customer) Analysis and design: A consultant firm produces a business model in DFD and E/R-diagrams. Central users participate.

Rest of 1992.

Database is implemented and prototyping in a 4GL is done in close cooperation with different user groups. Installation of LAN, WAN and servers.

Autumn 1992.

User training with in-house instructors. Managers were sent to take courses to learn to use the report facilities.

January 1, 1993.

System set into production.

Spring 1993.

System in production, but technical problems in client/server technology.

Autumn 1993.

Data quality problems.

Spring 1994.

Data quality problems attacked, but not solved. Confidence in system declining.

The Customer System was based on Sales-Maker from the small Norwegian company Software Innovation, extended with a module developed in-house. The system was, at the time, very modern: Windows based, integrated with both the financial system and with office software like MS Word. For an organization not used to CRM systems, it appeared complex, with many screens and a new terminology including words like "contacts," "relations" and "campaigns." All users were trained, concentrating on screens and terms.

The first problem was technical: The client/server technology at this time was not stable, and created a continuous demand for support. Also, the quality of the in-house developed module was not satisfying, and demanded more support.

A larger problem was the fact that the core of the system, the customer information, had quality problems. The reason was trivial: When registering a new customer, the user should check if the company was already registered. If you don't, the result may be a double or a triple registration of the customer (spelled a little bit differently), which in short time creates chaos in the system.

This was the origin of a vicious circle: The existence of double and triple customers very quickly threatened the confidence in the system: "One cannot trust the new system - it is useless" became a common comment. The positive users became reserved in their use, and the negative ones had lots of arguments in the company canteen.

The result of these problems was that the system was not used as intended. In spite of several activities to increase the quality of information, parts of the organization lost faith in the concept. The system did not give the expected benefits because of incorrect information and lack of trust. It also became evident that the user participation strategy had produced little effect: One reason why the data quality problem persisted was that the system was not considered important enough to spend the necessary time to learn properly. It was not integrated in the day-to-day working routines.

The investment was still financially sound, because the dialogue marketing, as a tool for the marketing department, was beginning to work. But the implementation had failed on important points, and we were looking for another way of doing it.

The Second Attempt from 1995-98: Elephants and Giraffes

Chronology

Autumn 1994.

The "Elephant Method" was developed: A step-by-step method to use the Customer System in dialogue marketing: Define your market, find the potential customers in the system, produce the brochure, mail it to the potentials, follow-up by telephone, register the response, correct any wrong information, summarize the learning. Easy, when assisted by marketing staff.

1995.

The Elephant Method was a success in most departments.

1996-98.

The Giraffe Project: Aimed at changing organization and culture:

- Marketing teams established.
- Each team had a marketing plan, with clear objectives.
- All customers segmented into groups, according to profitability. Main responsibility for each customer is assigned.
- Marketing activities are focused on "A" customers, aiming at creating partnerships.
- A number of motivating and learning activities are initiated by the IT/Marketing depts.

1998.

Project is evaluated partly successful, but local (department) culture is stronger than central push.

In the autumn of 1994 the steering group initiated a task force to help a troubled department perform their marketing activities more systematically. This attempt was gradually developed into the "Elephant Method" (after the how-to-eat-an-elephant joke), which was a step-wise method for market segmentation and Direct Marketing.

This method was gradually implemented in most departments during 1995, and led to more sales of TI's course portfolio, while the volume of DM was cut by half. Together this was the first visible success of the system, and this was also acknowledged.

The experience showed us two things: Firstly, the departments needed hands-on guidance in using the CRM system in a way that gave a commercial effect. Secondly, it showed that only very specific results could change the attitudes in the departments. Traditional user training and general information had very little effect.

In 1996 the perspective was broadened. Under the motto "stretching a little further," the Giraffe project was started. The aim was to concentrate the marketing activities on the most important customers ("A" customers) to increase the profitability of the institute, that is, to make it less dependent on government money.

All managers, secretaries and key consultants were taken to kick-offs and follow-ups, listening to national "relationship gurus" and discussing the concept. All departments were organized into marketing teams, and systematic reporting to the top management group every month was instigated.

For the following two years the Giraffe-1 and Giraffe-2 were run continuously, with a focus on changing the culture from focusing on technical disciplines to focusing on the customer. The whole bag of OD tricks was used, like image and brand building, team building, leadership development, skills development, parties and prizes.

The results were on the positive side, but progress was slow. Some departments worked very systematically, and achieved good results. Others were more half-hearted, and gave priority to other activities. A few were ignoring the whole project, and worked with other concepts. The attitude of the manager and the most senior consultants seemed to determine the culture. Also important was the fact that the CRM system did not support all kinds of products, and that two departments lacked loyal customers altogether, and were working in a spot market.

Summing up, in 1998 the CRM strategy had worked for five years. While having a partial success, the process was not self-sustained. It was still dominated by central staff pushing reluctant technicians into the market. The local cultures were stronger than the central push, and only when the commercial perspective was very short, there was a real commitment to the project. Thus, while the DM activities continued to be rather successful, the more long-term approach of using the customer relations more strategically was much harder to achieve. The Giraffe ambition of changing the culture was, therefore, mainly a failure.

We scratched our heads again, now wondering if the whole concept was wrong, not only the implementation. Our concept was built on releasing the potential synergies in cross-functional coordination. Did such a potential really exist - or is it, at the end of the day, only within the individual projects there are synergies? Is the modern knowledge organization too culturally complex, and immune to this kind of standardization? Should the focus be changed to satisfy the more immediate needs of the knowledge worker?

Third Attempt 1998-99 and Summing-up the Case

A new version of the Customer System was introduced at the start of 1999. The emphasis was now changed to the consultant users, and focused on calendar, document support and personal contacts. This was well received, but also signified a lower ambition on the organizational level.

Of the three original goals of the system, the first two goals, financial control of projects, and more efficient direct marketing, were achieved. The DM activities were concentrated in a new unit, and the "A customers" concept was implemented in the whole organization.

The third and most important goal, to establish partnerships with the "A customers," in a cross-functional cooperation, and to use this partnership systematically in changing the organization, had mainly failed. This goal was more or less abandoned, and the departments were left to develop their customer relationships individually.

The planned three-year implementation became a six-year continuing effort. Is there something to learn from the story?

SOLUTIONS AND RECOMMENDATIONS

Interpreting the case, it is obvious that the system was a success regarding the management goals (cost control, Direct Marketing), and a failure in the area of knowledge management.

The implementation of KM is directly affected by what Argyris has termed the "learning paradox" (Argyris, 1991). Studying professionals, he found (as expected) that they were good at single-loop learning, but surprisingly bad at double-loop learning. The explanation: These knowledge specialists seldom experienced failure, and, therefore, are not used to learning from failure. Thus, instead of double-loop learning, the response is defensive, often including blaming something or somebody else.

Returning to the initial question, how should we implement KM systems in a way that supports organizational learning, we may conclude with two perspectives: What is not working, and what may - in some cases - work?

What Does Not Work

The case illustrates that a technology-driven approach is not working. Implementing CRM is hard, and successful implementation requires a different strategy than systems development. This is a problem, because many CRM vendors still use a systems development implementation framework. Also Davenport and Prusak warn against the unrealistic expectations towards KM software: "Unfortunately, it is usually much harder to get organizational consensus for behaviour change and new roles than it is for technology - and if you start with the technology, the other necessary factors may never materialize" (p. 166).

More controversial, perhaps, is our view that traditional organization development may work well in the logistics and marketing area (for example within Direct Marketing), but not in knowledge management. Why not? One answer may be that the first type of project had support in pre-existing capability in the organization's formative context - the institutional arrangements and cognitive frames (Argyris, 1996), while the Giraffe project was a foreign and abstract concept in the language of management. The system and the concepts - espoused theory, in Argyris' terms- could not be translated into a departmental culture which had a very practical problem-solving way of working. The technical teams at TI were small and tightly knit, and the members preferred, vastly, projects to formal cross-functional coordination meetings. The most important learning was in the projects, and it was shared with the other members by the irregular coffee break. Such teams have, seen from within, no need for a CRM system.

Their response to the CRM challenge was defensive, and indeed not beneficial for a learning process. Moreover, the "management push," insisting on espoused theory, prohibited a more creative approach.

What May — In Some Cases — Work?

These are some elements in an alternative implementation strategy.

Could the teams at TI convert to double-loop learning, where they really attempted to achieve the cross-departmental synergies, and use the CRM system as a vehicle of support? Argyris and Schön (1996) suggest a strategy where members of the organization try to "learn strategically," where designers and implementers develop more open and non-determined communication, using failures as input to change their mind-sets. They also advocate developing managers with more "artistic sense" (p. 259).

Evidently this is not easy- and what does it mean to the actual case? We think it means to stage a more innovative process, to experiment with the following:

- Be honest about implementation problems. (This is harder than you may think, because the project has usually been "sold" with glossy promises.)
- Use the problem as a source of innovation. For example, if the system is used in a "wrong" way - explore if there is a potential in this direction.
- Bring in new people, especially critical ones.
- Reorganize teams which are not productive or creative.
- Do not play political games. Focus on business issues.
- Accept that technical problems are not always "trivial," and that systems in one sense are actors. They should be dealt with, not blamed.

We also think one should accept that implementation is inherently context sensitive. What works in one company, or one department, may not work in another. This seems a paradox, because the synergy expectation of KM systems usually implicates that knowledge should be standardized. We agree that this is an important aspect of KM, but that great care is necessary to distinguish between infrastructure information (like names, addresses) and specific domain knowledge. An infrastructure is clearly important, and should be developed early. On the other hand, standardizing domain knowledge is very challenging, and one may run the risk of jeopardizing the whole KM project if this is done insensitively.

CONCLUSION

This CRM case has been used to illustrate some challenges in KM implementation, and to suggest some possible solutions.

The main challenge is that top-down organization development, focusing on control and change management, is not necessarily a successful implementation strategy for knowledge management systems. Often this will appear as an uphill struggle, against defensive knowledge workers.

The solutions do not come easy. They involve staging a learning process, in which the KM system becomes an integrated part. The hardest part may be to leave the glossy image of KM systems behind, replacing it with promises of hard work.

Solutions may also require a partial loss of management control, because what is recommended is more of an innovation process. Managing such processes is rather different from goal-oriented change management, and should allow for more experimentation, and in particular for learning from failures.

REFERENCES

Applegate, L., McFarlan, F. W., & McKenney, J. (1999). *Corporate Information Systems Management.* Boston: Irwin McGraw-Hill.

Argyris, C. (1991, May-June). Teaching smart people how to learn. *Harvard Business Review,* 99-109.

Argyris, C., & Schön, D. A. (1996). *Organizational learning II.* Reading, MA: Addison-Wesley.

Christensen, G., Grønland, S. E., & Methlie, L. B. (1999). *Informasjonsteknologi*. Oslo: Cappelen.

Ciborra, C. (1996). *Groupware and Teamwork*. Chichester, UK: Wiley.

Ciborra, C., & Failla, A. (2000). *Infrastructure as a process: The case of CRM at IBM. From Control to Drift.* Oxford: Oxford University Press.

Drucker, P. (1999, March/April). Managing oneself. *Harvard Business Review.*

Ericsson, F., & Avdic, A. (2002). *Framework of knowledge management systems acceptance*. Paper presented at the IRMA 2002, Seattle.

Hakansson, H., & Snehota, I. (1995). *Developing relationships in business networks.* London: Routledge.

Kay, J. (1993). *The foundation of corporate success.* Oxford: Oxford University Press.

Kwon, T. H., & Zmud, W. (1987). *Unifying the fragmented models of information systems implementation. Critical Issues in Information Systems Research*. J. R. B. R. Hirscheim. Chichester, UK: Wiley.

Leonard-Barton, D. (1988). Implementation characteristics of organizational innovation. *Journal of Communication Research, 5*(15).

Marble, R. P. (2000). Operationalising the implementation puzzle: An argument for eclecticism in research and practice. *European Journal of Information Systems 9,* 132-147.

Markus, M. L., & Benjamin, R. (1997, Winter). The magic bullet of IT-enabled transformation. *Sloan Management Review*, 55-68.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis.* Thousand Oaks: Sage Publications.

Sommerville, I. (2001). *Software engineering.* Harlow: Pearson Education.

Tafti, M. H. A. (2002). Analysis of factors affecting implementation of customer relationship management sstems. *IRMA,* Seattle. Hershey, PA: Idea Group Publishing.

Authors Note: Sources from National Institute of Technology, Annual Reports 1989-98, Project documents from the Customer Project, User satisfaction evaluations

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Chapter 5.27
Measuring Organizational Learning as a Multidimensional Construct

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INTRODUCTION

The traditional way of measuring learning as a result has been through the so-called learning and experience curves. The learning curves, developed within the production framework (Levitt & March, 1988), relate the manufacturing cost of a product to the accumulated experience in its production. This establishes that its cost decreases as the number of units made increases. At first, although this relationship was limited to the direct labour cost, it later extends to the total production cost.

In the 70s, the Boston Consulting Group applied this idea to the manufacturing sectors with experience curves. These curves expand the learning effect to activities other than those typical of production (Albernathy & Wayne, 1974). They describe the influence that experience acquired through the repetition of a specific activity has on the variable cost and/or price.

Another form of learning evaluation is the half-life curves that measure the time taken in obtaining an improvement of 50% in a determined measurement performance: The greater slope curves indicate a faster learning (Garvin, 1993).

These systems of evaluation are, nevertheless, incomplete for a learning organization. The cognitive level, changes in conduct, and its influence on performance improvement must be taken into account in assessing a company's learning. Surveys, questionnaires, and interviews are, in this case, more useful (Garvin, 1993).

The research has, however, advanced with great slowness due to two matters: first, as a result of the complexity and multidimensional nature of the object of study; second, the absence of a solid common starting-point, caused by the theoretical disagreement that exists concerning the very definition of the concept and its dimensions. In this line, organization learning (OL), as multidimensional construct, has been analyzed through the dimensions related to the OL capability, according to a series of phases that define a sequential time process, or by means of a knowledge-creation process.

BACKGROUND

In spite of the extensive existing literature on OL, there are very few attempts to operate this construct (Chaston, Badger, & Sadler-Smith, 1999), especially case studies that try to induce theory from practice (Easterby-Smith & Araujo, 1999).

OL, as a result, has been treated as a unidimensional construct (Levitt & March, 1988), whereas its analysis as a lasting process connected with knowledge acquisition and performance improvement has allowed us to go further into its complex and multidimensional character.

Easterby-Smith, Crossan, and Nicolini (2000, p. 789) consider the question of the OL measurement to be lacking in methodological and epistemological debate. In most cases, a contingent vision prevails in which the methods used are appropriate for different kinds of research problems. In general, the studies in this field reveal three perspectives:

a. A macro/positivist perspective that uses quantitative methods—its unit of analysis being the organization or its significant subunits.
b. A micro/interpretative perspective, where the researchers are interested in the phenomenon known as "communities of practice." They collect qualitative data via formal interviews or informal conversations and they use the individual as their unit of analysis.
c. Intermediate perspective typically focusing on case studies. This assumes a combination of the previous methodologies. The studies follow the interpretative tradition to the extent that the researchers gather data mainly from interviews and observation. They differ in the sense that the focus is in on the complete case, or on comparisons between similar cases.

As Easterby-Smith et al. (2000) indicate, the different methods are appropriate for different kinds of research problems. Although the European works mainly use the interpretative methods, North American works place more emphasis on the quantitative empirical investigation. We will take this latter approach in this work to analyze the OL measurement, since this will allow its complex and multidimensional nature to be perceived via a quantitative analysis of its dimensions (Slater & Narver, 1995).

ORGANIZATIONAL LEARNING AS A MULTIDIMENSIONAL CONSTRUCT

The academic field has, in the last decade, shown an increasing interest in the development of a measurement scale that allows the valuing of the OL as a multidimensional construct, made up of a set of attributes or related dimensions. Thus, following a prescriptive approach (Vera & Crossan, 2003), there is a first workgroup referring to how organizations should really learn. In this way, an organization should show a high degree of learning in each and every one of the dimensions defined for its learning capability to be considered as high. In the line of the same prescriptive approach, a second workgroup is centred on how the organizations should manage their knowledge following a series of stages or phases. A third workgroup gathers a set of proposals considering OL to be a process of knowledge creation (Vera & Crossan, 2003).

Table 1. The measurement of the organizational learning capability

Author(s)	OL dimensions (items)	Unit of analysis	Research objective
Goh (2003)	• Clarity of mission and vision (4) • Leadership commitment and empowerment (5) • Experimentation and rewards (5) • Effective transfer of knowledge (4) • Teamwork and group problem-solving (3)	Individual: A longitudinal study with two samples formed by individuals of two companies	To describe a tool to measure an organization's learning capability
Goh & Richards (1997)	• Clarity of purpose and mission (4) • Leadership commitment and empowerment (5) • Experimentation and rewards (5) • Transfer of knowledge (4) • Teamwork and group problem-solving (3)	Individual: 632 people from four organizations, two from the public sector and two from the private sector	To measure the managerial practices that facilitate organizational learning or the conditions and enablers that can help an organization become a learning organization
Hult (1998)	• Team orientation (5) • Systems orientation (4) • Learning orientation (4) • Memory orientation (4)	International strategic business unit (SBU): A sample of 179 domestic and 167 international SBUs	To examine the role of organizational learning in the strategic sourcing process of a multinational service corporation
Hult & Ferrell (1997)	• Team orientation (5) • Systems orientation (4) • Learning orientation (4) • Memory orientation (4)	International strategic business unit (SBU): A sample of 179 domestic and 167 international SBUs	To develop and test a measurement of learning capability (OLC) using the purchaising process of a multinational corporation
Jerez-Gómez et al. (2004)	• Management commitment (5) • System perspective (3) • Openness and experimentation (4) • Knowledge transfer and integration (4)	Organization: 111 firms from the chemical industry	To develop a measurement scale for organizational learning capability
Yeung et al. (1999)	• Generate and generalize ideas with impact (24) • Incompetencies for learning (34)	Strategic business unit (SBU): 268 SBUs from large size and a wide variety of industries	To establish how variables of context (industry, business strategy and organizational culture) can influence how and why an organization learns, and how the organizational learning capability will affect business performance

Within the first workgroup, we find authors, such as Goh (2003), Goh, and Richards (1997), Hult (1998), Hult and Ferrell (1997), Jerez-Gómez, Céspedes-Lorente and Valle-Cabrera (2004), and Yeung, Ulrich, Nason, and von Glinow (1999). They identify as OL dimensions the critical components for the learning organization or intelligent organization, so described initially by Senge (1990). These are shown in Table 1.

OL is defined as the "to learn to learn" capability or "meta-learning": the organization follows a continuous change model, permanently challenging its basic assumptions and theories in use (Swiering & Wiersma, 1992). This idea of learning capability presents a clear link to the learning orientation concept or propensity of the company toward learning in connection with different elements that have to be present for OL to occur (Day, 1994; Galer & van der Heijden, 1992; Sinkula, Baker, & Noordewier, 1997). In order to build an organization with learning capacity, Senge (1990) considers as fundamental the implementation of a series of principles or management practices, that he calls "learning disciplines." Table 2 shows the relationship between these disciplines and the key dimensions of the works that use a learning capability measurement.

Personal mastery discipline means individuals clarify and rethink their personal vision, thus guiding future creation. This proposal implies experimentation and the search of innovative and flexible solutions to current and future problems allowing for the creation of ideas.

Mental models refer to assumptions or thinking schemes that conform the acts of the organization's members. For the organization, it is vitally important to be able to modify behavior lines set out in its organizational memory, offering a space for new knowledge creation. This is especially useful when such behavior lines do not correspond to the facts and continue to prevail and guide organizational activity.

Table 2. Basic aspects of learning organization and their relationship with the learning capability dimensions

Learning capability dimensions	Related factors according to authors revised
Personal mastery	• Team orientation (Hult, 1998; Hult & Ferrell, 1997) • Experimentation (Goh, 2003; Goh & Richards, 1997) • Generate and generalize ideas with impact (Yeung et al., 1999) • Openness and experimentation (Jerez-Gómez et al., 2004)
Mental models	• Learning orientation, systems orientation (Hult, 1998; Hult & Ferrell, 1997) • Incompetencies for learning (Yeung et al., 1999) • System perspective (Jerez-Gómez et al., 2004)
Shared vision	• Leadership commitment and empowerment (Goh & Richards, 1997) • Learning orientation, systems orientation (Hult, 1998; Hult & Ferrell, 1997) • Clarity of mission and vision (Goh, 2003; Goh & Richards, 1997) • System perspective (Jerez-Gómez et al., 2004)
Team learning	• Learning orientation, team orientation (Hult, 1998; Hult & Ferrell, 1997) • Transfer of knowledge (Goh, 2003; Goh & Richards, 1997) • Teamwork and group problem-solving (Goh, 2003; Goh & Richards, 1997) • Knowledge transfer and integration (Jerez-Gómez et al., 2004)
Systems thinking	• System perspective (Jerez-Gómez et al., 2004)

Building a shared vision is the shared ideal that agglutinates individual energies of organizational members and guides them in a common direction, generating a tension that leads to learning. This thought is supported by the managerial commitment, which implies that the management acknowledges the relevance of learning in the organization and supports it, promoting the development of a culture that fosters a learning atmosphere as a key value.

With reference to team learning, such learning can only be carried out via experience interchanges among individuals. This means generalizing ideas, that is, sharing ideas in the organization. Following this principle, there is the organizational ability to transfer knowledge both externally and internally. Teamwork allows an organization's members to be able to share knowledge and increase their understanding about needs and the ways in which other colleagues, in other parts of the organization, work.

Systems thinking allows the bringing together of learning results from previous disciplines and allows its extension to the rest of the organization.

Concerning OL definitions, most academics agree that OL is a process which starts from acquisition and creation of knowledge on behalf of individuals, and continues with its interchange and integration until reaching a body of collective knowledge. This idea, represented in Table 3, is proposed by the second group of works, such as Pérez López, Montes Peón, and Vázquez Ordás (2004), Templeton, Lewis, and Snyder (2002), and

Table 3. The measurement of OL as a process

Author(s)	OL dimensions (items)	Unit of analysis	Research objective
Pérez et al. (2004)	• Knowledge external acquisition (10) • Knowledge internal acquisition (7) • Knowledge distribution (7) • Knowledge interpretation (9) • Organizational memory (11)	Organization: 195 firms from the industrial and service sector	To analyze the relationship between organizational culture, OL and business performance
Templeton et al. (2002)	• Awareness (5) • Communications (3) • Performance assessment (4) • Intellectual cultivation (4) • Environmental adaptability(4) • Social learning (3) • Intellectual capital management (3) • Organizational grafting (2)	Organization: 119 knowledge-based firms	To develop a measure for the organizational learning construct
Tippins & Sohi (2003)	• Information acquisition (6) • Information dissemination (6) • Share interpretation (5) • Declarative memory (7) • Procedural memory (5)	Organization: 271 manufacturing firms	To examine the mediating role of OL in the linkage between information technology competency and firm performance

Tippins and Sohi (2003). These authors consider OL as a dynamic process that, according to Huber (1991), develops in time via several stages.

Table 4 sums up these phases of subprocesses with the dimensions identified in several works. These will be discussed subsequently.

Knowledge acquisition is defined as a process followed by organizations in order to actively search for information and knowledge from both internal and external sources. Such knowledge can have its origin in a firm's founders, intellectual capital management, learned from other organizations, embodiment of new members in the firm who have previously unavailable knowledge, and environmental scanning and observation (Huber, 1991).

Information distribution represents the stage at which information obtained in the previous step is delivered intentionally or not among units and members of the organization, promoting learning of new knowledge or its understanding (Garvin, 1993).

Information interpretation implies that one or more meanings could be given to this information (Daft & Weick, 1984). This requires the existence of a consensus among organizational members concerning information meaning. They learn about organizational matters via social channels.

Organizational memory is the last stage of learning. It refers to the group of systems and structures implemented in an organization to store knowledge created in the entity for this knowledge to be able to be used later (Walsh & Ungson, 1991).

Finally, with a different approach (as shown in Table 5), there is a group of authors which presents a scale for measuring the organizational learning

Table 4. Basic aspects of organizational learning processes and their relationship with the organizational learning dimensions

Organizational learning process dimensions	Related factors according to authors revised
Knowledge acquisition	• Social learning, awareness, intellectual cultivation, performance assessment, intellectual capital management, organizational grafting (Templeton et al., 2002) • Knowledge external/internal acquisition (Pérez et al., 2004) • Information acquisition (Tippins & Sohi, 2003)
Information distribution	• Environmental adaptability, social learning, awareness, intellectual cultivation (Templeton et al., 2002) • Knowledge distribution (Pérez et al., 2004) • Information dissemination (Tippins & Sohi, 2003)
Information interpretation	• Environmental adaptability, social learning, communications, performance assessment (Templeton et al., 2002) • Knowledge interpretation (Pérez et al., 2004) • Share interpretation (Tippins & Sohi, 2003)
Organizational memory	• Environmental adaptability, communications, intellectual cultivation, performance assessment, intellectual capital management (Templeton et al., 2002) • Organizational memory (Pérez et al., 2004) • Declarative and procedural memory (Tippins & Sohi, 2003)

Table 5. The measurement of OL and its integration within the knowledge-based view

Author(s)	OL dimensions (items)	Unit of analysis	Research objective
Bontis et al. (2002)	• Individual level learning (10) • Group level learning (10) • Organization level learning (10) • Feedforward learning (10) • Feedback learning (10)	Individual: A survey instrument based on the strategic learning assessment map (SLAM) was administered to 15 individuals from 32 organizations	To analyze the relationship between the stocks and flows of learning and business performance
Nonaka et al. (1994)	Knowledge conversion phases (SECI): • Socialization (10) • Externalization (9) • Combination(10) • Interiorization (9)	Organization: 105 firms	To validate a scale for measuring the knowledge creation process

as a knowledge creation process in organizations. In this sense, Nonaka, Byosiere, Borucki, and Konno (1994) consider that the dimensions of the knowledge creation are the four modes of knowledge conversion (SECI) in the theoretical model defined by Nonaka (1994).

Bontis, Crossan, and Hulland (2002) present a macro perspective of OL in which it relates to the phenomenon of strategic renewal. These authors describe OL as a process through which stocks and flows of learning are managed to increase a firm's performance. In this way, according to Crossan Lane, and White (1999), OL is a dynamic process, via levels, producing a tension between the incremental or amplified logic that involves the scanning or new assimilation of knowledge (feed-forward), and the reductive logic that implies the exploitation or use of learnt knowledge (feedback). Through a feed-forward process, new ideas and actions flow from the individual to the group and from them to the organization. While learning, a feedback process from the organization to the group takes place, and from the group to the individual level, thus affecting the way people think and act. According to this social approach of OL, learning happens and knowledge is created by social interaction developed among the different levels proposed by the ontological dimension of knowledge (i.e., individual, group, and organization).

FUTURE TRENDS

Future works are needed that consider the necessity of carrying out longitudinal studies using the intermediate perspective that complete the existing cross-sectional studies, especially if we consider the continuous nature of OL. This is an accumulative process in time, implying that the amount of knowledge reached at a specific moment in time is the result of learning accumulated up to this moment. In any case, the existence of a measurement method of OL will allow us to go further in the comprehension of mechanisms that facilitate the transformation process of OL into an increase of business performance. In this sense, in the future, it would be interesting to develop works in line with the micro/interpretative perspective that allows us to obtain objective indicators via case studies.

The measurement of the OL can help to reveal different areas in which the managers act to develop this capability. Also, it can allow the establishment of standard values with which to initiate processes of benchmarking between organizations. Those that score above these standards may be considered as learning organizations. Without a doubt, the existence of OL measures will be useful for evaluating more complex models in which different connections with antecedent and consequent variables can be analyzed (Jerez-Gómez et al., 2004). All this is going to contribute to eliminating part of the existing controversy in significant questions, such as its impact on business performance.

CONCLUSION

This article has shown how the limited consensus on OL meaning has led to a confusion regarding its measurement. This issue has not been considered enough by the literature developed during decades of organizational thought. This has produced a lack of empirical works on the matter and, in particular, the almost absence of an elaboration of multi-item scales.

We have, despite this, focused on analyzing different scales from a macro/positivist approach that allows the undertaking of the measurement of OL as a multidimensional latent construct. Via this approach, a first group of analyzed works measures the organizational learning ability through a set of attributes that defines a learning organization. A second group establishes the learning measurement throughout several stages or phases in time, producing a collective knowledge. Finally, we have presented the OL measurement by the concept of learning stock and flow, aiming to show that OL and organizational knowledge represent both one and the same organizational reality.

REFERENCES

Abernathy, W.J., & Wayne, K. (1974). Limits of the learning curve. *Harvard Business Review, 52*(5), 56-72.

Bontis, N., Crossan, M.M., & Hulland, J. (2002). Managing an organizational learning systems by aligning stocks and flows. *Journal of Management Studies, 39*(4), 437-469.

Chaston, I., Badger, B., & Sadler-Smith, E. (1999). Organisational learning: Research issues and applications in SME sector firms. *International Journal of Entrepreneurial Behaviour & Research, 5*(4), 191-203.

Crossan, M., Lane, H.W., & White, R.E. (1999). An organizational learning framework: From intuition to institution. *Academy of Management Review, 24*(3), 522-537.

Crossan, M., Lane, H.W., White, R.E., & Djurfeldt, L. (1995). Organizational learning: Dimensions for a theory. *International Journal of Organizational Analysis, 3*(4), 337-360.

Daft, R.L., & Weick, K.E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9,* 284-295.

Day, G.S. (1994). The capabilities of market-driven organizations. *Journal of Marketing, 58*(3), 37-52.

Easterby-Smith, M., & Araujo L. (1999). Organizational learning: Current debates and opportunities. In M. Easterby-Smith, J. Burgoine, & L. Araujo (Eds.), *Organizational learning and the learning organization* (pp. 1-21). London: Sage.

Easterby-Smith, M., Crossan, M., & Nicolini, D. (2000). Organizational learning: Debates past, present and future. *Journal of Management Studies, 37*(6), 783-796.

Galer, G., & van der Heijden, K. (1992). The learning organization: How planners create organizational learning. *Marketing Intelligence and Planning, 10*(6), 5-12.

Garvin, D.A. (1993). Building a learning organization. *Harvard Business Review,* July-August, 78-91.

Goh, S.C. (2003). Improving organizational learning capability: Lessons from two case studies. *The Learning Organization, 10*(4), 216-227.

Goh, S.C., & Richards, G. (1997). Benchmarking the learning capacity of organizations. *European Management Journal, 15*(5), 575-583.

Huber, G.P. (1991). Organizational learning: The contributing processes and the literature. *Organization Science, 2*(1), 88-115.

Hult, G.T.M. (1998). Managing the international strategic sourcing process as a market-driven organizational learning system. *Decision Science, 29*(1), 193-216.

Hult, G.T.M., & Ferrell, O.C. (1997). Global organizational learning capacity in purchasing: Construct and measurement. *Journal of Business Research, 40*(2), 97-111.

Jerez-Gómez, P., Céspedes-Lorente, J., & Valle-Cabrera, R. (2004). Organizational learning capability: A proposal of measurement. *Journal of Business Research, 58*(6), 715-725.

Levitt B.G., & March, J.G. (1988). Organizational learning. *Annual Review of Sociology, 14,* 319-340.

Nonaka, I. (1994). A dinamyc theory of organizational knowledge creation. *Organization Science, 1*(1), 14-37.

Nonaka, I., Byosiere, P., Borucki, C.C., & Konno, N. (1994). Organizational knowledge creation theory: A first comprehensive test. *International Business Review, 3*(4), 337-351.

Pérez López, S., Montes Peón, J.M., & Vázquez Ordás, C. (2004). Managing knowledge: The link between culture and organizational learning. *Journal of Knowledge Management, 8*(6), 93-104.

Senge, P.M. (1990). *The fifth discipline.* New York: Currency Doubleday.

Sinkula, J.M., Baker, W.E., & Noordewier, T. (1997). A framework for market-based organizational learning: Linking values, knowledge, and behaviour. *Journal of the Academy of Marketing Science, 25*(4), 305-318.

Slater, S.F., & Narver, J.C. (1995). Market orientation and the learning organization. *Journal of Marketing, 59*(3), 63-74.

Swieringa, J., & Wierdsma, A.F. (1992). *Becoming a learning organization.* MA: Addison-Wesley.

Templeton, G.F., Lewis, B.R., & Snyder, C.A. (2002). Development of a measure for the organizational learning construct. *Journal of Management Information Systems, 19*(2), 175-218.

Tippins, M.J., & Sohi, R.S. (2003). IT competency and firm performance: Is organizational learning a missing link? *Strategic Management Journal, 24*(8), 745-761.

Vera, D., & Crossan, M. (2003). Organizational learning and knowledge management. In M. Easterby-Smith & M. Lyles (Eds.), *Handbook of organizational learning and knowledge management* (pp. 122-141). MA: Blackwell.

Walsh, J.P., & Ungson, G.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Yeung, A.K., Ulrich, D.O., Nason, S.W., & von Glinow, M.A. (1999). *Organizational learning capability. Generating and generalizing ideas with impact.* New York: Oxford University Press.

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Chapter 5.28
Knowledge Management in Higher Education and Professional Development in the Construction Industry

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ABSTRACT

Development of a 'knowledge society' affects not only enterprises and organisations, but also individuals. Lifelong learning and continuing professional development are essential for graduates and workers to remain competent and competitive. Hence, knowledge management is not only important in business processes, but also in education. As the importance of knowledge management in the construction industry is growing, competence in knowledge management is essential for graduates of curricula related to the construction industry. Design and implementation of such curricula should take into account methods for enriching the knowledge management competences of students in higher education. This chapter reports on lessons learned from the design and implementation of a particular module where principles of knowledge management are integrated into the learning activities.

INTRODUCTION

Since the early eighties, knowledge management has become a 'hot' issue. Modern organisations consider knowledge as an important resource and a source of competitive advantage. Our society is evolving from an 'information society' to a 'knowledge society'. Advances in information technology and the accessibility to huge amounts of information on the Internet have made everyone aware of the potential for using and creating information and knowledge. The impact is not only on enterprises and organisations, but also on individuals. Lifelong learning and continuing professional development are essential for graduates and other workers to remain competent and competitive. Hence, knowledge management is not only important in business activities, but also in education.

The impact of knowledge management in higher education is multi-levelled. Educational administrators and teachers have begun to look at how they might use information systems to assist in creating effective learning environments. Knowledge management can also be used to support both educational administration and the teaching and learning environment. As the importance of knowledge management in the construction industry is growing, competence in knowledge management is essential for graduates of curricula related to the construction industry. Design and implementation of such curricula should take into account methods for enriching the knowledge management competencies of students in higher education. This chapter reports on lessons learned from the design and implementation of a particular module where principles of knowledge management are integrated into the learning activities. The module is Surveying Studio in the BSc (Surveying) curriculum of the Department of Real Estate and Construction at The University of Hong Kong.

Processes in knowledge management are not new. However, the knowledge management approach provides a more systematic way in which to design and facilitate learning activities. Students working in a team environment to solve problems are exposed to issues related to knowledge management such as communication, knowledge creation, knowledge acquisition, knowledge sharing, and collaborative work. Students are introduced to various tools to support knowledge management, including dialog mapping software, collaborative authoring, and concept mapping. The goal is to integrate principles of knowledge management into a constructivist learning environment so as to enhance students' competence in knowledge management.

LEARNING OBJECTIVES

1. Appreciate the relationship between learning, professional development, and knowledge management.
2. Integrate the principles of knowledge management in designing a course.
3. Design a course with a constructivist learning environment to promote self-learning and to develop skills of knowledge management.
4. Develop and implement learning activities that make use of knowledge sharing tools.

BACKGROUND

In an 'information society', competency in information literacy is an important requirement in business and in education. According to the Information Literacy Competency Standards for Higher Education (American Library Association, 2000), an information-literate individual is able to:

- Determine the extent of information needed
- Access the needed information effectively and efficiently
- Evaluate information and its sources critically
- Incorporate selected information into one's knowledge base
- Use information effectively to accomplish a specific purpose
- Understand the economic, legal, and social issues surrounding the use of information, and access and use information ethically and legally

The emergence of the 'knowledge society' and the knowledge-based economy signify a new era for knowledge workers. Globalisation has led to ever-increasing competition and shortening of the life cycles of products and services. New information and communication technologies continue to transform workplaces and work practices. There is a requirement from industry for continuous professional development and lifelong learning. Based on the report of the Careers Education and Placement Centre (2001), employers today expect undergraduates to have core competencies in:

- Communication skills
- Analytical reasoning
- Lateral thinking
- Interpersonal sensitivity
- Practical orientation
- Information technology proficiency
- Work attitude
- Emotional stability

The growing complexity and dynamics of professional work increasingly require teamwork. The above requirements call for a new paradigm for education and training which goes beyond information literacy. It encompasses creative and critical thinking, problem solving and communication skills, as well as the ability to interact with others in a collaborative manner. The requirements are evolving from competency in information literacy to competency in knowledge management.

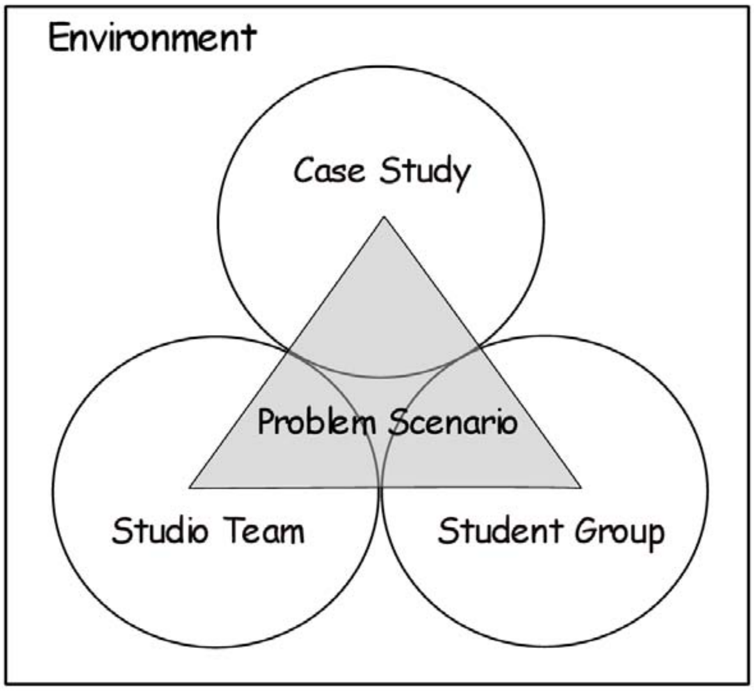
The trend of lifelong learning and learner-centred approaches to education actually reinforce the need for knowledge management competency. In the curriculum design of the BSc (Surveying) course, in addition to core subjects, is a module called Surveying Studio. The aim of Surveying Studio is to allow students to undertake work under their own initiative, and to test their abilities and understanding of professional skills and techniques. Surveying Studio originally started with a task-oriented approach. Feedback from both staff and students was collected and the design was revised. Other successful ideas from courses related to problem-based learning and peer learning were incorporated. The common feature of all these approaches is constructivism. Theories of constructivism suggest that for learning to be useful, the learner needs to be actively involved in constructing new knowledge within meaningful contexts, not merely absorbing it (Duffy, Lowyck, & Jonassen, 1993). Jonassen (1999) lists a number of design principles that can be used to develop what he calls the "constructivist learning environment." These design principles are:

- Create real-world environments that employ the context in which learning is relevant.
- Focus on realistic approaches to solving real-world problems.
- The instructor is a coach and analyser of the strategies used to solve these problems.
- Stress conceptual interrelatedness, providing multiple representations or perspectives on the content.
- Instructional goals and objectives should be negotiated and not imposed.
- Evaluation should serve as a self-analysis tool.
- Provide tools and environments that help learners interpret the multiple perspectives of the world.
- Learning should be internally controlled and mediated by the learner.

The outcome is a change from a transmission model of learning to a constructivist learning paradigm. In a student-centred approach to education, students are responsible for their own self-directed learning. Based on a student-centred framework, a conceptual model of Surveying Studio is shown in Figure 1.

There are four major components in the conceptual model: case study, studio team, student group, and the problem scenario. The case study is a real-life project in the field of real estate and

Figure 1. Conceptual model of Surveying Studio



construction. Information and documentation for the case study are collected from various organisations involved in the project. The case study is intended to set Surveying Studio in an authentic context or theme. The studio team is composed of four or five members of staff including the studio coordinator. The studio coordinator is responsible for planning, scheduling, and coordinating all studio activities. The studio team works together to develop problem scenarios with respect to the selected case study. A problem scenario is an open-ended and ill-structured problem in an authentic context. It allows students to explore the problem from different viewpoints, different pathways, with different learning styles, and to arrive at different solutions. The pathways are complex enough for a variety of investigation approaches by different ability levels. Students are divided into groups with four to six members. Group members remain the same for the whole academic year. Student learning groups work through the problem scenarios to achieve desired learning outcomes.

Studio space and furniture are provided within the department. Students have their own desks, which are usually grouped together according to their learning groups. Network connection points and a wireless network are available to enable the students to connect laptop computers to the Internet from their desks. The studio space is an environment in which students are able to work on their own and conduct informal group meetings. A weekly meeting between the facilitator and student learning group is conducted in a small meeting room. The problem scenario is delivered to the students. The student learning group discusses and defines the problem, distributes workload among group members, continues to explore the issues, and shares the findings and learning experiences with each other. At the conclusion of each problem scenario, the group produces the final learning outcome and deliverable(s). Also, students keep a learning journal to document and reflect on their learning experience and progress. As continuous assessment is employed, there is no written examination for Surveying Studio.

The above description is from the point of view of the module designer. As it is a student-centred learning framework, looking from the student's perspective would show the learning environment as a knowledge management system.

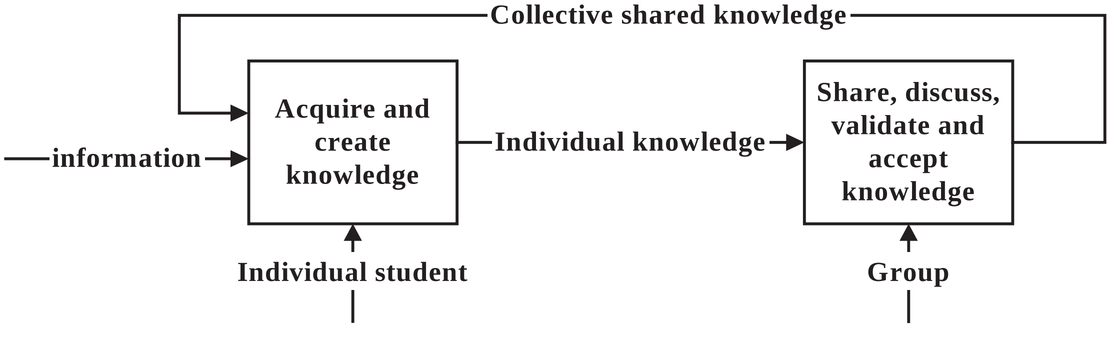
CONSTRUCTIVIST LEARNING ENVIRONMENT AS A KNOWLEDGE MANAGEMENT SYSTEM

Marshall and Rossett (2000) noted that knowledge management systems "are composed of two complimentary parts: one technical, the other social" (p. 26). The technical component seeks to "capture, package, and distribute tangible, documented products," while the social side "enables collaboration, connection, and reflection among system users." To adopt the student-centred learning paradigm, a constructivist learning environment should be created as a knowledge management system for the students. The technical components of the system include the infrastructure and resources to support the knowledge management processes carried out by students. The social components include the time, space, and culture to support collaborative work and peer learning.

Davenport (1998) indicates that knowledge is created invisibly in the human brain, and only the right organisational climate can persuade people to create, reveal, share, and use it. Learning is a process of creating knowledge. Learning how to learn is the spirit of knowledge management. Thinking in processes stresses the dynamic nature of knowledge management. Basically, there are two main categories of knowledge management processes:

- Acquire and create knowledge: When students search, read, organize, and understand information, they acquire and create knowledge in their minds and integrate the new knowledge with their existing knowl-

Figure 2. IDEF01 diagram of knowledge sharing



edge. Hence individual learning is about individual knowledge development and enhancing competences.

- Share and use knowledge: Facing a problem, students apply and use their knowledge to solve the problem. Working in a team environment, students share their knowledge to develop new knowledge, and apply knowledge for problem solving. Sharing knowledge is a way to use knowledge. Knowledge sharing is also the basis of organisational learning.

The relationship between individual learning and collaborative learning is shown in Figure 2.

In both education and business, it is important to create a culture and an environment to maximize individual knowledge development, as well as knowledge sharing, through collaborative work.

LEARNING ENVIRONMENT TO SUPPORT KNOWLEDGE SHARING

Individual students are responsible for their own self-directed learning to acquire and create knowledge. The learning environment should provide access to various information sources, including libraries and resources on the Internet. It should also facilitate the articulation and exchange of knowledge. Effective knowledge creation depends on an enabling context, which can foster ideas and facilitate the articulation, creation, and evaluation of experiences and knowledge. Creating a 'right context' is crucial to student-centred learning.

In Surveying Studio, a problem scenario is designed to stimulate the students' need for more knowledge to solve the problem. When the problem scenario is presented to a student group, the students brainstorm and clarify the issues during their first meeting with their facilitator. Individual students contribute ideas based on their existing knowledge. They need to identify the nature of the problem and the knowledge required for solving the problem. At the same time, they identify gaps in their existing knowledge, and the measures and actions required to fill the gaps.

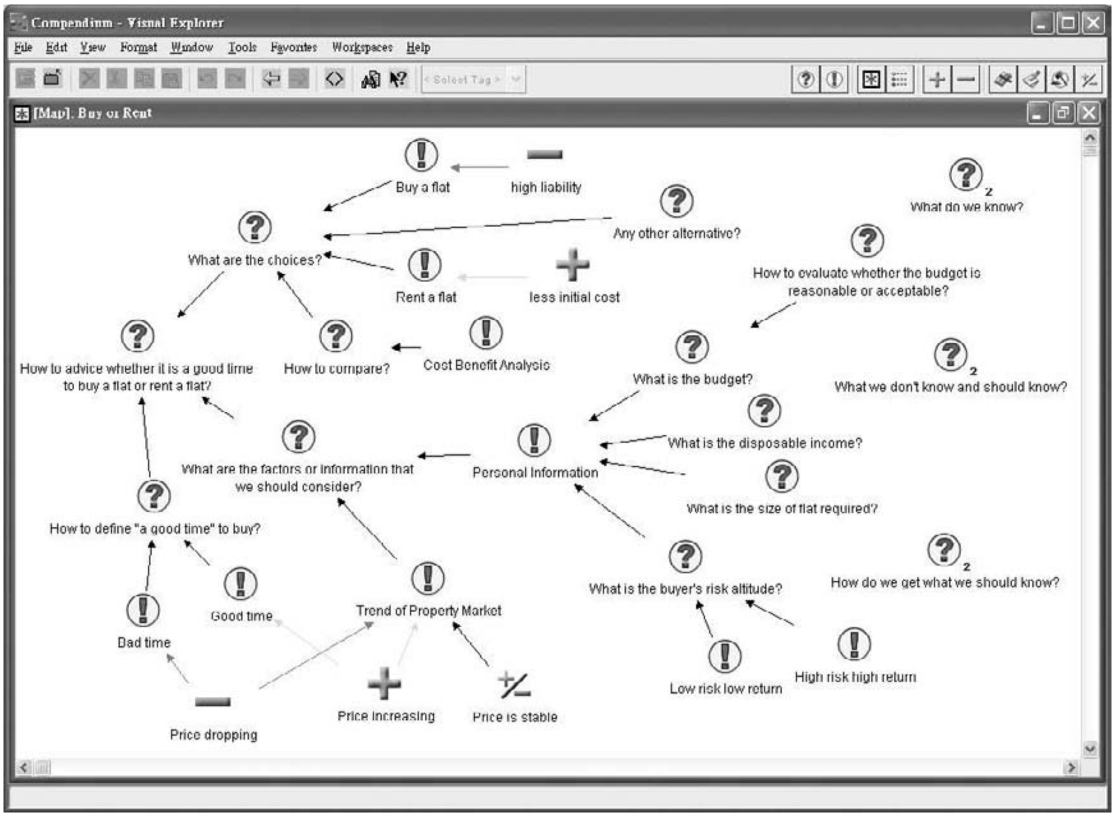
Knowledge Sharing: A Technical Perspective

Although students discuss the problem scenario in a face-to-face meeting, communication and knowledge sharing are not necessarily effective. A learning environment should enable the group to share their thinking and reformulate their assumptions as they expand their understanding. A dialog mapping software tool2 is used to facilitate discussion in a group meeting. The tool provides a visual presentation for tracking and visualizing the argument process. A laptop computer running the dialog mapping software is connected to a data projector. The projected dialog map consists of questions, ideas, and arguments generated from the discussion process (Figure 3). During the meeting, students raise issues, questions, ideas, and arguments. One student, acting as the group scribe, records the issues, ideas, and so forth, using the dialog mapping software on the laptop computer. The projected dialog map serves as a group memory, encouraging students to make their assumptions visible, while helping to clarify their thinking and improve on other students' ideas. The combination of information on the dialog map and visual thinking leads to a rich discussion. The following verbatim passage is part of a group discussion after the facilitator has delivered the problem scenario to the group. Student A is the chairperson and Student B the scribe.

Student A: Today, our task is to advise Janis whether she should buy or rent a flat. In my opinion, I would suggest her to rent a flat.

Student C: If Janis buys her own flat, she'll feel more secure. I think she should buy instead of rent a flat.

Figure 3. Using dialog mapping to augment discussion



Student B: Me too. How about we simply vote to determine our recommendation?

Student D: I don't think so. We should not only tell Janis about our recommendation. We need to advise and explain our suggestion to her.

Student E: In that case, we should compare the pros and cons of the two choices to see which one is better. I think timing is one of Janis's concerns also.

Facilitator: Good. How about establishing a focus question first to guide our discussion?

Student A: So, our question is whether it is a good time to buy or rent a flat.

Student D: Besides buy or rent, are there any other options?

Student B: I don't know. Anyway we'll put this down as a question.

Student C: How are we going to compare the two options?

Student A: We should find out the factors affecting the choice.

Student D: I think the decision may be a personal preference.

Student C: That means we have to consider some personal factors such as monthly income, family size, etc….

Student C: Don't forget that we have to judge whether it is a good time to buy a flat or not.
Student D: It depends on the current status of the property market. I think buying a flat is a big investment.
Student A: Do you know what are the costs involved in buying a property?
Student D: I don't know the details, but I know that there is legal fee, agent fee, and the buyer needs to arrange a mortgage loan with the bank….

Student A: So, in the coming week, (Student C) and I would find out more information about the status and trend of the property market.
Student B: I'll work with (Student D) to find out all the costs involved in renting a flat and buying a flat.
Student E: May be we should ask our parents, as they had made that choice already?...

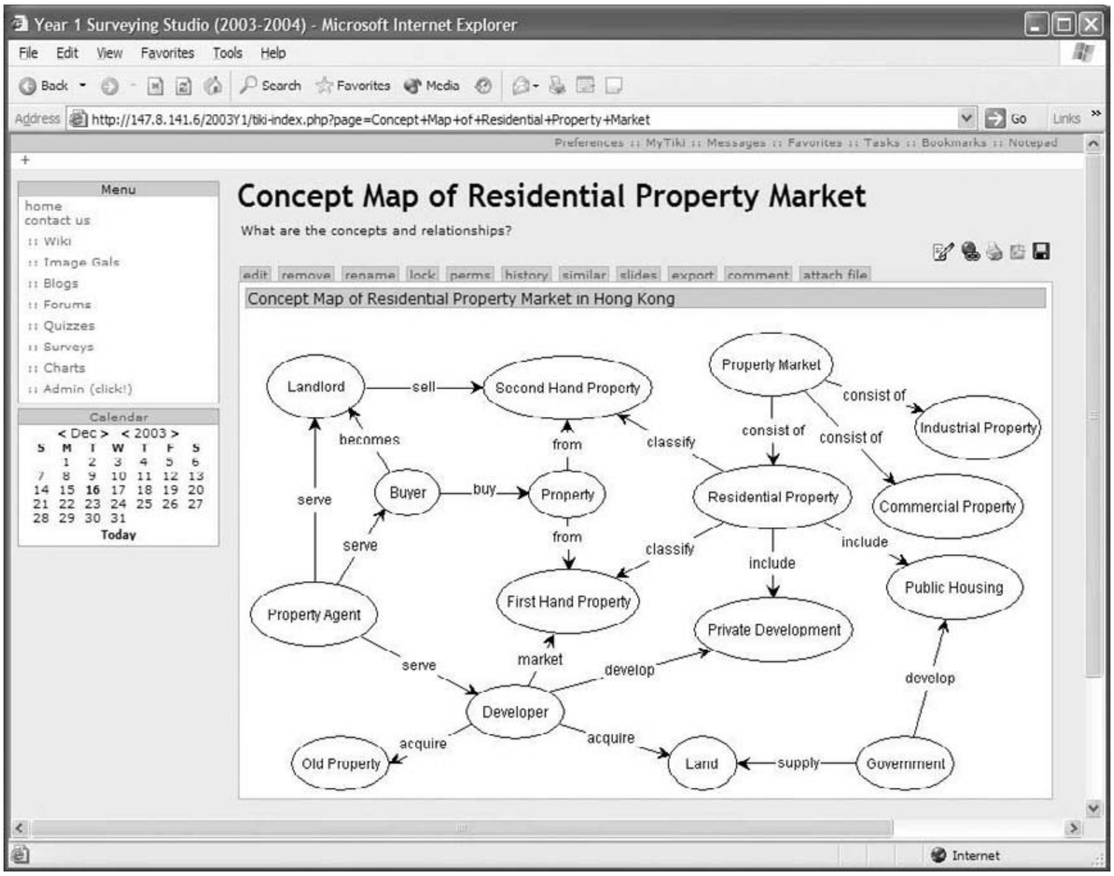
At the end of the meeting, the group has a road map to solve the issue and an action plan to guide the work of individual members. Each student then acquires further knowledge from various sources and shares the knowledge through other channels before the next meeting. The initial design intended to create a discussion forum on the Internet for students to share their findings and ideas in an asynchronous mode after the meeting. The result was not satisfactory. The outcome was a long list of threaded discussion postings. Some messages were subjective, without supporting arguments or follow up. Others were similar or simply repeating other member's ideas. The problem was that the collection of postings in a discussion forum was not consolidated to represent the shared-group knowledge. In fact, students preferred to use their usual channels, for example, ICQ for chatting and discussion rather, than using the prescribed discussion forum.

From the initial experience, we found that students are smart enough to find their own way to communicate and share ideas. What was missing was a repository to capture the collective shared group knowledge generated from the discussion process. Therefore, a knowledge repository was established on the Internet using a Wiki server.3 Instead of posting individual messages, students create and edit Wiki pages in a collaborative authoring environment. Students continue to use their preferred channels for discussion, but they are also required to create Wiki pages to consolidate their findings and ideas generated from discussions. Every member can edit the Wiki page to modify exiting information or add more information using a standard Web browser. The collective shared-group knowledge is represented as a set of linked Wiki pages. Students read the Wiki pages to acquire and create their own individual knowledge. However, students are not just passive receptacles of information, they are also creators. The system allows students to post and share documents. It also allows them to edit documents, to view the history of changes to a document, and to create and contribute documents.

To support meaningful learning from the shared-group knowledge, the technique of concept mapping is also introduced. Meaningful learning is a process in which new information is related to an existing relevant aspect of an individual's knowledge structure (Novak, 1998). A simple graphic editing tool4 is used for the students to create their own concept map. The tool also allows real-time collaborative editing of concept maps, as well as asynchronous editing integrated with the Wiki server (Figure 4).

To reflect and learn from one's own experience is an essential element in knowledge management. Students are required to write and post their learning journal on the Wiki server. A learning journal promotes self-assessment and evaluation which is critical in acquiring and creating individual knowledge. Both positive and negative learning experiences are found in the students' learning journal, for example:

Figure 4. Concept map integrated with Wiki page



Student V: I enjoy searching and exploring new knowledge.

Student W: I feel extremely stressful. I always don't know what to do at the beginning.

Student X: I learn how to work effectively within limited time and how to cooperate with other group members.

Student Y: Group members cannot compromise on issues. Lack of communication between group members is obvious.

Student Z: We learn how to think, how to organize working schedule, and how to solve problem as a group.

As students reflect on their learning experiences, they identify the way to improve or to solve the problem.

To summarize, the tools and technologies that support the constructivist learning environment include laptop computers, data projector, Internet connections, dialog mapping software, Wiki server, and a concept mapping tool. Technology helps to connect students so they can think and work together. However, to achieve effective knowledge sharing, the social and cultural context is also important.

Knowledge Sharing: A Social Perspective

Students learn on their own and together as a group. They see each other's thinking as they solve problems together, in peer reviews, or in arguing with each other. A critical factor to support effective knowledge creation and sharing is the necessity for students to be physically close to each other in space and time. The sense of "nearness" is crucial in stimulating the exchange of ideas, tacit knowledge, and experiences. Therefore, a studio space where students have their permanent working place is desirable. It establishes a stimulating social environment, and generates social pressure and a sense of mutual responsibility. In their studio, students usually group their desks together according to their group memberships (Figure 5).

The design of a constructivist learning environment faces challenges from various aspects. The social challenge is to develop communities

Figure 5. Studio space to augment knowledge sharing

that share knowledge and still maintain enough diversity of thought to encourage thinking rather than copying. The management challenge is to create an environment that truly values sharing of knowledge with trust and reward. The personal challenge is to be open to the ideas of others, to be willing to share ideas, and maintain a thirst for new knowledge.

Before the commencement of Surveying Studio, an orientation and explanation of the student-centred learning approach is delivered to all students. It is important to make sure that all students understand that assessment of their performance is criterion based and not norm referenced. Assessment is based on group performance and individual contribution to the group. Hence, there will be less competition between students. Competition between groups to achieve higher grades may exist, but group members are willing to share and help each other so as to perform effectively as a team.

In addition to the formal meeting to discuss the problem scenario in the presence of the facilitator, the main portion of learning takes place as peer learning in informal meetings among students. Students continually learn from each other on a daily basis. They learn a great deal by explaining their ideas to others and by participating in activities in which they can learn from their peers. They develop skills in organizing and planning learning activities, working collaboratively with others, giving and receiving feedback, and evaluating their own performance. Much peer learning occurs informally without staff involvement.

The design of a problem scenario focuses on the setting of open-ended issues for students, working as a group, to solve the issues. Students engage in exploration of ideas and knowledge, and learn to learn. A member of staff, acting as a facilitator, hands over more control to the students. The student group determines individual roles within the group and it is the personal sense of learning that signifies collaborative learning. Critical thinking, problem solving, making sense of complex issues and personal transformation, the social construction of knowledge—exploration, discussion, debate, criticism of ideas—are the essence of collaborative learning. Bruffee (1999) names this approach 'constructive conversation'—an educative experience in which students learn by constructing knowledge as they talk together and reach consensus or dissent. Dissent, questioning each other's views within a group, is a necessary part of learning.

CURRENT RESULTS

The design and development of Surveying Studio is an ongoing process. There have been both success and failure scenarios. Feedback and lessons learned are used to improve ongoing design and development. Preliminary observations indicate positive results in enhancing students' knowledge management competence in the following aspects:

- Working with others: A student group is a learning community. Students develop a sense of responsibility for their own and others' learning. They also develop confidence and self-esteem. They learn to acknowledge the backgrounds and contributions of other students they are working with to develop collaborative skills.
- Critical enquiry and reflection: A challenge to existing ways of thinking arises from more detailed interchanges between students in which points of view are argued and positions justified. Opportunities are present for formulating questions rather than simply responding to those posed by others. Students are able to articulate what they understand and to be more open to critique by peers, as well as learning from listening to and criticizing others.
- Articulation of knowledge: Concept development often occurs through the testing of ideas

on others and the rehearsing of positions that enable students to express their understanding of ideas and concepts. It is often only when they are expressed and challenged that students appreciate whether they have a good grasp of what they are studying.

- Learning how to learn: The learning activities in Surveying Studio require students to develop self-management skills and management of others. Students take collective responsibility for identifying their own learning needs and planning how these might be addressed. Learning to cooperate with others to reach mutual goals is a prerequisite for working in a complex society.
- Self- and peer-assessment: The learning activities require students to identify criteria to assess their own learning and to practice self- and peer assessment. This is a key element of sustainable assessment needed for lifelong learning.

Surveying Studio enhances students' experience of learning, and enables them to engage in the learning processes that reflect the working practices in which they will be expected to participate later, when they are in the workplace.

FUTURE TRENDS

Information and communications technologies are changing the nature of instructional design. Technology and the use of the Internet and World Wide Web have allowed major changes both in teaching practice and learning, and consequently, in the management of information and knowledge. Since the inception of the World Wide Web in the early 1990s, increasing numbers of educators have used this medium to make information, relevant to their courses, available to students. The ability to use the Internet to place information online for others to access, as well as to collaborate with others, creates a new way of thinking about the management of knowledge, information, and documents.

The challenge faced by both business and education is not only how to best manage the volume of information so that it is easily accessible to search and retrieve materials, but also how to provide people with the ability to post information and to enhance collaboration. It is important to create a culture where instructors and students are willing to share their information and knowledge, as well as contributing to the generation of new knowledge. The application of knowledge management principles and the desire to deliver documents to learners has opened the door for creating a more effective learning environment in higher education and professional development.

The rapidly changing knowledge economy has led to an increased interest in lifelong learning. Workplaces are in need of employees who can learn new skills and adapt quickly to social and technological changes. Educational institutions are faced with the challenge of providing students with the knowledge and skills to enable them to adapt successfully to job-related changes after completing their formal education.

The growing complexity and dynamics of professional work increasingly requires teamwork. Professionals piece information together, reflect on their experience, generate insights, and use those insights to solve problems. Continuous learning while working is obligatory to meet the performance requirements of the workplace. In the above context, there are many questions regarding new ways of working and learning still to be resolved.

CONCLUSION

In the developed world, the basis of the economy has changed from manufacturing products to creating and managing knowledge. In addition to the possession of professional knowledge, the ability to continue learning has become more and more important. Education is of increasing importance in its form as a lifelong and continuous learning process, both in business and in the individual context. The significance of lifelong learning and continuous learning raises the need for new teaching and learning paradigms. For example, lifelong learners typically plan their own learning, apply existing knowledge and skills effectively, evaluate their own learning, locate information from different sources, use different learning strategies in different situations, and resolve complex problems with multiple or uncertain solutions. These requirements need to be considered in both curriculum design and course delivery.

Although knowledge management has been developed within a business context, it can be applied to education. Knowledge management is not only essential at an organisational level. It should be a key competence at an individual level. Knowledge management should be integrated into higher education and professional development programs related to construction industry. The design and development of Surveying Studio is a step forward in the trend of integrating knowledge management principles to create a constructivist learning environment in higher education. This learning environment promotes students working as a team and augments knowledge sharing in both a technical and socio context. Various tools to support knowledge management are introduced to students, including dialog mapping, collaborative authoring, and concept mapping tools. Problem scenarios and learning activities are designed to integrate the use of knowledge sharing tools and knowledge management strategies. The primary objective is to enhance students' competence in knowledge management so that, after graduation, they are able to cope with the knowledge-based working environment.

The design and development of Surveying Studio is an ongoing process. We are learning from our experience by acquiring and creating our own knowledge. We are using our knowledge to improve, and also sharing our knowledge through this publication.

PRACTICAL TIPS AND LESSONS LEARNED

- Competence in knowledge management is important for graduates and professionals working in a knowledge-intensive industry.
- Learning how to learn is an essential skill of knowledge management.
- Learning to cooperate with others to reach mutual goals is a prerequisite for working in a knowledge society.
- Encourage the use of all possible types of communication channels (formal and informal, physical and virtual) to support knowledge sharing. The community will find the most effective way to share knowledge.

ENDNOTES

1. IDEF0 is a method designed to model the decisions, actions, and activities of an organisation or system. It is a public domain modelling system, and in fact it is an American standard (FIPS 183).
2. The dialog mapping software used is called Compendium, available at Compendium Institute, www.compendiuminstitute.org.
3. The Wiki server is established using TikiWiki, freely available at tikiwiki.org.
4. The graphic editing program is called JGraphPad, freely available at jgraph.sourceforge.net.

REFERENCES

American Library Association. (2000). *Information literacy competency standards for higher education*. Chicago: The Association of College and Research Libraries.

Boud, B., & Solomon, N. (Eds.). (2001). *Work-based learning: A new higher education?* Buckingham: SRHE and the Open University Press.

Boud, D., Cohen, R., & Sampson, J. (2001). *Peer learning in higher education*. London: Kogan Page.

Bruffee, K. (1999). *Collaborative learning: Higher education, interdependence and the authority of knowledge*. Baltimore: The Johns Hopkins University Press.

Candy, P. (2000). Knowledge navigators and lifelong learners: Producing graduates for the information society. *Higher Education Research & Development, 19*(3), 261-277.

Careers Education and Placement Centre. (2001). *Report of Careers Advisory Board Working Group on Competency Profile*. Hong Kong: The University of Hong Kong.

Davenport, T., DeLong, D., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(Winter), 287-300.

Duffy, T.M., Lowyck, J., & Jonassen, D.H. (1993). *Designing environments for constructive learning*. Berlin: Springer Verlag.

Hartley, D.E. (2000). *On-demand learning: Training in the new millennium*. Amherst, MA: HRD Press.

Homer-Dixon, T. (2000). *The ingenuity gap*. New York: Knopf.

Jonassen, D.H. (1999). Designing constructivist learning environments. In C.M. Reigeluth (Ed.), *Instructional design theories and models: A new paradigm of instructional theory* (Volume II, pp. 215-239). NJ: Lawrence Erlbaum.

Knapper, C.K., & Cropley, A.J. (2000). *Lifelong learning in higher education*. London: Kogan Page.

Marhsall, J., & Rossett, A. (2000). Knowledge management for school-based educators. In J.M. Spector & T.M. Anderson (Eds.), *Integrated and holistic perspectives on learning, instruction and technology: Understanding complexity*. Boston: Kluwer Academic Publishers.

Novak, J.D. (1998). *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations*. NJ: Lawrence Erlbaum.

Palmer, S. (2001). Engineering flexible teaching and learning in engineering education. *European Journal Engineering Education, 26*(1), 1-13.

Raven, J., & Stephenson, J. (2001). *Competence in the learning society*. New York: Peter Lang.

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Chapter 5.29
Legal Knowledge Management

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INTRODUCTION

Legal practice is primarily concerned with the transfer of legal knowledge from practitioners or clients. Whilst lawyers may draft contracts and make representations on behalf of their clients, their primary task is to advise their clients on appropriate remedies and courses of action. Rodríguez Morcón, Pérez García, and Sigüenza Pizarro Rodriguez (2002) claim that a lawyer sells what he knows, often in the form of a document (a contract, an opinion, a report) and much more often in a trial before a court or in a negotiation with a counterpart. Khandelwal and Gottschalk (2003) claim that lawyers can be defined as knowledge workers. They are professionals who have gained knowledge through formal education (explicit) and through learning on the job (tacit).

To carry out their daily work, lawyers also have to manage a great many sources of information. It is important for them to be aware of current changes in legislation and jurisprudence, and to consult books and articles. But it is also necessary to manage the information that is generated from within the practice in the course of lawyers' relationships with their clients. In a law firm's day-to-day work, a mass of information and knowledge is generated which has to be managed efficiently, so that it is easily, quickly. and intuitively accessible whenever it is needed by any of the firm's offices. Rusanow (2003) defines legal knowledge management as the leveraging of the firm's collective wisdom by using systems and processes to support and facilitate the identification, capture, dissemination, and use of the firm's knowledge to meet its business objectives.

We commence by emphasising the difficulty of developing generic legal knowledge management approaches given the multiplicity of different legal systems. We next focus on maintaining legal knowledge using an argumentation-based approach and building legal knowledge-based systems for World Wide Web. Since the goal of the legal process is to avoid litigation, we conclude by discussing how knowledge can be managed to provide Online Dispute Resolution.

BACKGROUND

One of the major difficulties in providing generic legal knowledge management tools is the fact that legal practice is very context dependent. Whilst the laws of gravity are fairly uniform throughout our earth, this is definitely not the case with legal norms. Even within Western Europe, Canada, and the United States, there are distinct legal traditions—namely Common Law and Civil Law.

David and Brierly (1985) note that common law and civil law legal traditions share similar social objectives (individualism, liberalism, and personal rights), and they have in fact been joined in one single family, the Western law family, because of this functional similarity. Other countries may have a code of law based upon tribal practice or religious principles.

Even within one country, there may be various modes of legal practice or major regional differences in the way law is practised. For example, in the United States, a state court determines Family Law. Because of the varying legislation between states, lawyers often engage in forum shopping to obtain an advantage for their client.

As well as regional differences, the different courts in the same region may rely upon distinct burdens of proof—the necessity or duty of affirmatively proving a fact or facts in dispute on an issue raised between the parties in a cause (Black, 1990). Except as otherwise provided by the common law, the burden of proof requires proof by a preponderance of the evidence (or the balance of probabilities). In a criminal case, the government must prove all the elements of the crime beyond a reasonable doubt. Except in cases of tax fraud, the burden of proof in a tax case is generally on the taxpayer.

Hence law is very domain specific. An ontology is an explicit conceptualization of a domain (Gruber, 1995). Legal ontologies represent legal norms and are very significant for developing legal knowledge-based systems on the World Wide Web.

Building generic legal ontologies is not possible. Breuker, Elhag, Petkov, and Winkels (2002) claim that unlike engineering, medicine, or psychology, law is not ontologically founded. They claim law is concerned with constraining and controlling social activities using documented norms. Zeleznikow (2004) conducts an overview of legal ontologies.

CLIME, e-COURT, and FFPOIROT are all legal ontology projects funded by the European Union. Because of the plethora of legal systems in Europe, there is a great need to develop legal ontologies that are applicable across the European Union.

Given the domain specific nature of legal knowledge, and the fact that law firms exploit their legal knowledge for commercial gain, legal knowledge management has often been conducted in-house. Perhaps the one exception to this rule has been legal aid organisations, which provide advice to a large number of indigent clients.

LEGAL KNOWLEDGE MANAGEMENT, DECISION SUPPORT, AND THE WORLD WIDE WEB

Gottschalk (1999) states that the use of advanced technologies enables the law firm to take advantage of the most appropriate tools to improve efficiency, increase effectiveness, streamline communication, and reduce costs for their clients. A law firm is a collection of fiefdoms—each lawyer has his or her own clients and keeps the information about them private. One of the greatest objectives of knowledge management in law firms seems to be consistency of work output in an increasingly global market. Knowledge management support systems in law firms are concerned with capturing and codifying knowledge, creating knowledge, distributing knowledge, and sharing knowledge (Edwards & Mahling, 1997).

Russanow (2003) claims that information technology creates an expectation of faster and alternative legal services. In the age of instantaneous communication, lawyers have been forced to find quicker ways to deliver traditional legal services. Knowledge management systems and processes enable lawyers to work more efficiently and provide legal services quicker than ever before.

The Internet has also opened a whole new market for lawyers to sell their services. Lawyers must examine how they will use technology to deliver services to their clients. Online advisory and drafting tools, developed and managed by law firms, are becoming commonplace. Knowledge management systems and processes provide the foundation of online services.

Ross (1980) states that the principal institution of the law in action is not trial: it is settlement out of court. Alternative dispute resolution involves alternatives to the traditional legal methods of solving disputes. It is difficult to construct a concise definition of alternative dispute resolution (to litigation) for resolving disputes. Online dispute resolution, the application of information communication technology in alternative dispute resolution, has become a new and enhanced technique for dispute resolution.

Russanow (2003) further claims that a large firm may find that there is little sharing of knowledge across practice groups and offices. There are a number of cultural reasons for this. Where the partner compensation model rewards the individual rather than the firm, practice groups tend to operate as separate business units, focused only on growing their own practices. There is no incentive to share work with others, since there may be no reward for referring work to colleagues. Indeed, there may be overlap in areas of practice between lawyers in different practice groups. These groups may be competing with each other in the market. Lawyers may also believe that their knowledge base is their power base, and that sharing that knowledge would dilute their value.

This lack of knowledge sharing between individuals and practice groups means that the firm is not leveraging its multi-practice, multi-office infrastructure. Practice groups are not looking at cross-selling opportunities with other practice groups. These inefficiencies and lost business opportunities may directly impact the firm's revenue. In some instances, the lack of cross-referrals to other, more appropriate practice groups may even affect the firm's risk exposure.

Carine (2003) claims key elements of knowledge management are collaboration, content management, and information sharing. These elements can occur concurrently.

Collaboration refers to colleagues exchanging ideas and generating new knowledge. Common terms used to describe collaboration include knowledge creation, generation, production, development, use, and organisational learning

Content management refers to the management of an organisation's internal and external knowledge using information management skills and information technology tools. Terms associated with content management include information classification, codification, storage and access, organisation, and coordination.

Information sharing refers to ways and means to distribute information and encourage colleagues to share and reuse knowledge in the firm. These activities may be described as knowledge distribution, transfer, or sharing.

Effective information technology (IT) support for knowledge management can serve as a competitive advantage and as a professional aid to law firms. To examine IT support for knowledge management in Norwegian law firms, Gottschalk (1999) conducted a study that involved two phases of data collection and analysis. The first phase was an initial field study of the largest law firm in Norway to identify issues and attitudes towards IT and knowledge management in a law firm as a basis for the survey approach in the second phase. The semi-structured interviews conducted in the initial field study documented a strong belief in the potential benefits from knowledge management. The second phase was a survey of Norwegian law firms. Firm culture, firm knowledge, and use of information technology were identified as potential predictors of information technology support for knowledge management in law firms in Norway. The extent to which law firms in Norway use information technology to support knowledge management is significantly influenced by the extent firms generally use information technology.

FUTURE TRENDS: LEGAL DECISION SUPPORT ON THE WORLD WIDE WEB

Susskind (2000) indicates that until recently, there was only limited use of IT by legal professionals. While the use of word processing, office automation, case management tools, client and case databases, electronic data/document interchange tools, and fax machines is now standard, for example, only recently have law firms commenced using IT for knowledge management purposes. He claims that the use of knowledge-based legal knowledge management tools will become common in large firms by 2007 and in all legal firms by 2012.

But how will such systems be constructed?

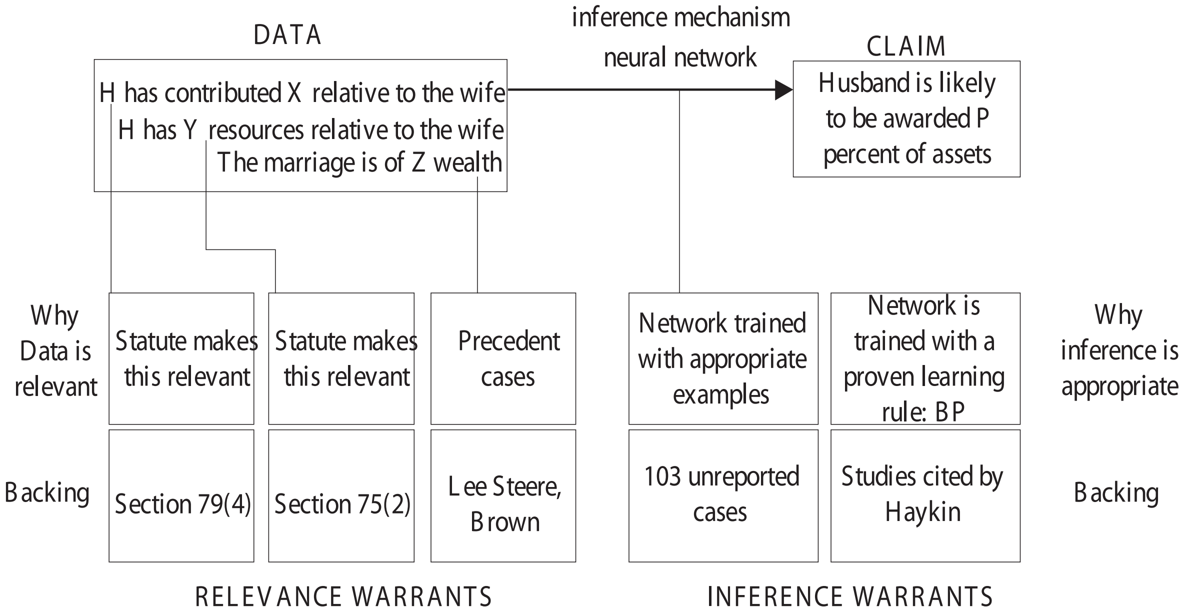
Argumentation has been used in knowledge engineering in two distinct ways: to structure knowledge and to model discourse (Stranieri & Zeleznikow, 2004). Stranieri, Zeleznikow, and Yearwood (2001) have used Toulmin's theory of argumentation to manage legal knowledge. Toulmin (1958) concluded that all arguments, regardless of the domain, have a structure that consists of six basic invariants: claim, data, modality, rebuttal, warrant, and backing. Every argument makes an assertion based on some data. The assertion of an argument stands as the claim of the argument. Knowing the data and the claim does not necessarily convince us that the claim follows from the data. A mechanism is required to act as a justification for the claim. This justification is known as the warrant. The backing supports the warrant and in a legal argument is typically a reference to a statute or a precedent case. The rebuttal component specifies an exception or condition that obviates the claim.

A system they constructed called Split-Up (Stranieri, Zeleznikow, Gawler, & Lewis, 1999) provides advice upon how Australian Family Court judges distribute marital property following divorce. Figure 1 illustrates one argument from the Split-Up system. We can see from that figure that there are three data items. Each of these is the claim item of other arguments, leading to a tree of arguments where the ultimate claim of the system is the root of the tree. In the argument in Figure 1, the inference mechanism is a neural network. The network, once trained with appropriate past cases, will output a claim value (percentage split of assets) given values of the three data items.

Figure 1 illustrates one argument from the Split-Up system. In 20 of the 35 arguments in Split-Up, claim values were inferred from data items with the use of neural networks, whereas heuristics were used to infer claim values in the remaining arguments. The Split-Up system produces an inference by the invocation of inference mechanisms stored in each argument. However, an explanation for an inference is generated after the event, in legal realist traditions by first invoking the data items that led to the claim. Additional explanatory text is supplied by reasons for relevance and backings. If the user questions either data item value, she is taken to the argument that generated that value as its claim.

The Split-Up system performed favourably on evaluation. Currently, the tree of arguments is being modified in conjunction with domain experts from Victoria Legal Aid (VLA) to accommodate recent changes in legislation. The argument-based representation facilitates the localization of changes and makes maintenance feasible. The use of the argument-based representation of knowledge enables machine-learning techniques to be

Figure 1. Argument for percentage split of assets to the husband



applied to model a field of law widely regarded as discretionary. JUSTREASON, developed by JUSTSYS (www.justsys.com.au) is a knowledge management shell that integrates a rule-based reasoning approach with argumentation structures similar to those used in the Split-Up system. To date the argument structure has been trialed in systems in family law (35 arguments), refugee law (200 arguments), sentencing (23 arguments), copyright law (50 arguments), evaluation of eyewitness evidence (23 arguments), and eligibility for legal aid (8 arguments).

The argument structure is also being used to support online dispute resolution. Lodder and Zeleznikow (2005) argue that an online dispute resolution environment can be appropriately designed through the use of dialogue tools and negotiation systems in a three-step model. Their proposal involves the use of collaboration and information sharing. The model involves: (a) determining the BATNA (according to Fisher and Ury, a BATNA—Best Alternative to a Negotiated Agreement—is what would occur if the issue were not resolved), which is a form of information sharing; (b) attempting to resolve the existing issues in conflict using argumentation techniques—a collaborative approach to resolving the dispute; (c) for those issues not resolved in (b), we use compensation/trade-off strategies to advise on a possible sequencing and resolution of a dispute—a further attempt at sharing information given the disputants' preferences. If the advice suggested in (c) is not acceptable to the parties, return to (b) and repeat the process recursively until either the dispute is resolved or a stalemate occurs.

We are currently using the JustReason Shell as a tool for building our online dispute resolution environment. It allows for the development of decision support systems to advise upon BATNAs, provides support for the disputants to conduct discussions and negotiations (argumentation), and allows for the use of game theory techniques to advise upon trade-offs. Our online dispute environment has been tested in the domain of property distribution in Australian Family Law.

CONCLUSION

In this article, we have noted that generic legal knowledge management is difficult, since legal knowledge is very domain and region dependent. Recently, there has been an increased focus on providing legal knowledge through the World Wide Web. We argue that future legal knowledge management systems that provide support for dispute resolution will become available on the World Wide Web. We introduce one approach for building such systems.

REFERENCES

Black, H.C. (1990). *Black's law dictionary.* St. Paul, MN: West Publishing Company.

Breuker, J., Elhag, A., Petkov, E., & Winkels, R. (2002). Ontologies for legal information serving and knowledge management. *Proceedings of Jurix 2002, the 15th Annual Conference on Legal Knowledge and Information Systems* (pp. 73-82). Amsterdam: IOS Press.

Carine, H. (2003, August 24-27). Applying knowledge management in law firm alliances. *Proceedings of the 10th Asia Pacific Special Health and Law Librarians Conference,* Adelaide, Australia.

David, R., & Brierley, J.E.C. (1985). *Major legal systems in the world today.* London: Stevens & Sons.

Edwards, D.L., & Mahling, D.E. (1997). Towards knowledge management systems in the legal domain. *Proceedings of Group 97, ACM,* (pp. 158-166), Phoenix, AZ.

Gottschalk, P. (1999). Use of IT for knowledge management in law firms. *The Journal of Information, Law and Technology, 3.* Retrieved from http://www.law.warwick.ac.uk/jilt/99-3/gottschalk.html

Gruber, T.R. (1995). Towards principles for the design of ontologies used for knowledge sharing. *International Journal of Human-Computer Studies, 43,* 907-928.

Khandelwal, V.K., & Gottschalk, P. (2003). Information technology support for interorganizational knowledge transfer: An empirical study of law firms in Norway and Australia. *Information Resource Management Journal, 16*(1), 14-23.

Lodder, A.R., & Zeleznikow, J. (2005). Developing an online dispute resolution environment: Dialogue tools and negotiation systems in a three-step model. *Harvard Negotiation Law Review, 10,* 287-338.

Rodríguez Morcón, C., Pérez García, J., & Sigüenza Pizarro, J.A. (2002). Knowledge management in a law firm. *UPGRADE, 3*(1), 51-55. Retrieved from http://www.upgrade-cepis.org

Ross, H.L. (1980). *Settled out of court.* UK: Aldine Publishing.

Rusanow, G. (2003). *Knowledge management and the smarter lawyer.* New York: ALM Publishing.

Stranieri, A., Zeleznikow, J., Gawler, M., & Lewis, B. (1999). A hybrid–neural approach to the automation of legal reasoning in the discretionary domain of family law in Australia. *Artificial Intelligence and Law, 7*(2-3), 153-183.

Stranieri, A., Zeleznikow, J., & Yearwood, J. (2001). Argumentation structures that integrate dialectical and monoletical reasoning. *Knowledge Engineering Review, 16*(4), 331-348.

Stranieri, A., & Zeleznikow, J. (2001). WebShell: The development of Web-based expert systems. Research and Development in Expert Systems XVIII. *Proceedings of ES2001—The 21st SGES International Conference on Knowledge Based Systems and Applied Artificial Intelligence* (pp. 245-258). London: Springer-Verlag.

Stranieri, A., & Zeleznikow, J. (2004). Knowledge discovery from legal databases. *Springer Law and Philosophy Library, 69.*

Susskind, R. (2000). *Transforming the law: Essays on technology, justice and the legal marketplace.* Oxford: Oxford University Press.

Toulmin, S. (1958). *The uses of arguments.* MA: Cambridge University Press.

Zeleznikow, J. (2004). Building intelligent legal decision support systems: Past practice and future challenges. In J.A. Fulcher & L.C. Jain (Eds.), *Applied intelligent systems: New directions* (pp. 201-254). Berlin: Springer-Verlag.

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Chapter 5.30
Operational Knowledge Management in the Military

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INTRODUCTION

This article intends to cover operational-knowledge management (KM) as implemented in the military. In particular, it is based on experience and published examples from the U.S. Army and the IDF (Israeli Defense Forces). It concentrates on the characteristics of operational knowledge as the core type of interest for the military due to the nature of the mission. The proxy of human lives and mission success are used vs. the more common currencies in the business industry.

The article covers common vehicles in KM through examples implemented in the military (such as communities of practice in the U.S. Navy, storytelling, and scenario planning), with special attention given to a detailed description of the AAR (after-action review). This is a military-originated KM process now widely adopted by industry. Although all these are familiar KM methods and concepts in industry, their value and uniqueness for military applicability are illustrated.

In the current and future battlefield, knowledge and information are critical resources (both of the enemy and of our forces). Through innovative and dispersed IT systems, KM has transformed the modern battlefield situational awareness, both for the individual soldier and the very core of command and control.

A section is devoted to KM in low-intensity conflicts (LICs) that emphasizes learning throughout fighting due to the unique and asymmetric nature of LIC as the contemporary and most common modern form of warfare. In LIC, the learning cycles are short as opposed to those of classic wars where the main learning is done before and after conflicts. In LIC, as a prolonged process (of varying intensities), learning must be conducted throughout the fighting.

BACKGROUND

Liddell Hart (1991) stressed that throughout history, militaries that should have been organizations of the highest adaptability capabilities (due to the nature of their mission) have been the least flexible, harming their own functioning. This has promoted the adoption, for more than a decade in the military, of the learning-organization concept aimed at transforming the military into a dynamic organization that continuously implements organizational learning. Indeed the learning-organization concept (Senge, 1990) is closely entwined with, and is one of the drivers of, the KM movement.

The concentration of knowledge management is derived from the military's mission and vision. The U.S. Army, in its "knowledge vision" (2004), defines "a transformed Army, with agile capabilities and adaptive processes, powered by world class network-centric access to knowledge, systems and services, interoperable with joint environment." Indeed, a continuum strategy to such vision transforms the Army into "a network-centric, knowledge-based force."

Why Operational-Knowledge Management?

Operational has two different meanings in the military context: a knowledge type, and a level of fighting forces and warfare. This article refers to the first.

As a knowledge type, operational knowledge has meaning in industry as well. Although operational research (OR) started in the British Military during WWII, it evolved as a discipline into industry and different domains and areas (Keys, 1995).

However, operations are entwined in most organizations on their way to achieve organizational goals. In the military, the operations (in the sense of military operations) are the very core and essence of the organization. A military organization is established and trained toward operations, be it peacekeeping, defense preparedness, or wartime operations. Hence, operational knowledge is a salient.

The characteristics of operational knowledge demand exploration as the core type of interest for the military (due to the nature of the mission). Indeed, this supports the usage of proxy indicators, such as human lives and mission success vs. the more common currencies in industry.

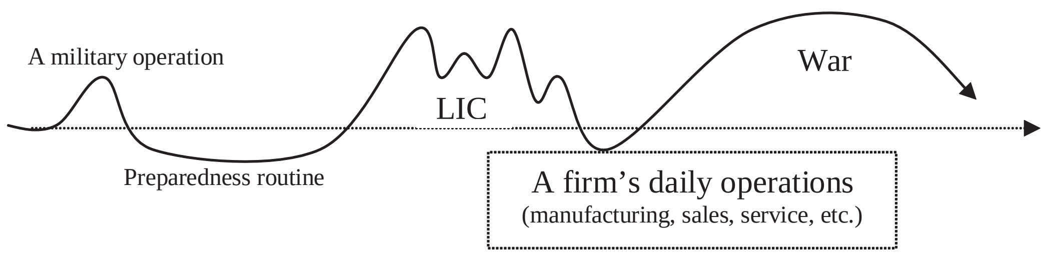
Although various knowledge types exist in the military (e.g., professional or procedural knowledge in different domains), most of these may be differentiated in their connection to operations, hence to operational knowledge. Whether knowledge is entwined with the conduct of military operations, or indirectly connected merely due to the eventual goals of a military, makes a difference in the way it is referred to.

The military is a competencies-based, mission-oriented organization, which is operational in nature. Hence, operational knowledge is the very essence of the military. So, we need to focus on managing it first, for more reasons than one.

- It is the best testing ground for KM in the military, rendering the fastest ROI.
- Every operational KM implementation is principally applicable toward other knowledge types in the military (once the methodologies are familiar).
- Since commanders' and sponsors' attention are scarce (as are other resources), it is aimed at the operational goals of the military.

Since operational in this context refers to knowledge type, the discrimination from the analogous military term for a level must be determined. Operational refers in the army command also to levels of forces and warfare (i.e., strategic, operational, tactical levels). However, KM can be implemented at all these levels, aimed at operational goals.

Figure 1. A simplification of a firm's operations compared to the nature of military operations



Although presumably KM is more applicable at organizational levels, tactical implementation yields a higher mission success rate. Exploring new operational paradigms is especially crucial for special-operations success (Gagnon 2002), where a clear delineation between essentially tactical missions and possible operational or strategic effects does not exist.

FIRST FOCUS: ADAPTING KM VEHICLES FROM (AND TO) INDUSTRY

Most common KM vehicles implemented in industry are applicable to the military with appropriate adaptation. Furthermore, some KM practices that originated from the military have been adopted by industry. However, the military might have called it by a different name, or did not consider it a KM process. The scope of this article allows a sample of only a few such prominent vehicles, but many more exist, entwined in the daily operations of the military. Even regular officers' gatherings, from the battalion level to divisions, account for such KM processes that aim to create a knowledge-sharing culture as well as sharing specific knowledge.

Since even the titles of these KM processes may differ from those familiar in industry, it is essential to describe their military reembodiment and value. Furthermore, KM in the military context requires adaptations to operational settings, for instance, to "match the pace of operations" (McIntyre, Gauvin, & Waruszynski, 2003, p. 38): "Knowledge management and the knowledge cycle within the context of military operational environments, therefore, require emphasis on these additional requirements of robustness, content and speed."

The current synergy of the military, the academic community, and industry practitioners and researchers promises to benefit the military from the progress of KM.

The After-Action Review

One of the fundamental tools of KM in the Army is the after-action review process. It was developed by the U.S. Army, although it is in use by other militaries as well, sometimes under different titles and a slightly different process (e.g., debriefing). Due to the intense nature of events in the Army, it allows for almost real-time learning in a brief session.

There are four distinct phases in the after-action review.

1. What was supposed to happen? What was the action plan, and what did we aim to do?
2. What actually happened? There is a reviewing and establishing of the facts of the events.
3. What was the gap? What went wrong, causing the gap between 1 and 2?
4. What can we learn? What are the lessons learned that could be implemented in future circumstances (vs. just erroneous judgments)?

Furthermore, a fifth phase may be added.

5. How can we disseminate the lessons learned and to whom should we communicate them?

Higher resolution AAR requires a more detailed prescription, but the principal phases are kept, and so are some cultural principles.

- The AAR is a learning event and not an inquiry aimed at blaming.
- The AAR should be conducted as soon as possible after the action or event, when facts are clear and memory is fresh. In some cases, it can also be conducted throughout events.
- The action itself may be a mission, a training exercise, a project phase, or any clearly defined event.
- Participants should be inclusive of all those in the action reviewed.
- The climate should be open and nonhierarchical, contrary to military culture.

The product of the after-action review is an after-action report detailing the lessons learned. The terms might differ slightly; for example, the Australian Army refers to PAR and POR (post-action review and post-operation report) templates for similar purposes.

Since the U.S. Army's after-action reviews are "probably the best known example of leveraging knowledge within a team" (Dixon Nancy, 2000, p. 37), they are widely adopted by industry. For instance, "British Petroleum has made it the middle step of its three-part knowledge management process" (p. 38) since the AAR is so intuitive and appropriate to the "serial transfer" of knowledge and of lessons learned in the organization.

Sullivan and Harper (1997) observed the direct, immediate personal benefits and usefulness to participants in action and in AAR as its success rationale. Indeed, AARs produce local value: knowledge to be used at the decision-making point (Sullivan & Harper). What the basic AAR process lacks is a system to transform and disseminate it beyond local knowledge and value to the organizational level, and to permeate it throughout the Army. That system is the Center for Army Lessons Learned (CALL).

The CALL

Since the disadvantage of AAR is that it is conducted locally and produces local value, the CALL aims to disseminate AARs and lessons learned organizationally throughout the Army while validating their content in a wider context.

Military knowledge management is far from secretive (although the knowledge itself might be). Voluminous unclassified material exists (methodological and core) on the Web site of the CALL(http://call.army.mil/).

Similar examples are the Australian Army's CAL (http://www.defence.gov.au/army/cal/) and the IDF Central-Command Operational-KM Site on the internal intranet.

The CALL may also assign learning observers to specific units or training exercises. Their role is to accompany a unit on its duties, bring lessons learned through AARs back to the CALL, and disseminate them to the forces. An excellent example of such conduct was with the U.S. Army's 10th

Mountain Division on the naval aircraft carrier Eisenhower during the 1994 Haitian peacekeeping efforts (Baird & Henderson, 2001).

Organizational Knowledge Portal

One of the first steps to the implementation of a dispersed IT-enabled organization like the Army is the creation of accessible knowledge centers containing codified, explicit knowledge and information. An effective infrastructure vehicle for such knowledge centers are organizational portals, which the military as a whole (or specific units) implement extensively on internally accessible networks.

The collaborative IT infrastructure is the foundation for many KM and knowledge-sharing vehicles, especially for a geographically dispersed organization. Some (like CoPs [communities of practice]) are elaborated upon in this article.

The U.S. Army Knowledge Online (AKO) is the Army's intranet portal, which "features content-management software, e-mail, instant messaging, chat rooms, knowledge centers, a people locator and white pages" (U.S. Army, 2004, p. 374). "AKO, the army's knowledge portal has grown to over one million soldier and civilian registered users."

Communities of Practice

IT collaboration tools and environments, like organizational portals, are crucial for the establishment of geographically dispersed communities of practice, a common vehicle in KM.

Indeed, the Army has long acknowledged the role of communities of practice in the creation, sharing, and leveraging of tacit knowledge. CoPs cross units and domains since they may share a professional interest or practice, or rather an operational one. They may be active (as is usually the case) during routine times, but should aim at maintaining, and if possible, implementing, the support networks of relationships and knowledge where and when needed operationally in real time.

An example of implementation guidelines can be found in the U.S. Navy's CoPs manual (http://www. hq.usace.army.mil/cecc/PG/Starter-Kit.doc).

Indeed, CoPs are implemented widely in the military and yield high operational results: "Communities of Practice (CoPs) are the cornerstone of NAVSEA's strategy for evolving a knowledge enterprise. CoPs offer a collaboration structure that facilitates the creation and transfer of knowledge" (Department of the Navy's Knowledge-Centric Organization).

The ultimate implementation goal of CoPs in a network-centric military should be operational (due to the nature of the mission). It is improved operational ability resulting from real-time support amongst combating units (geographically or task tangential). Such collaboration is based on acquaintance and common language, values, and knowledge nurtured in routine times in these communities of practice.

Storytelling

Nothing is more common and familiar in the Army than war stories. However, besides being just good stories, they also act as a key learning vehicle. They are perhaps even the most ancient and intuitive learning vehicle to human nature as recent research of narration and storytelling proves and promotes.

From the minute a unit returns from mission activity, even before formal AAR or debriefing, storytelling takes form at all levels: from a personal level to a group. This ontological re-creation of events in memory allows for the screening of events through learning binoculars on different levels, formal or nonformal.

Once researched and made explicit through KM processes such as AAR, stories become a formal military learning apparatus—as battle stories are taught not only in military colleges, but are also communicated in other surroundings many times as heritage and history.

KM supports the transition of such processes toward the organizationally cognitive by entwining storytelling beyond heritage: the dissemination of currently relevant or emphasized lessons learned from past occurrences.

For example, a history quiz prepared in the Counter-Terrorism School of IDF was aimed to disseminate contemporarily validated lessons learned from past hostage-rescue events to instructors.

Scenario Planning, War Games, and Simulations

Scenarios are of instrumental core use in the military. They detail contingency plans for a range of eventualities from which the action plan is chosen and formed.

In a similar manner, throughout the process of intelligence analysis, the enemy's possible scenarios are created and analyzed in light of probability and perilousness to our forces. This is done not merely as a risk analysis, but is entwined into the force's own scenarios.

In industry, scenarios are used in different contexts. Ringland (2002, p. 2) says, "In the creative media, it may mean a storyline…strategists, policy makers and planners use scenarios in a 'future-oriented' sense." Indeed, in the field of knowledge management, the usage of scenarios has been researched and promoted as a vehicle for the creation and dissemination of common knowledge and vision through the creation of common future scenarios. This allows for the creation of a unified organizational paradigm. According to Ringland, "Scenarios have been in use at Royal Dutch Shell since the 1960s," and they "help us to understand today better by imagining tomorrow, increasing the breadth of vision and enabling us to spot change earlier" (http://www.shell.com).

The synergy between the KM scenarios approach and the common one in the military allows for a step further in other knowledge and KM military implementations—when using simulations for training.

In the '70s, an experiment with two groups of flight controllers showed that the learning of one group a priori was much less effective than the other group, which was in control towers in a real-life context. Indeed, critical-incidents professions emphasize this notion, which I refer to as context-dependent learning, most applicable in the Army.

Context-dependent learning uses familiar methodologies in the Army like war games and simulations that are implemented for various tasks and enhances them.

The U.S. Army prairie-warrior simulation, for instance, tested the effects of digitizing the battlefield, allowing the consideration of possible changes before actual combat deployment (Baird and Henderson, 2001).

Such war games and simulations are also the most effective learning vehicle for soldiers and commanders at all levels of the systems they operate in (social or technological). Furthermore, they allow participants to learn about themselves in a unique context, and they trigger the most inherent level of learning that comes only from doing.

War games were always used by military organizations on strategic and operational levels. However, recent research shows (Ariely, 2004) that even the learning of a terrain cell becomes more effective through context-dependent learning when taken to tactical levels (e.g., a tactical war game played on that terrain cell).

Further goals of scenarios, war games, and simulations include the following (Ariely & Fighel, 2004).

- Testing different scenarios as they develop, including accordance with enemy scenarios

- Testing of specific subjects (e.g., battlefield digitization in the prairie-warrior simulation)
- Context-dependent learning for new commanders and decision makers
- Rehearsal and repetitive knowledge aimed at testing and maintaining readiness
- Dissemination of lessons learned (either through other simulations or AARs)

As illustrated, the blend of KM methods and concepts used in industry are of critical value when adapted and implemented in the military. Experience from KM in industry promoted the cognitive and explicit implementation of KM and KM managerial education, which leads to the appointment of KM-related roles to leverage knowledge as a resource. Hence, it is requisite in a modern military. According to Kaplinski (2004), in the IDF's Central Command, for instance, operational CKOs were appointed up to battalion level (as cited in Lubetzki, 2004).

It is the duty of operational knowledge officers to disseminate methodologically and to implement the KM vehicles proven to be so effective operationally (such as the AAR, which leverages local knowledge, and the lessons-learned repositories that complement it organizationally). The ability of a unit arriving at a unique terrain cell to learn from the past experience of other units operating in the same place before is crucial for maintaining human life and mission success.

SECOND FOCUS: KM AND MODERN WARFARE

KM Transforming the Modern Battlefield

Information technology and the network-centric approach are transforming the nature of the modern battlefield. It is not the existence of voluminous, immediate information from multiple sources that makes the transformation the application in fighting. Tactical knowledge has become a major resource for fighting from the individual level to command and control at all levels. Anyone with combat experience is familiar with the battlefield "information fog" during chaotic events.

Combat KM and IT systems aim at minimizing this fog while not overloading with unnecessary information. Such an example is the Blue Force Tracker system, which Col. Mike Linnington of the 101st Airborne's Third Brigade in Iraq described, dealing with one of the biggest problems of "situational awareness and the ability to battle track blue force, or friendly units" (as cited in Chilcote, 2003). It allows locating units (through GPS [Global Positioning System]) and friend or foe identification that prevent friendly fire (or "blue-on-blue") incidents. Other systems allow intelligence to be transmitted to the battlefield in real time, for example, visual digital aerial imagery of enemy locations and status.

Today, the field commander manages a battle picture loaded with information and knowledge through a variety of supporting measures. These measures are supportive in managing and integrating (mainly technologically) the knowledge and information both of our forces and of the enemy. However, they demand a cultural adaptation of command and control as strategic commanders must reject the temptation to micromanage the battlefield.

Furthermore, knowledge and information that were conveyed to field commanders (and back) are now dispersed to the individual level, allowing a whole new concept of the "knowledge warrior."

KM and Information Warfare

Information warfare stands as a military domain of its own. Clearly, where the ammunitions are information and knowledge, managing both becomes a core military competency, both offensively and defensively (protecting information, infrastructure, and knowledge risk analysis). The scope of this article does not allow full coverage of the relationship between KM and information warfare (e.g., Hall, 2003), however, it suffices to posture knowledge warfare as the next evolutionary phase in information warfare. The fight is not only for information superiority, but rather the way it is implemented toward action and the widening effect of knowledge (e.g., on public opinion and consciousness in low-intensity conflicts, directly affecting military stakeholders).

Learning throughout Fighting: KM in Low-Intensity Conflicts

In his book Low Intensity Operations (1971), Frank Kitson claimed that during the quarter of the century since WWII, the British Army participated in only four conflicts classified as "limited war," while at the same time it was active in about 30 other low-intensity operations, not confronting regular forces of enemy nations.

The elusive nature of such warfare (even more than other forms of modern urban warfare that is fought amongst civilians) is asymmetric by definition. The advantages of conventional military force cannot be expressed vs. the full implementation of the opponent's advantages. The LIC is a very demanding form of warfare for the Army (challenging Clausewitz's focus on decisive battle (Clausewitz, 1956)) since it is a prolonged process of varying intensities. It demands the extraction of resources including knowledge, and managing them skillfully.

In the LIC, learning cycles are short, and contrary to classic wars when the main learning is done before and after, the learning must be conducted throughout the fighting. It can be compared to two learning sinus waves adapting one to the other, where every event obliges the opponent to quickly adapt through a short learning cycle and vise versa (Nir, Or, Bareket, & Ariely, 2002). Such an example is the IRA vs. the British detonation-devices learning cycles, or the equivalent learning cycles relating to detonation devices between Hizbulla and the IDF in Lebanon (Gordon, 2002). Hence, in LIC, operational KM is crucial not only amongst the Army's forces, but also in learning from the enemy's activities. Confronting the asymmetric nature of the LIC is achieved through the replication of the opponent's advantages (e.g., through special forces), only implementing that knowledge better. Such an example is the replication of guerilla warfare tactics from Hizbulla in Lebanon to the EGOZ IDF unit (Gordon).

One of the main tasks of the military today is the global war on terrorism. In the current global era of state-sponsored and postmodern terrorism, no clear delineation can be drawn between LIC involving terrorist organizations or guerilla forces and other forms of global terrorism. This is greatly due to the lack of an agreed-on definition of terrorism (Ganor, 2001). Hence, further attention is needed on the synergy between military KM in LIC and other organizations countering terrorism.

Brig. Gen. Kochavi of the IDF referred to the main insight from LIC as the need for having a learning mechanism: "Victory in a changing reality = the ability to learn" (as cited in Yair, et al., 2004).

The Transformation of KM toward Intellectual Capital

Intellectual capital (IC) is briefly defined as intangible assets, and since there is no clear delineation between IC and KM, the relationship clearly deserves further attention (see in this publication "Intellectual Capital and its Relationship with KM" by the same author).

In fact, much of the resources used in the military are intangible: Within the soldiers exist their knowledge and training, there are the weapon systems required for implementation and planning, and so forth. For all these, the IC paradigm developed in the last decade is useful.

The U.S. Army (2004, p. 367) KM strategy defines intellectual capital as "[i]ndividual, team, and enterprise knowledge, systems, and services, and workforce strategies that are necessary to improve operations and decision making."

What forms does IC take in the military? As opposed to the more common currencies in industry (that transform to "hard capital"), proxies in the military for IC differ.

Human casualties within the military and between civilians seems to be the ultimate cost, both the trivial and the critical one when considering the mission of the Army.

However, in the current economically oriented militaries, we may find interesting examples of how military KM becomes through intellectual capital hard currency. In a recent example, the Israeli Army chief of staff offered training knowledge and facilities (part of IDF's intellectual capital) to be marketed to foreign armies (Shapiro, 2003). Some of that intellectual capital relates directly to KM since the Army's tactical training center includes sophisticated debriefing and AAR technological systems that allow 3D images of the conducted training.

Recent research in the military (Ariely, 2004) proposes that internal stakeholders perceive operational KM as a core competency in itself, and that various proxy indicators exist to common industry financial indicators for valuing IC and knowledge assets. In many cases, these may be achieving the mission objectives or minimizing casualties (e.g., reducing cases of friendly fire on soldiers' own forces). Nevertheless, a particular unit's IC is perceived as its ability to be assigned the mission vs. other competing units being assigned. Hence, many concepts relevant to competitive edge and the intellectual-capital paradigm may be very relevant indeed for the military (internally or amongst units).

FUTURE TRENDS

KM is prominent for the future of the military. In the short and medium run, KM promises to continue revolutionizing the battlefield, not just technologically but culturally (as seen in the past and in the present with embedded reporters in fighting). Every soldier and vehicle should arrive at full real-time knowledge autonomy, free to engage in fighting. The network-centric approach requires new operational paradigms to be revisited at all levels.

In the long run, the combination of technology, IT, and the human factor (the soldier as a knowledge worker) is of consequences beyond any imagination.

Forecasts predict unmanned vehicles and even possibly (with progress in research) brain-machine interfaces (BMIs; Shran, Hauptman, & Marcus-Kalish, 2003). Parallel progress in the research of knowledge management, cognitive science, and artificial intelligence may bring a whole new era of knowledge-based warfare aiming at a lower rate of casualties. The U.S. DARPA (Defense Advanced Research Projects Agency) predicts the future warrior to wear clothing that will include processors and sensors, allowing more information to be available at the individual level and thus requiring less (scarce) attention.

Since knowledge is humane and knowledge management is societal, the real transformation is expected in the essence of modern warfare through trends like transparency to the public, casualty sensitivity, and wider global trends.

The result is only greater dependencies on knowledge, and hence, on managing it best.

Subsequently, the explicit understanding of knowledge as a resource renders it vulnerable and as such a target in itself. KM might support further development in the field of information warfare toward a whole new concept of knowledge warfare.

CONCLUSION

Nowhere is the transformation from the industrial age to the information age more evident than in the modern battlefield. Knowledge has become a major resource for fighting from the individual level to strategic command. The skills of managing and implementing methodologies relating to knowledge (like learning throughout fighting) are now critical fighting skills. Thus, knowledge management may become not only a mission-improving and life-saving vehicle, but the very difference between defeat and victory.

REFERENCES

Ariely, G. (2005). *Knowledge management as a methodology towards intellectual capital*. PhD thesis, University of Westminster, London.

Ariely, G., & Fighel, J. (2004). *"Unilateral cooperation" in response to terrorist attacks*. Retrieved from http://www.ict.org.il/articles/articledet.cfm?articleid=521

Baird, L., & Henderson, J. C. (2001). *The knowledge engine*. San Francisco: BK.

Chilcote, R. (2003). *Technology links 101st on the battlefield*. Behind the Scenes. CNN.

Clausewitz, C.v. (1956). *On war*. (New and revised ed). New York: Barnes & Noble.

Dixon Nancy, M. (2000). *Common knowledge: How companies thrive by sharing what they know*. Boston: Harvard Business School Press.

Gagnon, G. (2002). Network-centric special operations: Exploring new operational paradigms. *Air & Space Power Chronicles*.

Ganor, B. (2001). *Defining terrorism: Is one man's terrorist another man's freedom fighter?* Retrieved from http://www.ict.org.il/

Gordon, S. L. (2002). *Israel against terror: A national assessment*. Efi Meltzer.

Hall, W. M. (2003). *Stray voltage: War in the information age*. Annapolis, MD: Naval Institute Press.

Hart, B. H. L. (1991). *Strategy* (2nd ed.). Meridian Books.

Keys, P. (Ed.). (1995). *Understanding the process of operational research*. John Wiley & Sons.

Kitson, F. (1971). *Low intensity operations: Subversion, insurgency, peace-keeping* (1st ed.). Harrisburg, PA: Stackpole Books.

Lubetzki, G. (2004, August 20). *Knowledge management in central command*. Bamahane—IDF Weekly Newspaper.

McIntyre, S. G., Gauvin, M., & Waruszynski, B. (2003). Knowledge management in the military context. *Canadian Military Journal,* 35-40.

Nir, S., Or, S., Bareket, Y., & Ariely, G. (2002). *Implications of characteristics of low intensity conflict on the issue of learning and operational knowledge management*. Learning throughout Fighting Conference, School of Command.

Ringland, G. (2002). *Scenarios in business*. John Wiley & Sons.

Senge, P. M. (1990). *The fifth discipline* (1st ed.). New York: Doubleday/Currency.

Shapiro, M. (2003, October 14). *For rent: New base, first hand*. Bamahane: IDF Weekly Newspaper.

Shran, Y., Hauptman, A., & Marcus-Kalish, M. (2003). *Future technologies and effect on defence R&D presentation*. Paper presented at Future Technologies and Effect on Defence R&D, Tel Aviv, Israel.

Sullivan, G., & Harper, M. (1997). *Hope is not a method*. New York: Broadway Books.

U.S. Army. (2004). *Army knowledge management. In How the army runs* (2003/2004 ed.). Carlisle: U.S. Army War College.

Yair, Y., Ariely, G., Fighel, J., Kochavi, A., Pratt, A.N., & Tamic, D. (2004). *Panel on military aspects of terrorism*. Paper presented at the Terrorism's Global Impact Conference, Herzliya, September 2004.

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Chapter 5.31
Military Knowledge Management

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INTRODUCTION

Knowledge is a critical component of military operations, and the military has been an early adopter of knowledge management (KM) technologies. Significant events include a strategic use of tools to filter information into knowledge, the designation of knowledge officers in high-level strategic positions, and the implementation of knowledge systems as a means to support situational awareness and understanding. Following is a brief overview of knowledge management within the military and a review of knowledge theory and practice pertinent to military knowledge management.

MILITARY KNOWLEDGE MANAGEMENT

The military is extremely diverse in its knowledge systems and practices. In the collective, the military would be the equivalent of many large corporate conglomerates, each with multiple research and development (R & D) branches. Adding to the complexity is the secrecy of many of the systems. To attempt to summarize military knowledge management in its entirety would be presumptuous, if not impossible. Rather, this discussion will focus on some representative systems and approaches being advanced in military-sponsored KM research and practice. Included are comparisons to knowledge-management initiatives in the private sector. The discussion begins with an overview of private-sector and academic-research practices that have carried forward into the military.

Relevant Research

The importance of knowledge management has been equated to the importance of natural resources in previous generations wherein strategies that companies once devoted to optimizing capital and labor are now being applied to maximize the productivity of knowledge resources (Silver, 2001). A means to maximize productivity in the military is to integrate systems, technologies, and information resources. Such aggregations are increasingly under the umbrella of knowledge management.

At a technical level, military knowledge management is addressed within enterprise-systems engineering initiatives, with a current initiative force transformation through network-centric systems (MIT, 2002). Knowledge systems may be an adjunct to specialized computing systems or an umbrella under which information and communications technologies can be grouped. Similar to the private sector, military KM integrates disciplines addressing computer and communications technology, cognitive science and artificial intelligence (AI), and human-computer and human-systems integration. There is additional research addressing information synthesis or fusion, with XML (extensible markup language) as a categorization schema and ontology structure in support of semantic understanding. In addition are military-specific KM initiatives such as command and control, military intelligence, and sensors.

Common to both the military and private sector is research into mechanisms to consolidate data and information into knowledge, and once integrated, to understand strategic options and cause-effect relationships (Primix Solutions, 2000). The desired result is improved decision making, interorganizational communications, cooperation, and interaction (Schwartz, Divitini, & Brasethvik, 1999). An example at the macrolevel is Army knowledge management with its transformation mission toward a knowledge-based organization that integrates best practices into professional duties through active involvement with the knowledge infostructure (MIT, 2003).

At a microlevel are issues in knowledge design that address navigation and search mechanisms (Sherman, 2000), and knowledge structures to help achieve a goal or objective (Saward, 2000). In the military, a current focus is on context to help document knowledge flows (Nissen, 2001). Metrics are important for the assessment of knowledge initiatives, and means have been advanced to address the value of specific knowledge units (Gao & Sterling, 2000), to include relevance weightings for context-integration points, and to allow the knowledge value added (KVA) methodology to ascertain return on knowledge investments (Housel & Bell, 2001).

Both the military and private sector have an interest in cognitive understanding and research to encode process, procedural, and expert knowledge into software (Storey, Goldstein, & Ullrich, 2002); to find techniques to capture common-sense knowledge in a context-sensitive manner and extract expert-level specifics (Storey & Day, 2002); to derive metacognitive attributes to help define relationships between user cognitive needs and knowledge metadata (Maule, 1998, 2000, 2001); and to implement reasoning tools to identify patterns of behavior to resolve problems or identify opportunities (Fensel & Motta, 2001). All of these approaches are active in military research as a means to structure or derive knowledge for decision-support applications.

A next step is to make this processed knowledge readily available. Portals with collaborative tools are mechanisms to establish relevance (Silver, 2001); to personalize, sort, and filter information (Moore, 2001); and to enhance business intelligence with decision support (Ruber, 2000). A portal with real-time chat and messaging empowers users with collaborative abilities (Loria, 2001). In the Navy, portals have become a primary means for information, communications, collaboration, work-flow coordination, and decision support (Maule, Gallup, & Schacher, 2003).

Also notable is the trend toward communities of practice as a means to build knowledge expertise. Communities increase social capital or the economic value of relationships within an organization and therein lower the cost of knowledge. Workers find information more quickly and realize overall information efficiencies as a life cycle of involvement forms around the knowledge community (DoN CIO, 2000). In the military, knowledge communities support work-group collaboration around specific knowledge concepts or initiatives. They help extend and expedite the traditional reach of individuals to colleagues who can share knowledge in a just-in-time manner (Tate, 2001). For example, the Air Force Materiel Command is fielding an Air Force-wide knowledge management initiative using the community-of-practice methodology to support collaboration among a widely dispersed workforce to enable teamwork, communication, and sharing within a virtual environment (AFMC, 2003).

Warriors need specific data in a timely manner. As in the private sector, semantics, ontology, and XML are emerging techniques to support transparent, automated knowledge exchange. Research in semantics has established that (a) content can be embedded with meaning, (b) relationships between meanings are delineated, and (c) access methods are coordinated around those meanings (Grimes, 2002). Semantics can additionally characterize participant roles in an interaction to establish relationships between entities, context, and knowledge bases (Storey et al., 2002). XML provides the syntax and structure, and ontology provides the means to define terms and relationships (Berners-Lee, Hendler, & Lassila, 2001). Value is added through classification and metadata (Chandrasekaran, Josephson, & Benjamins, 1999).

Military-specific ontology has been developed to aid in experimentation analysis and to contextualize problem scenarios in support of detailed situational assessment and understanding (Maule, Schacher, Gallup, Marachi, & McClain, 2000; Schacher, Maule, & Gallup, 2001). Military-specific ontology is being developed by agencies including DARPA (Defense Advanced Research Projects Agency) with its DAML (DARPA agent markup language), and the North Atlantic Treaty Organization (NATO) with its LC2IEDM (Land C2 information exchange data model; NATO, 2000).

MILITARY KNOWLEDGE SYSTEMS

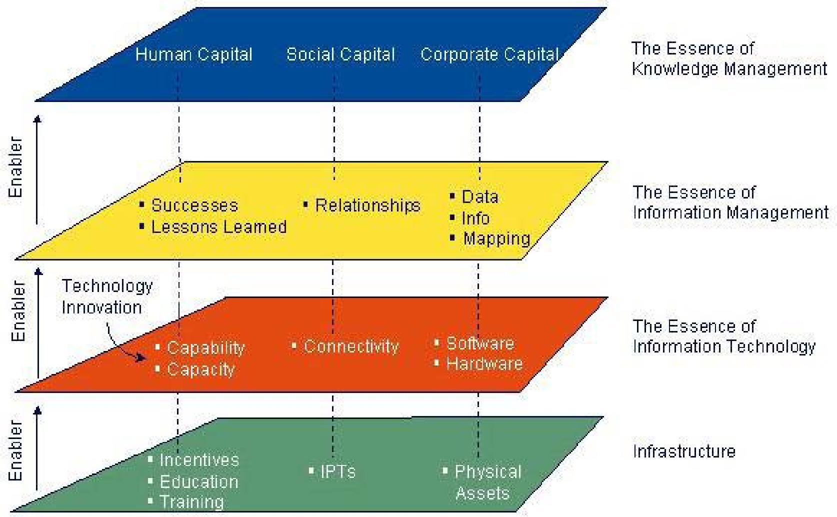
Similar to KM private-sector research, there are many approaches to knowledge management in the military, each with its own set of tools, techniques, and methodologies. These range from AI-based techniques, to the statistical analysis of content, to ontology and metadata for categorization, to structural methodologies for cognitive profiling and user personalization, and to data mining for content pattern recognition. In complex environments, such as the military, an effective approach might involve several techniques, multiple tool sets in various combinations, and the integration of knowledge outputs with current situational data to help form an understanding for decision makers.

The services have taken somewhat different routes to KM. The Navy has its wide-reaching $6.9 billion Navy-Marine Corps intranet program that is converting 200 networks into the world's largest intranet while simultaneously consolidating date, information, and knowledge resources. The Army is using knowledge management as a way to centralize systems management at major commands under the CIO's (chief information officer's) office, and the Air Force portal will consolidate hundreds of disparate legacy data systems into a single decentralized point of access (Onley, 2001).

Current Practices

Joint-forces operations and cross-service integration is a current focus in the military. With this comes the challenge of data, information, and knowledge integration across the services. In response to such challenges are new techniques to evolve data into information, and informa-

Figure 1. Evolution from information to knowledge (DoN CIO, 2000)



tion into knowledge and understanding. Figure 1 provides a Navy perspective to illustrate how knowledge is evolved from learning and training to address technology, connectivity, and access. Then, information management is where data and information are mapped, relationships are explored, and lessons are derived. Finally, knowledge management is where human, social, and corporate capital are integrated.

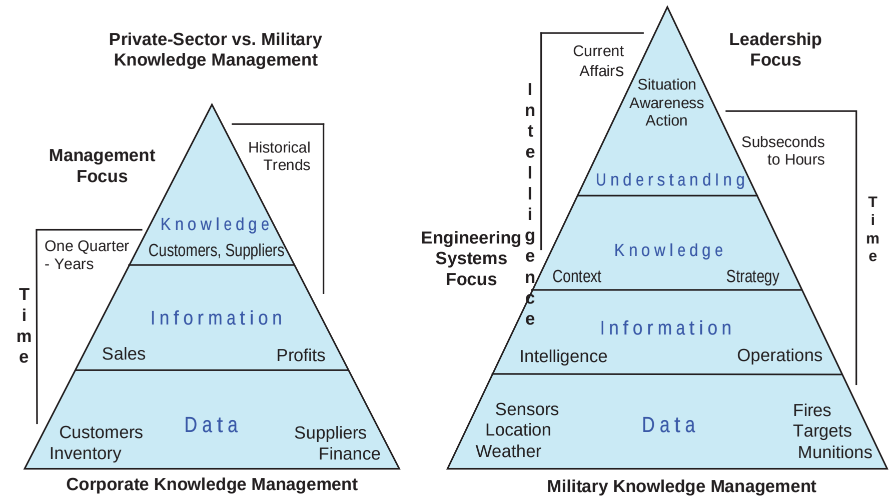
Knowledge management in the military is often used in the broadest sense to include such variables as the management of numerical values obtained from automated collection systems, qualitative data from human subjective opinions, synthetic results from both human and machine simulation, and systems output or result sets tailored to address specific long-range plans or objectives (Maule, Schacher, & Gallup, 2002). Military knowledge applications are often designed to support specific strategic, operational, or tactical decision-making processes and related questions.

Many knowledge tools are adopted from the commercial sector, but there are some notable differences in application, especially for warfare. Of course, there are unique demands placed upon the military for just-in-time knowledge for the warriors.

For example, in corporate knowledge management, a dynamic situational assessment for a real-time attack is not a typical company objective. In the military, knowledge systems for such an objective would need to help convey understanding. The concept is modeled in Figure 2.

Military knowledge systems may be called upon to integrate information and knowledge output with current situational data to form an understanding in the mind of the decision maker. Understanding requires a real-time context. The idea is to develop real-time understanding faster

Figure 2. Corporate vs. military knowledge management



than the enemy, and this cannot be achieved if decision makers are overloaded with too much information. Knowledge should enable a commander to develop an understanding of the situation, make good decisions, and implement them faster than the enemy (Harrigan, Jenkins, Winters, Mohs, & Hay, 2001). The Army is attacking information overload by developing knowledge ontology and infrastructure, evaluating existing knowledge-fusion algorithms, and developing computational models to address specific knowledge-management needs (MIT, 2002).

Collaborative tools are important in military knowledge systems because they can integrate resources to enhance situational awareness and understanding. Chat, instant messaging, online meetings, and shared application technologies are hallmarks of current knowledge-management initiatives (Donnelly, 2003). The integration of traditional knowledge technologies with collaborative capabilities has increased overall complexity, and knowledge officers have been assigned to monitor information flow, encourage the use of collaborative planning tools, and assist with knowledge-based communications. An example is the global war games in which the "knowledge warrior" has emerged as a facilitator of information for the Commander Joint Task Force with responsibilities for shaping knowledge in response to information requirements and therein speeding decision times within multitiered collaborative environments (Harrigan et al., 2001).

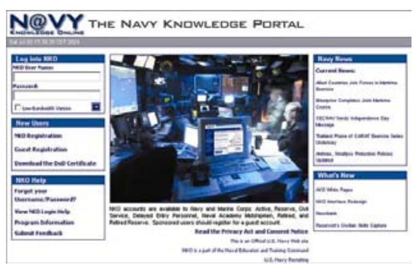
Portals are a popular means to provide access to information and knowledge repositories. Military portal initiatives focus on the aggregation of Web services, information sites, collaboration tools, and decision-support applications into centralized portals (Tate, 2001). Portals are often supported through communities of practice to ensure active participation by key decision makers. Portals additionally offer a means to implement system-wide security policies through single sign-on and common-directory services for the authentication of specific information items on a need-to-know basis (MIT, 2003). Portals are often implemented to provide warriors with access to tacit or know-how knowledge from communities of practice and collaborative access to subject-matter experts (Donnelley, 2003).

Some examples include Army Knowledge Online and Navy Knowledge Online that, in addition to current events and operations, integrate e-mail, chat, personal Web portals, and communities (Onley, 2004; Figure 3). The Air Force portal gives people the ability to view information needed to do their job without regard to the system which manages that information such that a soldier anywhere in the world can log on to a computer, check e-mail, and get the status of an order or review a schedule.

The Army Knowledge Awards Program acknowledges initiatives, programs, and concepts that exploit knowledge-management tools and principles. The program recognizes KM-based reengineering enterprise initiatives that focus on major commands, functional areas, and process transformation (DOIM, 2004). The Center for Army Lessons Learned (CALL) (a) transforms raw data into knowledge that can be acted upon, (b) sends the knowledge out to the whole organization, and (c) produces rapid behavioral change based on the knowledge. Teams of experts observe missions firsthand, collect and analyze information, ask experts to validate it, and once the information is validated, produce lessons learned that are delivered as written reports, videos, or simulations to the troops (CALL, 2004).

The Knowledge-Centric Organization (KCO) is a Navy initiative wherein personnel organize virtually around knowledge needs such that the virtual organization becomes an overlay to existing command structures (Millward, 2000). Focus areas include preparation and issues of culture, leadership, relationships, and communications; knowledge-centric systems and the development of strategy, performance measures, and incentives; knowledge-centric organizations and the measurement of performance, assessment, validation, and strategy revision; knowledge creation and brokering to address learning styles and knowledge facilitation and instruction; and knowledge communities to aid in knowledge design, mobilization, and connection (DoN CIO, 2000). Sailors reporting to a new command would previously spend days acclimating to new processes and procedures, while with a KCO, learning time has been reduced up to 80% as sailors, marines, and civilians can immediately access lessons learned and command knowledge stored in the knowledge systems (Millward).

Figure 3. Army knowledge online and navy knowledge online knowledge portals



Knowledge Metrics

Metrics are an important component of military knowledge-management initiatives. In the private sector, requirements and specifications typically lead to product evaluations, demonstrations from vendors, selection, and implementation. The process is somewhat more complicated in the military where production selection often involves a rigorous test and evaluation cycle in live operational experiments, with a focus on systems interoperability and knowledge integration at both technical and organizational levels. It is in this context that metrics provide the basis for evaluation. A few prominent themes and categories of metrics are identified in Table 1. The metrics are largely extracted from the research presented above, so the references will not be repeated. This categorization of knowledge metrics pertinent to the military will hopefully aid future researchers in military knowledge management.

Metrics addressing cognition consider knowledge needs of classes of decision makers. Initiatives may consider metadata and perception,

Table 1. Military knowledge functions and metric categories

KM Function	Metric Categories
Discovery	Acquisition, query optimization, indexing, filtering, link analysis, ontology, agents, semantics, concurrency, domains, interfaces, visualization, AI tools, sequences, streams, temporal, spatial, clustering, mining, pattern matching
Management	Logs, interviews, surveys, observers, coverage, evolution, sustenance, reuse, domains, requirements, documentation, value added, scalability, planning, scheduling, agents, organization, cleansing, unification, maintenance, safety, migration
Performance	System, process, communications, events, flows, status, readiness, integration, latency, behavior, interoperability, optimization, maintenance, survivability, fault tolerance
Decision Support	Effectiveness, efficiency, prediction, integration, representation, reaction, concurrency, agents, optimization, disambiguation, categorization, summarization, filters, mining, pattern matching, cleansing, unification
Work Flow	Planning, scheduling, domains, interfaces, concurrency, agents, sequences, streams, constraints, optimization, organization, clustering, unification
Collaboration	Synergism, domains, media, interfaces, behavior, agents, temporal, spatial, constraints, organization, clustering, pattern matching, unification
Assurance	Security, privacy, trustworthiness, authentication, aggregation, nonrepudiation, reliability, survivability, validation, consistency, documentation, verification, concurrency, interoperability, constraints, maintenance, safety, survivability, fault tolerance
Metadata	Schemas, XML structures, objects, inheritance, temporal, spatial, optimization, organization, categorization, profiles, clustering, unification, migration
Fusion	Algorithms, inference, relationships, uncertainty, ambiguity, ambience, value added, incompleteness, concurrency, sequences, streams, temporal, spatial, constraints, optimization, organization, categorization, summarization, filters, clustering, pattern matching, cleansing, unification, maintenance, migration, ubiquity
Reasoning	Integration, multimodal, inconsistency, uncertainty, incompleteness, behavior, agents, AI tools, sequences, streams, temporal, spatial, constraints, optimization, organization, disambiguation, filters

visualization, or interpretation. Reasoning models specific to a given situation may assess concept formation and evolution, collaborative behavior, inference, case-based reasoning, problem solving, or adaptation and learning. The decomposition of interactions, and cause-effect relationships based on knowledge and resultant decisions help in reasoning about information flows. Artificial-intelligence tools may be tested as aids in the information-synthesis and -extraction process.

Knowledge fusion is a related area providing a basis for the integration of content, often addressing semantics and ontology as the knowledge infrastructure. Fusion research generally considers the processes involved in combining data and information to produce knowledge to make estimates and predictions. As previously discussed, in the military, the focus is on situation assessment and impact (threat) analysis. Other fusion areas address metadata, information interaction and integration, knowledge discovery and visualization, and knowledge and information flow. Process models are means to capture organizational and system processes. Metrics may consider the impact of knowledge injects or fusions into specific processes.

Collaboration metrics address the results of human-human interchanges concerning generated information, and the impact of new variables introduced during the course of any given flow of events (ad hoc alliances, changed positions or objectives, etc.). Work-flow technologies in the military are increasingly grouped under collaborative technologies, which are in turn a driving force in military knowledge management. Metrics would stress integration between supporting technologies, systems, and organizational processes.

FUTURE TRENDS

Predicting new developments in knowledge management in the military is challenging given the size of the organizations and the complexity of the operations. Some trends that do seem certain involve the increase in interoperability of knowledge across the branches, likely occurring under joint-forces initiatives. Web services will continue to expand, integrate operations, and provide a means for knowledge sharing to increase situational awareness and understanding.

Of special interest are emerging opportunities to synthesize or fuse knowledge, and then supplement the collective with visualization or reasoning. This may be considered an area of research akin to artificial intelligence in the previous decade, but today it crosses into real-world military operations, with concerns in performance and decision support.

Virtualization and distributed knowledge through the Global Information Grid and grid computing architectures will offer many possibilities for the cross-pollination of knowledge and the integration of previously disparate knowledge operations and applications. The impact of peer-to-peer technologies for knowledge sharing will be an interesting area for future research. Experimentation is currently underway with many peer-peer technologies, however, security concerns are evident.

CONCLUSION

Knowledge management is a serious area of inquiry in the military. Given the life-threatening situations modern warriors confront and the new types of behaviors exhibited in conflict, knowledge systems have become a priority area. Many knowledge technologies and research approaches have come from the commercial sector, while many others remain proprietary and classified. This discussion has attempted to provide a bridge between public KM technologies and research in current military R & D, highlighting common areas in each. Examples of military knowledge portals and management practices provide some insight on current thinking, and the areas synthesized in the metrics and future-trends sections above hopefully provide visibility in some of the areas in which the military seeks active research and development.

REFERENCES

AFMC. (2003). *AFMC finance team leads Air Force-wide knowledge management initiative* (Air Force Materiel Command News Service Release No. 0602). Retrieved from http://www.afmc-pub.wpafb.af.mil/HQ-AFMC/PA/news/archive/2003/June/0602-03.htm

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). *The semantic Web. Scientific American.* Retrieved from http://scientificamerican.com/2001/0501issue/0501berners-lee.html

CALL. (2004). *Welcome to the center for army lessons learned public Web site.* Retrieved from http://call.army.mil

Chandrasekaran, B., Josephson, J., & Benjamins, V. (1999). What are ontologies, and why do we need them. *IEEE Intelligent Systems, 14*(1), 20-26.

DOIM. (2004). *Army knowledge awards winners list.* Retrieved from http://www.doim.army.mil/Army_Awards_Dispatch.html

DoN CIO. (2000). *Knowledge-centric organization toolkit.* Washington, DC: Department of the Navy, Chief Information Officer.

Donnelly, H. (2003). Capturing a community of knowledge. *Military Information Technology, 7*(5). Retrieved from http://www.military-information techn ology.com /archive_article.cfm?DocID=147

Fensel, D., & Motta, E. (2001). Structured development of problem solving methods. *IEEE Transactions on Knowledge and Data Engineering, 13*(6), 913-932.

Gao, X., & Sterling, L. (2000). Semi-structured data extraction from heterogeneous sources. In D. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management* (pp. 83-102). Hershey, PA: Idea Group Publishing.

Grimes, S. (2002). The semantic Web. *Intelligent Enterprise, 5*(6), 16-52.

Harrigan, G., Jenkins, N., Winters, M., Mohs, S., & Hay, O. (2001). *Knowledge management in global war games. CHIPS*. Retrieved from http://www.chips.navy.mil/archives/01_fall/knowledge_management_in_global_w.htm

Housel, T., & Bell, A. (2001). *Measuring and managing knowledge*. New York: McGraw-Hill Irwin.

Loria, M. (2001). Knowledge management and collaboration. *KMWorld,* S8-S9.

Maule, R. (1998). Cognitive maps, AI agents and personalized virtual environments in Internet learning experiences. *Journal of Internet Research, 8*(4), 347-358.

Maule, R. (2000). Metacognitive research & development framework (MRDF) for Internet instructional science software. *Journal of Internet Research, 10*(4), 329-345.

Maule, R. (2001). Framework for metacognitive mapping to design metadata for intelligent hypermedia presentations. *Journal of Educational Multimedia and Hypermedia, 10*(1), 27-45.

Maule, R., Gallup, S., & Schacher, G. (2003). Broadband Internet applications for multi-organizational collaborative processes, workflow automation, and complexity analysis in multinational experimentation. *Proceedings of the 2003 Pacific Telecommunications Conference,* Honolulu, Hawaii.

Maule, R., Schacher, G., & Gallup, S. (2002). Knowledge management for the analysis of complex experimentation. *Journal of Internet Research, 12*(5), 427-435.

Maule, R., Schacher, G., Gallup, S., Marachi, C., & McClain, B. (2000). *IJWA ethnographic qualitative knowledge management system*. Monterey, CA: Naval Postgraduate School, Institute for Joint Warfare Analysis.

Millward, B. (2000). *Knowledge-centric organizations. CHIPS*. http://www.chips.navy.mil/archives/00_apr/kco.htm

MIT. (2002). Communications and electronics technology for transformation: Interview with Major General William H. Russ. *Military Information Technology, 6*(9). Retrieved from http://www.military-information-technology.com/archive_article.cfm?DocID=49

MIT. (2003). Infostructure commander: Interview with Major General James C. Hylton. *Military Information Technology, 7*(8). Retrieved from http://www.military-information-technology.com/archive_ article.cfm?DocID=230

Moore, A. (2001). Enterprise information portals: The power and the peril. *KMWorld,* S2-S3.

Nissen, M. (2001). *Facilitating naval knowledge flow.* Monterey, CA: Naval Postgraduate School.

North Atlantic Treaty Organization (NATO). (2000). *The land C2 information exchange data model*. Internal report: ADatP-32 Edition 2.0. Brussels, Belgium: Author.

Onley, D. (2001, September 24). *Service branches take different routes to KM. Government Computer News*. Retrieved from http://www.gcn.com/20_29/news/17174-1.html

Onley, D. (2004, June 7). Army knowledge online portal seeks one vendor, upgrades. *Government Computer News,* 30.

Primix Solutions. (2000). Customer knowledge management. *Knowledge Management,* 90-91.

Ruber, P. (2000). Opening doors to structured data. *Knowledge Management,* 81.

Saward, G. (2000). The challenge for customer service: Managing heterogeneous knowledge. In D. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management* (pp. 57-81). Hershey, PA: Idea Group Publishing.

Schacher, G., Maule, R., & Gallup, S. (2001). Knowledge management system for joint experimentation. *Proceedings of the NATO OSLO Symposium. Building a Vision: NATO's Future Transformation,* Oslo, Norway.

Schwartz, D., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management* (pp. 1-19). Hershey, PA: Idea Group Publishing.

Sherman, L. (2000). Creating useful knowledge structures. *Knowledge Management,* 82-83.

Silver, B. (2001). The face of knowledge management: A status report. *KMWorld*, 14-15.

Storey, V., & Dey, D. (2002). A methodology for learning across application domains for database design systems. *IEEE Transactions on Knowledge and Data Engineering, 14*(1), 13-28.

Storey, V., Goldstein, R., & Ullrich, H. (2002). Naïve semantics to support automated database design. *IEEE Transactions on Knowledge and Data Engineering, 14*(1), 1-12.

Tate, B. (2001). *DON enterprise portal initiative: Following the NMCI path to knowledge. CHIPS*. Retrieved from http://www.chips.navy.mil/archives/01_nmci/portal.htm

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Chapter 5.32
Challenges in Developing a Knowledge Management Strategy for the Air Force Material Command

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EXECUTIVE SUMMARY

It is widely acknowledged that an organizational knowledge management strategy is a desired precursor to the development of specific knowledge management (KM) initiatives. The development of such a strategy is often difficult in the face of a lack of organizational understanding about KM and other organizational constraints. This case study describes the issues involved in developing a new KM strategy for the Air Force Material Command (AFMC). It centers around the AFMC KM program manager, Randy Adkins, and his challenges in developing the future KM strategy direction for the AFMC enterprise. The case study begins with a description of the history of the AFMC KM program and the existing KM system, but then focuses primarily on issues to be considered in future strategy development, such as maintaining top leadership support and understanding, conflict with the IT organization, funding cuts, future KM system configuration needs, and outsourcing of KM. The intent of this case study is to demonstrate, using Randy Adkins and AFMC as an example, many common issues that can be encountered as leaders struggle to develop viable KM strategies.

BACKGROUND

The Air Force Material Command

The Air Force Material Command (AFMC) is one of the Air Force's nine major commands (Figure 1). It is headquartered at Wright-Patterson Air Force Base in Dayton, Ohio, and employs 85,000 military and civilian employees across the globe. The primary mission of AFMC is to "develop, acquire, and sustain the aerospace power needed to defend the United States and its interests . . . today and tomorrow" (HQ AFMC PA, 2001a). As such, it has cradle-to-grave oversight for the Air Force's aircraft, missiles, and munitions (HQ AFMC PA, 2001a). Key mission essential tasks

Figure 1. U.S. Air Force major commands

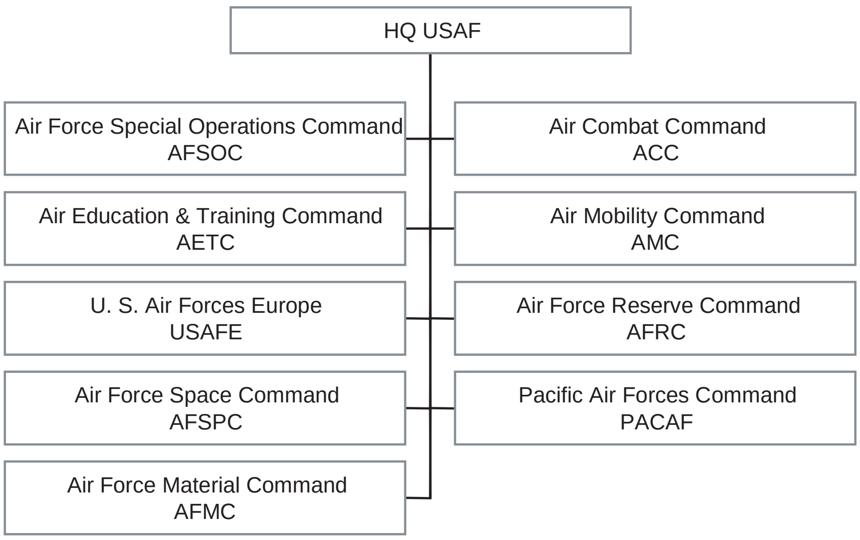
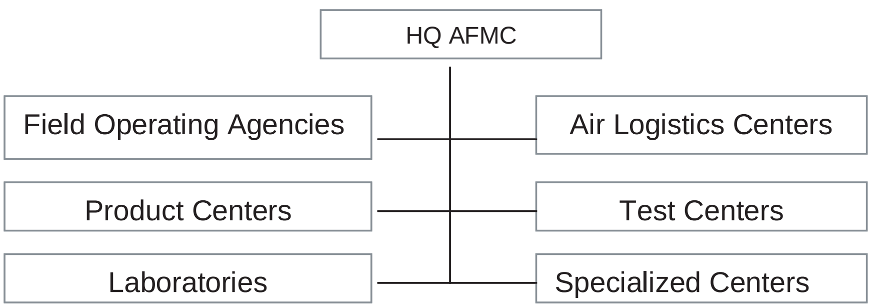


Figure 2. Air Force Material Command organization



supported by AFMC include product support, supply management, and depot maintenance (see Appendix 1 for a further breakdown).

According to the AFMC Public Affairs Fact Sheet (HQ AFMC PA, 2001a), AFMC fulfills its responsibilities through organizations that serve as product centers, research laboratories, test centers, air logistic centers for maintenance, and specialized centers (Figure 2). Weapon systems, such as aircraft and missiles, are developed and acquired through four product centers, using science and technology from the research laboratories. These weapon systems are then tested at AFMC's two test centers and are serviced and repaired at its three air logistics maintenance depots. The command's specialized centers perform various other development and logistics functions. Eventually, aircraft and missiles are "retired" to its Aircraft Maintenance and Regeneration Center in Tucson, Arizona.

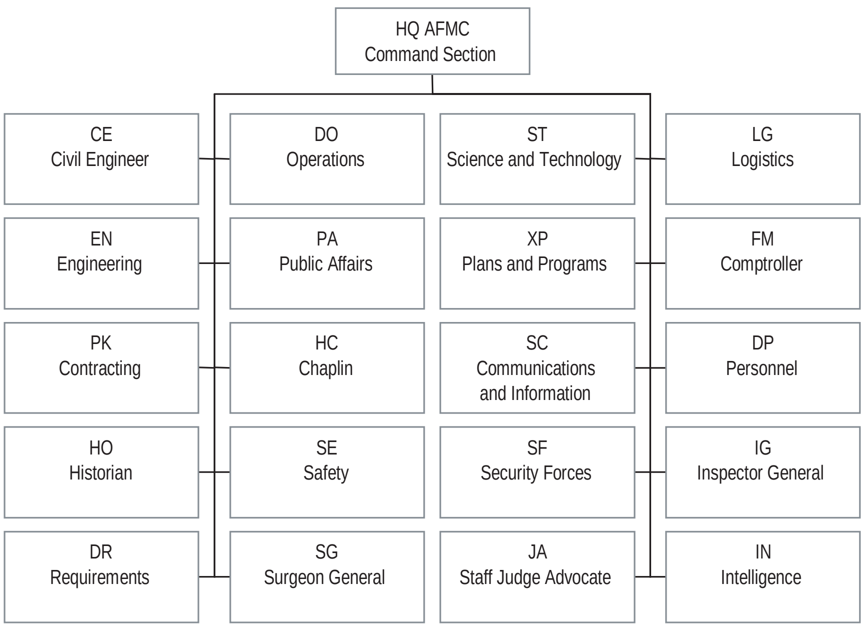
AFMC's central governing organization, Headquarters (HQ) AFMC (Figure 3), consists of all the functional areas that provide support for command organizations. The Directorate of Requirements (DR)—the focus of this case study—is the command's focal point for policies, processes, and resources that support the product and information services mission (HQ AFMC PA, 2001b) and is the home of AFMC's Knowledge Management program which has the official name, Air Force Knowledge Management (AFKM).

SETTING THE STAGE

Evolution of KM in AFMC

In the early 1990s, the U.S. Department of Defense (DoD) recognized the need to streamline its acquisition process. As a result, the Air Force

Figure 3. HQ AFMC organization and directorates



(AF) created a System Program Office (SPO) to develop technology solutions to help achieve that end. One such technology solution was called the AF Acquisition Model. Initially, this information system included an online repository of all acquisition regulations, step-by-step processes for conducting acquisitions, and miscellaneous help information such as points of contact and lessons learned. Although the technology used was immature, this digital repository was a first of its kind in the military and an idea quickly copied by the other services.

After its initial success, the SPO proposed the same idea to the Office of the Under Secretary of Defense for Acquisition Technology for possible implementation across the DoD. The proposal was approved in 1998 and the resulting effort became known as the Defense Acquisition Deskbook program. Now, as a DoD-level project, the program (and the accompanying information system) was to be managed and developed by an interservice Joint Program Office. As such, major Deskbook activities were transferred to the Joint Program Office and AFMC/DR personnel were assigned the remaining task of keeping the AF's Deskbook documents that resided on the system updated and current. Although the Joint Program Office retained oversight responsibility for the Deskbook program, a yearly funding stream of $1.5 million remained to support AFMC/DR's portion of the effort. Of this $1.5 million budget, only $500,000 was committed to maintenance of the Deskbook program. As such, AFMC/DR found itself asking, "What can we do with an extra million dollars?"

The answer came quickly in the form of an AF Inspection Agency study that identified a need for an overarching "lessons learned" program for the AF. While the need was AF-wide, the AFMC/DR Deskbook Team decided to use its own expertise and excess funding from the Deskbook program to address the problem for the AF. As a result, it produced a formal requirement to develop an information system-based AF Lessons Learned pilot program. Using the AFMC Deskbook system design as a foundation, the Deskbook Team added additional capabilities that allowed the capture and dissemination of "lessons learned" information.

While researching and developing the Lessons Learned pilot program, the Deskbook Team decided that the new business concept touted as "KM" captured the essence of what they were doing. The Team's understanding of KM was that it should be used to enhance organizational performance by explicitly designing and implementing tools, processes, systems, structures, and cultures to improve the creation, sharing, and use of knowledge that was critical for decision making. With this understanding, the Team felt that the goals of KM and the goals of the Deskbook and Lessons Learned projects were consistent. The Team also strategized that if it labeled its efforts as KM, it was possible the Team could receive more leadership support and funding. From that point forward, AFMC/DR Deskbook Team approached its projects and proposals from a KM perspective.

In addition to the Deskbook and Lessons Learned projects, the AFMC/DR Deskbook Team had also developed Web-based acquisition training to educate the acquisition workforce in lieu of sending them to classroom training. Randy Adkins, a civil service employee with 20 years of experience in various positions at Headquarters AFMC, was in charge of the development of this Web-based training program. At the same time, Robert Mulcahy, the deputy director of AFMC/DR, expressed concern with the impending retirement-driven talent drain that was soon to affect his organization as well as all of the AFMC enterprise. Previous studies both inside and outside the AF indicated that more than 50% of the AF's civilian acquisition personnel would be eligible to retire by 2005 (Cho, Jerrell, & Landay, 2000). Unless this issue was immediately addressed, Mulcahy knew that the acquisition workforce would lack the talent, leadership, and diversity needed to succeed in the new millennium. In searching for a solution, he recognized the value of KM concepts as they applied to his organization. He soon became a KM champion and pushed for a merger of the Deskbook, Lessons Learned, and Web-based training programs. He felt these programs, and the information systems that comprised their foundation, were synergistic and could be used in tandem to help capture and disseminate the knowledge of the rapidly retiring civilian workforce. In early 1999, Mulcahy turned to Adkins to spearhead the consolidation which would result in a new combined effort called the AF Knowledge Management (AFKM) program. Together, he believed they could bring KM to AFMC.

Developing the AFKM Program

Randy Adkins worked tirelessly to educate himself on KM and to develop an overarching strategic direction for the many existing elements of the AFKM program and AFKM system. His initial efforts in developing the AFKM program were aimed primarily at applying commercial KM processes and technologies to solve specific business problems. In doing so, his focus was on identifying, capturing, and leveraging knowledge and expertise within the organization. The ultimate goal of the AFKM program was to design information system solutions so that AFMC users could share information and knowledge and, at the same time, create a supportive, collaborative, and information- and knowledge-sharing culture (HQ AFMC/DRI, 2001).

The AFKM "System"

Under Adkins' direction, the Deskbook Team, deemed the AFKM System Development Team 1999, continued to grow the Web-based system beyond its original three components (Lessons Learned database, DoD Acquisition Deskbook, and Web-based training). The AFKM System Development Team structure is shown in Appendix 2. By mid 2000, the AFKM system was comprised of five basic components (Figure 4) — the Lessons Learned database, the AFMC portion of the DoD Acquisition Deskbook, the AFMC Virtual Schoolhouse (Web-based training), the AFMC

Figure 4. AFKM system components

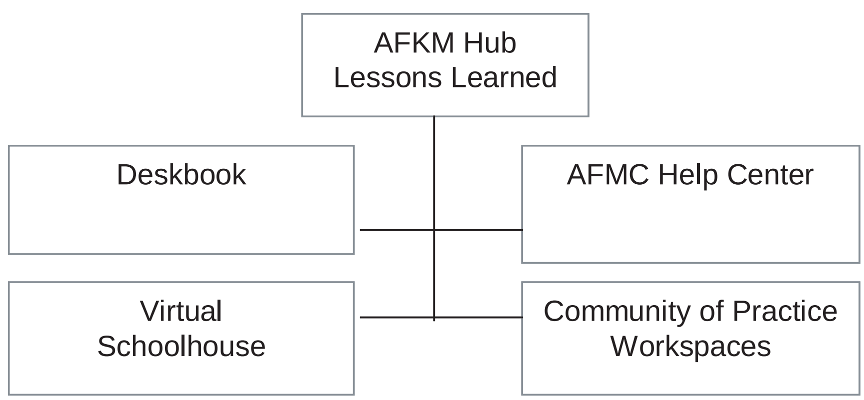
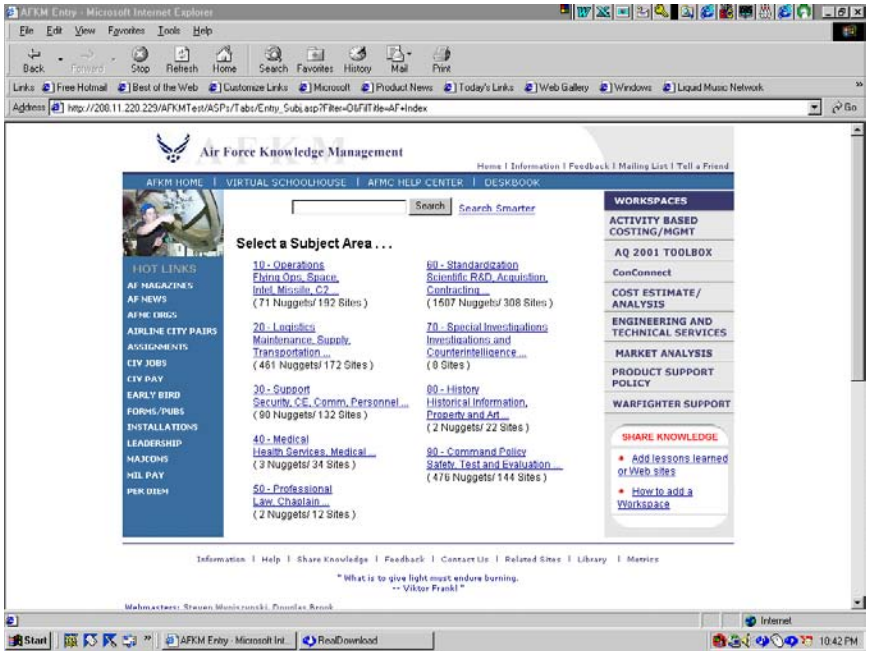


Figure 5. AFKM home page



Help Center module, and a Community of Practice (CoP) collaboration workspace module.

The AFKM home page (Figure 5) described the functionality of the AFKM system as follows:

Air Force Knowledge Management is the place to go to find out what you need and to share what you know. . . . [It] applies commercial knowledge management concepts and technologies to address AF business problems. It includes: collaborative workspaces for communities of practice, high-value Internet links, Internet-based learning technology to provide training via the Web, and a repository of lessons learned, best practices, and other bits of usable knowledge. The objective is to make our jobs easier and to enhance job performance by integrating organizational lessons learned, community wisdom, training and collaborative technology to support current and future projects. (AFKM Home Page, 2001)

The AFKM system was designed to be used as a portal. The main portal entry point is the AFKM Hub (or AFKM home page) which includes access to Lessons Learned, DoD Acquisition Deskbook, AFMC Help Center, Virtual Schoolhouse, and CoP workspaces. The AFKM Hub evolved from the original Lessons Learned Web site and now serves as the access point to a range of knowledge and information resources. The DoD Acquisition Deskbook provides a variety of documents describing the laws, directives, policies, and regulations related to DoD acquisitions. The AFMC Help Center provides an English-language search engine for both AFMC and other customers to find information or documents that may reside on any of the many AFMC Web sites. The Virtual Schoolhouse delivers over 20 online courses for AF acquisition training. And finally, the CoP workspaces allow for information exchange, collaboration, and problem solving. The specific functions of each of these portal components is further described in Appendix 3.

CASE DESCRIPTION

It wasn't long after Adkins had taken charge of the AFKM program that he realized it was approaching a crossroads. Specifically, a strategic vision and plan for the future of the program and underlying system was lacking. With strong leadership support and sufficient funding, the AFKM program and system had grown; however, there were now a variety of emerging issues that had to be considered in any future KM strategy development. Some of these key issues are discussed.

Leadership Support

As the deputy director of AFMC/DR, Robert Mulcahy had been a staunch supporter and champion of AFMC's KM efforts. It was his vision that had brought the program together under Adkins. He knew the value of creating the AFKM program and understood the benefits it could bring to AFMC, the AF, and the DoD. Mulcahy had protected and given support to the AFKM System Development Team so that it could expand and explore new opportunities. He believed all of AFMC, not just the headquarters organization, could benefit from KM. Mulcahy was a key reason the AFKM program was successful.

Upon Mulcahy's departure to a new job in early 2000, David Franke was appointed as his replacement. Major General Michael Wiedemer had also become the new Director of Requirements. Both were very open to KM concepts and the AFKM program, but neither was as educated or enthused about KM as Mulcahy had been. Franke, to whom Adkins primarily reported, was not sure that KM should be a centerpiece of AFMC strategy. Franke saw the primary benefits of KM as coming from the building "of" and participation "in" communities of practice. While encouraging Adkins and the AFKM Team to continue their pursuits, he did not have a firm vision for KM or the AFKM program in the future. He was also not sure that AFKM could compete with other programs for additional resources given all the other AFMC priorities. All in all, it was Adkins' assessment that Franke simply didn't see KM as needing emphasis above and beyond other programs. As a result, Adkins predicted that he might have increased difficulty getting the backing and exposure for AFKM that it needed to compete with other AFMC programs for scarce resources.

Conflict with AFMC's IT Organization

Dealing with the headquarters' information technology (IT) organization, referred to as the Directorate of Communications and Information, was a continual challenge. This organization saw many conflicts between its responsibilities and the direction being pursued by the AFKM System Development Team. The Directorate saw its role as providing technology solutions; AFKM was also providing technology solutions. Although the conflict had not escalated to an intolerable level, Adkins noted that his Team and the IT folks "just didn't talk anymore."

Within HQ AFMC, the Directorate of Communications and Information had primary responsibility for command, control, communications, computer, and information (C4I) issues and execution. As such, it possessed sole authority for policy, procedures, and standards with respect to

C4I systems and programs. As the AFKM System Development Team expanded its efforts, a conflict had arisen regarding collaboration software tools. The IT organization had mandated and implemented LiveLink® software as the only authorized collaboration tool. This action not only conflicted with the AFKM System Development Team's work on CoP workspaces, but appeared to be, in the Team's estimation, a much more sophisticated collaboration tool than was needed by the average customer. Based on the AFKM Team's in-depth experience, Adkins had tried to convince the IT folks that an AFMC-wide LiveLink® implementation would be a waste of money at this point. Although Adkins had hoped to work with the IT organization on KM issues, this "disagreement" had driven them farther apart. Adkins stated:

We've had numerous discussions, but we have never been able to partner. So they're off getting everybody to do LiveLink®, trying to force everybody to do LiveLink®. I'm off trying just to get people stuff to help them do their jobs better.

Knowledge of the conflict with the IT organization was not limited to the HQ either. When asked by Adkins about his experience with LiveLink®, one of his CoP customers had remarked, "I will tell you . . . you are on the radar warning receiver. They know you're out there and you are a huge threat to them."

Although Adkins had been able to continue the AFKM efforts, he knew the conflict with the IT organization, regarding LiveLink® and other information system issues, was not going away. Since both organizations claimed a role in providing and establishing KM systems, disputes would be ongoing. While Adkins and his Team had a wealth of KM knowledge and system development expertise, the IT organization was still the authorized policy maker. If conflicts continued, the AFKM program and system risked being changed, dismantled, or simply "taken over." This, too, was something that weighed heavily on Adkins' mind.

Funding Cuts

It was Adkins' understanding that a $600,000 budget cut was in the offing for 2001. Such a cut would force him to make hard choices that would affect the AFKM program's future. In practical terms, the budget cut would require Adkins to let go of six AFKM System Development Team contractor personnel. If cuts did come to pass, he knew he would have to reassess, reprioritize, and reorganize the current AFKM system development workload distribution.

Adkins was also worried about the impact on AFKM system customers. From its inception, the AFKM program had attempted to serve a wide range of customers. Whether it was supporting DoD-wide efforts such as Deskbook, AFMC internal efforts such as the Help Center, or outside command efforts such as the Engineering and Technical Services CoP for Air Combat Command, the AFKM System Development Team had eagerly built new applications. While some of the projects had been fully funded by the requesting customers, many had been accomplished on an as-can-pay basis or without funding support at all. Adkins knew that without AFKM program funding assistance, some customers would never be able to get their KM efforts off the ground. With the budget cuts looming, customer support practices would have to be reevaluated as well.

AFKM System Usage Concerns

Despite rave reviews about the usefulness of the AFKM system from customers, Adkins was disturbed by low use, or "hit" rates. Simple system access metrics showed that, although use continued to rise, it was only a small portion of what it could or should be. To counter this phenomenon, Adkins and the AFKM System Development Team attempted to improve awareness with a series of road shows. They traveled to many AFMC bases to market the AFKM system's many capabilities. While this effort had increased usage somewhat, overall AFKM usage was still low. From a macro view, Adkins understood that KM and the AFKM system tools were still in their infancy. However, the low usage statistics did not help the AFKM System Development Team justify the benefit or the budget. Adkins was glad that his superiors had supported the Team's efforts on intuition and common sense; however, he also understood that he could be asked at any time to measure the true impact and return on investment. Remarking about the necessity of good metrics, Adkins said, "we had a budget drill not too long ago where I lost a little bit of money and some people . . . that reinforced the fact that I needed better metrics." In preparation of such requests, Adkins needed to seriously consider how he could improve results.

Lack of Understanding about KM

Adkins constantly encountered a lack of knowledge about KM. Few individuals, at any level across AFMC, had much idea of what KM was all about. Adding to the confusion was the fact that there seemed to be no accepted standard definition for KM. While it was easy to communicate the importance of individual KM applications, such as lessons learned databases, document repositories, and electronic yellow pages for experts, it was much more difficult to explain the more comprehensive KM concepts. This made it hard to get people interested in the purpose and goals of the AFKM program. Adkins realized that "learning about KM" took time, but also understood that ignorance by those whom he relied on for support could threaten the AFKM program's survival before it really had a chance to prove itself on a large scale. Again, any strategy for the future of AFKM had to address an education element.

Technological Challenges

The AFKM System Development Team was facing technological challenges even though it was very skilled in responding to the fast-paced changes in technology. In the past, it had Web enabled all of its products, making extensive use of technologies such as HTML, java script, active server pages, and so forth. After the Deskbook, Lessons Learned, and Help Center products achieved stability, the Team continued development efforts and had found a niche in developing CoP workspaces for customers. The Team became so efficient in developing workspaces that it could hand over a "CoP in a box" with a few minor customer-specific tweaks in only a few days' time. Instead of providing content, as it had done with Deskbook and Lessons Learned systems, the Team now simply provided the software framework and the customer became responsible for adding the information and knowledge. Actually, the CoP workspace component had been an important addition to the AFKM system as it had resulted in immediate benefits to various customers and helped to spread the word about the AFMC KM efforts. Adkins believed that continued development of CoPs might, in time, provide a central focus for the AFKM System Development Team's development efforts.

Along with this development, however, another technological challenge had arisen with the development of the AF portal. The new AF portal was to be, by decree, the de facto "single access point" for all AF information and knowledge. This raised a key question of how to design future AFKM system applications. Adkins acknowledged that his team was still heavily involved in the "technology piece" of building CoPs, but saw that the capabilities of the AF portal might eventually change that. Because the AF portal offered some "community" features, he saw the technical nature of the AFKM Team's work on CoPs possibly changing. As such, he now had to consider yet another host of issues such as how should AFKM products tie in to the AF portal? How could the AFKM Team take advantage of AF portal capabilities? Would the AFMC-centered KM system lose its identity and mission with the establishment of the AF portal? Would the AF Portal provide new collaboration tools that would conflict or supersede those developed by the team at AFMC? These questions, again, made a clear future strategy very difficult for Adkins to envision.

The AFKM Name

Another issue for consideration in AFKM strategy development involved the AFKM name. When the AFKM Team began the Deskbook and Lessons Learned initiatives, there were no other known KM programs in the AF. This situation, combined with the fact that the Lessons Learned tool was originally designed to serve the entire AF, gave cause for the Team to label the program "AF" KM instead of "AFMC" KM. As time passed, however, KM initiatives began popping up across the service and the "AF" KM label seemed suddenly inappropriate. A representative from the AF chief information officer's office, who was heading the AF-wide KM movement, had even called Adkins to insist that his program's name be changed to avoid confusion with what would become the real AF-wide KM program.

Adkins realized this was not a simple name change from "AFKM" to "AFMC KM" — it had significant implications for his organization. On the positive side, Adkins thought a name change might actually be a good thing. With other KM initiatives surfacing throughout the AF and with the advent of the AF portal, he had found that the title "AFKM" was no longer descriptive of what his Team was providing. His thoughts were that the specific AFMC KM system and products had to be identifiable, especially now that they would be "buried" behind the AF portal. He used the following example:

And so, if I was Joe Blow out there at Ogden Air Logistics Center and I open the [AF] Portal and I happen to see this link [AFKM Hub], I wouldn't click on it . . . because I don't have any idea [of what it is] unless I happened to have that wonderful briefing we gave them.

On the negative side, Adkins knew a name change wasn't that simple. In addition to generating confusion among existing customers, a name change could signal a reduction in program scope and applicability, which might ultimately impact leadership support at the highest levels and funding.

Outsourcing AFKM Strategy

Since the initial collection of programs and systems (e.g., Deskbook and Lessons Learned) had been brought under the AFKM umbrella, Adkins had lacked a coherent strategy to guide future developments. Although most of the previous work of the AFKM Team had been technology-oriented, Adkins realized that a more comprehensive KM strategy that also addressed people and cultural issues was needed. So far, most AFKM program and system development priorities had been opportunistically selected depending on funding source and visibility potential, but were not consistent with an overall objective or strategy. However, with so many issues developing that could ultimately impact AFKM's existence, Adkins realized that a strategic vision, and ultimately an implementation road map, were needed to guide future AFKM developments and to help him make "hard decisions."

Not confident that he or the existing AFKM System Development Team had the expertise or time to develop a comprehensive strategic plan and roadmap on their own, Adkins contracted to AeroCorp[2] to lead the development. Although AeroCorp contractor personnel had composed a portion of the AFKM System Development Team all along, Adkins had only recently selected them as the primary contractor due to their growing KM expertise. To their credit, AeroCorp, with more than 5,000 employees nationwide, had successfully completed other government KM projects since 1997. In outsourcing to AeroCorp, Adkins justified his decision by saying,

We find AeroCorp provides unique benefits to the government and is the best value for the technical services required. AeroCorp rates are competitive with the other contractors reviewed; AeroCorp is a highly regarded supporter of KM at the OSD [Office of the Secretary of Defense] level; AeroCorp is the developer of the AFKM Virtual Schoolhouse; and AeroCorp has proven integration expertise. In addition, AeroCorp rated extremely high in the area of customer service and past performance.

Although the final statement of work for the AeroCorp contract reflected a number of specific deliverables (see Appendix 4) that ranged from strategic visioning to deployment plan and execution, Adkins' foremost concern was the development of the AFKM strategic vision and plan (or roadmap). These documents would be key in helping him to decide the future direction of AFKM. With a strategic vision and road map, he would have at least a starting point for decision making.

CURRENT CHALLENGES/ PROBLEMS FACING THE ORGANIZATION

Randy Adkins had hoped that by outsourcing the AFKM strategy development to AeroCorp that resolution of major issues associated with the evolution of the AFKM program and system would be addressed. The statement of work outlined that it was AeroCorp's job to do the following (HQ AFMC/DRI, 2000):

1. Help AFMC management define a strategic vision for KM to support the AF acquisition community mission.
2. Integrate the AFKM Lessons Learned database, AFMC Help Center, and the Virtual Schoolhouse into a single dynamic system based on this strategic vision.
3. Provide support to these existing systems throughout the integration effort and ultimately for the integrated AFKM system.

AeroCorp's initial deliverable was to build an AFKM strategic vision and plan within 60 days. According to the statement of work, this plan should incorporate both the cultural and technical aspects of the acquisition environment. The resultant document was to include a road map of how to proceed from the current business environment to the envisioned environment (HQAFMC/DRI, 2000).

Consequences of Outsourcing KM Strategy Development

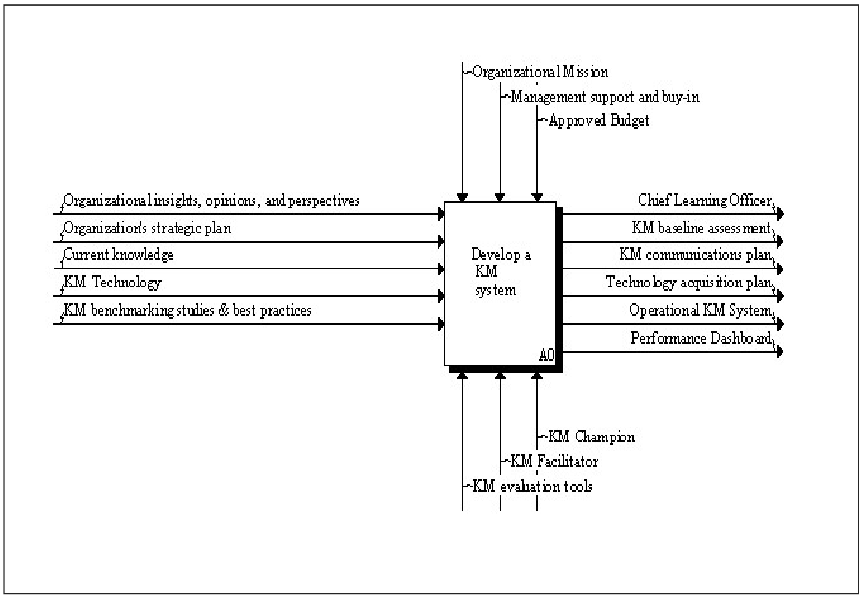
The first action taken by AeroCorp under the new contract was to conduct both a cultural and technical needs assessment "snapshot" of AFMC with respect to KM. These needs assessments were to provide the "as is" picture of AFMC's environment while providing recommendations for the "to be" vision and the necessary supporting policies and processes. Actual completion of the needs assessments went rather quickly and were presented to Adkins in early 2001. Each report included both specific, one-liner recommendations for transitioning from the "as is" state to the "to be" state, and an additional section provided an even more in-depth description of recommendations of what needed to be done to achieve the "to be" state. These assessments with the final recommendation descriptions are detailed in Appendix 5. On the whole, the assessments were comprehensive and surfaced many technical and cultural issues that had to be addressed if AFMC was to transform itself into a true knowledge-sharing organization. These final reports, however, were not what Adkins had expected the strategic vision and plan document to be. The recommendations captured the complicated nature of the current AFMC environment yet, while providing a good road map for the future, were so broad and involved that it was difficult to determine a starting point. To further compound his disappointment, Adkins also learned that AeroCorp considered completion of the assessment reports as having not only fulfilled deliverable #1, the AFKM Strategic Vision and Plan, but also deliverable #2, the AFKM Integration Recommendations Document. He was baffled.

Although Adkins had not gotten exactly what he expected from AeroCorp, the company was allowed to continue work on the remaining deliverables. Adkins hoped that the subsequent documents would make things clearer. Deliverable #3, the AFKM Integration Blueprint, which AeroCorp referred to as a KM methodology, took much longer to produce than the assessments. Delays resulted, first of all, from the turnover of two AeroCorp program managers during early 2001. The current program manager, Mike Lipka, though very knowledgeable about KM, was relatively new to AeroCorp and had to get up to speed on the AFKM project. The key delay, however, stemmed from the fact that AeroCorp had difficulty developing a concise KM methodology or "blueprint" that could address the enormity of what AFMC needed to do to develop a comprehensive KM program that would help it evolve into a true knowledge-sharing organization.

Although the initial assessment and recommendations documents had stated that a systems engineering approach would be used to design the "integration blueprint," the use of integrated definition (IDEF) process modeling methodology surprised Adkins and Lipka. Neither Adkins, nor his superiors, were familiar with this methodology. Lipka, having not been the program manager when the decision to use IDEF was made, had not seen it applied to KM before. Developed for use in systems engineering, IDEF modeling had been around for quite a few years. Its primary users had been the DoD and other large organizations. IDEF had originated with the AF's Integrated Computer Aided Manufacturing (ICAM) program in the mid 1970s, but had evolved over the past six or seven years to also address modeling enterprise and business areas. As such, it was used for modeling "as is" enterprise processes and defining information requirements for improved planning. On the whole, there were 14 separate methods being developed within the IDEF family for use in business process engineering and reengineering, software process definition and improvement, and software development and maintenance areas. It provided a multitude of viewpoints required to describe business area processes and software life-cycle processes and activities. As such, it stood that IDEF could be appropriate for modeling an enterprise approach to KM and subsequent KM systems development, but it did not appear to be a really usable methodology for the average customer. After seeing the initial draft of the high-level IDEF model (Figure 6), neither Adkins nor Lipka were satisfied. Lipka expressed his opinion thus: "I think we have too much methodology for what we need . . . I think it's [been] a little overengineered."

No one was more frustrated, however, than Adkins. After almost a year of working with AeroCorp and waiting patiently for a strategic vision and plan he could really use to press forward, what he had now was a cultural and technical needs assessment, some recommendations for transitioning AFMC into a knowledge-sharing organization, and a road map (or methodology) for doing so that was too unfamiliar and complicated for him or others to practically implement. And faced with the impending budget cut, it did not appear that AeroCorp would have the opportunity to make needed changes. Adkins knew, however, as the AFKM program lead he was still responsible for the strategic direction and success of the

Figure 6. AeroCorp's proposed KM blueprint (IDEF model)



AFKM program. He was unsure exactly what to do next, but he knew the responsibility for a solution was his alone. He began to ponder the facts and options. Would he ever get a document from AeroCorp that would provide a KM strategy and vision for AFMC? Had he made a mistake in outsourcing AFKM strategy development? If not, would there be time and money for AeroCorp to prepare something that was more practical? What parts of the needs assessments and strategic plan were usable? In absence of a clear KM strategy for AFMC, what was the right direction for his AFKM Team to take? How did the AFKM effort now fit (technically and conceptually) into the evolving AF-level KM approach? Would his AFKM program and Team survive? At this point, Adkins had no good answers. The only thing he knew for sure was that there had been and would continue to be many challenges in bringing KM to AFMC, but it was he, if anyone, who still had the opportunity to make it a reality.

REFERENCES

AFKM Home Page. (2001). *Information Page*. Retrieved August 7, 2001, from https://afkm.wpafb.af.mil/ASPs/Tabs/Entry_Subject.asp [only accessible from .mil domains]

Cho, G., Jerrell, H., & Landay, W. (2000). *Program management 2000: Know the way how knowledge management can improve DoD acquisition*. Fort Belvoir: Defense Systems Management College.

HQ AFMC/DRI. (2000). *Statement of work*. Wright-Patterson AFB, OH: Air Force Knowledge Management Integration and Support.

HQ AFMC PA. (2001a). Air Force Material Command fact sheet. Retrieved October 17, 2001, from www.afmc-pub.wpafb.af.mil/HQ-AFMC/PA/fact_sheet/afmcfact.htm

HQ AFMC PA. (2001b). HQ AFMC/DR home page. Retrieved October 17, 2001, from https://afkm.wpafb.af.mil/ASPs/Tabs/Entry_Subject.asp [only accessible from .mil domains]

ENDNOTES

* The views expressed in this case study are those of the authors and do not necessarily reflect the official policy or position of the Air Force, the Department of Defense, or the U.S. Government.

1 Information for this case, except where stated otherwise, is based on personal interviews conducted in October 2001.

2 Pseudonyms have been used to protect the confidentiality of the contract organizations.

APPENDIX 1

Air Force Material Command

Mission Essential Tasks and Objectives

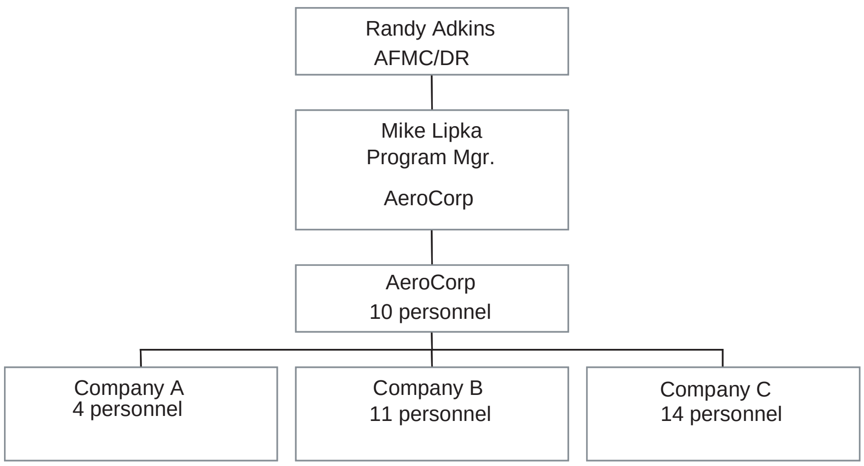
Tasks	Objectives
Product Support	To provide world class products and services, delivering dominant aerospace systems and superior life cycle management.
Information Services	To develop, acquire, integrate, implement, protect and sustain combat support information systems for the USAF and DoD customers.
Supply Management	To provide and deliver repairable and consumable items (right product -- right place -- right time -- right price).
Depot Maintenance	To repair systems and spare parts that ensure readiness in peacetime and provide sustainment to combat forces in wartime.
Science and Technology	To develop, demonstrate and transition affordable advanced technologies to achieve AF Core Competencies.
Test and Evaluation	To provide timely, accurate and affordable knowledge and resources to support weapons and systems research, development and employment.
Information Management	To provide secure, reliable, interoperable communication and information services/access anytime, anywhere, to AFMC customers, partners and employees.
Installations and Support	To provide base support services, property management and environmental protection at AFMC installations.
Combat Support	To provide the trained and equipped expeditionary combat support forces and capabilities to meet worldwide taskings.

APPENDIX 2

AFKM Team and Structure

Throughout the history of the AFKM program, contractors played a key role. Although final authority was always vested in a military officer or civil service employee assigned to AFMC/DR, most programming and technology for the AFKM System came from contractors. The primary contractor for the DoD Acquisition Deskbook development had been Company A.[2] With additional projects, Company B[2] and Company C[2] joined the team. The specific responsibilities and tasks varied from year to year as projects evolved and as the contracts were renewed and renegotiated. The resulting AFKM program organization is shown in Figure 1. AeroCorp was charged with establishing the basic AFKM program by bringing together the existing AFKM Lessons Learned database, AFMC Help Center, and Virtual Schoolhouse. Most of the AFKM System Development Team's work was split between maintaining and updating existing functions and developing new applications. The majority of the new applications focused on building workspaces for CoPs. Each contractor used a number of personnel to work on projects—some personnel worked on AFKM projects exclusively while others came in and out of the projects as necessary. Prior to the 2001 budget cuts, with AeroCorp acting as the lead contractor, 41 personnel had been assigned to the AFKM Team.

Appendix 2 – Figure 1. AFKM Team structure



APPENDIX 3

Explanation of AFKM System Components

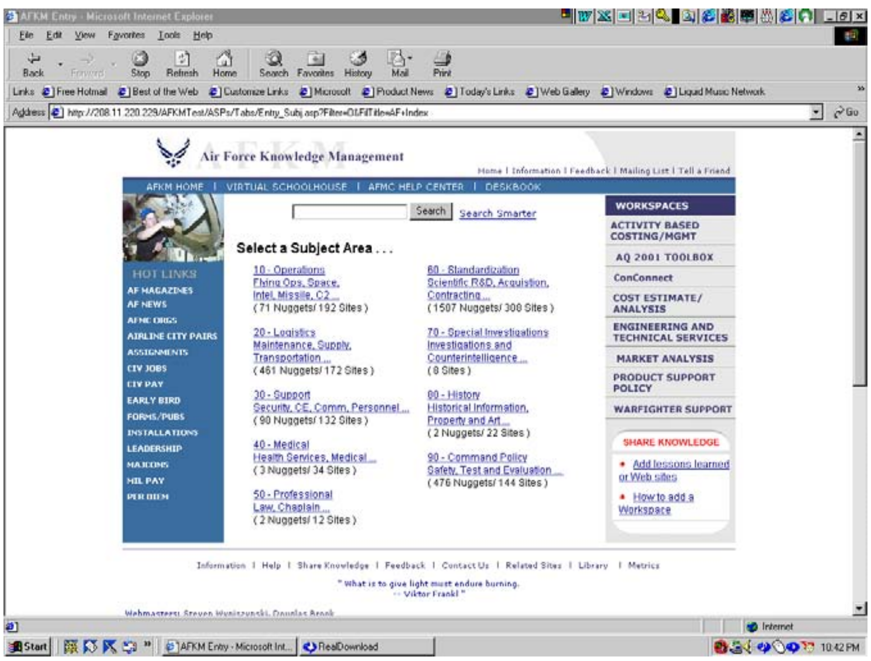
AFKM Hub. What is now the AFKM Hub was originally the primary Web site for the AF Lessons Learned utility. Although the Web site has evolved, the Lessons Learned are still the centerpiece of the Hub (Figure 1). Lessons Learned have been captured and categorized by subject area and provide valuable knowledge about past processes and events. The AFKM Hub also acts as a portal for all other AFKM components and, as such, it also serves as the default AFKM home page. The AFKM Hub provides a conduit to select relevant information and knowledge resources and provides an avenue for creating a knowledge-sharing organization.

Deskbook. The DoD Acquisition Deskbook (Figure 2) is an automated reference tool that provides the most current acquisition information for all DoD services and agencies. Deskbook simplifies the acquisition process by maintaining a single source of up-to-date reference material on acquisition policy and practices.

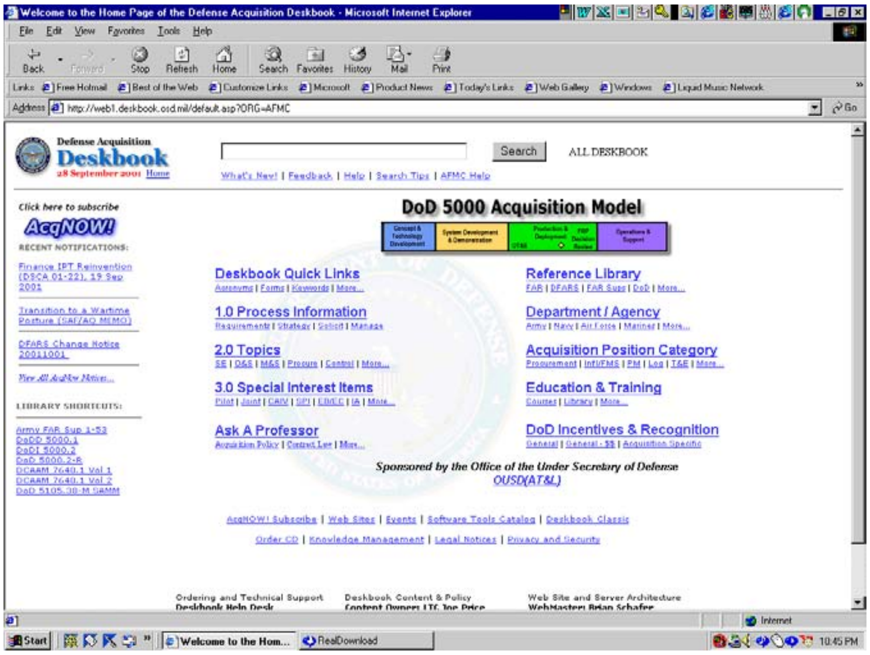
AFMC Help Center. The AFMC Help Center (Figure 3) allows AFMC customers to perform a natural language or keyword search of over 130 AFMC Web sites and selected databases. It connects AFMC customers throughout the AF and DoD with the appropriate AFMC information source or point of contact. The search engine used dynamically creates a unique results page separated into four categories:

- ranked list of related Web documents and links

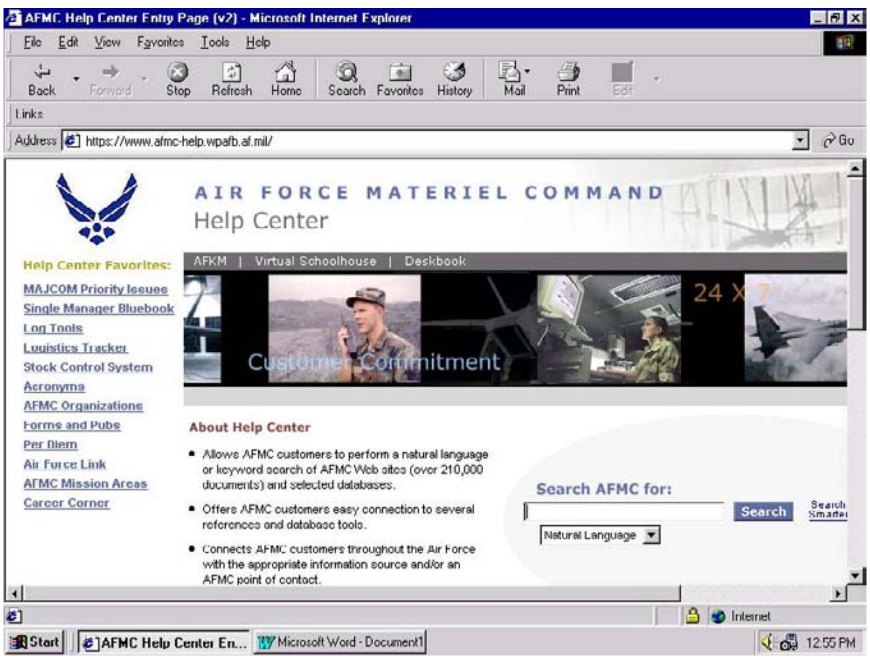
Appendix 3 – Figure 1. AFKM Hub



Appendix 3 – Figure 2. DoD Acquisition Deskbook



Appendix 3 – Figure 3. AFMC Help Center

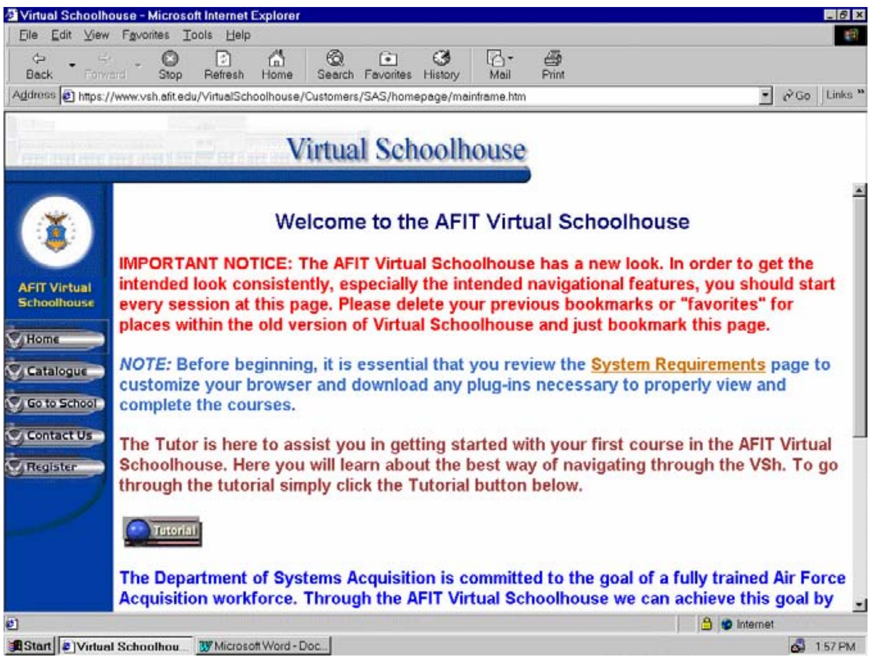


- top-priority major command issues
- bulletin board discussion entries
- contact information for the AFMC command liaisons and topic area points of contact

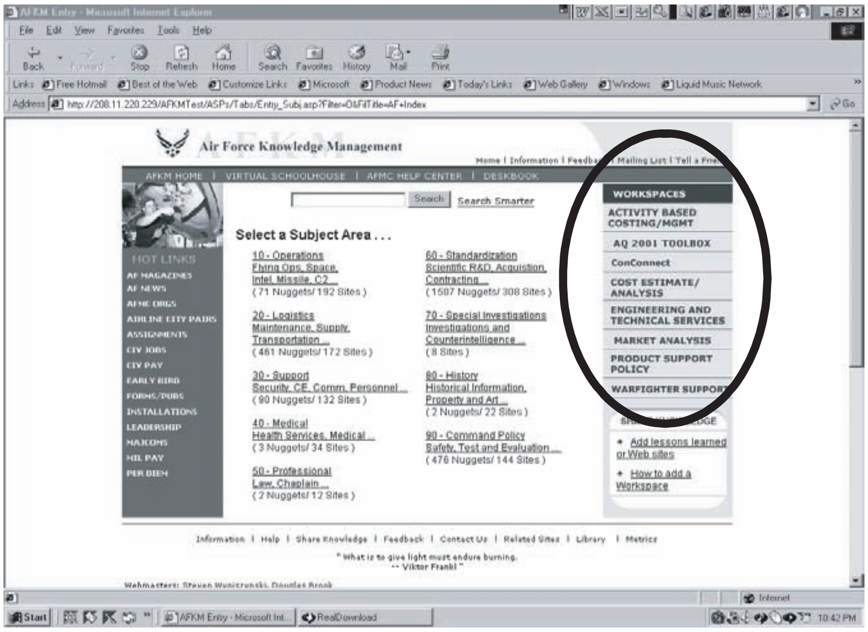
Virtual Schoolhouse. The Virtual Schoolhouse (Figure 4) is a cooperative effort between AFMC/DR and the AF Institute of Technology (AFIT). The Virtual Schoolhouse provides an integrated Web-based learning management system with over 20 online courses. Its purpose is to support the goal of a fully trained AF acquisition workforce.

CoP Workspaces. A CoP is a network of people who share a common goal. CoP workspaces are virtual environments where members of these CoPs can exchange information to complete work tasks and solve problems. Each CoP serves a specific customer set. The AFKM Hub provides workspaces (Figure 5) for a variety of CoPs.

Appendix 3 – Figure 4. Virtual Schoolhouse component



Appendix 3 – Figure 5. CoP Workspaces



APPENDIX 4

AeroCorp's Contract Deliverables

1. Deliverable 60 days: AF Knowledge Management Strategic Vision and Plan. Description: A document that should incorporate both the cultural and technical aspects of the acquisition environment and include a "road map" from the current business environment to the envisioned environment.
2. Deliverable 120 days: AFKM Integration Recommendations Document. Description: An integration plan that should define user operational requirements with detailed cultural and technical consequences as well as time and material requirements to implement the recommendations.
3. Deliverable: AFKM Integration Blueprint. Description: Based on the approved integration plan, the blueprint document should show how the three existing knowledge management systems will operate in the new integrated environment.
4. Deliverable: AFKM Integrated Products. Description: The result of the contractor integrating the three AFKM systems using a phased approach. Each integration effort should provide a working product that can be accessed by the acquisition users in the organizational environment.
5. Deliverable: AFKM Deployment Plan and Execution. Description: The plan should support the deployment of the AFKM system. It should identify user support, and release change management support, including training, communications, and measurement, as well as time and material requirements.
6. Deliverable: Ongoing AFKM Sustainment Support. Description: Sustainment support should be provided for all AFKM elements. The contractor should provide all the functional and technical support necessary for the maintenance and upkeep of the Lessons Learned, Help Center, and Virtual Schoolhouse components.
7. Deliverable: Contractor's Progress, Status, and Management Report. Description: The contractor should use a management and cost-tracking system to support the AFKM effort and ensure technical and funding requirements are accomplished on time and on budget. The contractor should also maintain a continuing dialogue with the government program manager to ensure that schedule and budgetary requirements are met and potential problems are proactively addressed. The contractor will prepare and submit monthly progress and financial reports summarizing the technical accomplishments and expenditures for each task.
8. Deliverable: Weekly/Monthly Functional Analysis Support Analysis Reports. Description: The contractor should provide fielded system product support analysis and readiness assessments as directed by HQ AFMC/DR based upon immediate supportability concerns of the command.
9. Deliverable: 180 Days After Receipt of Order (ARO), Market Research Decision Support Tool. Description: The contractor should provide a Web-based decision support tool integrated within the Market Research Post Tool.

APPENDIX 5

AeroCorp Cultural and Technical Needs Assessment and Recommendations

Cultural Needs Assessment—Recommendation Descriptions

1. Design a KM Action Plan that combines the results of the Cultural Needs Assessment with the results of the Technical Needs Assessment. Data from both assessments will be used to design a "track to action" plan that includes:
   - Methodology and systems engineering
   - Project management procedures
   - Top business technical process needs to streamline for efficiency
2. Create a KM communications plan with a centralized formulation strategy. Establish a clear road map so that the big picture can be articulated to all groups; this includes leadership support of the decisions communicated. The communications plan should clearly define why a project is being done and the benefits to the employees. This should support the mission/vision of AFMC in regards to process improvement. Document the strategy and create a plan to achieve the strategy and explain how each project supports the mission/vision. Establish a clear vocabulary for communication of ideas across teams; standardization of vocabulary for communication of ideas across groups is essential. Initiate team-building/communication activities to foster relationships across the organization (dialogue, inquiry vs. advocacy). Balance being a visionary against execution of jobs.
3. Perform an Organizational Cultural Inventory (OCI) across AFMC. The OCI expands the point-in-time picture of the AFMC culture collected in this report to include a broader pool. The OCI pinpoints 12 specific types of behavioral norms which focus on behavioral patterns that members believe are required to accommodate the expectations of the organization. Norms are organized into three general clusters that distinguish between constructive cultures, passive/defensive cultures, and aggressive/defensive cultures. In addition to measuring shared behavioral norms, the OCI will also identify the ideal operating culture within an organization, providing an opportunity for quantitative data collection on information about the organization's culture at multiple levels, and add additional confirmation to this qualitative Cultural Needs Assessment. This cultural alignment tool will determine the cultural issues prevalent within AFMC.
4. Develop a KM transition plan from current practices to the new KM system. Create a plan of action identifying those items that are helping and hindering AFMC from moving toward their business direction; determine the present state of organization, the desired state, and what must occur during the transition from one to the other. This transition plan should include both internal and external changes within the organization and do the following:
   - Create or incorporate a change management plan that focuses on cultural (and technical) issues within AFMC. A great deal of disillusionment, discouragement, and resistance may need to be overcome. Include a cohesive story of where the group is going and what it is doing. Consider projects that empower people more with authority and accountability for measurable results.

- Establish clear documentation, which defines roles, responsibilities, and boundaries within AFMC. Create a detailed corporate plan on how business is to be conducted in AFMC and with its customers.
- Establish priorities with specifics that provide needed direction to be executed effectively. Have project contacts to call as subject matter experts. Establish clear transition points of projects between groups. Require that decisions be discussed at the appropriate leadership level prior to being evaluated to upper levels of leadership.
- Identify and change business processes that need to be changed so that business can be run more effectively and efficiently.
- Provide extensive training for all aspects of developed KM protocols.

5. Create an AFMC knowledge market. The AFMC knowledge market concept has knowledge "buyers" (seekers of specific knowledge) and "sellers" (suppliers of specific knowledge) who negotiate to reach a mutually satisfactory price for the knowledge exchange. Knowledge "brokers" (people who know who in the organization possesses the information sought) would make connections between buyers and the sellers. Knowledge transactions occur because people expect that knowledge helps them solve problems and succeed in their work. The knowledge market design puts into perspective the sharing culture and provides a framework for formulating actionable steps for building each category within AFMC.

   In addition, the knowledge market will work more efficiently if places are created where people can meet to buy and sell knowledge. Establish "talk rooms" where researchers are expected to spend 20 to 30 minutes casually discussing each other's work. Several organizations have held "knowledge fairs" at which sellers display their expertise for others in the organization. Intranet discussion groups provide an electronic gathering place for people to share knowledge.

6. Establish a multidisciplined AFMC KM integration team. This team will work on organizational and KM technical and continuous improvement teams. The initial tasks assigned to the team will be to do the following:
   - Organize in such a way that all AFMC interests and disciplines are represented.
   - Determine clear and measurable business and technical processes.
   - Identify areas where activities overlap and create a business plan which includes management and technical requirements, with metrics to measure the success or failure of the effort. The metric system will be aligned directly with the business case issues and the KM requirements such that it will access and demonstrate incremental progress being made across the AFMC organization.
   - Develop a reporting mechanism for continuous improvement item tracking to keep record of items that have been successfully identified (based on data collections) and resolved. Report the findings to AFMC management. Establishment of a clearly defined measurement process will provide the momentum and sustainment of the KM program.
   - Foster a workplace that lends itself toward continuous improvement versus policing or auditing of organization in-

formation. The ideal workplace would be where peoples' growth and participation occur within the framework of open teamwork, collaboration, and open flow of new ideas. This way, a link exists between the bottom and top of the organization. Address leadership styles and determine which leadership style is appropriate for which situation (situational leadership).

7. Create a KM Executive Board to oversee KM implementation activities. The KM Executive Board will include community-wide members whose major role is to define the AFMC KM requirements. Create a KM Executive Board Charter. Start a focused pilot (business case development, lessons learned deployment, strategy, etc.). AFMC leadership needs to know and participate on the Board, chaired by the Deputy AFMC Commander. The AFMC Chief Learning Officer (CLO) should serve as the liaison between the integration team and the KM Executive Board. The responsibilities of the Board should include:

   Endorsing mechanisms for transferring knowledge within the organization, including creating a knowledge map, providing mentoring programs, encouraging job transfers, and holding knowledge fairs.

7A. Approving the use of Rapid Improvement Teams (RITs) to work complex issues that the community is either unable to agree on a remedy or for which attempted remedies have not worked. The integration team should recommend RIT campaigns as a part of its activities. The CLO would serve as the RIT sponsor and bring RIT recommendations to the KM Executive Board for approval.

8. Launch a reshaping mission by the AFMC Commander that links the KM strategy to the AFMC Acquisition and Sustainment Strategic Vision and Plan. The architecture for the KM capability must be explicitly linked to the business processes that are required to implement the AFMC KM Strategic Plan. Without this linkage, one of these two planning elements becomes irrelevant as a guide for achieving AFMC's long-term interests. Establish a task force consisting of representatives from SAF/AQ, AFMC, and each center that will report to the Executive Board. The task force would rely on the collective ideas of many people throughout the AF community, using a number of approaches to obtain input from industry, academia, other federal agencies, members of the acquisition workforce, and employee unions. The task force deliverable should outline initiatives to make it easier and more efficient to manage, reshape the acquisition workforce, and advance the current AFMC program to share best practices within the AFMC acquisition workforce. By documenting the deficiencies in the availability of core knowledge; the effectiveness of knowledge capture, storage, and retrieval systems; and the adequacy of personnel skills and attitudes, AFMC will be able to establish tailored remedies that will provide the most efficient knowledge management capability to its members, partners, and customers. The task force should work in concert with the AFMC internal KM team's objectives.

9. Establish a rewards and incentive policy for sharing knowledge. To ensure that such people will share their expertise, AFMC management must make sharing more lucrative than hoarding knowledge. To establish value, evaluation criteria should be established, written, and eventually incorporated in the Human Resources evaluation process so as to provide direct evidence of AFMC employees being rewarded for sharing knowledge. The reward policies should

be valuable, such as substantial monetary awards, high recognition, salary increases, or promotions. Such incentives promote a shift in behavior toward nurturing a sharing culture.

Technical Needs Assessment: Recommendation Descriptions

1. Develop a technology evaluation and approval mechanism that explicitly links requirements for new information technology to process improvements that impact mission accomplishment and customer satisfaction. As organizations have begun to recognize the value of KM to their future well-being, technology providers have been scrambling to recast their data warehousing, intranet, document management, workflow, and so forth, products and the ultimate KM solution. All of these providers fall short in that KM solutions are not "one size fits all" but, rather, organization specific. Without a business strategy, there is no rational basis to evaluate the various technology solutions and craft a KM toolkit that delivers value to the organization and its customers. Organizational evaluation, then, needs to start with an assessment of the mission and business strategy. Value chain activities (research, develop, test, acquire, deliver, and support) should be used as the first level of indenture for evaluating AFMC's KM system.
2. Review AFMC Web sites and identify improvements to increase their effectiveness in making knowledge available to the users. When Web technology was new and viewed as a supplement to accomplishing work, efficiency did not seem very important. Web engineers were more concerned with the eye appeal and user friendliness of the site than whether it provided valuable information. Users readily accepted the fact that they would be directed through several Web sites before accessing any meaningful information. Today, however, the Web is becoming a key work tool for many of AFMC's personnel. For this reason, reduction in search and retrieval time and one-click access to information is no longer an option but a necessity. All AFMC Web sites should be reviewed for their ability to provide value-added knowledge to the workforce.
3. Establish a working group to reduce redundancy in transactional databases. Much of the KM literature is focused on collaboration and the extraction of tacit knowledge. However, the foundation of an organization's knowledge and the source of many of its business metrics are found in its rather mundane workhorse transactional data systems. Several of the interviewees for this assessment commented on their inability to trust the data without independent validation. They reported that the same data element could be found in multiple sources with different values. Technology in and of itself cannot fix this problem, but enforcing the rules of good data management can go a long way to establishing trust in the data. Among these rules is assigning responsibility for ensuring the validity of each data element to the maximum possible extent. Each AFMC CoP should form a working group comprised of its database managers to address issues of data accuracy, replication transparency, and report validity.
4. Establish a task force to improve the capture of tacit knowledge from CoP designated experts. Each CoP has its own set of expert and tacit knowledge that should be captured and put in the organization's knowledge repositories. The pervasive dilemma is that expert knowledge is the most difficult to obtain because it is often ill-defined (knowledge holders do not know what they should be contributing) and difficult to provide (experts are usually too busy to provide this

knowledge). Every CoP has its novices, apprentices, masters, and gurus. Each of these experience levels has an expectation for the knowledge that is required to perform work. An effective KM system should capture knowledge from the top of the experience pyramid and pass that knowledge down and across the CoP. Learning tools, such as the Virtual Schoolhouse, could provide training to knowledge workers on how to determine what constitutes value-added knowledge. The second important aspect of this recommendation is how to influence the collection of this kind of subjective knowledge. It is important that this not be viewed as an additional duty but as a routine and fundamental part of the job. Performance metrics should include contributions to the knowledge base. Technical equipment (e.g., electronic notes and journals) or personal whiteboards may make it easier to contribute.

5. Develop a plan for reducing restricted access to data and data repositories. An effective KM system is open to all participants. Though we are all familiar with the phrase "knowledge is power," many organizations have cultures that treat knowledge as political capital—something to be hoarded and shared only when it is deemed advantageous. If KM is to flourish, that cultural value needs to change from "having knowledge" to "sharing knowledge." Therefore, AFMC should review internally imposed firewalls and password protections to determine those that are needed for security or sensitive data reasons. AFMC should also consider using software that reduces the need for blanket restrictions.
6. Create a metadata-tagging plan to improve AFMC's ability to search and retrieve stored knowledge. AFMC currently uses user profile metadata to improve ease of access to Web-enabled search engines. However, user profiles are limited if the desired data files are not also tagged. It is relatively easy to issue a policy that requires all new data files to be appropriately marked. The real question is, "How much of the legacy data can AFMC afford to retroactively tag?" This raises the economic questions of return on investment. AFMC should create a plan that provides the necessary guidelines for tagging data files.
7. Require each AFMC CoP to develop a collaboration plan. Knowledge-based activities related to innovation and responsiveness are highly collaborative. The attention that AFMC pays to collaboration can be attributed to its role in leveraging the expertise that is often distributed throughout the organization. Frequently, a CoP—the epitome of a collaborative body—cuts across formal organizational boundaries. A CoP often extends across departments and into other organizations, including customers, allies, partners, and sometimes competitors. The range of collaboration-enabling technology can present a daunting task to the people responsible for selecting the best solution for their organizations. Additionally, collaboration needs might vary from one CoP to another. AFMC should require each of its formally recognized CoPs to develop a collaboration plan that describes how that community intends to foster collaborative activity and the recommended technology to enable that collaboration.

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Chapter 5.33
Reserve Bank of New Zealand: Journey Toward Knowledge Management

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EXECUTIVE SUMMARY

This chapter outlines the adoption and implementation of knowledge management within the New Zealand Reserve Bank. In 1999, the Bank recognised that it had a very high exposure to loss of knowledge on departure of key staff. This was mainly due to two factors: recruitment of staff from a limited global pool of specifically skilled labour, and an average length of service of more than nine years during which time staff members accumulated an extensive knowledge of the Bank and its operations. In response to this and other challenges, the Bank embarked on an ongoing knowledge management program. The Bank invested significant resources into the program and from an initial corporate vision developed a knowledge management framework that led to the identification of potential areas of improvement within the organisation. The resulting knowledge strategy encompassed several key initiatives, the most significant of which was the goal of changing the organisational culture. Other initiatives included the consolidation of the Bank's contact management into a single system, a review of the existing document management system, and information mapping. To date, while some initiatives have been achieved, others remain to be done. The challenge for the Bank now is to move from structured to unstructured processes for knowl-

edge management and maintain the knowledge management focus while balancing available resources. The Bank must also consider how best to progress initiatives without necessarily attaching a specific knowledge management label, and identify ways to move ongoing development of knowledge management strategies to the next level.

BACKGROUND

The Reserve Bank is the central bank of New Zealand and a unique entity. Due to its exclusive status, it is not therefore afforded the recruitment opportunities available to organisations in more prolific industries. In addition, the average lifetime of staff members is more than nine years, resulting in a significant potential loss of knowledge on departure. Consequently, the Bank has identified knowledge loss as a high risk within the organisation. In response to this risk, an extensive knowledge management program has been initiated that now spans a five-year period.

This paper presents a background to the case study organisation, and details the steps taken to implement knowledge management through the organisation.

Organization Background

The Reserve Bank of New Zealand (RBNZ) is wholly owned by the New Zealand Government and serves as the nation's central bank. The Bank has the mission of building national and international confidence in the stability and integrity of New Zealand's currency and the country's monetary system. The Bank has three main functions:

- Operating monetary policy to maintain price stability;
- Promoting the maintenance of a sound and efficient financial system; and
- Meeting the currency needs of the public.

More specifically, the Bank is charged with:

- the registration and prudential supervision of banks, and the promotion of a sound and efficient financial system;
- the provision of interbank settlement facilities and related payment services to New Zealand banks;
- advising the New Zealand Government on the operation of the financial system;
- the provision of cash and debt management services to the Government as well as secretariat services to the Overseas Investment Commission; and
- the issue of New Zealand currency and management of foreign exchange reserves.

The Bank's core functions also include the management of NZ $4+ billion of foreign reserves and the management of relationships with international bodies such as the World Bank and the International Monetary Fund (IMF) in order to ensure that the interests of New Zealand are promoted.

Management Structure

The governor leads the Reserve Bank. The minister of finance, on the recommendation of the board, appoints the governor for a five-year term. In accordance with the RBNZ legislative framework (RBNZ Act of 1989), the governor is the single decision maker for the organization and accountable for all activities of the bank.

The minister of finance is responsible for appointing the board of directors. It is the task of the board to regularly review both the performance of the governor and the bank, and provide feedback to the minister of finance. The board must comprise not less than seven, but not more than 10 non-executive members, and does not have any decision-making authority, although they do make recommendations to the minister regarding the appointment of the Reserve Bank governor.

The governor is provided advice from a number of internal committees, including the following:

- the Governor's Committee;
- the Monetary Policy Committee;
- the Official Cash Rate Advisory Group;
- the Financial System Oversight Committee;
- the Risk Management Committee;
- the Reserves Oversight Committee; and
- the Communications Committee.

The Bank is structured into nine departments including the Knowledge Services Group. The senior management team consists of the governor, a deputy governor, and the heads of the various departments as detailed in Figure 1.

Financial Status

The Reserve Bank income is mainly derived from investing the proceeds that the Reserve Bank receives from issuing currency. The Bank spends some of the money to pay its operating costs, the extent of which are fixed in a five-year funding agreement with the Government. The remaining earnings are passed directly to the Government. The balance sheet of the Reserve Bank is shown in Table 1. Further financial information is included in Appendix 1.

Organizational Climate

The Reserve Bank employs approximately 220 staff, a figure which has been much reduced from the mid 1980s, mainly as a result of a "rightsizing" program.

The Bank works to ensure that it has the right people, systems, and structures in place. In keeping with this policy, in 2002, the Bank carried out a review of its human resource and corporate policies with the aim of ensuring flexibility in responding to changing priorities. The Bank has a commitment to a process of staff consultation and involvement when making changes and believes that the presence of a very flat organizational structure provides greater integration, flexibility, and cooperation across departments.

More recently, the results of a staff survey focused the Bank on the need to develop leadership and communication programs for its staff. The purpose of the survey was to identify areas that would improve the overall organisational environment to make the Bank a more effective and better place of work. The results identified several opportunities for the Bank including the following:

- Changes to the management practices;
- Improvement in communication within the Bank;
- Better tools and information; and
- Recognition for work done.

The Bank is an advanced and proactive user of technology, comprising predominantly technology-literate, highly skilled specialist staff. Due to the nature of policy development, there is a requirement for collaboration across business units and this has been primarily facilitated through either face-to-face meetings or through the use of e-mail. The Bank was an early adopter of a document management solution as a way of encouraging collaboration and the sharing of unstructured information across business units.

At an early stage, management identified issues related to collaboration and investment in both human and technology capital. However, business case justification of any major investments in technology has been challenging, given the size of the organization, particularly in the last five years. This has been countered by a management philosophy that accepts that some initiatives are strategic and, as such, may not always stand to business case justification in the traditional sense. The management also had the foresight to recognise the risks related to management of

Figure 1. Reserve Bank management structure (adapted from Reserve Bank, 2002)

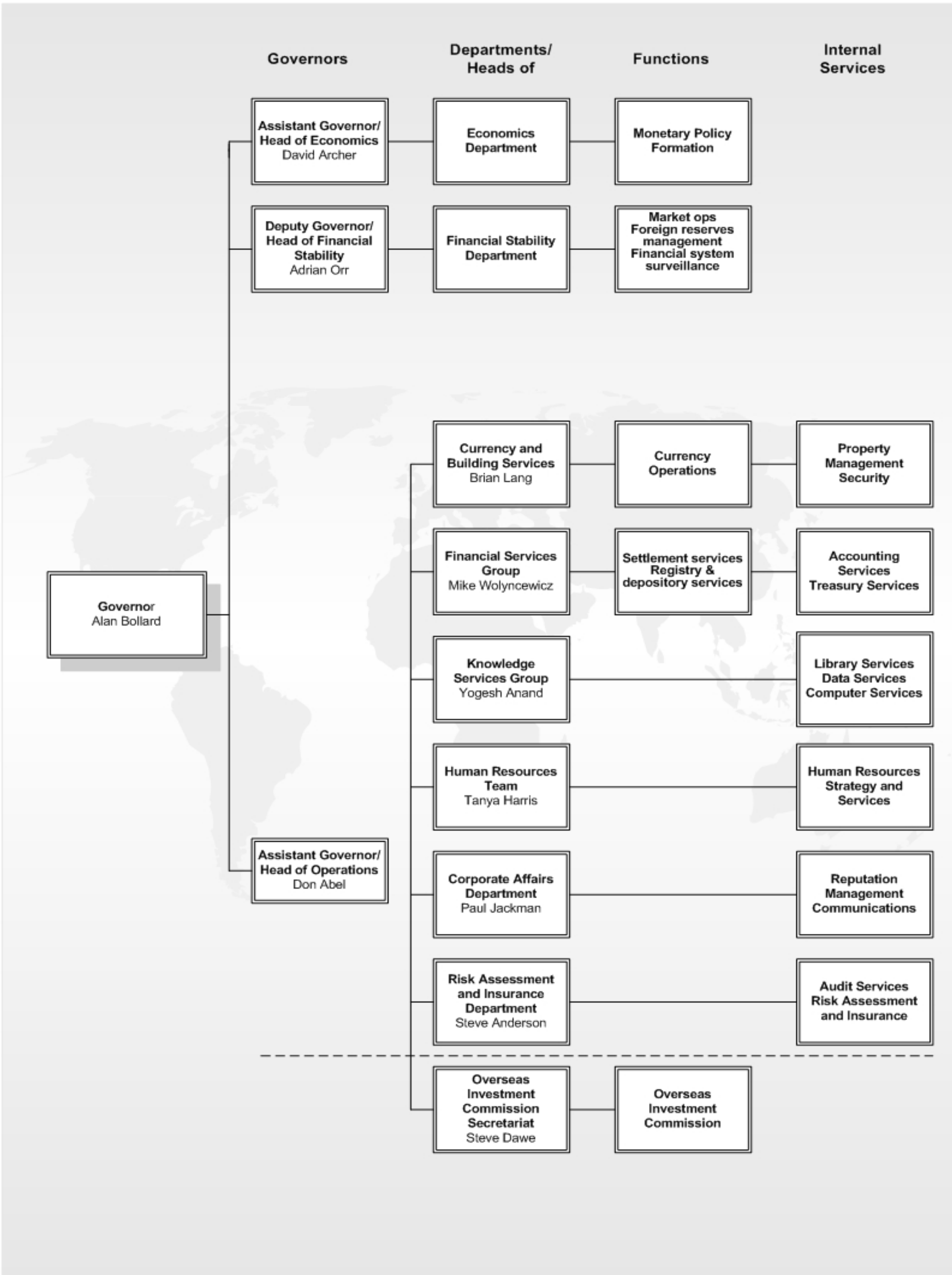


Table 1. The Reserve Bank's balance sheet (adapted from Reserve Bank, 2002)

Assets	2002/03	Liabilities
Foreign Reserves.	$5.1 billion	Debt to fund the purchase of foreign reserves.
Assets arising from managing the Crown's cash operations.	$3.4 billion	Obligation to repay the Crown's and others' deposits with the Reserve Bank.
Government bonds purchased with monies received from issuing currency.	$2.8 billion	Obligation to replace bank notes and coins already in circulation.
		Equity
Assets, including the Reserve Bank building in Wellington etc, and government stock, bought with equity.	$0.4 billion	The Government's net investment in the Reserve Bank.
	Total **$11.7 billion**	

intellectual capital and embarked on initiatives to mitigate these risks.

SETTING THE STAGE

In the early 1990s, the Bank employed approximately 800 staff, many of whom had been with the organization for a considerable period of time. In one instance, a staff member had been with the Bank for over 40 years. In another, a governor of the Bank recently left after 33 years of service. The length of service, combined with the specialist skill set required by Bank staff, resulted in a high percentage of knowledge workers. Consequently, there was a significant risk of potential loss of knowledge as a result of a staff member leaving.

Towards the end of the 1990s, with the rapid advances in technology and the accompanying shift to a global community, the Bank began to experience a slight rise in the level of staff departures. Initially, staff were leaving from predominantly operational areas where the loss of knowledge was not as critical. In these areas, much knowledge had been captured through documented processes and procedures. However, when staff concerned with policy started leaving, it became critical to consider how to deal with this potential loss of knowledge.

As a policy-making organization, the Bank had always been reasonably good at sharing information. When any development was taking place, it was normal practice for information to be readily exchanged with problems arising only where previous actions had been forgotten about, or staff members had left the organisation and, as a result, the information was not readily accessible. However, despite this seemingly strong knowledge-sharing practice, there was still a culture of structural silos within the organisation, with little boundary crossing between departments. This was emphasized in the policy areas where staff members were closeted in offices and were rarely seen to leave other than at lunchtime or at the end of the day.

Concurrent to the increasing level of staff turnover and problems arising from structural silos, the Bank was going through an organisational "rightsizing" program. There was also growing interest in knowledge management within the wider environment at a national level from the government and public sector as well as within commercial and academic circles.

Knowledge management, as it is currently understood, has been around for more than a decade. The term has, however, spawned a proliferation of definitions. Snowden defines it succinctly (1999) as:

The identification, optimisation, and active management of intellectual assets, either in the form of explicit knowledge held in artefacts or as tacit knowledge possessed by individuals or communities (p. 63).

The predominant focus of organisations embracing knowledge management has been the potential for higher levels of profitability, greater market share, and increased innovation. However, there are wider potential benefits for organisations that successfully manage their knowledge, including a flexible approach to change and better workplace morale (Scherer, 2001). In the public sector, Wiig (2002) contends that knowledge management can enhance decision making, assist public participation in decision making, build competitive societal intellectual capital capabilities, and assist in the development of a knowledge-intensive workforce. It can also bring much needed assistance in the area of knowledge sharing, which has historically been an area of difficulty for the public sector (OECD, 2003).

Much academic research pertaining to knowledge management has been predominantly published in the information science/information technology (IS/IT) literature (Newell et al., 2002) and has led to information systems and technology becoming synonymous with knowledge management. More recently, the field has undergone a change in focus from a predominantly technological approach to a more integrated approach (Gold, Malhotra, & Segars, 2001), which has encouraged organisations to bring a more holistic approach to their knowledge management efforts.

Implementation of knowledge management has proved a problem for many organisations. Despite recognition of the potential benefits that knowledge management may offer, many organisations simply did not know where to start (Earl, 2001). Knowledge management best practice has been well documented (Davenport, De Long, & Beers, 1998; Chourides, Longbottom, & Murphy, 2003; Mertins, Heisig, & Vorbeck, 2001) and is often an approach advocated by knowledge management consultants. The downside of best practice is that while it provides examples of implementation approaches that organisations may adopt, it does not take into account the individual factors of the organisation, including the external environment, the internal environment, technology, culture, and infrastructure. Knowledge management is not a "one size fits all" solution, but must be carefully tailored to meet the unique organisational characteristics. By contrast, Snowden's principles of "organic knowledge management" and interest in complex adaptive theory support the view that knowledge management solutions are unique to the organisational context in which they are created (Lelic, 2002).

As a quasi-government department, the Reserve Bank was able to leverage public sector interest in knowledge management in support of its knowledge management journey.

CASE DESCRIPTION

The nature of the work of the Reserve Bank was such that it required a range of specialist skill sets that were not readily available within New Zealand. This was mainly due to the fact that each country has only one central bank, and therefore does not have a large pool of individuals with the specialist skill sets, such as macro-economics and

Table 2. Human resource statistics (adapted from Reserve Bank, 2002)

	1994/ 1995	1995/ 1996	1996/ 1997	1997/ 1998	1998/ 1999	1999/ 2000	2000/ 2001	2001/ 2002	**2002/ 2003**
Total staff at 30 June (FTE)	293	290	289	281	283	237	199	182	**193**
Average years of service at 30 June	8.6	8.6	8.7	8.3	8.8	9.4	9.4	9.2	**9.2**
Annual staff turnover	9.6%	15.0%	10.6%	8.8%	10.0%	10.4%	14.9%	13.5%	**11.3%**

banking supervision, that are required. Consequently, recruitment of staff was effectively limited to a global pool of specifically skilled labour drawn from central banks around the world.

In addition to the scarcity of skill sets, the average length of service at the Reserve Bank was more than nine years, as shown in Table 2.

During this time, staff members accumulated an extensive knowledge of the Bank and its operations, resulting in a very high exposure to loss of knowledge on the departure of key staff. As a consequence of this exposure and of the "rightsizing" program that the Bank was then undergoing, the Bank recognised that it needed to take action to minimise the risk of knowledge loss. Although the NZRB was one of the first to recognise the significance of these issues, other central banks such as the Bank of Canada have also expanded their research programs to include the issues of talent and knowledge sharing (Bank of Canada, 2002).

In 1999, the Bank was not alone in recognising the growing importance of knowledge management. At the same time, the Information Technology Advisory Group (ITAG), comprising academics and representatives from the business community and public sector, presented a report to the New Zealand Government, titled "The Knowledge Economy." The report focussed on the need for New Zealand to change its economic mix and warned that if the nation failed to make the transition from a pastoral to a knowledge economy, then it was destined to become nothing more than a holiday destination for visitors from countries where the knowledge economy had been embraced (ITAG, 1999). As a result of this report, the New Zealand Government developed a vision of New Zealand as a world leader in e-government, with the Internet being the dominant means of access to government information, services, and processes. In addition, it was their intention that public sector innovation should support a wider knowledge based society. Hearn and Rooney (2002) posit that it is the role of governments to facilitate the technical, cultural, and social aspects of waves of innovation. This role is widely supported throughout the Organisation for Economic Co-operation and Development (OECD), where the majority of central government organisations regard knowledge management as a priority and have knowledge management strategies in place (OECD, 2003).

It was at this point, and with the combination of national and local drivers, that the Bank developed a corporate vision that focussed on knowledge management as a key component. The vision was led by the then deputy governor, whose involvement signified the high level of importance that the Bank attributed to knowledge management. This was an important first step and allowed the Bank's vision to permeate the organisation, providing staff with a needed sense of purpose that transcended everyday activities (Gold, Malhotra, & Segars, 2001). The Bank's new corporate vision prompted the required changes within the organisation (Kanter, Stein, & Jick, 1992). In this case, the vision encapsulated the contribution that knowledge-based value creation can make (Earl, 2001).

The first step after development of the corporate vision was for the Bank to develop a business case to move forward in developing a knowledge management program. Development of a business case for knowledge management is difficult given the seemingly intangible benefits and difficulty in quantifying or measuring the potential outcomes of initiatives. Although the Government vision and the national drivers arising from this were a key source of support for the Reserve Bank vision, they did not assist in the development of a direct business case for the undertaking of a knowledge management program. However, the Bank's status as a quasi-government department enabled it to leverage government interest in building the knowledge economy and positioning the public sector as the driver of the knowledge economy was of particular importance to the Bank. The Bank also emphasised its view that government departments should be showing leadership. By emphasising the importance of leadership from the public sector, the Bank was able to add significant weight to its own business case.

One of the most significant steps in the Bank's journey to knowledge management was the establishment of the Knowledge Services Group. This group, comprising staff from across the organisation, was charged with identifying the importance of knowledge management for the Bank and, subsequent to this, implementation and maintenance of organisational knowledge management practices. The Bank appointed Yogesh Anand to the role of chief information officer (CIO). His role was to head the Knowledge Services Group and take overall responsibility for the Group's combined areas of knowledge management, information management, and technology. A critical part of Anand's role was to take the knowledge management vision and understand what it meant for the Bank, to refine it, to elaborate it, and finally to replace theory with action.

From the outset, involvement in the knowledge management initiative came from all levels. The Bank's governor directly sponsored the initiative, and this top-level support was particularly helpful in communicating the importance of the initiative to all staff. A clear corporate vision (Kanter, Stein, & Jick, 1992; Nonaka & Takeuchi, 1995) and top-level support (Blackler, 1995; Nonaka & Konno, 1998) are widely acknowledged as fundamental to the development of a strong knowledge culture. At the same time, staff from the library and records management area as well as other parts of the Bank came together to form an informal, grassroots network. This network followed the growth of thinking on knowledge management theory and could be categorised as an early community of practice, defined as one of three key critical components of knowledge management (Cohen & Prusak, 2001). Other critical components were identified as the trust of the organisation's staff and the presence of appropriate social norms and organizational culture, both of which were confirmed by the experience of the Bank. Communities of practice have an important role to play in sharing learning and knowledge across an organisation (DiBella & Nevis, 1998), as evidenced within the Bank, where this informal network initiated brown-bag lunchtime sessions, where those interested in finding out more about knowledge management and how it would work in the Bank could meet and discuss the various issues. This group also helped to identify the barriers that existed in terms of knowledge sharing.

Building a KM Framework/Strategy

Thus far, the Bank had developed a vision and seen the formation of both the Knowledge Services Group and more informal knowledge management-friendly networks. However, although knowledge management was much discussed, very few organisations were actually implementing knowledge management programs. Despite recognition that knowledge management could be beneficial to an organisation, many organisations simply did not know where to start (Earl, 2001). The Bank found itself in a similar position and determined that the most logical starting point was to gain an understanding of knowledge management, to investigate global best-practice thinking, and to identify a preferred development process or framework that would be most appropriate to the Bank. Development of knowledge management frameworks can assist organisations to understand the sorts of knowledge management initiatives that are possible and to identify those that are most suitable to the context of the organisation (Earl, 2001).

To enable this development, the Bank sought to develop its own local framework with the help of an outside individual who could bring in best practice and knowledge in terms of what was happening in other parts of the world. However, a critical concern for the Bank was loss of control of ownership of the process. In order to maximise potential of the appointment, the Bank secured the services of an individual through whom it could gain access to established networks and the individual's organisation. By doing this, the Bank was able to harness significant information on what other organisations were doing in relation to knowledge management, and assessment of this information would assist the Bank to develop its own knowledge management strategy. The aim of a strategic approach to knowledge management is "to build, nurture, and fully exploit knowledge assets through systems, processes, and people and convert them into value as knowledge-based products and services" (Earl, 2001, p. 228). This was the Bank's objective.

The Bank then undertook a 12-week program that effectively developed the framework into a workable strategy.

Strategy Development

Developing the Bank's knowledge management strategy involved all areas of the organisation, and contained four main phases as shown in Figure 2. As part of this work, examination was made of the organisational culture, structure, and infrastructure to determine what changes would be needed.

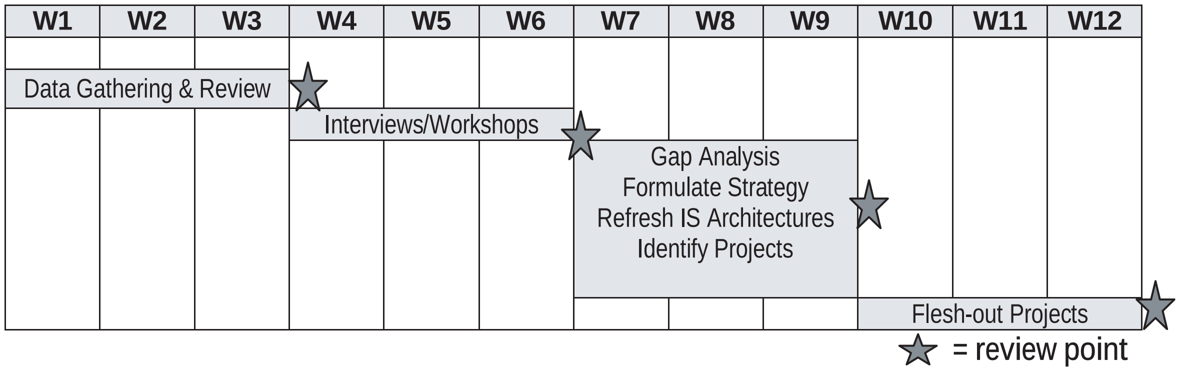
In the initial three-week phase, the Knowledge Services Group worked with the external consultant to gather and review the knowledge management data and best practice from around the world.

The second phase focussed on internal data gathering during which a number of structured interviews and workshops were carried out throughout the organisation to investigate the knowledge required by each function and to understand what individuals saw as being the opportunities (see Appendix 3). Additional input was sought from the members of the informal brown-bag network who had been meeting prior to the onset of the strategy development. This group had valuable information regarding knowledge management thinking at the grassroots level and had helped to identify some of the existing barriers to knowledge sharing within the Bank.

One area of the strategy development that posed particular difficulty was the identification of specific knowledge that would have to be managed in each function. In order to overcome this difficulty, three separate categories were identified for classification purposes:

1. Structured data (S)
2. Unstructured and semistructured information (U)

Figure 2. Knowledge management strategy development process (adapted from Anand, 2003)



3. Experience/knowledge (E)

The information gathered through the interviews and workshops was then structured into these three categories as denoted in Figure 3. For example, one workshop focussed on experience and information into the development of monetary policy. Feeding into the process was structured (data) and unstructured information (reports, etc.) along with experience from external and internal organizations. This was then used to identify where the exposures may be in terms of risks or barriers.

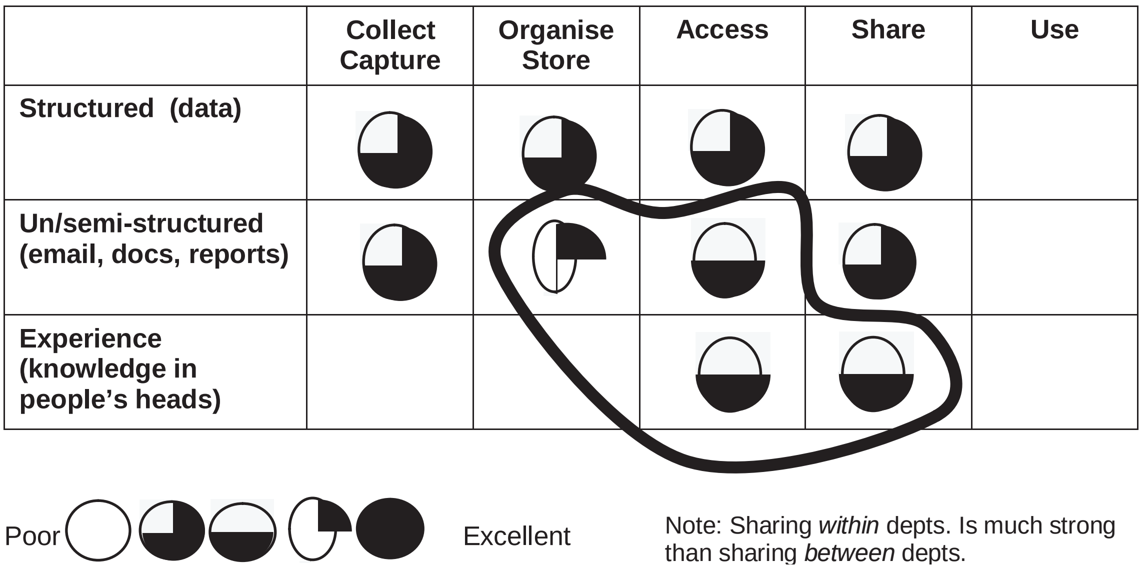
The three categories were also analysed in terms of their collection, storage, access, sharing, and use as shown in Figure 3.

This outcome of this process indicated that, as expected, the Bank was reasonably good at managing the structured information (data) in terms of sharing it and providing access to it. With unstructured or semistructured information, the Bank considered it was good at its collection, but not so good at organising and storing it. For example, although a document management system was in place, it did not integrate well with the e-mail system and so e-mails tended to be held personally. The same thing was found with experience — while the Bank considered it was good at recruiting both graduates and globally experienced staff, its view of their experience then tended to become limited to their specific role rather than their entire experience, which was often far wider. The Bank also found that sharing of information within departments was far better than the sharing between departments.

Armed with this knowledge, the Bank then carried out phase three of the program, which included a gap analysis that would be used to formulate the strategy. The gap analysis identified four threads:

- People to Information. This category consisted of infrastructure-type activities aimed at improving knowledge repositories as well as making them easier to access. This ensured that individuals had timely, secure, and accurate data and information to be able to carry out their work. These infrastructure-type activities operated at two levels: management of information coming into the organization, and handling the dissemination of captured information. To carry out

Figure 3. Categorisation of information (adapted from Anand, 2003)



the activities required an understanding of what information was needed, or at least, anticipation of the broader requirements. To achieve this, staff in the Bank's information centre worked closely with the different departments to ensure that they knew all that was available within the organisation.

- People to People. This category was identified primarily as a culture issue and focussed on sharing the experience and knowledge of staff and making it easily accessible through maintaining and developing contact networks. In this instance, an environment was required, for example, "coffee machine discussions," which enabled and encouraged the exchange of ideas, and which ensured that staff were aware of who knew what within the organisation, as well as allowing new experiences to be shared.
- Institutionalise Knowledge. While the Bank was good at capturing decisions, it was not always as efficient in its responses to them. For example, the thinking that went into its decisions, the alternatives discussed, and market reactions were not always captured. Consequently, there was little learning captured for reuse. The challenge here was to turn individual knowledge into an institutional repository, so that it became part of the corporate memory.
- Collaborative Culture. The intent of this was to change the culture so that sharing became second nature within the organisation, and as a consequence, moved away from the view that "knowledge is power" to one of "knowledge sharing is power." From an organisational perspective, this meant ensuring that the organisation allowed shar-

ing to happen, with executives leading by example to develop and actively reinforce the organizational culture (Schein, 1992).

An example of facilitating opportunities to share is the recognition of the importance of staff mixing in the cafeteria. When the existence of the cafeteria came under review, the Bank decided to keep it as its benefits in this regard had been recognised. Activities in this area were focussed on creating a collaborative culture in order to make the most of the resources that the Bank had, and a collaborative working environment in which sharing is active and deliberate.

The completion of the gap analysis allowed the Knowledge Services Group to identify a number of specific initiatives that would enhance knowledge management within the Bank. These initiatives were developed and categorised in terms of cost and importance as shown in Figure 4.

In general, the initiatives were aimed at improving the accessibility to structured and unstructured data and to the knowledge held by people, improving the corporate memory, and developing the right culture. In particular, they focussed on infrastructure issues such as the tools required. These issues could be regarded as the low-hanging fruit since they were more easily understood by people and provided a catalyst for a change in culture. However, they also included more difficult cultural and leadership issues. In keeping with the complex nature of knowledge management, these initiatives presented a multifaceted approach that included cultural, technological, and organisational infrastructures as identified by Gold, Malhotra, and Segars (2001).

During the strategy development process the general feeling amongst many within the organisation, apart from the knowledge management enthusiasts, seemed to be one of nonchalance. In many respects, it was recognised that the concept of knowledge management was not new, and there was an underlying feeling of a new label being placed on an old problem. The Knowledge Services Group countered this by talking not about knowledge management, but about the specific issues that were being identified and how these might be resolved. While the term "knowledge strategy" or "knowledge framework" was found to be useful in terms of discussions with the senior management team and in the development of individual business cases, at the grassroots level, people wanted issues to be resolved. In removing the "knowledge management" label, more credibility was able to be added to the initiative.

Specific Initiatives

The most significant knowledge management initiative to be undertaken at the Bank was aimed at changing the organisational culture. The Bank recognised that although this change had the mandate of the senior management group, it would require much more than this. To facilitate the change, three key areas were identified. First, it was understood that it required leadership by example. Shaping culture is critical to an organisation's ability to manage its knowledge more effectively (Gold, Malhotra, & Segars, 2001), and an important aspect of culture is the vision that is presented from top-level management (Davenport, DeLong, & Beers, 1998). The initial vision had been shaped by the then deputy governor, and mandated by the governor, it was important that this high-level support was seen to be continued. Unlike many organisations embarking on knowledge management initiatives, the relatively small size of the Bank was to prove advantageous, as it was possible to sustain strong lines of communication. As the CIO points out:

There are about 215 people located in this building. If I can't walk to everyone of them and tell them something, there is a problem. In this way, it could be seen that the initiative was being supported at the highest levels in the organization (Anand, 2004).

Figure 4. Reserve Bank knowledge management strategies (adapted from Anand, 2003)

	Low cost	High cost
A (highly recommended)	❑ Develop policies/standards & training programs for document management and email usage ❑ Work with departments to review file classification and handling of records/physical files ❑ Scan selected incoming correspondence ➢ Document lessons learned in formal manner ➢ Make corporate history more visible using timelines o Implement the Learning and Development Project and evaluate outcomes o Assess job rotation, multi-department projects and committees as part of development plans for all staff o Develop communications strategy to support culture change o Continue with Leadership Project & evaluate outcomes o Job evaluation, rewards and motivation initiatives ● Grow info publishing and data analysis with DU	❑ Work toward integrated KM system. Start by reviewing document management system and using this as an opportunity to review KM solutions available in marketplace. 1 Web enable applicationsGoveStatistics NZ 2 dBoaBanks *manageme* *t dat* ❖ base *Data warehou* ● e pilot
B (should do)	● Review data acquisition ● XML enable external data feeds ➢ Build knowledge into standard operating procedures and systems	● Standardise data storage ● Develop data warehouse
C (could do)	● Develop high level data map ❖ Implement e-collaboration tools (project & chat rooms) ❖ Develop a who's who directory within the Bank ❑ Review Bank's document scanning/OCR requirement	

LEGEND

- ● Make structured data more accessible
- ❑ Make unstructured information more accessible
- ❖ Make knowledge held by people more accessible
- ➢ Develop corporate memory
- o Develop the right culture

To further enhance the leadership role and embed knowledge management into the organisational psyche, the Bank identified knowledge management as being a core competency for all managers, and a key element of the appraisal process. Within the performance appraisal, knowledge sharing was broken into multiple statements and the employees measure themselves as to where they think they are at on a scale of one to five, with one being "needs lots of development" and five being "walking on water." The manager then carries out the same assessment. The idea being that once both parties have completed the assessment, they then sit down and look at any gaps or discrepancies in the assessment. This method of assessment has been received well and has prompted staff to look at how they are sharing knowledge in terms of documentation and both internal and external networking. The appraisal is not linked to pay, therefore there is no disincentive attached.

Knowledge management also became an integral part of the Bank's recruitment program, and was used during the recruitment process to capture candidates' thinking on knowledge management and determine their likely approach.

The second key area of priority in terms of changing the organisational culture was to increase opportunities for collaboration. Prior to the onset of the initiative, the Bank had begun to move to open-plan offices for the whole organisation. Only the chief executive and the deputy chief executive retained their own offices. The driver for the change had not been an overt attempt at increasing knowledge sharing. Rather, it was the initiative of a new head of department in the policy area. One of his first observations was that the current environment, comprising individual offices, was not conducive to facilitating policy making, and did little to promote communication between staff. This initiative initially met with strong resistance principally because staff equated offices to status. By removing the offices, individuals felt that they no longer had particular status within the organisation. Having observed the resentment toward the plan, the head of department first took the time to explain the reasons behind the change. However, there continued to be resistance within the workforce, with some staff feeling so strongly that they threatened to leave. This did not eventuate and the change was made. Ironically, three years later, with the Bank still located across a number of floors, the staff requested that the Bank relocates to a single floor location to remove barriers to communication. Another of the key concerns put forward by the staff prior to the change, was that an open-plan layout would be noisy and interfere with their ability to concentrate. In the initial stages, the open-plan approach was found to be noisier; however, complaints about this soon died away and people were now talking far more than when there had been the physical barrier of the offices.

The third area identified as a potential contributor to facilitating a change in organisational culture was the provision of incentives for knowledge sharing. This area has generated much thought within the knowledge management literature and the Bank was not convinced that the introduction of incentives, particularly in terms of financial rewards, was necessarily a positive step. Through careful research, the Bank found that although this approach had appeared to work in other organisations, some problems had occurred. These problems included determining the value of the knowledge and the need for increased payments for greater amounts of knowledge to avoid some being held back. The literature in this area is also divided. While some posit that that productivity and quality occur within corporate cultures that systematically recognise and reward individuals, both symbolically and materially (Willmott, 1993), others argue that extrinsic rewards, such as monetary awards, will have a negative impact on intrinsic motivation (Deci & Ryan, 1985). The Bank decided that while it would continue to monitor developments in this area, the incentive approach was counter to what it was trying to achieve in terms of its culture.

The gaps analysis also made apparent difficulties in the availability of information in terms of access and integrity. A good example of this was the proliferation of contact databases operating within the Bank. It was common for each database to contain the same or similar information as that contained elsewhere and there was no common system for updating or deleting material. As a consequence, there were significant overlaps, data redundancy, and integrity-type issues. In addition, access was not available to everyone and some staff were still operating using business cards. The approach to this problem was to consolidate the databases in order to bring the contact information into one location.

On the surface, consolidation of the various contact databases appeared to be a very low-level issue. In reality, it was one of the most difficult and time-consuming projects that was undertaken. The main difficulties arose from the reluctance of individuals to move from their own contact database, which in some cases had been used for over 15 years, to a database that would be maintained centrally and where access would be available to all.

A large project team was formed to work through the issues that the changeover presented. The project team consisted of three working groups each consisting of 12 people. With the participation of the working groups, a new intranet solution was identified, and the changeover commenced. In order to ensure that the changeover ran as smoothly as possible, the Bank ran multiple training seminars and carried out a great deal of one-on-one hand-holding. Today, the intranet is the primary contact source within the Bank and has been extended to include a contracts link so that all the contracts held within the bank are also held centrally. However, as the CIO states:

> *I know that probably some people have still got business cards. You can't force people to give them, but now if you spot an anomaly you can fix it, and that updated information is available to everyone (Anand, 2004).*

In total, this process took 18 months, which was longer than expected, and was mainly due to the reaction to the change and the feelings of loss of direct control.

The Bank also undertook a review of all of its electronic records and document management activities. The Bank had been an early adopter of document management and had a system in place since 1993. The gaps analysis had shown there were several areas in which the Bank could improve its document management activities, including better management of all external and internal information resources such as the integration of e-mail. Although the current system captured a significant amount of external documentation, the aim was to now electronically capture internal documentation as well. Successful capture of both internal and external documentation would result in staff having a wide and ready access to a range of information.

In contrast to many organisations, the Bank operated as a totally open organisation, which meant that there was no security on any documents, including the discussions of the senior management group. The culture within the senior management group was to discuss why such documents would not be shared in the organisation, as opposed to shared. The only exceptions to this policy were around market-sensitive information on monetary policy where information remained private to protect staff from the results of any leakage, and the staff understood and accepted this. Mintzberg (1979) sees this form of semiadhocracy as one that facilitates knowledge sharing and an intensity of knowledge work, and is particularly appropriate in a knowledge-based organisation comprised of professional knowledge workers.

The review of the document management system was initially considered in terms of a data warehousing issue; however, as the review progressed, it became clear that the issues were more about providing a single point of access to information. As a result, data warehousing was removed from the agenda.

The review is ongoing, with the project team about to introduce the potential new solution to the wider organisation. With the experience gained from the integration of the contact databases, it is at this point that the CIO believes the document review program may encounter possible resistance as the current solution has been in place for 10 years. To counter this, the Bank has in place an extensive change management strategy, which includes "fun parts," strong messages, as well as heads of departments taking an active role in promoting and selling the messages to their respective departments.

There were also a number of smaller initiatives, including increased use of information mapping techniques, as well as use of scanning with a pilot on how best to enable access to documents that were not currently available online.

As well as improving the Bank's infrastructure tools, some of these initiatives are also intended to reinforce the values of the organisation, for example, in support of providing a family-friendly environment.

CURRENT CHALLENGES/ PROBLEMS FACING THE ORGANIZATION

The Bank has committed sizeable resources to the initial development and subsequent implementation of knowledge management strategies. These have resulted in significant benefits to the organisation, the most important of which was to mitigate the risk of loss of knowledge through staff departure. There are several other subjective benefits that the Bank attributes to knowledge management, including the culture of the organisation, the extent of current knowledge-sharing practice, and the accessibility of a wider range of documentation of all staff. Despite the difficulty in quantifying the potential benefits of knowledge management, the Bank was, from the outset, comfortable with the idea that the potential benefits were not easily measurable.

The Bank's journey to knowledge management has been a holistic one, and has focussed on culture, structure, and infrastructure. In some ways, the CIO regards technology as the easy part and believes that the greater challenge is in bringing about the change, especially when benefits are more intangible. Change is easier to enact when it can be hooked to something rather than change for the sake of change; therefore, technology is often used as the hook. However, he stresses, that from the Bank's viewpoint, knowledge management is not all about technology. It is not the technologists but the information manager who has responsibility for the Bank's knowledge management strategy. He said:

They're the ones who are used to thinking about unstructured information, whereas if I was to give it to a technology person, they'd be trying to put a structure round it. When you do that, you're going to lose a lot of value from it (Anand, 2004).

There are still several strategies that have not yet been put into place. Although the review of the document management system is partially completed, the introduction of a potential solution is seen to be one that will potentially meet some resistance. The Bank will approach this with the insight gained from previous initiatives and with the experience of knowing that while the road may at times be difficult, the view from the other side is generally better.

There has certainly been progress made in terms of recording past decisions. This has mainly been achieved by targeting individuals developing an e-mail-centric organisation whereby the majority of discussions and debate are captured in threads within e-mails. This has proved successful to date, but moving forward, there may be less use of e-mail and so the Bank will need to initiate alternative approaches to formalise some of the processes.

There are also a number of legacy systems operating within parts of the organisation, such as Human Resources. The integration of these is being addressed in the single point of access activity. At this point, the project is still largely in the stages of trying to understand exactly what is the boundary and scope of the project.

The Bank is also investigating the idea of "yellow pages," a system of identifying those within the organisation with specific expertise. The context of the system will be somewhat wider than other systems in operation in that the extent of the experience will relate not just to that of the person's job but in terms of their wider experience. A good example of this is a staff member who survived the Kobe earthquake in 1995. He has talked to many groups within the Bank about preparedness and issues such as business continuity. Although that experience may not relate directly to his position at the Bank, it is invaluable in the wider context and makes him an excellent knowledge source for a yellow pages system.

An ongoing challenge for the Bank, like several other organisations, is that of continuing to meet the ongoing business demands with the level of available resources. In that environment, keeping knowledge management in the forefront is a challenge and needs to be achieved through practical initiatives that can demonstrably provide tangible and/or strategic benefits. This requires commitment from within the organisation as well as ongoing communication. In the Bank's case, it looked on knowledge management as a sunk investment and focussed on getting acceptance to the framework. Once this was completed, it provided a reference point for the specific initiatives that could be looked at in terms of how well they delivered against the framework.

Culturally, the Bank is at an interesting crossroads. The organisation is becoming wary of what might be termed as "consulting labels." As the organisation's awareness of knowledge management concepts has increased, the term "knowledge management" has become a less favoured label. As a result, one of the challenges for the Bank is to progress the knowledge management initiatives but package them differently.

There is also a need to move the Bank's ongoing development of knowledge management strategies to the next level. To date, a best-practice-based approach has provided a good framework for the Bank. However, one school of thought for ongoing evolution is to explore the more unstructured process for developing knowledge management strategies. Embracing complex adaptive systems theory, this approach can be used to create a sense-making model that utilises self-organising capabilities to identify a natural flow model of knowledge creation, disruption, and utilisation (Snowden, 2002). Snowden concludes that the enabling of such descriptive self-awareness within an organisation will provide a new simplicity that can facilitate new meaning through the interaction of the formal and informal in a complex ecology of knowledge (Snowden, 2002).

EPILOGUE AND LESSONS LEARNED

Epilogue

This case illustrates the challenges inherent in implementing knowledge management initiatives into knowledge-intensive organisations. With no tried-and-true frameworks or models to follow, organisations, such as the Reserve Bank, must grapple with devising and implementing strategies appropriate to their own needs and circumstances. Although it is unlikely that prescribed knowledge management implementation strategies will ever be off the shelf in the sense of providing an easy and effective solution for any given organisation, it is possible to foresee a time when a great enough body of research and practice has been accumulated to offer an organisation such as the Bank enough successful models of knowledge management implementation to pick and choose strategies that might be appropriate to at least begin working with. This case helps point the way forward for others by detailing the journey of one organisation that is seriously pursuing a comprehensive programme.

Lessons Learned

Knowledge management is not a project; it is a continuum

At the outset, the Bank viewed knowledge management in terms of a project, with a distinct time frame and process. In broad terms, knowledge management was viewed as a problem that required fixing. In retrospect, the Bank considers that knowledge management is not a distinct task, but rather as the way you work, encompassing all aspects of the organisation. Essentially, it is an intrinsic part of an individual's approach to work, as well as intrinsic to the Bank's culture.

Committing to a framework that will evolve in a more organic way

In keeping with the view of knowledge management as a continuum, commitment to an organically evolving framework retains a close alignment to the individual nature and requirements of the particular business environment. This avoids the need to put a tight structure around things, which is likely to constrain thinking and result in a less-than-optimum result. While best practice can work well, essentially it is transferring someone else's idea to your individual business circumstance, and can stifle innovation because you are constraining yourself to what others have done. Rather than applying scope and boundaries from others, the challenge is to say, "let us just throw everything up in the air and see where it lands."

It is not exclusively about technology or business process or culture; it is a combination of culture-change initiatives with technology as an enabler.

The combination of technology and business process were important components of the Bank's knowledge management initiative, but neither was considered in isolation. The Bank's knowledge management program necessitated changes to the way things had previously been done. Change is often easier to enact when it has a hook. Often, technology is used as the hook for facilitating change.

High level of commitment from within the organisation

The Bank's knowledge management program was sponsored from the highest level, the governor. If this top-level support had not been apparent, it is believed that the Bank would not have made as much progress as it did. Although it could have been pushed, to a certain extent, by the CIO, there were a number of business cases where the projected benefits were intangible and not able to quantified. Without high-level support, it would have been difficult to secure funding for these business cases in the absence of a tangible return on investment.

The intangible nature of benefits

The benefits derived from knowledge management initiatives are often intangible and hard to quantify. Most organisations require a strong business case to be in place before committing funds to an initiative or project. The Bank found it difficult to identify and measure benefits in terms of financial return and was therefore unable to present these as part of its business cases. The Bank took the approach that by addressing the problems that existed, this would result in intangible benefits, such as a happier workforce, thus leading to increased productivity. The investment was, therefore, more a strategic investment in the business in the long term. Success of earlier business cases has also added support for future business cases.

REFERENCES

Anand, Y. (2003). *Reserve Bank of New Zealand: Knowledge management. Presentation*. Wellington, New Zealand.

Anand, Y. (2004). *Personal interview with Reserve Bank CIO,* Yogesh Anand.

Bank of Canada. (2002). *Annual report.* Retrieved July 2004, from www.bankofcanada.ca/en/annual/2002/bank.pdf

Bartol, K., & Srivastava, A. (2002). Encouraging knowledge sharing. *Journal of Leadership & Organizational Studies, 9*(1), 64-76.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Chourides, P., Longbottom, D., & Murphy, W. (2003). Excellence in knowledge management: An empirical study to identify critical factors and performance measures. *Journal of Business Performance Management, 7*(2), 29-45.

Cohen, D., & Prusak, L. (2001). *In good company.* Boston: Harvard Business School Press.

Davenport, T., DeLong, D., & Beers, M. (1998). Successful knowledge management projects. *Sloan Management Review, 39*, 43-57.

Davenport, T.H. (2002). *Some principles of knowledge management.* Retrieved July 2004, from www.bus.utexas.edu/kman/kmprin.htm

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Deci, E.L., & Ryan, R.M. (1985). *Intrinsic motivation and self-determination in human behaviour.* New York: Plenum.

DiBella, A., & Nevis, E. (1998). *How organizations learn: An integrated strategy for building learning capability.* San Francisco: Jossey-Bass.

Drucker, R.E. (1993). *The post capitalist society.* Oxford: Butterworth-Heinemann.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Gold, A., Malhotra, A., & Segars, A. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hearn, G., & Rooney, D. (2002). The future role of government in knowledge-based economies. *Foresight, 4*(6), 23-33.

Information Technology Advisory Group (ITAG). (1999). *The knowledge economy.* Retrieved December 14, 2004, from www.med.govt.nz

Kanter, R., Stein, B., & Jick, T. (1992). *The challenge of organizational change: How companies experience it and leaders guide it.* New York: The Free Press.

Mertins, K., Heisig, P., & Vorbeck, J. (Eds.). (2001). *Knowledge management. Best practice in Europe*. Berlin: Springer-Verlag.

Mintzberg, H. (1979). *The structuring of organizations: A synthesis of the research*. Englewood Cliffs, NJ: Prentice-Hall.

Nahapiet, J., & Ghoshal, S. (n.d.). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-258.

Newell, S., Robertson, M., Scarbrough, H., & Swan J. (2002). *Managing knowledge work*. New York: Palgrave.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(10), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "ba": Building a foundation of knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Organisation for Economic Co-operation and Development (OECD). (2003). *Conclusions from the results of the survey of knowledge management practices for Ministries/Departments/Agencies of Central Government in OECD member countries.* Retrieved February 12, 2004, from www.oecd.org/document/20/0,2340,en_2649_201185_1946900_119826_1_1_1,00.html

Reserve Bank of New Zealand. (2002). *Annual report 2002/2003.* Wellington.

Schein, E. (1992). *Organizational culture and leadership* (2nd ed.). San Francisco: Jossey-Bass.

Scherer, K. (2001, July 27). Knowledge as a power tool. *New Zealand Herald,* p. C7.

Snowden, D. (1999). A framework for creating a sustainable knowledge management program. In J.W. Cortada & J.A. Woods (Eds.), *The knowledge management yearbook, 1999-2000* (pp. 52-64). Boston: Butterworth-Heinemann.

Snowden, D. (2002). Complex acts of knowing: Paradox and descriptive self awareness. *Journal of Knowledge Management, 18*(1), 1-28.

Teece, D. (n.d.). Capturing value from knowledge assets: The new economy, markets for knowhow and intangible assets. *California Management Review, 40*(3), 55-79.

von Krogh, G. (1998). Care in knowledge creation. *California Management Review, 40*(3), 133-153.

Wiig, K.M. (2002). Knowledge management in public administration. *Journal of Knowledge Management, 6*(3), 224-239.

Willmott, H. (1993). Strength is ignorance; slavery is freedom: Managing culture in modern organizations. *Journal of Management Studies, 30*, 515-552.

FURTHER READING

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Cohen, D., & Prusak, L. (2001). *In good company.* Boston: Harvard Business School Press.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Gold, A., Malhotra, A., & Segars, A. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Nahapiet, J., & Ghoshal, S. (1988). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-258.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(10), 14-37.

Snowden, D. (1999). A framework for creating a sustainable knowledge management program. In J.W. Cortada & J.A. Woods (Eds.), *The knowledge management yearbook, 1999-2000* (pp. 52-64). Boston: Butterworth-Heinemann.

ENDNOTE

1 "Foreign Currency Financial" and "Local Currency Financial" mean assets and liabilities denominated in either foreign currency (e.g., U.S. dollar bonds) or local currency (e.g., New Zealand government bonds).

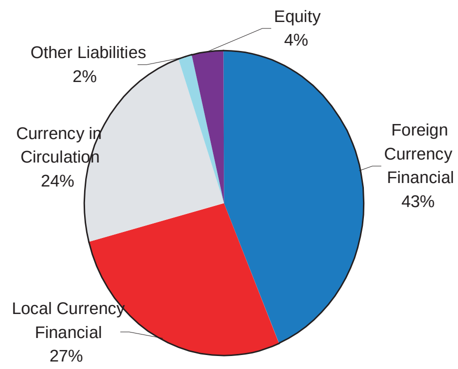
APPENDIX 1: RESERVE BANK FINANCIAL POSITION 2002/2003

	2002 June ($m)	**2003 June ($m)**
Assets:		
Foreign Currency Financial[1]	5,606	**6,216**
Local Currency Financial	5,821	**5,430**
Other Assets	38	**38**
Total Assets	11,465	**11,684**
Liabilities and Equity:		
Foreign Currency Financial	5,253	**5,102**
Local Currency Financial	2,962	**3,165**
Currency in Circulation	2,659	**2,806**
Other Liabilities	180	**195**
Equity	411	**416**
Total Liabilities and Equity	11,465	**11,684**

Graph 1

Composition of Liabilities and

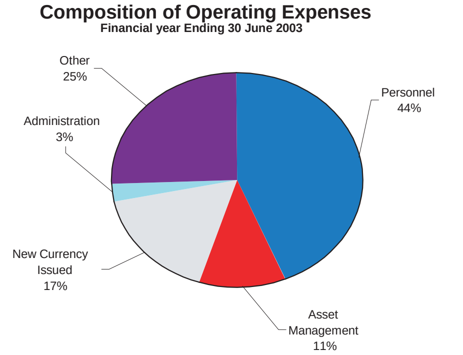
Financial year ending 30 June 2003



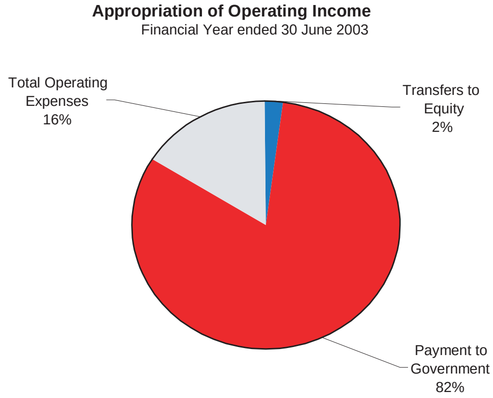
APPENDIX 2: THE RESERVE BANK FINANCIAL PERFORMANCE 2002/2003

	2002 June ($m)	2003 June Budget ($m)	**Actual ($m)**
Operating Income:			
Net Investment Income	200.7	221.0	**215.6**
Other Income	10.3	9.0	**9.3**
Total Operating Income	211.0	230.0	**224.9**
Operating Expenses:			
Personnel	15.6	16.0	**15.6**
Asset Management	5.0	4.0	**4.0**
New Currency Issued	4.7	4.5	**6.1**
Administration	1.1	1.4	**1.0**
Other	9.3	10.5	**9.1**
Loss on Disposal of Property	0.3	0	**0**
Total Operating Expenses	36.0	36.4	**35.8**
Operating Surplus	175.0	193.6	**189.1**
Net Expenditure under Funding Agreement	24.9	26.9	**26.3**
Surplus for Appropriation	175.0	193.6	**189.1**
Transfers to Equity	6.1	4.1	**4.7**
Payment to Government	168.9	189.5	**184.4**

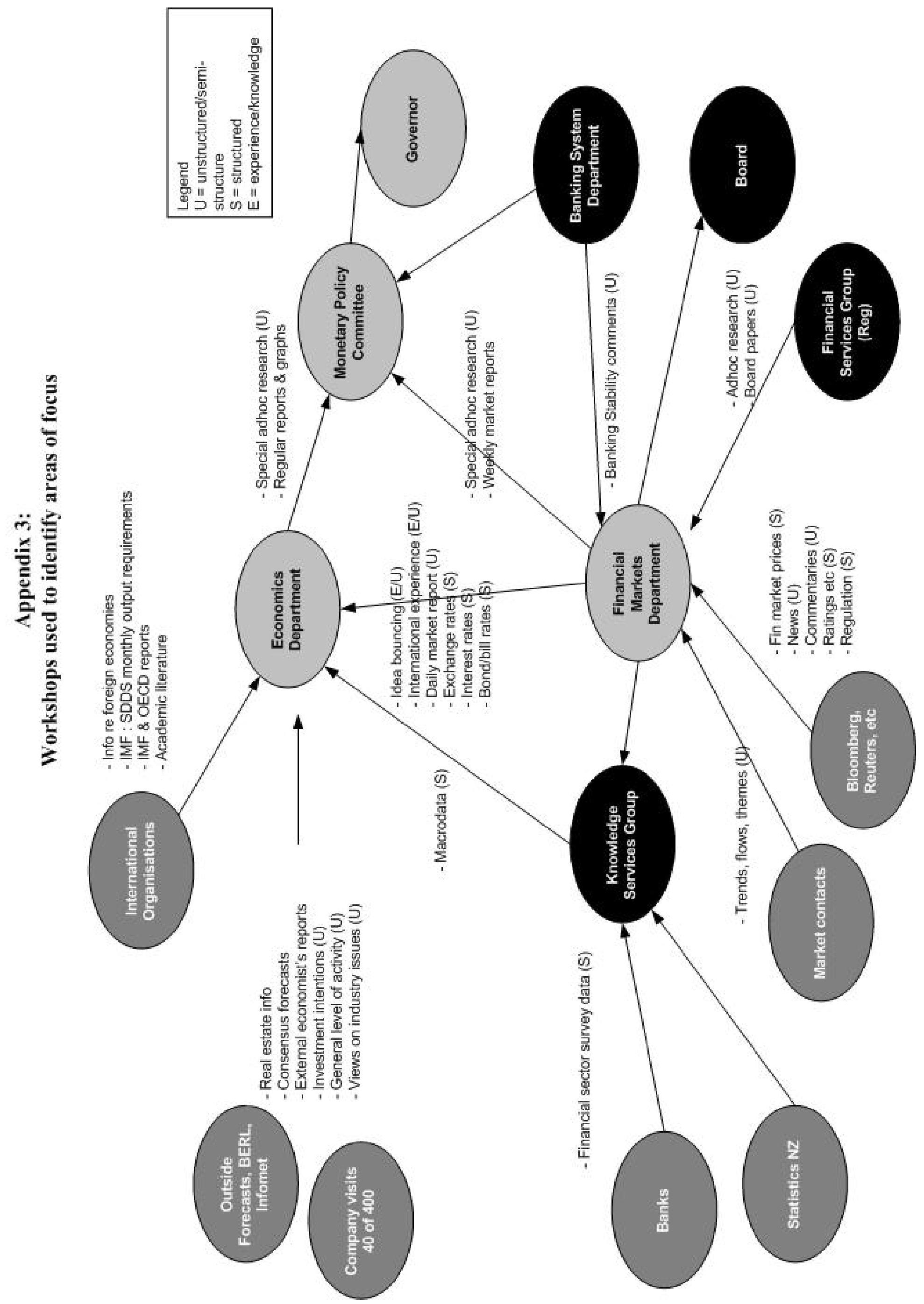
Graph 2



Graph 3



APPENDIX 3: WORKSHOPS USED TO IDENTIFY AREAS OF FOCUS



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Chapter 5.34
Learning about the Organization via Knowledge Management:
The Case of JPL 101

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ABSTRACT

This article describes the development and operation of a knowledge system to support learning of organizational knowledge at the Jet Propulsion Laboratory (JPL), a U.S. national research laboratory whose mission is planetary exploration and to "do what no one has done before". JPL 101 is a Web-accessible database of general organizational knowledge, captured in a series of quizzes. The heart of JPL 101 is the content that is encoded as questions and annotated answers with connections to related information and resources. This article describes the requirements generation process, implementation, and roll-out of the JPL 101 system. Data collected over 19 weeks of operation were used to assess system performance with respect to design considerations, participation, effectiveness of communication mechanisms, and individual-based learning. These results are

discussed in the context of organizational learning research and implications for practice.

BACKGROUND

The Jet Propulsion Laboratory (JPL) is a United States Federally Funded Research and Development Center (FFRDC) operated for the National Aeronautics and Space Administration (NASA) by the California Institute of Technology (Caltech). JPL's primary mission is to explore our own and neighboring planetary systems. In pursuit of this mission, JPL has a rich program of technology development, science, and mission development (the three "value adding" processes of the Laboratory), as well as an extensive infrastructure to support Research and Development.

SETTING THE STAGE

The JPL 101 system described in this article is a Web-accessible database of general organizational knowledge, which is encoded as questions and annotated answers with connections to related information and resources, and captured in a series of quizzes. The Knowledge Capture (KC) team, a subset of JPL's Knowledge Management (KM) Project, conceived of JPL 101. This four-person team consisted of a librarian, two Web and database system designers, and an engineer who alternated between KM-related projects and working on Mars missions.

The motivation for the system was two-fold. First, there was a growing concern by KC team members that the KM project in general was isolated from the value-adding processes that formed the mainstream work of the Laboratory. This isolation was believed to lead to products and services that did not fully address user needs.

The second motivation was a desire to share valuable knowledge gained through a previous knowledge capture task. Prior to his retirement in the fall of 2001, the Deputy Director of the Laboratory agreed to do a series of retrospective interviews. During his tenure, JPL went through a decade of sweeping changes that fundamentally altered the way JPL did business. The primary purpose of the interviews was to collect information for the incoming Deputy Director, who was new to the organization. However, it was felt that the insights gained during the interviews were of potential value to the greater Laboratory population. In particular, discussion about stakeholder relations and the interplay between NASA, Caltech, and JPL served to make sense of the changes that occurred throughout the 1990s.

This combination of motives led to the concept for "JPL 101". It was felt that by calling attention to work related to the value-adding processes, the system could help improve the connection of the KM team to the rest of the Laboratory. In addition, by incorporating information gained through the interviews with the Deputy Director, valuable insights on stakeholder issues and basic operations could be shared with the Laboratory population.

Although inspired by events local to the KC team, the circumstances correspond to a broader organizational issue. To perform the planetary exploration mission and "do what no one has done before," large numbers of technical and professional disciplines must be integrated to support innovation (the value-adding process). In addition, infrastructure and support services are required to perform routine organizational functions (the enabling processes). While cross-functional project teams have become a common approach to integrating multi-disciplinary knowledge in support of product development (Brown & Eisenhardt, 1995), less attention has been paid to bridging gaps between value-adding and enabling processes.

In established firms, emergent knowledge processes (EKPs) (Markus, Majchrzak & Gasser, 2002) such as product development take place within the context of the organization's bureaucracy. The clash between those tasked with operating the bureaucracy and those who must work within it can be viewed as another flavor of "thought world". Dougherty (1992) describes thought world differences between members from the marketing, engineering, and manufacturing functions in new product development teams. Areas such as human resources, contracting, accounting, and information technology also draw from different professional disciplines, focus on different critical issues, and use different approaches to define and solve problems. While cross-functional teams serve to bridge thought worlds by creating a shared vision of a successful, marketable product, there are few resources (e.g., mission statements) that are effective at providing the same sort of actionable focus for the organization as a whole.

Thought-world related problems, such as conflict and miscommunication, can be mitigated by helping people to learn about other domains and to recognize and exploit differences (Dougherty, 1992). Knowledge management systems (KMS) have the potential to support this type of learning. Knowledge-based approaches have been used to support transfer of best practices (Markus, 2001), knowledge reuse for innovation (Majchrzak, Cooper & Neece, 2004), identifying experts, and a variety of business processes (Davenport, Jarvenpaa & Beers, 1996).

Therefore, JPL 101 was envisioned as an educational resource for Laboratory personnel, and a way to assist them in exploring the abundance of electronic and other resources available to them. The orienting question that guided development was "how do you help people to make sense of the 'big picture' given that direct work-related exposure may be minimal (or non-existent)?"

CASE DESCRIPTION

This case describes the 11-month evolution of JPL 101 from initial concept to fully operational system. There were three distinct stages: (1) beta test of initial concept, (2) feasibility analysis for use as a contest, and (3) implementation. Each of these phases is addressed in the following sections.

Beta Test

The goal of the beta test phase was to quickly assess whether it was worth pursuing implementation. Due to the structure of the KM project there was flexibility to explore interesting concepts, but implementation required explicit approval and sponsorship by the KM project. From the very beginning, JPL 101 was conceived of as a quiz. The name was chosen as a tongue-in-cheek reference to beginners' classes in college to emphasize the educational nature of the resource, and to convey that much of the content is basic material that employees should know. The "quiz" metaphor seemed like a natural approach in an organization that values education as highly as JPL does.

The beta test version consisted of a paper prototype. Over the course of one week, the team brainstormed questions, experimented with different formats, difficulty and wording of questions, and had a lot of fun creating wrong answers. The resulting list of 81 questions was divided up into three roughly equal groups. Participants were given the three sets of questions, in different orders to make sure that all the test questions would have at least a subset of the group looking at them. Timed tests were then conducted where people worked their way through the quizzes. As expected there were the occasional chuckles as people viewed the more humorous entries.

Reaction to the quiz from the KM Project team was generally positive but skeptical as to the potential value of the system. While this beta testing did not garner enthusiastic support from the KM Project, it did provide feedback used to determine the rough size of the quiz, appropriate mix of questions, and what constituted a reasonable level of difficulty for the questions.

Beta testing of content provided insight into the types of questions that had the potential to be controversial — primarily those that asked about absolutes such as "firsts," "only," or "bests". This led to standards for structuring a "good" question and guidelines for a reasonable amount of material to include in the answer.

Following the internal beta test, organizations within JPL that were perceived as potential stakeholders of the eventual system were contacted: Internal Communications, Human Resources, and the Ethics Office. Additionally, a shortened, improved set of questions was tested as a demonstration model on actual work groups from the team's home organizations. The response was overwhelmingly enthusiastic. People were anxious to share the information with their colleagues, contribute questions and answers, and considered it both valuable and fun. Everyone, including people who had been with the organization for multiple decades, indicated that they learned something either through the questions or the supporting information given in the answers. In addition to encouraging proceeding with development, people also began suggesting questions that they thought would be good to include.

The beta test phase ended in a surprising way with the serendipitous opportunity to show one of the Laboratory's highest ranking executives the paper prototype. He was instantly interested in the concept, brought his staff members in to have them take the quiz, and formulated the idea of using the JPL 101 concept as a Lab-wide contest as part of the 40th anniversary of planetary exploration being celebrated that year. Given this level of advocacy, the go-ahead from the KM Project was granted and the second phase of development, the feasibility analysis of using JPL 101 for a contest, began immediately.

By the end of the beta test phase the following was achieved:

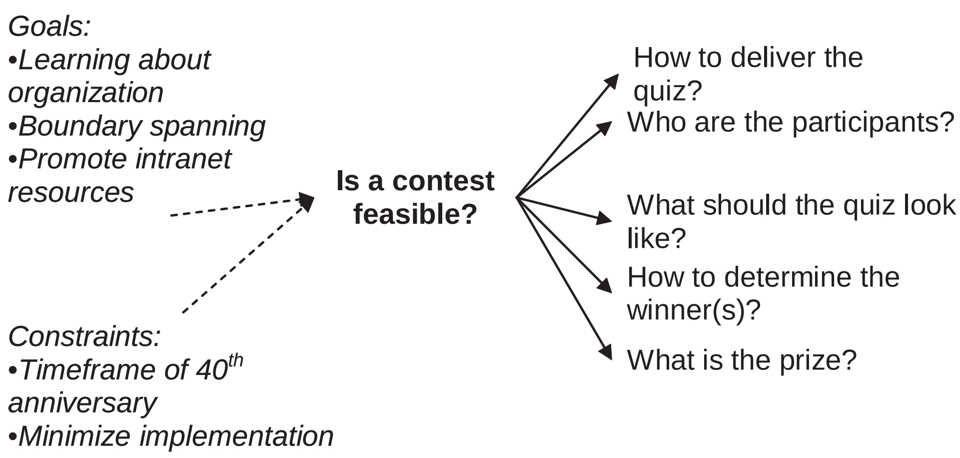
- Confirmation that the basic concept was sound, and likely to be positively received by the Laboratory population.
- A cadre of stakeholders interested in seeing the system implemented.
- A clear understanding of what constituted a well-formulated question: clear, concise, simple structure, cautious use of absolutes, and humorous wording.
- A practical approach to ensure correctness of the question by either triangulating an answer (two-sources to confirm) or verification through an unimpeachable source.
- A requirement from the Knowledge Management Project that the system encourage employees to explore the JPL intranet.

Feasibility Assessment

The direction to evaluate if and how JPL 101 could be used to support a Lab-wide contest led to a detailed requirements analysis and the design decisions described in the following. At the same time, the team was also involved in a separate effort investigating how to capture decision rationale. It was decided to test some of the ideas from that effort internally using informal decision-mapping techniques to capture the requirements generation process. These decision maps form the basis for the following discussion.

Answering the question "Is a contest feasible?" first required answering a set of key questions (Figure 1). An assessment was conducted by methodically working through each of these questions, identifying additional constraints, and incorporating stakeholder concerns. The decision maps were used to track open issues, options, assumptions, information sources, and resulting requirements and design decisions. Even for a simple system such as JPL 101, the decision map quickly became a tangled web of interactions and information that did not easily fit into single

Figure 1. High-level decision map



categories. The decision maps presented in the following sections are simplified for illustration purposes.

How Do You Deliver the Quiz?

This turned out to be the easiest question to answer. Two potential methods were considered as shown in Figure 2. The first was to use a paper system, by sending a hard copy to all participants. This option was quickly eliminated as too burdensome due to the need for hand scoring of the quizzes, no ability to time-tag responses, and the reproduction and mailing costs. This option also was contrary to the KM requirement to promote exploration of the intranet.

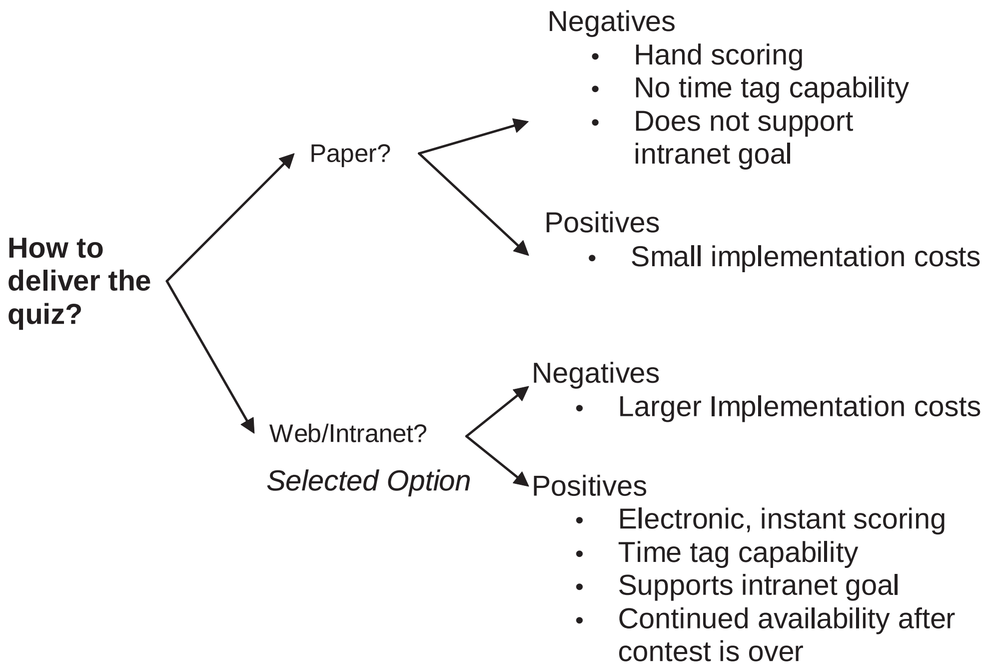
The second option was to use a Web-based delivery mechanism via the JPL internal intranet. In addition to being the area of expertise for our team members, this option eliminated the negatives from the first option and contributed to a reasonable definition of our participants. After making this decision, the team immediately began prototyping activities so we would have a system to experiment on during the rest of the assessment period.

Who are the Participants?

The delivery mechanism decision effectively limited participation to those people who had legitimate access to the JPL intranet. Four categories of potential participants were identified based on the derived requirement that participants have a JPL badge and identification number: current JPL employees, current JPL contractors, retirees, and others resident at JPL but not falling into the previous categories. From within these categories several issues were identified.

1. Timekeeping constraints: How much time could people in the individual categories commit to participating before we needed to provide them with an account code? This was resolved through the ethics office and resulted in a requirement that each individual

Figure 2. Delivery mechanism decision map



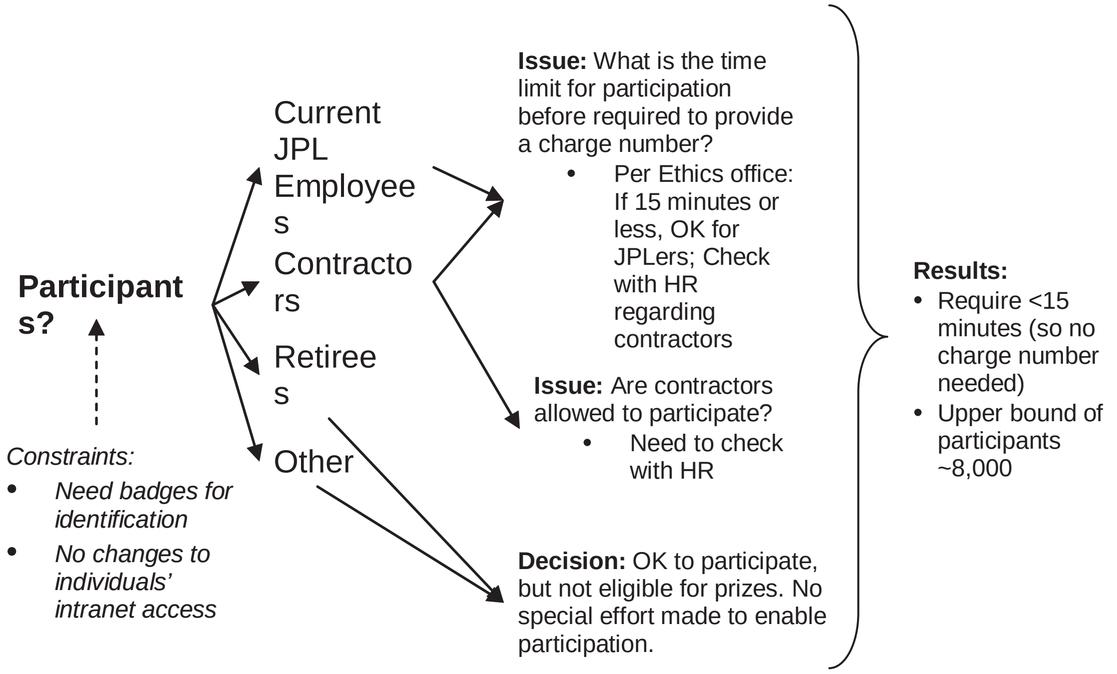
quiz take 15 minutes or less. Also, our Ethics Office confirmed that JPL personnel could participate, but that the Human Resources department would have to make a determination on whether contractors could participate.

2. Contractor constraints: Could contractors participate, and if so, were there any time-keeping constraints, and were they eligible for prizes? These issues remained open during the feasibility analysis.
3. Retiree participation: Would we actively work to enable retiree participation, and if so, were they eligible for prizes? It was decided that our system should not preclude participation from retirees as long as they had intranet access (we would not provide external access) and they had a JPL badge. However, they would not be eligible for prizes.

As shown in Figure 3, these decisions led to the following:

- System must be capable of supporting an upper bound of 8,000 participants.
- The individual quizzes must be sized to keep participation under 15 minutes.
- Participants must have a current JPL badge and intranet access.
- Only JPL current employees are eligible for prizes.

Figure 3. Participation decision map



What Should the Quiz Look Like?

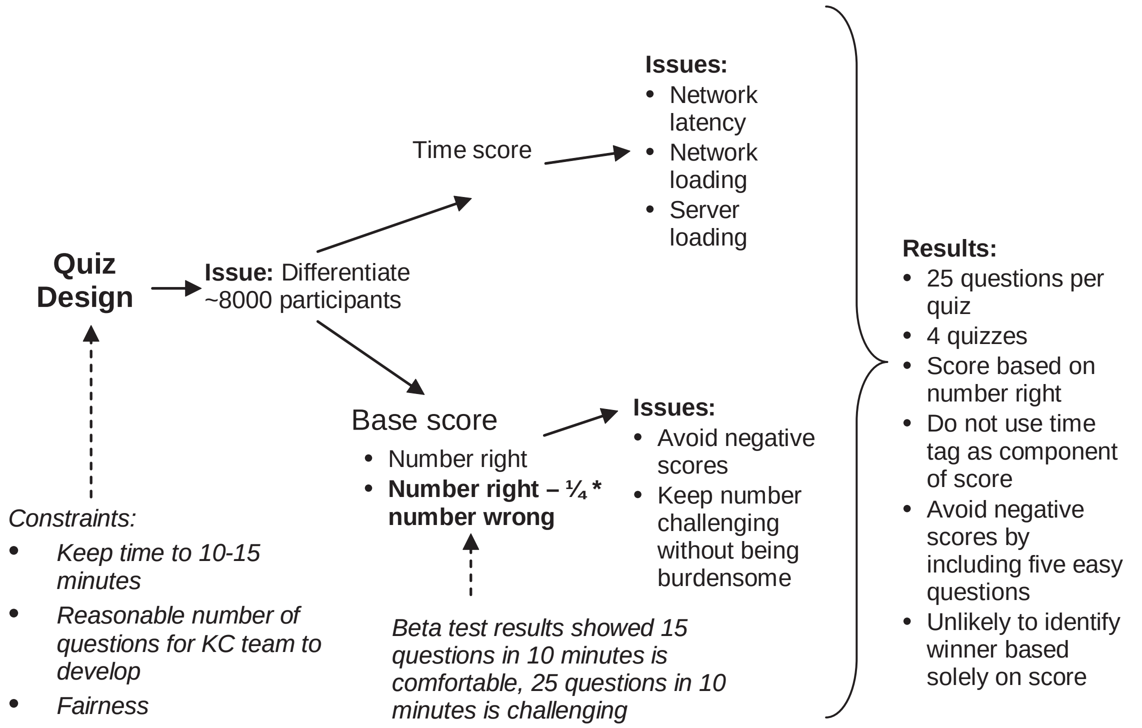
Beta testing determined how to construct good individual questions. The next set of decisions addressed how to construct the quizzes. Figure 4 shows the decision map for the quiz design. In addition to requirements to keep participation under 15 minutes and able to differentiate 8,000 participants, specific goals that we set for the system were:

1. Make the quizzes challenging, but not burdensome.
2. Keep the number of questions required to a reasonable amount.
3. Have a broad mix of questions that include some aspect from all areas of the Laboratory community.

The driving factor in the quiz design was the need to differentiate 8,000 participants to determine the winner(s). We knew there was limited project support for this effort and therefore felt that we would have resources to reliably develop only 100 to 120 questions. This is too small a number of questions to be able to distinguish the number of potential participants solely based on score, so we determined that a time component was also needed.

Several options were considered for incorporating a time-based component to the score. Our executive advocate had suggested a "fastest finger" approach where whoever got the most right in the shortest time would win. This approach, however, brought to bear issues of network latency (which is a function of the number of users) and would

Figure 4. Quiz design decision map



require that the system time-tag all quizzes, leading to concerns about server load.

A technically feasible approach to the quiz design was not possible until we answered the question of how to determine the winner. However, it was determined that we were looking at a four-week contest, consisting of four quizzes at 25 questions each, and that it was highly unlikely that we would be able to identify a single winner based on this design.

Summary

Additional analyses investigated how to determine contest winner(s) and potential prizes. Despite the relatively simple nature of JPL 101, the decision space quickly became complicated with multiple interacting requirements and constraints. Management was presented the following options:

Option 1: Use the JPL 101 quiz for a Lab-wide contest. Winners in each category would be chosen based on best score over the four weeks of the contest. Token prizes, as permitted, would be given to the finalists, with the ultimate grand prize winner(s) chosen from a random drawing of the finalists. This option required additional software development and coordination across multiple departments, but had the potential to generate significant interest and participation. Additional details would be worked out with the internal contest sponsor.

Option 2: Proceed with JPL 101 as originally conceived without the contest element. This option required minimal software development, kept the focus on the content and therefore the goals of the KM project to promote intranet capabilities, and was considered less risk. However, it would not benefit from the executive level attention and did not have prize incentives as a way of gaining interest.

After several months of debate, cost considerations won out, and we went with Option 2.

Implementation

JPL 101 is a Web-accessible database of general organizational knowledge. Knowledge is encoded as questions, answers, and connections to related information and resources (see Cooper, 2003a for a detailed discussion of the use of the "quiz" interface). The system is organized into quizzes containing five to 10 multiple choice and matching questions each. The deployment of the system took place over 12 weeks, after which it entered steady-state operation. During each of the first 12 weeks a new quiz was added. Following the 12-week initial deployment of the content, the system provided access to the full set of past quizzes.

The implementation of JPL 101 was relatively simple, with a minimal amount of user functions. Due to rapidly dwindling support from the KM project, low maintenance costs were essential and the questions and answers needed to be robust with regard to obsolescence. In addition to question and answer fields, the JPL 101 database also included administrative fields for identifying the category, originator, quiz, and validation date for each question.

During the initial 12-week deployment, the entry page for JPL 101 featured a direct link to the current week's quiz. Access to previous quizzes, background information, and feedback mechanisms were provided through pull-down menus. Following the 12-week deployment period and continuing on, the entry page provided a direct link to the list of previous quizzes as well as the menu-accessible items.

Design Considerations

JPL 101 was designed based on the assumptions that the general JPL population had access to a computer, was able to effectively use a Web interface, and would find the use of a quiz-based model for the knowledge acceptable. The first two are reasonable given the proliferation of Web-based institutional applications for general exchange of information, support of business and administrative functions, and organizational communications. The third assumption was validated during preliminary beta testing of the concept.

Based on the assessment of the organization and with guidance from ethics, human resources, and internal communications offices, several constraints were incorporated into the design process. First, the overall set of quizzes were made representative of concerns across the wide range of disciplines on Lab so that no group would feel "ignored" in the process and to ensure that the thought-world issues were addressed. Second, in order to avoid potential problems with time-keeping rules the quizzes were kept short. Third was ensuring that people could participate at their convenience, and that pragmatics, such as individuals being on travel, would not limit participation. Fourth, since participation would be voluntary, there had to be motivations to use the system. Fifth, the goal of the system was learning, and therefore it was critical that there were mechanisms for assessing whether people actually benefited from the system. Finally, it was important that people not feel that they were being graded or assessed in any way. Therefore, it was necessary to ensure that participants could take the quizzes without fear of violating their privacy. This limited the type of performance and participation data that could be collected.

Content

The heart of JPL 101 is the content. The content categories were carefully chosen to emphasize areas important to the laboratory; essentially representing the different thought worlds. Table 1

Table 1. JPL 101 question categories

Area	Description	Rationale	Example
Basics (n=22)	General knowledge about how JPL operates at and below the level of published procedures	Make it easier for employees to learn about things that make it easier to get their job done (and correct misconceptions)	What is the number to call if you're having computer hardware or software-related problems? (A: x4-HELP)
History (n=6)	Knowledge of key accomplishments and of individuals who contributed greatly to the Lab	Establish a connection to the past and share accomplishments that contribute to a sense of pride. Share the excitement of space exploration, which is the reason for existence for the Lab.	Who was the director of GALCIT, and co-founder of JPL? (A: Theodore von Karman)
Missions (n=10)	Knowledge about missions, which are the primary product of the Laboratory and the focus of our work		What is the name of the rover that explored the surface of Mars in 1997? (A: Sojourner)
Product Development (n=9)	Knowledge about how the Laboratory builds and operates space missions and instruments	The three JPL core processes represent the reason the Lab exists: our mission of space exploration. All work at the Laboratory contributes either directly to one of these three areas, or is responsible for supporting these processes.	Where could you go at JPL to evaluate your spacecraft under environmental conditions that are similar to those found in space? (A: 25-foot Space Simulator)
Science (n=5)	Knowledge about key scientific principles of importance in space exploration		What is the most active volcanic body currently known in the solar system? (A: Jupiter's moon, Io)
Technology (n=4)	Knowledge about the development of technology of importance in space exploration		What is the name of the substance nicknamed "frozen smoke"? (A: Aerogel)
Stakeholders (n=10)	Knowledge about external entities that impact or are impacted by JPL	JPL is answerable to multiple constituencies and is often highly constrained in the way it can operate. It is critical for JPL personnel to understand these factors and how they impact their work.	Who is the President of Caltech? (A: Dr. David Baltimore)

provides a description of the different categories, the rationale for including them, and an example of each.

Over the course of the 12 weeks, a total of 66 questions were presented. Each question went through a rigorous quality check to ensure accuracy and that it met the standards for a well-formulated question. The distribution of questions across categories is also provided in Table 1.

Two areas received special attention in developing the questions: JPL Basics and Stakeholders. The 21 questions in the Basics category covered material ranging from how to get help with computer problems to knowledge on new institutional resources and local restaurants available after hours. This is the type of knowledge that generally does not get high visibility, but contributes to the overall work environment. The Stakeholder category consisted of 10 questions that covered the multiple constituencies to which JPL is responsible. Because JPL is a National Laboratory operated for NASA by the California Institute of Technology, there is a wide spectrum of stakeholders who influence the operations of the Laboratory. Understanding the nature of these stakeholder relationships and the various legal, contractual and public trust concerns of the Laboratory is important for efficient operation.

DATA COLLECTION

Two primary methods were used for collecting performance, participation, and user data: background collection of usage statistics and quiz answers, and user participation in the form of e-mail feedback, an online survey, and an online form to submit comments. The background data collection was performed using a commercial monitoring package associated with the Web server. It provided information such as hit rates, IP addresses, number of unique visitors, amount of time spent on site, and time distributions of users. In addition, the quiz database recorded the answers submitted each time someone took a quiz.

The online survey was used to collect basic organizational demographics (tenure, organizational unit, job category, and whether a manager or not) and responses to two questions: “Did you learn anything from the questions?” and “Did you learn anything from the answers?” Taking the survey was voluntary, as was responding to the demographic questions. The second anonymous response method was an online feedback form. Users could submit comments, problems, feedback, and candidate questions for the system. While most users decided to remain anonymous, some made the effort to include their names and contact information. Finally, the e-mail based feedback form was available to contact the development team directly. This was not anonymous and was the least used form of feedback.

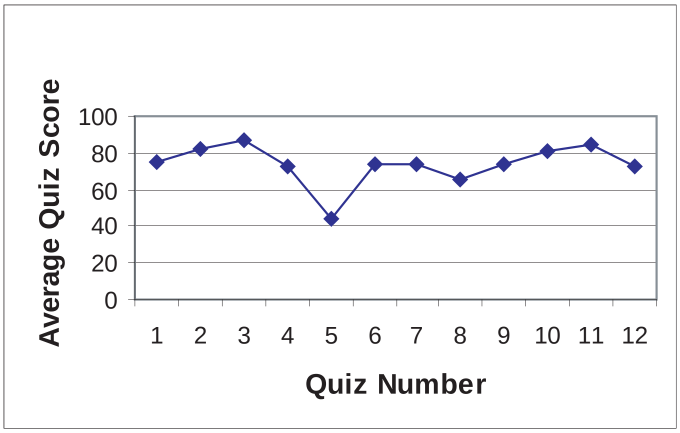
RESULTS

JPL 101 premiered on January 13, 2003 and ran for 12 weeks, ending its initial deployment on April 6. It remains in operation, although new content is not currently being developed. Results are presented based on analysis of the data collected during the initial 12 weeks, and extending through week 19 of operations relative to the following: design considerations, usage, motivation for use, learning results, and general reaction.

Design Considerations

Background usage and database data were analyzed to assess how well the design considerations were met. Background usage data indicated success in meeting the participation time goals of the system. The average time spent in the system each workday ranged from 2:01 minutes to 8:21 minutes, with the mean being 3:53, which are within the limits recommended by JPL Ethics and Human Resources offices.

Figure 5. Average quiz score per quiz



A second consideration was that the quizzes needed to be challenging but not too hard. Figure 5 shows the average quiz scores for the 12 quizzes, based on data from the entire operational period. With the exceptions of weeks five and eight, the average quiz scores stayed between 70-90%, meeting the goal.

Additionally, there was a concern with question quality. Because the JPL culture is such that participants would readily point out any errors in the questions, evaluation of question quality was based on the number of corrections required. Two inputs regarding the accuracy of questions were received, one of which resulted in a minor change (attributing an additional source for information in an answer). Given the volume of material in 66 questions plus all the associated ancillary information, two minor comments were well within the range for acceptable performance.

Participation

Ultimately, a measure of success for a system is the number of people who use it (DeLone & McLean, 1992). Given that this is a voluntary-use resource, and not required for anyone's job, participation statistics are critical for gauging overall success. Background usage statistics were collected, including hit rates and unique visitors based on IP addresses, modified to filter out members of the development team and automated Web crawlers. During the 19 weeks of operation covered in this study, a total of 2,144 employees participated, roughly 40% of the Laboratory population. Figure 6 shows the usage statistics over time for the 19 weeks.

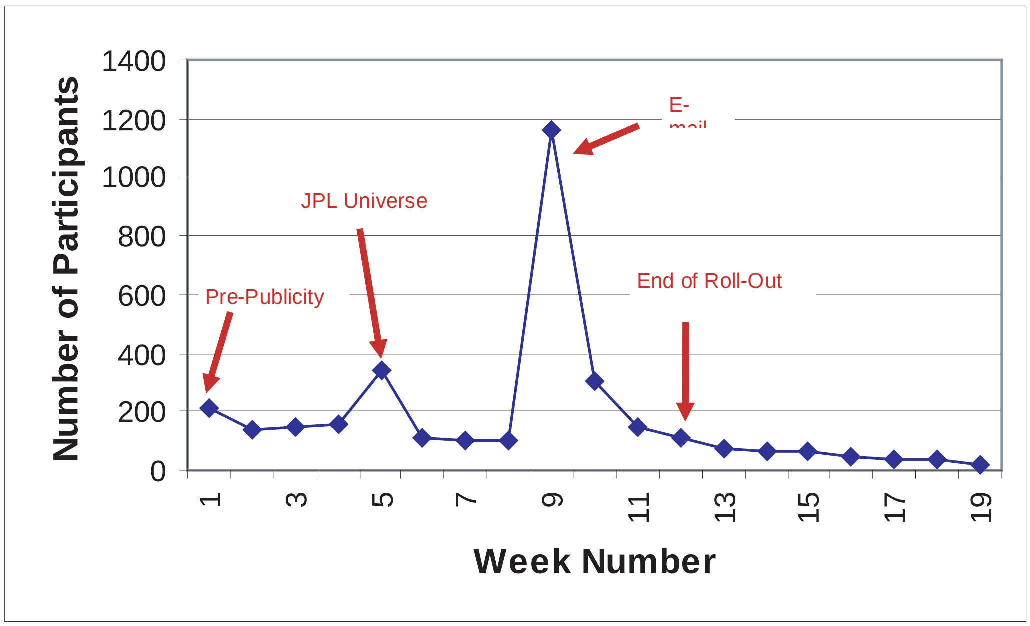
In addition to reaching a large audience, the goal was to reach a broad audience. Although privacy and user-burden concerns prevented automatic collection of organizational demographics on general participants, a voluntary survey instrument was used to collect some data. Five hundred and fifty surveys have been received to date (the response rate during operations was 25%). The organizational tenure for participants ranged from brand new (0 years) to a maximum of 47 years, with an average of 15.1 years and a standard deviation of 10.5 years. Users spanned the entire Laboratory, with participation concentrated most heavily in the Technical and Administrative divisions, where the majority of Laboratory personnel are assigned. Participants were distributed across technical, administrative, and science disciplines, and included both managers and non-managers. Taken in total, the data collected via the online survey indicate a broad and substantial audience.

Impact of Communication Mechanisms

Because JPL 101 is a voluntary-use system, providing general rather than job-specific knowledge, a number of institutional communication mechanisms were employed to let people know this resource existed. These mechanisms were:

- JPL Universe: a traditional, bi-weekly organizational "newspaper" distributed to personnel through interoffice mail. There was a multi-column story about JPL 101 plus a sample quiz the week before rollout.
- Cafeteria Monitors: closed circuit television screens in the cafeterias that broadcast announcements. Consisted of "teaser" questions — shorter versions of quiz questions, plus the URL for the site, for three days prior to rollout.
- Daily Planet: electronic daily "newspaper" for JPL personnel. Accessible via intranet. Publicity was via a small graphic posted on the sidebar of the page that linked to JPL 101, starting the first day of rollout and continuing through the 12-week rollout period. In addition, a short informational article was

Figure 6. Participation by week, annotated to show key communication activities



placed in the center column "news item" area during Week 5 of rollout.
- Inside JPL Portal: Web portal that provides central access to JPL Webspace for internal users. A link to JPL 101 was included in sections for new employees and institutional knowledge management during the first week.
- This Week: electronically distributed (e-mail announcement with link to Web page) weekly newsletter that highlights personnel announcements, organizational changes, upcoming talks and events. A one-paragraph blurb about JPL 101 plus access information was included several times throughout the 12-week rollout.
- All.Personnel e-mail: a tightly controlled list that sends e-mail to entire Laboratory population. A single all.personnel e-mail was sent during Week 9.

Publicity for JPL 101 began one week prior to its rollout. Pre-release publicity included an article in the JPL Universe and announcements on the JPL monitors. In partnership with the Internal Communications office, the primary entry point for JPL 101 was the Daily Planet. Unfortunately, higher priority events limited entry to a single sidebar icon during the initial weeks. This icon remained until the end of the initial 12-week run. Later during the first week, access was added via the Inside JPL portal. These links continued throughout the entire period.

The impact of each of these devices can be seen in the usage statistics shown in Figure 6. The first spike in the graph occurs during Week 5 and corresponds to the publication of the Daily Planet article. Additionally, a smaller increase, not visible in the weekly statistics, but present in the daily statistics, occurred when links were added to the Inside JPL portal. The most prominent feature of the graph, however, is the gigantic spike that occurs during Week 9. This corresponds to the sending of the all.personnel e-mail publicizing JPL 101. This spike is due almost entirely to the day that the e-mail was sent.

Learning Results

The primary goal of the system was individual learning. Success was assessed in attaining this goal in two ways. The first, and most direct way was to use the survey to simply ask participants if they learned anything. Over 90% of the survey respondents indicated that they had learned something from either the questions, the answers, or both. No significant correlations were found between learning, tenure, or job category (Table 2).

The second approach to evaluating learning was to look at the quiz response data. Figure 1 shows the average scores for each of the 12 quizzes. These data indicate that on average, people missed one to two questions per quiz, indicating a learning opportunity existed. Detailed analysis of individual questions shows that the number of respondents getting a specific question right varied from a low of 33% to one question where everyone who answered got it right.

There was also interest in how well people performed across the different categories of questions and in what questions were skipped. Table 3 provides a summary of the performance in each of the categories. Inspection of Table 3 data indicates that JPLers performed well on questions relating to the three value-adding processes, slightly below average on Basics, History, and Missions, and significantly below average on Stakeholder questions. While JPL 101 is not intended as a diagnostic system for organizational knowledge, these results suggest a gap in knowledge about stakeholders that should be remedied. Inspection of the data on questions that were skipped clearly showed that matching-type questions were skipped more often than multiple choices, with all five matching questions placing within the bottom six-response rates. We believe this was due to the extra effort required to answer these questions.

Table 2. Correlation data

	N	(1)	(2)	(3)	(4)	(5)	(6)
(1) Years	550	1.0					
(2) Learned	550	-.083	1.0				
(3) Technical	285	.035	-.054				
(4) Administrative	143	.002	.068				
(5) Scientist	26	.059	-.047				
(6) Other	51	-.104*	.041				
(7) Manager	77	.373**	-.056	.251**	-.229**	.040	-.105
(8) Non-Manager	104	-.373**	.056	-.251**	.229**	-.040	.105

** p < .05, **p < .01, Note Items (3) – (6) and (7)-(8) represent categorical data; therefore intra-correlations are not shown*

Table 3. Summary of performance across question categories

	Basics	History	Missions	Prod Dev	Science	Stake holders	Technology	Total/ Avg
Number of Qs	22	6	10	9	5	10	4	66
Avg%Skipped	2.1	1.7	1.4	0.8	0.8	1.5	0.6	1.3
Avg%Right	73.2	70.9	75.6	83.5	85.2	66.0	85.1	77.1

Feedback via e-mail and through the online form was overwhelmingly positive. (The sole negative comment received via any of the feedback mechanisms was a complaint about the use of the all.personnel e-mail.) For example, one respondent wrote, “This is great and I love it! I learned more about JPL in the past few weeks just by taking these quizzes then the three years I have been here. Thank you.” Several constructive comments were made about how to improve the system. Respondents were pleased with the quiz-type presentation and one suggested that “JPL 101 is the paradigm that should be used for all training and knowledge dissemination at JPL”.

One area of disappointment was the lack of suggestions for questions. During beta testing for JPL 101, one of the most surprising results was the level of excitement individuals had over the idea of the quiz, and their desire to contribute questions and make suggestions for material. Because of this response the feedback form in the system included a field specifically for submitting potential questions. Only three suggestions were received, resulting in two new questions.

Summary

In summary, the variety of data collected during the 19 weeks of operation for JPL 101 provided valuable information that can hopefully be applied to future efforts. Although unable to collect all the data as originally planned, sufficient data were collected for a pragmatic approach that is reasonable for practitioner analysis. The following section discusses these results and the potential learning to be gained from them.

CURRENT CHALLENGES FACING THE ORGANIZATION

JPL 101 was a small effort created to share special information and promote intra-organizational appreciation for the different areas that need to work together to accomplish the JPL mission. When JPL controls spacecraft en route to other planets, small forces applied in the right direction at the right time are the difference between reaching the destination and missing by hundreds of kilometers. These efforts are viewed in a similar light.

As with many KM systems, the effects of the knowledge conveyed through JPL 101 cannot be measured directly (Cooper, 2003b). Conditions before and after remain virtually indistinguishable. The differences, if any, were small and below the surface, for example: less frustration when following a policy, a little more respect for others doing their jobs, a greater sense of community. By having a positive individual impact, we expect to have a positive organizational impact, as suggested by Jennex and Olfman (2002). While we cannot measure it, the net effect of JPL 101 was that nearly half the employees learned something new that is relevant to the organization. And that should be a good thing.

As noted by Kuchinke (1995), "organizations have in fact little control over whether learning takes place, but they do have potentially substantial amounts of control over the kind of learning that occurs within their bounds" (p. 309). In this respect, JPL 101 provides a learning opportunity where the content, by its mere presence, indicates a degree of organizational importance and the system serves as an intervention aimed at reducing thought world differences between personnel.

Insights

There are a number of valuable lessons for the organization to be gained from JPL 101. First, fun works. The use of humor and clever construction of questions and answers did not diminish the fundamental value of the content, but instead contributed to user satisfaction.

Second, there were remarkable differences in the effectiveness of different institutional communications channels, as evidenced by the usage data. While one must be cautious about extrapolating from a small number of experiences, the data for JPL 101 imply that specific channels are more effective in motivating participation than others. In this case, the all.personnel e-mail (which was short and clearly indicated that participation would take a small time investment with high potential for payoff) resulted in orders of magnitude increases in participation. The e-mail message differed from the other mechanisms because it was initiated by the team and sent directly to the users, rather than requiring the users to initiate contact by, for example, visiting the InsideJPL Web portal. It essentially caught their attention without requiring any effort on their part at a time (when they were logged on to the intranet and reading their e-mail) when it was easy to access the system.

Third, the differences in successful response rates for different question categories do provide a level of diagnostic information regarding gaps in individual knowledge about the organization. The particularly low scores in the stakeholder category reinforced the concern about general awareness of stakeholder issues. This information could be used to modify communication and training activities to place special emphasis on areas with sub-par performance.

Fourth, the feedback responses were overwhelmingly positive, particularly with respect to the quiz interface. Given the JPL culture, it was felt that this was a good approach (Cooper, 2003a), but there was surprise at the level of enthusiasm, and with the degree of frustration expressed regarding other online training interfaces. This result indicates that modifications to existing training approaches may be warranted.

Finally, the future value of a KMS is dependent upon continued support. Management support (e.g., funding) for JPL 101 stopped immediately after the initial 12-week deployment. While JPL 101 continues to remain in operation, no new content has been developed and updating of the current content is on a volunteer basis. This was anticipated and the questions were designed to minimize obsolescence and the system incorporated mechanisms to make content maintenance easy (e.g., on the order of minutes to update questions or answer content). It is the sense of ownership felt by the development team coupled with the intentionally low maintenance design that keeps this system operational.

Individual Learning & Organizational Learning

JPL 101 is first and foremost a system for individual learning. If one adopts the perspective of Huber (1991) that an organization learns if "any of its units acquires knowledge that it recognizes as potentially useful to the organization" (p. 89), then JPL 101 can also be seen as supporting organizational learning. Using the framework of Senge et al. (1994), JPL 101 supports organizational learning by:

1. Mental Models: Contributing to the development and maintenance of mental models of how the organization operates and why it operates that way. For JPL, the natures of the work and of the institution both drive and constrain the work environment in many different ways. Mental models that accurately predict the behavior of this complex environment will contribute to improvements in the people's ability to work more effectively. JPL 101 attempted to contribute to mental model development, for example, by providing information about how JPL's special status as an FFRDC affects operations. A number of policies that might not make sense under a for-profit business model appear much more logical with a fuller understanding of FFRDC status.
2. Personal mastery: JPL 101 provides a mechanism for both validating the personal knowledge of individuals who are well-informed about how the Lab operates, and for guiding less experienced personnel to important material. The privacy afforded by the quiz interface allows individuals to assess their own knowledge in a non-threatening environment. There are no penalties for getting answers wrong. By structuring JPL 101 for self-learning, and by keeping the general tone light and fun, individuals were encouraged to "test themselves" strictly for their own knowledge.
3. Shared vision: JPL 101 served to provide insights into the culture as shaped by past accomplishments and an understanding of important components of current projects. Simply asking a question in a given area sends the message that this area is important. JPL 101 was intended to help bridge boundaries between different groups at the Laboratory. By highlighting critical issues associated with different disciplines, JPL 101 served to expose participants to areas outside of their normal working environment.
4. Team Learning: JPL 101 is an individual learning tool that can also be used in a shared

mode. For example, there were instances where versions of the quizzes were used as an activity during group meetings. One common approach was to print out a quiz and complete it as an exercise at a group meeting. Members would share their own insights to the answers presented in the quiz with each other, debate answers, and describe their personal experiences relative to a topic covered in the quiz. Several requests were received to generate longer versions of the quizzes with special groupings of questions to support larger organizational meetings.

5. Systems thinking: JPL 101 contributes to systems thinking by providing insights into the internal structure, processes, and players, as well as external influences. All of the areas covered in the quiz contribute to JPL's overall mission. A better understanding of the competing constraints, differing perspectives, and the coupling between different functions leads to a better ability to make sense of the organization.

Questions for Future Research

The work reported in this article raises several questions regarding both knowledge management and organizational learning:

1. JPL 101 was designed to support boundary spanning between different technical and administrative disciplines, and to promote sharing of cultural information. While the literature on cross-functional teams has looked at the benefits of integrating technical disciplines for new product development, the cross-organizational integration of knowledge attempted by JPL 101 represents an under-explored boundary.
2. The relationship between individual and organizational learning is the subject of debate in the organizational learning literature (Argyris, 1999). How does learning about the organization, as supported by JPL 101, relate to organizational learning?
3. There are obvious connections between learning and knowledge management systems. JPL 101 is a KMS explicitly created to provide a learning opportunity. It collects knowledge and codifies it in a way to make it appealing to a broad audience. It also provides a starting point for deeper exploration of the topics presented in the quizzes. Based on the JPL 101 experience, the use of a quiz interface provides a mechanism to transform a KMS into a tool for learning. While this proved true at JPL, additional research is needed to identify general approaches to merging KMSs with learning support.
4. The JPL 101 experience clearly demonstrated that different communication media have different results with respect to increasing participation. The huge increase in participation following the all.personnel e-mail indicates that, at JPL, this is a powerful tool for instigating initial attention. However, in this environment, broadcast e-mail could only be used once during the 12 weeks of primary operations due to internal communications policies. Questions remain regarding how effective e-mail would be if employed on subsequent occasions, how to increase long-term participation (i.e., as compared to the significant fall-off in participation in weeks after the e-mail "blip"), and theories for how to predict which communication mechanism would be most effective in general.
5. The categories of questions included in JPL 101 were chosen specifically for this organization and weighted toward topics (i.e., Basics and Stakeholders) where it was felt there was both unique information to share and a special need to do so. The generalizability of these categories, however, remains an open question. From a process-based

perspective, all organizations have a reason to exist that represents value to external customers and need internal processes to enable the organization to function. In addition, most organizations develop a culture that influences how work gets done. From this perspective four general categories can be identified as common across organizations: value-adding processes, enabling processes, external interfaces, and culture. From within these broader categories, organizations can focus on areas of particular importance to them.

6. Finally, the question of whether organizational learning actually occurred is unanswered. While there is clearly evidence that individuals learned — and considered what they learned to be valuable — organizational learning could not be assessed. For example, it is not known if or how knowledge conveyed by JPL 101 may have changed attitudes or work behavior. It also is not known if there was a sufficient enough change (e.g., by many individuals) to have a measurable impact on the organization.

CONCLUSIONS

This case contributes to the on-going discussion of knowledge management and organizational learning by providing a detailed description of the deployment and operation of an organizational knowledge-based resource specifically targeted to support general learning. A clear goal for knowledge management systems is to expand the knowledge base of the organization — in other words, learning. The work presented in this article describes one instance of the deployment of such a knowledge management system and provides some lessons learned that can be applied to future systems.

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REFERENCES

Argyris, C. (1999). *On organizational learning* (2nd edition). Malden, MA: Blackwell Business.

Brown, S.L., & Eisenhardt, K.M. (1995). Product development: Past research, present findings, and future directions. *Academy of Management Review, 20*(2), 343-378.

Cooper, L.P. (2003a). The power of a question: A case study of two organizational knowledge capture systems. *Proceedings of the 36th Annual Hawaii International Conference on System Sciences.* Computer Society Press.

Cooper, L.P. (2003b). A research agenda to reduce risk in new product development through knowledge management: A practitioner perspective. *Journal of Engineering and Technology Management, 20*, 117-140.

Davenport, T.H., Jarvenpaa, S.L., & Beers, M.C. (1996, Summer). Improving knowledge work processes. *Sloan Management Review,* 53-65.

DeLone, W.H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*(1), 60-96.

Dougherty, D. (1992). Interpretative barriers to successful product innovation in large firms. *Organization Science, 3*(2), 179-202.

Huber, G.P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity, a longitudinal study. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences.* Computer Society Press.

Kuchinke, K.P. (1995). Managing learning for performance. *Human Resource Development Quarterly, 6,* 307-316.

Majchrzak, A., Cooper, L., & Neece, O. (2004). Knowledge reuse for innovation. *Management Science, 50*(2), 174-188.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Markus, M.L., Majchrzak, A., & Gasser, L.A. (2002). Design theory for systems that support emergent knowledge processes. *MIS Quarterly, 26*(3), 179-212.

Senge, P., Kleiner, A., Roberts, C., Ross, R., & Smith, B. (1994). *The fifth discipline fieldbook: Strategies and tools for building a learning organization*. New York: Currency Doubleday.

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Chapter 5.35
Knowledge Management and Social Learning

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INTRODUCTION

There are probably as many variations of knowledge management definitions as there are practitioners and researchers in the discipline. Complete consensus in such a group would be a surprising finding. This is because the two words are loaded with pre-existing meanings that do not always sit comfortably in juxtaposition, so what it means to "manage knowledge" is difficult to ascertain, and hence comes to mean different things to different people.

We do know, however, that knowledge exists in the minds of individuals and is generated and shaped through interaction with others. In an organizational setting, knowledge management must, at the very least, be about how knowledge is acquired, constructed, transferred, and otherwise shared with other members of the organization, in a way that seeks to achieve the organization's objectives. Put another way, knowledge management seeks to harness the power of individuals by supporting them with information technologies and other tools, with the broad aim of enhancing the learning capability of individuals, groups, and, in turn, organizations.

BACKGROUND

In this article, we examine both theoretical and practical socio-cultural aspects of knowledge management based on years of research by the authors in a large and diverse organization. The study involved numerous functional settings of the organization and the researchers used qualitative and quantitative methodology to gather data. Elements required to build an organizational culture that supports knowledge management are discussed. Unless otherwise specified, words in double quotes in the text are direct quotes from personnel in research settings.

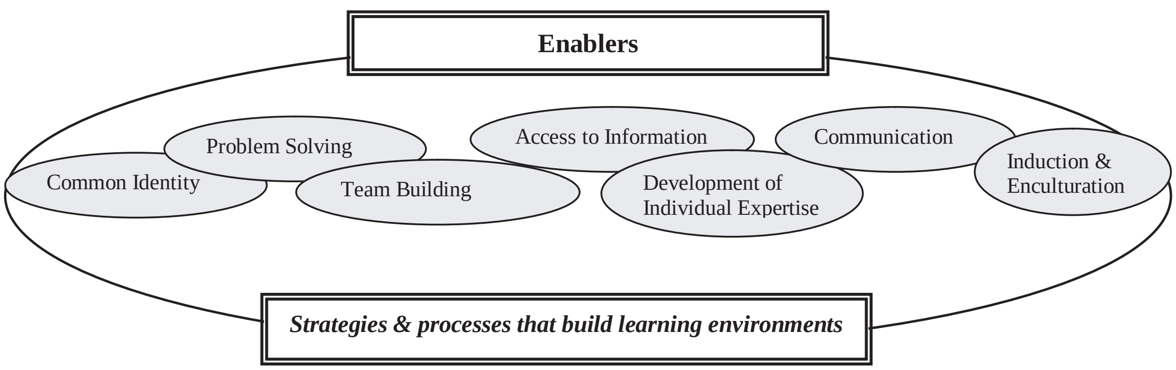
MAIN THRUST OF THE ARTICLE

The research team identified seven basic categories that constitute enabling processes and strategies to facilitate social learning: common identity; problem solving; team building; access to information; development of individual expertise; communication; and induction and enculturation (see Figure 1).

Common identity: a common ground/understanding to which many people/groups can subscribe, and requires a shift from seeing oneself as separate to seeing oneself as connected to and part of an organization unit. Based on our research, motivators impacting on common identity are: goal alignment, cultural identity, gendered identity, language, morale, and workplace design (spatial and physical design).

- Doney, Cannon et al. (1998) discuss the relationship between goal alignment and group cohesiveness, claiming that the extent of group cohesiveness relies on the extent to which a team's goals are clear and accepted and also on the degree to which all members adopt team behaviors.
- The term cultural identity refers to a member's sense of self in relation to the specific "tribe" and "tradition" to which they belong and how this distinctiveness applies in their workplace. Cultural identity is another important motivator for social learning because, like common identity, it impacts on the extent to which staff feels that they are part of the system or alienated from it.
- Gendered identity relates specifically to one's sense of self, which is imbued with the social, cultural and historical constructions surrounding femininity and masculinity. Gender identity, because of its relationship with common identity, was also seen to impact on social learning.
- Language is another important factor fundamental to the overall social learning processes. By reflecting the social and politi-

Figure 1. Constructs enabling social learning



cal relationship between various members, language can impact on common identity. Language is also important in terms of creating a shared understanding among workers and their relationship to the wider organization. "Words are bullets. Never, never use imprecise language." Thus learning the specific work-related language is of central importance to broader social learning development, and is an important outcome of the enculturation process.

- Morale has been a significant focus in the overall study because the research team found evidence of low morale being coupled with higher levels of alienation towards senior management. Such alienation has obvious implications for the broader understanding of a common identity and thus for social learning.
- Workplace design and proximity also threatens common identity when staff are not working in the same location. "[Building X] and us. We don't see them. There is not any spirit that we are belonging to one branch. I have more to do with [a specific area] than anything else and I've made some good contacts in there,... who I sit around with."

Problem solving: a core activity. It fosters social learning, because each problem represents an opportunity to generate knowledge. Motivators associated with this enabler are: networking, perceptions of the organization, systemic understanding, and time for inquiry and reflection.

- An individual's personal and social networks are an important means of acquiring, propagating, and sharing knowledge. As Davenport and Prusack (1998) claim, when those who are in a position of "know-how" share their expertise they contribute to problem solving. Personal networks were seen to function as channels supporting both "information pull" and "information push".
- Individual and shared perceptions of the organization, and how they operate, provide an essential backdrop to problem solving within an organizational context. These perceptions may consist of deeply ingrained assumptions, generalizations, or even pictures or images that influence how people understand their organizational world and how they should act within it (Senge, 1992). The importance of these perceptions cannot be stressed enough, because they directly influence the construction of individuals' knowledge and understandings that they draw upon in their day-to-day-activities.
- Effective problem solving often requires a systemic understanding of organizational and inter-organizational issues. Systemic understanding requires a holistic view of an organization and its interrelationships, an understanding of the fabric of relationships and the likely effect of interrelated actions (Senge, 1992).
- Inquiry and reflection together are a powerful means of enhancing social learning and knowledge creation. Inquiries, or questions, are triggered by problems that require solutions or explanation. Reflection allows time for examination, contemplation and, often, resolution of the inquiries. To use a common metaphor, it is perhaps the best means for distinguishing between the forests and the trees of everyday working life.

Team building: working together and understanding what each member is trying to do. Team building was seen to be essential for effective social learning and problem solving. Motivators associated are: leadership, team-based morale, performance management, public recognition and reward systems, use of humour, and workplace design.

- In general, the caliber of leadership within the settings studied was to be admired. The leaders and managers were innovative and they motivated and developed their staff, mainly by demonstrating that staff are highly valued and by acknowledging expertise and knowledge regardless of their pay or position. Another team building issue that emerged was that people were appreciative of informal "drop-ins" by senior managers inquiring how they were doing. This "roving management" was said to contribute to better cohesion of teams, to promote system thinking, to help focus on overall goals, and to facilitate communication and feedback.
- "Team spirit" and "team cohesiveness" are both important values within the work culture and work ethic; nonetheless, there was nothing uniform about this in the settings studied. Some teams did not see the significance of their particular tasks to the overall goals of the organization. However, good examples of teamwork and team spirit were also evident. There were instances where teamwork was well integrated into daily work and where people worked collaboratively. Such teams were goal-oriented and were not only teams in structure but in spirit and were led by a leader who saw his/her role as serving team members rather than just having the position of a leader.
- For many employees, the performance cycle is annual and the outcome of a performance report often determines the prospects of one's career progression. Some felt somewhat uneasy as their performance evaluation was due relatively early into their posting cycle. A well-planned performance appraisal system should help to make equitable and unbiased decisions regarding staff selection, placement, development and training (Wood, 1989). Researchers were told that there was often a lack of clear communication about performance expectations. Also, an annual performance appraisal appears to be too long to wait for recognition of good work and too late to correct a performance problem. Morgan (1989) and Wood (1989) explain that to maximize positive results, the appraisal process should be two ways: it should facilitate and coach staff in doing their jobs effectively; and it should be frequent and informal.
- It was observed that humor was used for smoothing discussions that were becoming heated and to stop the conflict from escalating while also enabling the conflicting subordinates to save face. At meetings, humor was used to assist in uniting people around common themes and to make criticism palatable.
- One way of increasing team and individual morale is to publicly acknowledge outstanding work. Making employees feel appreciated, and saying, "Thank you, we know that you are a good employee, we value you and your work", is a big factor in motivation (Mitchell, 2000). Key informants stated that public recognition of good work was scarce and that a written or verbal word of praise, a pat on the back often means more, for example, than a pay raise – "praise is better than money" and praise is needed at all levels.
- Workplace design was seen to have impact on social learning. Staff located at small isolated outposts were at risk of feeling isolated and did not identify strongly with the parent organization. As stated earlier, out-posted staff identified more with the workplace with which they were based than their branch where they affiliated. This was further exacerbated by the fact that they often felt excluded by their colleagues.

Access to information: the easy availability of corporate information in whatever format was observed to effect knowledge acquisition and generation of new knowledge and social learning. Motivators associated are: record keeping, networking, meetings, and information technology (IT) infrastructure.

- The researchers observed that general familiarity with records keeping procedures was quite poor. Some people have developed their own personal records keeping systems but there was little uniformity in these and no adherence to file naming conventions and standards. As some informants stated: "I believe that physical files in the … are no longer managed well because their management has been farmed out to outside bodies." Or "I think we have problems with passing on information in the organization as a whole. We just don't do it very well." The issue of electronic records, particularly e-mail messages containing evidence of business transactions, posed problems not only in the setting studied but also in the whole of organization.
- Personal networks from previous postings as well as newly acquired contacts in the new environment play a vital role in knowledge construction and acquisition. New knowledge often begins with the individual and through conversations people discover what they know, what others know and in the process of sharing, new knowledge is created. Knowledge sharing depends on the quality of conversations, formal or informal, that people have. Webber (1993) aptly describes it: "Conversations – not rank, title, or the trappings of power – determine who is literally and figuratively 'in the loop' and who is not."
- Meetings are another means of accessing information and those that were observed varied significantly in format and the protocols in place. At the tactical headquarters, meetings that were mission-related provided excellent opportunities for learning. Strict protocols were observed at these briefings, for example, allowing participants to discuss errors or problems encountered during missions without assigning blame or shame to individuals. There were few equivalent meetings at the strategic headquarters, other than some induction sessions and briefings, and it appeared that learning how to do one's job was not given quite the same priority.
- The researchers observed that information access due to failings in the IT infrastructure inhibited access to information within the strategic settings. Another issue that caused problems was the difficulty in finding information on the shared drive. Since there was no specific person responsible for maintaining the shared drive and for naming folders, it was left to the discretion of the document originator where information would be stored.

Development of individual expertise: the acquisition and development of expertise was seen as an integral part of social learning. Motivators associated with this enabler are: career trajectories, professional currency, professional training, postings and promotion, and mentoring.

- A career trajectory describes the positions, roles and experience that individuals have accumulated, up to and including the position they currently hold. While not excluding personal experiences outside of a work or training context, a well-designed career trajectory generally equips an individual with the skills, experience, maturity and personal networks needed to successfully fill a particular posting.
- The term professional currency has a somewhat different meaning within different environments. However, professional currency promotes social learning in the same way that appropriate career trajectories do so "

by providing a foundation for the generation of new knowledge.
- Appropriate professional training is a significant component of the development of individual expertise and, therefore, a fundamental for generating new knowledge. Training courses are important for furthering individuals' expertise, as well as for forming the personal networks that subsequently develop. However, in times of budgetary constraints, training money is often the first to go, with damaging consequences for the organization's ability to learn and manage their knowledge.
- Mentoring is regarded as an effective method of assisting the development of individual expertise; especially for junior staff, a degree of informal mentoring was seen to be built into elements of the training program in some of the settings studied. In terms of developing a career trajectory, the knowledge acquired through mentoring may also be important when individuals want to prepare themselves for specific roles in the future.

Communication: essential to effective learning within an organization and to effective social learning. Motivators associated with this enabler are: overall communication climate, formal and informal information flows, time for inquiry and reflection, use of humor, language, and workplace design.

- Supportive communication climates are being positively linked to open and free exchange of information and constructive conflict management. Characteristics of a supportive communication climate include a culture of sharing knowledge, treating each other with respect, and generally behaving in a cooperative manner. Research has established the link between supportive organizational communication climates and generative learning (Bokeno, 2000; Ruppel, 2000) and with higher levels of organizational commitment (Guzley, 1992).
- An important element of generative learning is for organizational members to be able to engage in dialogue which is open and is based on inquiry and reflection. A supportive communication climate is a prerequisite for such dialogue, and it requires learning how to recognize defensive patterns of interaction that undermine learning (Senge, 1992).
- The issue of workplace design and its impact on teams, network building, and on accessing information arose repeatedly during the study. Physical location and proximity to each other had the potential to promote the transfer of pertinent knowledge. The point was made that in addition to more quickly obtaining answers to questions about particular tasks, an open plan workplace enabled one to tap into pertinent knowledge by overhearing others' conversations. Hutchins (1996) uses the term "horizon of observation" to describe the area of the task environment which can be seen, and is therefore available as a context for learning by team members.

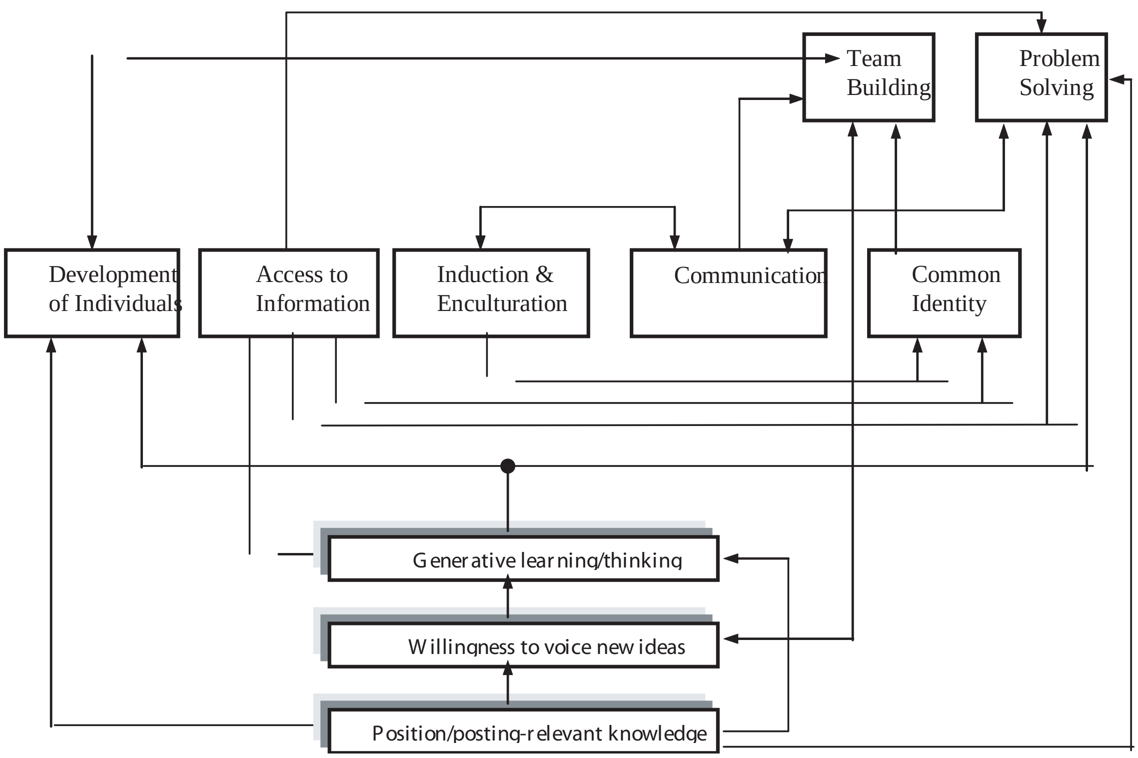
Induction and enculturation: facilitates social learning by providing a foundation upon which an individual can become fully productive. Issues associated with this enabler are: timeliness and comprehensiveness of the process, buddy/mentoring system, handovers and information packages, and training.

- Good induction is more than just an introduction to a new job and workmates; it is a way of helping people find their feet. Attitudes and expectations are shaped during the early days of new employment, and work satisfaction is linked to well-timed and conducted work orientation (Dunford, 1992; George & Cole, 1992). The interviews clearly indicated a relationship between meaningful and timely induction and subsequent job satisfaction. An interesting finding was that those who were not properly inducted or enculturated into the organization saw no need and responsibility to actually prepare any form of handover for anyone who may take over their position in the future.

- Although highly desirable, it was not always feasible to conduct an induction program at the beginning of a new posting cycle. In the interim, a "buddy" or "mentoring" system could fill in the gap. A "buddy" would be an experienced workmate who could be available to answer questions and assist the orientation of new members during the initial few weeks. Some interviewees said that having a buddy when they started was invaluable to settling into a new job and to effective learning.
- The researchers were repeatedly told that early training is an important part of effective induction and enculturation. It is an opportunity to learn the explicit knowledge that is taught as part of formal training. It is also an opportunity to be exposed to the attitude and cultural perceptions of colleagues and peers.

These factors enabling social learning identified from our data are by no means exhaustive, however, based on the available data, the research team could see a relationship between these enablers and social and generative learning. Figure 2 depicts these relationships and their impact on social learning.

Figure 2. Enabling processes and their impact on social learning



CONCLUSION

Therefore, organizations seeking to improve information sharing and knowledge generation need to develop a greater awareness of the processes and strategies of organizational learning. Organizational knowledge is distributed across functional groups, and its generation and continual existence is dependant on the overall communication climate which is embedded in the organizational culture. This study indicates that information sharing and subsequent knowledge generation would be successful when interactive environments are cultivated before other, for example, technology-based solutions are implemented.

BIBLIOGRAPHY

The information in this article is largely derived from the following sources:

Agostino, K. (1998). The making of warriors: Men, identity and military culture. *JIGS: Australian Masculinities, 3*(2).

Ali, I., Pascoe, C., & Warne, L. (2002). Interactions of organizational culture and collaboration in working and learning. *Educational Technology and Society, 5*(2): 60-69. ISSN 1436-4522.

Argyris, C. (1973). *On organisations of the future*. Beverley Hills, CA: Sage.

Drucker, P.F. (1999, October). Beyond the information revolution. *The Atlantic Monthly*.

Enneking, N.E. (1998). Managing email: Working toward an effective solution. *Records Management Quarterly, 32*(3), 24-43.

Ganzel, R. (1998). Elements of a great orientation. *Training, 35*(3), 56.

Warne, L., Agostino, K., Ali, I., Pascoe, C., & Bopping, D. (2002). The knowledge edge: Knowledge management and social learning in military settings. In A. Gunasekaran, O. Khalil & S.M. Rahman (Eds.), *Knowledge and information technology management: Human and social perspectives* (pp. 324-353). Hershey, PA: Idea Group Publishing, ISBN 1-59140-032-5.

REFERENCES

Bokeno, R.M. (2000). Dialogic mentoring. *Management Communication Quarterly, 14,* 237 270.

Cooke, R. (1998). Welcome aboard. *Credit Union Management, 21*(7), 46-47.

Davenport, T.H. & Prusack, L. (1998). *Working knowledge: How organisations manage what they know,* Harvard Business School Press.

Doney, P.M., Cannon, J.P., et al. (1998). Understanding the influence of national culture on the development of trust. *Academy of Management Review, 23*(3), 601-623.

Drucker, P.F. (1999, October). Beyond the information revolution. *The Atlantic Monthly*.

Dunford, R.W. (1992). *Organisational behaviour: An organisational analysis perspective*. Sydney: Addison Wesley.

George, C.S., & Cole, K. (1992). *Supervision in action: The art of managing*. Sydney: Prentice Hall.

Guzley, R.M. (1992). Organizational climate and communication climate: Predictors of commitment to the organization. *Management Communication Quarterly, 5*(4), 379-402.

Hutchins, E. (1996). *Cognition in the wild*. Cambridge, Mass: MIT Press.

Mitchell, S. (2000). *Be bold and discover the power of praise*. East Roseville: Simon & Schuster.

Morgan, T. (1989). Performance management - the missing link in strategic management and planning. In D.C. Corbett (Ed.), *Public sector policies for the 1990's* (pp. 243-250). Melbourne, Public Sector Management Institute, Faculty of Economics and Politics, Monash University.

Ruppel, P.C.a.S.J.H. (2000). The relationship of communication, ethical work climate, and trust to commitment and innovation. *Journal of Business Ethics, 25,* 313-328.

Senge, P.M. (1992). *The fifth discipline: The art & practice of the learning organisation*. Australia: Random House.

Webber, A.M. (1993, Jan-Feb). What's so new about the new economy? *Harvard Business Review*, 24-42.

Wood, R. (1989). Performance appraisal in the reform of public sector management practices. In D.C. Corbett (Ed.), *Public sector policies for the 1990's* (pp. 225-242). Melbourne, Public Sector Management Institute, Faculty of Economics and Politics, Monash University.

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Chapter 5.36
Knowledge Management Trends:
Challenges and Opportunities for Educational Institutions

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ABSTRACT

While the pressure of public accountability has placed increasing pressure on higher education institutions to provide information regarding critical outcomes, this chapter describes how knowledge management (KM) can be used by educational institutions to gain a more comprehensive, integrative, and reflexive understanding of the impact of information on their organizations. The practice of KM, initially derived from theory and practice in the business sector, has typically been used to address isolated data and information transfer, rather than actual systemwide change. However, higher education institutions should not simply appropriate KM strategies and practices as they have appeared in the business sector. Instead, higher education institutions should use KM to focus on long-term, organization-wide strategies.

INTRODUCTION

Knowledge management (KM) can be used by educational institutions to gain a more comprehensive, integrative, and reflexive understanding of the impact of information on their organizations. Specifically, the practice of KM, initially derived from theory and practice in the business sector as described in the previous chapter, provides a framework to illuminate and address organizational obstacles around issues of information use and access (Davenport, 1997; Friedman & Hoffman, 2001). Yet introducing the concept of KM into the educational arena from the business sector has been a slow and often underutilized process. This is partially due to the fact that KM is a multi-layered and systems-oriented process that requires organizations to rethink what they do and how they do it (Brown & Duguid, 2000; Senge, 1990). Additionally, educational institutions are traditionally hierarchical with silo-like functions, making cross-functional initiatives difficult to implement (Friedman & Hoffman, 2001; Petrides, McClelland, & Nodine, 2004).

However, educational institutions can perhaps learn from KM efforts in the business sector, in terms of the limitations and drawbacks associated with KM. In fact, there are several compelling reasons why educational institutions have not, and perhaps should not, simply re-appropriate KM, as popularized by the business sector, into their own organizations. For example, in the business sector, there has been an appeal to focus on information technology and systems as solutions to problems of knowledge transfer and knowledge sharing (Hovland, 2003; Huysman & de Wit, 2004). Coupled with a profit motive, KM as it exists in the business sector is often limited in its ability to create far-reaching organizational change (Hammer, Leonard, & Davenport 2004). Furthermore, recent trends in the field also fail to fully distinguish between data, information, and knowledge (Huysman & de Wit, 2002). Consequently, organizations merely address singular and isolated data and information transfer, rather than actual systemwide and organization-wide change.

These particular limitations are especially salient now as higher-education institutions face an increasing number of challenges that have forced them to rethink how they are accountable to external demands, as well as how to improve internal accountability. Rather than focus on micro-level information-sharing activities, implementing KM strategies and practices requires these educational institutions to examine the larger context of information sharing within the organization, specifically how their people, processes, and technology function within it. As such, neither data-sharing activities nor technological implementation should be viewed as the ultimate objective and final stage of a KM strategy. Instead, KM practices necessitate strategies that build upon current practice, leading to more comprehensive and organization-wide changes in knowledge practices and actions.

How then can educational institutions translate isolated sharing activities into long-term learning? This chapter illustrates how KM strategies and practices enable higher-education institutions to distinguish between data, information, knowledge, and action and how this iterative cycle can help organizations assess their available resources—that is, their people and processes along with their technology. In turn, this chapter demonstrates how KM can help educational institutions place themselves on the path toward continuous learning and organizational reflexivity.

CONCEPTS AND THEORIES

An overview of KM practices in the business sector demonstrates an overwhelming focus on simplified solutions, specific applications, and singular information-transfer activities. Recent accounts suggest that KM has seen limited impacts in the private sector due to overemphasis on technological hardware and software (Hammer et al., 2004; Hovland, 2003; Huysman & de Wit, 2004). This may be due in part to the fact that it is often easier to persuade organizations to acquire new technology tools than to modify or redesign existing organizational processes (Coate, 1996).

However, these particular approaches to KM are less likely to embrace a systematic approach to how organizations function. By focusing too narrowly on isolated information-sharing activities, organizations are prematurely confined and prevented from engaging in a more integrative approach to KM. These information-sharing activities, which some might argue are wrongly classified as KM, may include electronic search and retrieval, document management, and data warehousing systems. These examples demonstrate important yet isolated occurrences of information activities and practices. However, these practices are often implemented disassociated from a larger organization-wide strategy. Secondly, and perhaps more importantly, the interpretation of these as KM does not acknowledge a vital distinction between information and knowledge. It is this delineation that pinpoints the incremental process behind the implementation of KM strategies and practices: Information is data with contextual meaning, data that has been categorized, or subjected to a process of sense-making and interpretation. Knowledge is information that is put into action through the process of problem-solving, decision-making, feedback processes, and so on (Davenport, 1997).

Therefore, developing policies and processes that fundamentally support and organizationally align information-sharing activities to each other is one of the first steps an organization must take to embrace and develop successful KM strategies. Often, an organization will try, yet fail, to implement an entire host of activities related to data collection and information access, only to find that the necessary organizational conduits for information sharing and new knowledge creation are not in place. How an organization shares information, along with the incentives and rewards to do so, and a culture that supports information-based decision-making are all key components that need to be in place before KM can be successfully implemented.

People, Processes, and Technology

KM strategies and practices come to embody the interactions between people, processes, and technology. These three—people, processes, and technology—all function as an integral part of the ongoing dynamics as organizations struggle to meet their information needs. First, it is people, not systems or technology, who "know." Thus, it is people who manage the policies, priorities, and processes that support the use of data, information, and knowledge. KM strategies and practices seek to engage different groups of people across various levels of an organization in the process of collective sense-making and decision-making. Whether these groups are formal or informal, a KM strategy includes supporting individuals in coming together to share information to address their collective needs.

Likewise, self-evident processes or embedded, day-to-day work practices can greatly affect the exchange and sharing of information within any organization. For example, it may be common practice within an organization for decision-making authority to be exercised only at the most senior level. These kinds of decision-making processes can create barriers to ownership, in which individuals are not provided with the appropriate incentives to make their own decisions and changes, let alone use data and share information. By uncovering these processes, KM strategies and practices can help identify knowledge gaps, and thus enable people to obtain the information they need and encourage them to share it with others, sometimes creating new knowledge and improved decisions. In highlighting patterns of information use that might not be evident otherwise, KM practices encourage a certain level of organizational reflexivity, which allows organizations to better understand themselves, in turn leading to more informed decision-making.

Rather than situating technology as the focal point, KM practices approach technology as an essential resource that is necessary for changes in organizational process to occur, but not sufficient. Recent trends in KM may grant technology disproportionate authority in how organizations share information. However, technology and information systems are neither the driver of information sharing, nor are they tangential to the process. Instead, technology is of equal importance in its ability to impact how information flows throughout an organization. Therefore, KM is the combination of people, processes, and technology that come together to promote a robust system of information sharing, while guiding organizations toward ongoing reflexivity and learning.

In summary, recent KM trends in the business sector often do not explicitly address all of the organizational resources necessary to implement KM, namely, the people and processes as well as the technology. To some, KM is used as a phrase to describe the technology that is used to manage an organization's data, such as data on monthly sales figures or a database of successful sales strategies. However, the way that these information systems are used is fully contingent on the strategies and policies employed by the organization, and does not constitute KM on its own. It is not uncommon to hear a claim that a vendor has developed "knowledge management software," rather than "developing software that could be used to help an organization implement KM strategies and practices." Although this distinction may appear to split semantical hairs, we argue that these types of technology present only one part of a larger whole within organizations, but they often do not address the necessary steps to become an organization that uses information and knowledge to develop continuous learning throughout.

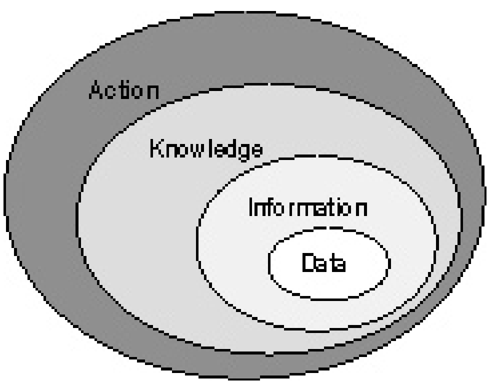
Data–Information–Knowledge–Action

KM strategies and practices are predicated on the distinction between information and knowledge. Other research in KM makes this distinction to highlight that information undergoes a series of processes that transform it into knowledge as it flows and is exchanged among individuals within an organization (Davenport & Prusack, 1997; Drucker, 1998; Wilson, 2002). To further refine this notion, we assert that information and knowledge need to be further delineated. As such, we propose four stages that comprise the KM cycle: data, information, knowledge, and action. Data are the facts and quantitative measures that are available within any organization. When groups or individuals take data and contribute their own interpretation and categorization, data can be transformed into information. In turn, knowledge is the resulting understanding that allows people to share and use this information that is now available to them. Once this knowledge is applied to make specific decisions or address problems, it is transformed into an action. Each component of the cycle builds upon the preceding element, feeding back and connecting actions and decisions and new learning, which eventually translates back to new questions that are informed by data once again.

There is a certain set of activities and practices that typically takes place in each part of the cycle, where each component builds upon the one before it, making it an iterative process of change or improvement. Data activities in the KM cycle can include accessing data by departmental request, or retrieving data directly from information systems and placing them within personalized spreadsheets. Information activities may include analyzing data to find patterns, problems, and discrepancies, or aggregating and disaggregating data, writing reports, or discussing findings from the data with colleagues. Knowledge activities entail formal and informal discussion and collaboration to address issues and problems in the context of the data and information. It is important to note that the knowledge stage of the KM cycle encompasses a process of collective sense-making, which includes ongoing discussion, collaboration, and feedback, thus shifting individual data and information practices into the organizational environment. The last stage of the cycle is then implementation of changes and action that result from the iterative process.

Therefore, organizations that simply engage in the collection and distribution of data are engaged in data management activities only. However, knowledge management is more than the mere aggregation of data management practices. KM practices include the management of the infrastructure that supports the data–information–knowledge–action cycle, as well as the implementation of the process. In these examples, we see then that KM activities and practices bring together all four components of the cycle: data, as well as information, knowledge, and action. In turn, KM strategies embrace practices at every stage of this cycle, and integrate the people, processes, and technology within the organization. It is important to note that each stage of the KM cycle is not mutually exclusive. An organization that fully adopts KM strategies and practices also demonstrates activities within each component of the KM cycle simultaneously. Engaging in the knowledge stage of the KM cycle also includes individuals engaging in data and information activities. In fact, KM practices necessitate that individuals simultaneously engage all three stages of practice, data, information, and knowledge as they implement changes and action (see Figure 1).

Figure 1. The data-information-knowledge-action cycle



Thus, the KM cycle demonstrates the dynamic qualities of KM strategies and practices. Their simultaneous, ongoing, and cyclical nature further highlights the necessary feedback and iterations that serve as the foundations for ongoing reflexivity and learning. As such, KM practices demonstrate how knowledge is most valuable not when stored in static repositories, but when exchanged across groups of people, used and applied to inform actions and change. KM strategies and practices can help organizations better identify their information-sharing and knowledge-generating activities, which, in turn, can help organizations capitalize on the iterative nature of knowledge-sharing activities.

CURRENT CHALLENGES FOR KM IN HIGHER EDUCATION

Increasing pressures and demands for data on student success have translated into an increased call for reliable information regarding critical outcomes in higher education. Due to rising public accountability pressures and strains on fiscal resources, many legislators have begun to demand information that can be directly linked to academic outcomes. As a result, these institutions are faced with requirements to provide accurate data and information around a growing number of issues and outcomes. In order to do so, the institutions are now re-evaluating their own knowledge strategies and practices.

However, these processes of re-evaluation have proven to be challenging. To begin with, the information technology infrastructure at many higher-education institutions is problematic. Rather than having one robust and integrated system, educational institutions more often maintain several information systems that support various functions throughout the organization, some of which are antiquated legacy systems. In addition to this fragmented information technology infrastructure, there are often inconsistent priorities around data collection, which can result in inaccessible or unreliable data. These characteristics translate into disparate data silos throughout the organization, redundant data gathering, and information hoarding, the cost of which is an impaired ability to sustain knowledge development, growth, and effective decision-making (Petrides et al., 2004). In an increasingly performance-driven climate, this only exacerbates these already problematic and costly practices.

Furthermore, cultural issues associated with information hoarding and overall disincentives for sharing and cross-functional cooperation can undermine KM implementation strategies in educational institutions. In a climate of accountability, data and information can appear threatening as well as politically charged, particularly when programs or other initiatives are under fiscal strain. Nevertheless, educational institutions can minimize these potentially negative consequences by developing KM strategies under a set of policies that explicitly encourage change and progress rather than penalize mistakes. A culture that is intolerant of mistakes can severely impede KM initiatives (Davenport & Prusack, 1997). The psychological instability that can arise is a very real challenge that can curtail any change initiative. As such, when implementing a KM strategy, educational institutions are better served by fostering an environment that reduces the sense of fear and retribution that individuals within the organization may face, for example, as they uncover data and information that may support unpopular opinions.

KM practices also require long-term strategies and commitments in order to fully realize their benefits. While educational institutions have tentatively begun to incorporate KM strategies, they will benefit from gaining a better understanding of the current limitations of these recent approaches to KM in the business sector, such as the narrow focus on seemingly easier-to-address solutions—for example, creating a data warehouse from which to extract student data. In microscopically fixating on specific information solutions, many current trends in KM do not help these institutions build the capacity to sustain long-term organization-wide change, but instead limit the potential that information and knowledge sharing can have.

While KM researchers may recognize the importance of distinguishing between data, information, and knowledge, KM practitioners in the private sector have not necessarily taken into account these distinctions. In this particular conception of KM, knowledge is then simply used as an overarching term for all three—data, information, and knowledge. Subsequently, many of the products, repositories, and exchange activities that are currently termed KM prove to merely support data and information, rather than actual knowledge. Doing so runs the risk of prematurely curtailing the necessary feedback mechanisms for continuous organizational learning.

However, it becomes much more difficult to address systemic barriers to knowledge sharing. The desire to find narrow and short-reaching solutions is often rooted in a compartmentalized understanding of the nature of organizational barriers to information sharing, even though these problems are more than technological. These problems include people's prevailing attitudes, beliefs around knowledge sharing, and systematic and structural disincentives to share and exchange. For example, the politics of information are often heavily embedded in organizational culture and structure, which complicates efforts to change processes that could be used to potentially support and drive knowledge sharing and creation. Recent evolutions of KM do not necessarily take into account the organizational cultures and structures that serve as barriers to data sharing, information sharing, and eventually knowledge sharing. Furthermore, these recent developments in KM fail to acknowledge the evolving and iterative qualities of knowledge. Knowledge is only useful when it is shared, transmitted, or acted on in some capacity. During these exchanges, knowledge undergoes an ongoing and continual cycle of change from data, information, knowledge, and action. However, these distinctions are lost as KM practitioners attempt to find solitary solutions to problems of data and information.

If these attempts at KM remain truncated and narrowly focused on simplified solutions, specific applications, and singular knowledge-transfer activities, these tools can only marginally improve an organization's use of information and knowledge and do not address the deep-rooted processes and strategies necessary to overcome these barriers. Information technologies and applications only incrementally improve an organization's ability to facilitate data sharing and information exchange. As such, these approaches demonstrate a bounded set of limitations that ultimately prevent organizations from overcoming their current obstacles and diminish their ability to build a self-sustaining and long-term organization-wide system, thus undermining the very benefits KM practices have to offer.

Therefore, we suggest that educational institutions should not simply appropriate KM strategies from the business sector and apply them to their organizations. If KM is being implemented poorly, does that mean it should be done away with completely? Or does it hold its own as a concept worth striving for? The current limitations and drawbacks of KM in the private sector should serve as a warning for educational institutions. These organizations should be careful not to prematurely fragment their KM practices and focus on narrow applications and solutions. Instead, higher-education institutions stand to benefit from an approach that incorporates a more long-term and inclusive strategy to their knowledge activities. As such, improved methods of data and information sharing need to be coupled with embedded and long-term KM strategies in order to address the organization-wide factors that can either impede or promote an ongoing culture of research, reflexivity, and long-term organizational learning. If the evolutionary qualities of knowledge management—as it evolves from data, information, and knowledge—cross through multiple groups of people within an organization, as well as traverse the three key organizational resources available—that is, people, processes, and technology—then the dynamic process that guides successful KM strategies and practices is more readily supported and maintained.

OPPORTUNITIES FOR KM IN EDUCATION

Educational institutions demonstrate a great need for improved knowledge-based systems. We already find that there are many formal and informal administrative processes, information-sharing patterns, work incentives, information silos, and other work practices that have flourished over time, yet these can also critically impede organizational and systematic information flow and knowledge exchange. KM strategies and practices can begin to integrate these disjointed systems. For example, the use of information maps and audits can initially be used to obtain a bird's-eye view of the current processes and practices, and their corresponding strengths and weaknesses. This type of initial diagnosis proves to be important for implementing KM in order to identify the most appropriate entry point for change. The cyclical quality of KM encourages organizations to take an honest and reflexive stance on what is already going on in their organization. KM requires that educational institutions candidly address their current patterns and processes, and only from this position begin to capitalize on the opportunities that KM strategies and practices can offer. This process of organizational re-evaluation and reflexivity proves to be the most difficult challenge for educational institutions. At the same time, the process offers the ideal opportunity for these institutions to integrate KM to promote sustainable learning within their organizations in order to meet these external demands as well as improve organization-wide effectiveness.

Higher-education institutions can begin to translate these strategies into action by identifying their information shortages and needs, including finding out where people are already requesting more data and information. These institutions can also start by identifying groups of people who already maintain synergistic relationships of collaboration and sharing within the institution. In fact, educational settings already demonstrate many information-sharing activities in effect, such as existing formal or informal communities of practice. However, to sustain ongoing inquiry and continuous learning, educational institutions need to strategize as to how they will systemically embed these activities and practices within the very fabric of the organization. Taken individually, information-sharing activities can be used toward incremental improvement; however, when KM is adopted and executed as an organization-wide strategy, improved methods of data and information sharing can be used to continually promote the development of KM-based practices. This can help educational institutions become more informed in their decision-making as a whole. All of this helps to lay the foundation for a robust culture of inquiry and reflexivity, thus establishing the mechanisms for sustainable, long-term organizational learning.

Perhaps more importantly, student access and success are the likely benefactors of these KM practices. KM practices can promote organizational reflexivity in such a way that educational institutions better understand their own weaknesses and strengths, and can then allocate their resources to where they are most needed. As demands for accountability rise, educational institutions need to become much more adept at assessing students' needs along with their own institutional capabilities. KM practices can help bring these two together, that is, aligning institutional capabilities and resources to better address students' needs and thus student success. Subsequently, educational institutions that engage in KM practices for continuous learning at the organizational level also engage in promoting continuous learning for their students.

OPPORTUNITIES FOR CONTINUOUS LEARNING

In conclusion, to fully realize the potential of KM, educational institutions will need to change the focus of KM from isolated knowledge-sharing activities to long-term, organization-wide strategies. Thus, KM practices can help educational institutions meet their goal of improved decision-making to advance student learning, allowing these institutions to begin to identify the value of programs and services that contribute to student access and success. This requires not only addressing information policies, but also taking a closer look at the institution's own processes and current practices to stimulate ongoing and constructive data use. Therefore, KM practices can be used to help educational institutions develop a sense of reflexivity across all levels of the organization, thereby providing these institutions with the means for a sustainable culture of inquiry and continuous learning.

REFERENCES

Brown, J.S. & Duguid, P. (2000). Balancing act: How to capture knowledge without killing it. *Harvard Business Review, 78*(5), 3-7.

Coate, L.E. (1996). Beyond re-engineering: Changing the organizational paradigm. In A. Kendrick (Ed.), *Organizational paradigm shifts* (pp. 1-18). Washington, DC: National Association of College and University Business Officers (NACUBO).

Davenport, T.H. (1997). *Information ecology: Mastering the information and knowledge environment.* New York: Oxford University Press.

Davenport, T.H. & Prusack, L. (1997). *Working knowledge: How organizations manage what they know.* Cambridge, MA: Harvard Business School Press.

Drucker, P. (1998). The knowledge-creating company. In Drucker, P. et al. (Eds.), *Harvard Business Review on knowledge management* (pp. 1-19). Cambridge, MA: Harvard Business School Press.

Friedman, D. & Hoffman, P. (2001). *The politics of information. Change, 33*(2), 50-57.

Hammer, M., Leonard, D., & Davenport, T. (2004). Why don't we know more about knowledge? *MIT Sloan Management Review, 45*(4), 14-18.

Hovland, I. (2003). Knowledge management and organisational learning, an international development perspective: An annotated bibliography, *Working Paper 224.* Retrieved October 7, 2004, from Overseas Development Institute (ODI) Web site: http://www.odi.org.uk/rapid/Publications/Documents/WP224.pdf

Huysman, M. & de Wit, D. (2004). Practices of managing knowledge sharing: Towards a second wave of knowledge management. *Knowledge Process Management, 11*(2), 81-92.

Petrides, L.A., McClelland, S.I., & Nodine, T.R. (2004). Costs and benefits of the workaround: Inventive solution of costly alternative. *The International Journal of Educational Management, 18*(2), 100-108.

Senge, P.M. (1990). *The fifth discipline: The art and practice of the learning organization.* New York: Currency.

Wilson, T.D. (2002). The nonsense of knowledge management. *Information Research, 18*(1), Paper 144. Retrieved October 7, 2004, from http://InformationR.net/ir/8-1/paper144.html

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Chapter 5.37
Wise Organizations?

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ABSTRACT

In seeking wisdom, the first step is silence; the second, listening; the third, remembering; the fourth, practicing; the fifth teaching others. Solomon Ibn Gabirol, Jewish Poet and Philosopher (c. 1021-1058)

"There is no use trying," said Alice; "one can't believe impossible things." "I dare say you haven't had much practice," said the Queen. "When I was your age, I always did it for half an hour a day. Why, sometimes I've believed as many as six impossible things before breakfast." Lewis Carroll, Alice in Wonderland

This chapter explores the ways that wisdom and wise action appear in the work of organizations and asks how systems can be designed to support that. Building on C. West Churchman's thought experiment with five philosophers about how to improve the design of systems, the author asks and brings fresh answers to the questions, "What is wisdom?" and "What is wisdom in organizations?" The author offers a series of six brief reflections about foundations that he believes can make the design of systems that support people in acting wisely far easier to do. The chapter concludes with a case example of a system illustrating many of the chapter's themes and specific recommendations for IT designers about how to think from the chapter's suggestions. The author hopes to build a richer background for IT designers, leading to systems that do a better job of supporting people in the wise exercise of their responsibilities in all kinds of organizations.

INTRODUCTION

In this chapter, I want to help put a richer background in place to support the work of IT designers. I hope that an examination of wisdom may inform those who have the ambition, or are charged with, designing and building software systems, and lead to the development of systems that do a better job of supporting people in the wise exercise of their responsibilities in all kinds of organizations. The subject is too big for a chapter in a book, but perhaps with the following I can inspire, suggest some foundations, suggest directions for exploration, and, at the same time, point out some goofy interpretations that may be adjusted or altered.

In his exploration of the idea of designing inquiring systems, C. West Churchman (1968) challenged himself to invent a basis for building systems that support human action more effectively:

"Instead of just asking the traditional questions of how human minds come to learn from experience, [I] asked how one could design a system that would learn from its experience in some 'optimal fashion.' My plan was to translate some of the historical texts in the theory of knowledge into modern systems terminology, by assuming that the authors were discussing the components of a system design…I was struck again [while studying Leibniz] by the fact that in his approach to the inquiring system he was insisting that a concept of the whole system was essential in understanding how each 'part' worked…Now in these days of rather intense study of systems and their management, few seem in the least concerned about…the characteristics of the whole system in any but a very narrow sense. If Leibniz was right, then modern theories of system design and managerial control are sadly lacking in their reasoning." (pp. v-vi)

I am a designer of business habits. I design ways that human beings— in explicit or tacit collaboration with others—do things to shape their futures by adjusting or changing their habits. Mostly, I work in large institutions. In the process of building new working habits in a number of industries over the years, I have designed and led the development of several complex software systems.

We human beings are creatures of habit, and habits are deeply relevant to the question of wisdom. Even before we notice we are doing it, we act out of structures in which we are predisposed to act in particular ways—ways that are shaped by habits of thought, word, and deed. Most of the time, people pay little attention to the way that acting in habitual and unexamined ways shapes our world. I have for many years been interested in ways of thinking and acting that allow me and my clients to look beneath the world's neatly ordered stories about why and how people do the things they do. Further, because the construction of new habits always involves breaking or reshaping old habits, I also study how to intervene in old habits. As the reader will see, these matters are deeply relevant to the subject of designing and building systems that support wise action in organizations.

The chapter is organized into five parts followed by a short conclusion.

1. In What is Wisdom? we begin by exploring what we mean by that word and the implications of setting out in pursuit of it.
2. In What About Wisdom in an Organization? we do the same with organizations, asking questions about what happens to people when they work together in organizations.
3. In Churchman's Gathering of Philosophers, I turn to a series of reflections on the philosophical traditions in which C. West Churchman gathered five philosophers to help him in his work and open an exploration of what those traditions tell us that could be important for the job of IT designers.
4. Preparing the Way for Wisdom in Organizations offers a set of reflections about underpinnings, or conditions, in which wisdom can be cultivated and exercised in organizational settings.
5. A Well-Tooled Investment Management Process sketches a case example of design, implementation, the underlying logic of a set of practices and supporting tools for investment management in large organizations, and makes a series of specific recommendations for systems designers.

WHAT IS WISDOM?

For Churchman, knowledge bespoke an accumulation of the capacity to act wisely. His interpretation of what would need to be examined in order to develop systems that engender wise action was remarkable. Courtney (2001) tells us that Churchman saw knowledge as at once collection, activity, and potential:

1. Deeply connected to action, "a vital force, which makes an enormous difference in the world," in the midst of action, or as "potential for action";
2. Dynamic, as one of knowledge is able "to learn as circumstances change";
3. Somehow deeply connected to ethics and morality; and
4. In some way requiring the actor to break with rationalist scientific traditions and become entangled in one's own feelings and thought processes. (p. 22)

In this chapter, we want to interpret wisdom as the substrate of what Churchman was observing—the base metal if you will. We will explore the construction of wisdom and its appearance in enterprises so that when it comes time to cultivate or accumulate wise action, we have explored what that is and where it comes from.

Looking in http://www.dictionary.com, we find wise defined as "Having the ability to discern or judge what is true, right, or lasting; sagacious: a wise leader."2 The behavior of organizations,3 and of people working in organizations, seems at first glance to be a good place to observe everything but wise behaviors. Something about the notion of a wise organization is oxymoronic, like a deafening silence. Why are organizations not automatically bastions of wisdom? After all, a whole lot of people should be smarter than any one of us, right? Our experience with the behavior of people in organizations tells us that this logic doesn't work reliably.

Let us first turn our attention more to the question of what we mean when we say wise or wisdom. Think back to an interaction you had at some moment in your life with someone you consider wise. Think about what happened before, during, and after your saying to yourself, or to another, "That is wise," or the equivalent. Here are three examples of my own, the first personal and the second and third institutional. See how your example is similar to and different from these examples:

1. During our teens, 20s, and into our 30s, my younger brother and I were not close. He is two and a half years younger and on coming into adulthood, he concluded that I was not interested in listening to him or learning from him. For my part, I carried forward one of those standard older brother irritations with the too-full-of-himself younger brother. As a result, when we were together at family affairs, we would be found at opposite ends of the room, and we did not speak between such events. Unbeknownst to me, as he came into his thirties, my brother had shared with our mother his yearning for a relationship with me. In the spring of 1984, my wife suddenly became very ill, lost the child with whom she was nearly at term in her pregnancy, and found herself at death's door. In that moment, my mother called my brother and said to him, "I know that you have wanted a relationship with your brother. He is in trouble and he needs you. If you want that relationship, figure out how to drop everything and go and be beside him immediately, where he is sitting in the hospital praying and waiting to see what will happen with his wife." He followed her suggestion, and, in the ensuing weeks, our relationship transformed.
2. Perhaps some of you reading this are familiar with the "Iron Ring" that Canadian Engineers wear on the fifth finger of their

right hands. The ceremony in which the ring is delivered to a young engineer about to graduate from engineering school, called the "Ritual of the Calling of an Engineer" was invented early in the 1900s by the engineering professors Herbert Haultain and Rudyard Kipling after a railway bridge to link Winnipeg, Manitoba, and Moncton, New Brunswick twice collapsed while under construction, over the course of 10 years, at a human cost of 85 lives and untold other damage. An inquiry revealed that the collapses resulted from errors in judgment by the bridge's engineers. Haultain and Kipling invented the ritual to alter Canadian engineers' sense of their responsibilities and their experience of the realities of their profession. Graduating new engineers are told, "The ring itself symbolizes the pride we have in our profession while, at the same time, reminds us of our humility." The humility is cemented into the memories of those engineers by the fact that the rings were originally crafted from the iron of the bridge that collapsed.4

3. A decade ago, I was working on the management practices at one of the world's largest copper mines, operating more than two miles up, and at the end of one day, a colleague of mine arrived back from the smelter in a terrible mood. A young man he had met and formed a small friendship with had died during the day when a huge oven belched a cloud of toxic gas while he was walking across the top of it. I asked my colleague many questions about the accident, and here is what we pieced together. This had happened before. I don't remember the numbers, but let us say there had been three deaths over the previous four or five years. The conditions in which the belching occurred were understood by the engineers but could not be predicted or stopped in any way that the engineers could figure out. The engineers involved were skillful, well-educated, and dedicated. All of the deaths recorded under these circumstances were of young workers. I suggested to my colleague that he discuss with the responsible engineers and managers the advisability of a new work practice to the effect that young workers would not go onto the top of this oven without being accompanied by an older worker. In the discussion, some older workers acknowledged that they sometimes had a weird sense about when not to be on top of the oven, a sense that they obeyed, although they did not even know how to describe it. The new work practice was instituted immediately and without further discussion.

Using only these few examples as a point of departure, what can we begin to say about wisdom? Here are some of the elements that I think are essential:

1. When we enter into a conversation about wisdom and wise action, one of our central concerns is to intervene in some set of current behaviors, to bring about possible futures that will not otherwise happen, and to lead people away from other futures that would be better avoided. I am grateful to James Gosling (Sun Microsystems, inventor of Java) for introducing me to the use of the word goofy for pointing to situations in which sincere, otherwise intelligent people behave in ways that are wildly inconsistent with their ambitions, declarations, and/or capabilities. A whole lot of behavior in organizations, including much of what we call bureaucratic behavior, is goofy.
2. Wisdom is born in a concern for action to take care of things that matter to people, and it is fundamentally connected to human bodies and language. Wisdom is something that we ascribe after some actions are taken in response to some set of circumstances

that we find in our world. The actions can be of word or deed, but they are not purely cognitive actions.

3. Some change, or learning, or new adaptation is possible in the moment of such actions. Wise people have their attention on different things than those who are primarily absorbed in everyday activities. Before the actions, there was a continuity of circumstances, but in the moment of action, the whole world changes. Deep caring and solidarity is evidenced in the way that the wise party acts to take care of things that matter to the futures of the other party.
4. Wisdom happens in the right kinds of conversations and practices and in the right kinds of communities. It is not a solitary occupation. Buddhist monks who spend years or even decades apparently alone and silent are participating in conversations that have been going on for generations.
5. The wise party in an event of wisdom is using the moment of change to illuminate, emphasize, and expand some human ethical values. Wisdom is about getting the best out of individuals and communities of people and inventing futures and relationships from a new expanded point of departure. To be wise is to be able to observe deep and abiding stabilities and regularities in the world. We are each born unable to care for ourselves; the sun comes up every morning and goes down every night; each of us will die, and we do not know or control the moment of our death. At the same time, to be wise in action is more about changes than it is about these regularities that are the foundations of wisdom.
6. At the moment of the intervention (about which we will subsequently say, "That was wise"), it is not clear that the intended beneficiary of the wisdom actually has the qualities, virtues, or skills that are called forth by the wise action. The wise speaker or actor is, in effect, making a bet that the other parties have those qualities, virtues, or skills as possibilities, is inviting those parties to commit themselves to learn and grow, and is inventing a future out of that invention and invitation.

Now, for a moment, before we go on in our exploration of wisdom and wisdom in organizations, let us consider the alternative. Not all opportunities for wise action produce reinvented relationships, transformed professions, or lives saved. We have all spent countless hours observing and participating in conversations in which people were communicating with each other, but the actions that bring the moment of wise action were missing:

- Someone declares responsibility for a matter of concern.
- Someone proposes, offers, or requests new actions.
- Someone criticizes the results of our historic actions as being below what we are capable of.

What do we observe instead of wisdom? People immobilized in the moment of possible action; people repeating standard actions from the past; people in private conversations of intentions, but not in action.

The moment of a possibility of wisdom is a moment in which people are called to respond to some situation with integrity and authenticity, stepping outside of traditional ways of observing the situation, entering a domain in which they put themselves at risk of being ridiculed or assessed negatively by the community of their peers. In this regard, my colleague Guillermo Wechsler reminds me that this conversation about wisdom is also a conversation about a human tragedy—about the enormous numbers of intelligent caring people who are coupled together in the wrong ways—having organized themselves to continue their lives along paths of behavior that are recurrently unproductive, self-defeating, or, worse, that literally produce damage to the lives involved.

Finally along these lines, a deep look into the question of wisdom will also show us that sometimes it is better to be silent. Sometimes we call someone wise after we see that they have "smelled" a tragedy coming, and then let it happen, thereby bringing hidden emotions to the fore, unfreezing the situation, accepting the consequences, and building out of that with relentless intention. Sometimes it is wiser to be patient and wait, let things happen, and deal with the ensuing mess.

Then we need to conclude that wisdom is paradoxical, contradictory, controversial, and sometimes vexing. It does not follow the kinds of rules under which we build stable recurrent practices or systems. Think about how we understand the roles of managers and leaders in enterprises today. Professor John Kotter5 (1990), Harvard Business School Professor and expert on leadership, tells us that:

"... the pioneers who invented modern management… were trying to produce consistent results on key dimensions expected by customers, stockholders, employees, and other organizational constituencies, despite the complexity caused by large size, modern technologies, and geographic dispersion.… Leadership is very different. It does not produce consistency and order, as the word itself implies. It produces movement. Throughout the ages, individuals who have been seen as leaders have created change, sometimes for the better, and sometimes not." (p. 4)

Building on top of the claim that we should understand wisdom as associated with actions responding to circumstances we encounter, we can add one more distinction at the beginning of this exploration. I propose we distinguish three levels or orders of wisdom to observe from:

1. Level One Wisdom has to do with learning from mistakes, finding ways to eliminate waste, inventing shortcuts, the like. Continuous improvement programs set up the conditions for this level. Finding ways of doing more with less is an example of the kind of result of this level of wisdom.
2. Level Two Wisdom is what is needed for producing discontinuous changes. Instead of learning from your mistakes or eliminating waste, you invent circumstances in which particular mistakes or wastes cannot happen. Poka-yoke is a Japanese expression that originated in the Toyota Production System that means a way of eliminating mistakes by design. Simple mechanical examples are the throttles on railway trains that stop the train if continuous pressure is not placed on them or switches for dangerous equipment that stop the equipment if the operator's hand leaves the switch before a hand can come into contact with the equipment.
3. Level Three Wisdom is where I will speak about philosophical breakthroughs and reinvention of social realities. Such wisdom creates alternative interpretations of what is possible and builds new discourses in which to observe changes. The Toyota Production System, an example, creates a kind of mass production in which each car is customizable as it moves down the production line. It is less expensive to put quality into a production line than it is to leave it out, the absence of inventories helps, rather than hindering the process of producing, and in which the place to put the final authority for determining when the production line needs to stop for process repairs is in the hands of the lowest employees on the totem pole.

Wisdom is not something that lands on the planet automatically like moonlight; it belongs to the world of intentional human action, not to accident, and it has been the subject of intense attention for millennia.6 To call someone or something wise is to make an historical assessment 7 that we ascribe to particular behaviors within specific traditions and structures at particular moments of time. We cultivate the capacity to make that assessment within the communities that ascribe wisdom to particular behaviors. Human beings live uncertain existences. We live with historical possibilities, facts, courage, and to navigate in our worlds we make judgments and interpretations to underpin our actions. As we invent meaning and actions for ourselves, we invent assessments like wise (and standards for judging what we mean by them) when we need them for preparing a space of action. Whom shall we turn to in the moment of a particular difficulty? Why, someone wise in the matters at hand, of course!

What About Wisdom in an Organization?

Now let us turn our attention to wisdom in organizations, per se. The first thing that we will do is to introduce several questions and foundations that we will employ for thinking with you about wisdom, mostly without resolving them.

Do you admire the way that the bank handles your questions, the supermarket manages your experience, the dealer handles the maintenance of your car, or manufacturers of things you buy handle your questions and suggestions? We may admire the wisdom of someone in dealing with his children, spouse, or even colleagues or employees in his company, but a wise organization? Can you remember a real sustained experience with an organization that learns from its mistakes, as Churchman dreamed?

Even those small community and fraternal organizations over which we might think we have the greatest control are often sources of epic frustration. I listen to my neighbor: "You will not believe what just happened at the neighborhood association meeting." (Yes, I will.) Does anyone admire the way our governments interact with us? Take a deep breath and prepare yourself to stand patiently in line and wait. When, as does occasionally happen, we have the experience of someone in an organization listening carefully and acting with alacrity in response to our request, this is an occasion for a celebration. "A miracle happened!" My wife will begin a report of that rare event: an organization acting wisely.

Some institutions produce disproportionately large numbers of people adjudged wise in their communities. Consider, for example, the histories of the great religious institutions of the East and West, the institution of science itself, and the institution of medicine down through the ages. These are not the only examples by any means. Can you think of other examples of your own? Why does this happen? And why are these histories so uneven? Why great wisdom at some moments and behaviors that we would call stupid, self-serving, or even criminal at others?

Churchman (1968) speaks particularly of his admiration for the institution of science and points directly at the revolutionary nature of the life of that institution:

"The inspiration of Singer's story was his account of the history of science, one episode after another in which complacency was shattered, by Copernicus, by Newton, by Einstein, by Heisenberg. One 'ideal' of progress is to create the 'optimal' shatterer of old tablets, a shatterer that does not simultaneously shatter all chance of further progress in the cooperative ideals. Mood plays its part in all this process: The mood of the cooperative ideals is sanguine, phlegmatic, comic; the mood of the shattering ideal is filled with despair and joy, is tragic." (p. 215)

Sometimes organizations exhibit behaviors we call wise, and sometimes they do that over long periods of time. We can find examples of moments in which leaders set organizations on paths that produced luminous results for the people in and served by those organizations. Consider, for a big example, the founding of the United States of America. This country also provides ample examples of goofy behaviors, for example, in a long history of supporting oppressive dictatorships around the world while we have simultaneously kept our borders open to new citizens and espoused freedom, equal opportunity, and governance under the rule of law.

The point of organizations has to do with what we can do together that we cannot do alone. Working in organizations, people can do things the scope and scale of which is not possible for individual people or even for people gathered together in other assembly. It is in what we call organizations that we human beings constitute the capacity to deliver products and services of an extraordinary variety on local and global scales. Effective organizations create value for their clients and customers, focus on expanding possibilities for them, and demonstrate commitments to cultivating authentic styles. When those characteristics appear together, we create space for people to be wise in that culture.

Here is one source of confusion in the matter. Organizations are not human unities; they are unities constituted of and by human beings. Frequently, we describe the behavior of organizations with analogies, metaphors, and assessments that are more properly applied to human beings. I will do that in this chapter. For example, we can, with validity and to good effect, characterize organizations as existing in or having emotional states or moods.

Nevertheless, I insist that humans and organizations are different kinds of beings. The temptation to anthropomorphize organizations—to speak of them as collective human beings—is not valid and will mislead us in this conversation. Organizations, per se, are not capable of being wise. We need to look to human beings, not the organizations in which they work, for wisdom. The central reason for this is that wisdom comes from a capacity made up of other capacities that are dependent on the existence of human will and intellect, the emotions, and other structures, all of which require the presence of a human body.8 People sometimes are wise; organizations are not.

Churchman pursued the question of how an organization could learn from its experience. What does this mean? I propose that it means, for a start, that people in such an organization would continuously adjust the organization to the concerns of client/constituents and to changes in the world. The organization will be continuously reinvented in ways that encourage people to listen to each other, bring people together to be responsible for things that matter in the world, and so forth.

If we look closely at any moment of organizational reinvention, we will see that one or more people are speaking, guiding the institution into a new future. We may call these phenomena one of the attributes of wisdom in organizations. When this happens repeatedly over time, if we look closely, we will see that the institution has organized itself around a set of rules and practices (sometimes set out explicitly in documents of its governance and more often embodied in a common sense shared by those responsible for the organization) that govern its operation by (1) specifying who will occupy certain roles of responsibility in which they promise to take care of the future of the organization and (2) specifying who will declare those roles obsolete over time and see that they are changed. I think that families often are more reliable than traditional business organizations for taking care of these particularly important roles over long periods.

We speak about wisdom in many contexts, especially in ethical and spiritual domains, in spiritual, religious, and community leaders, in the arts and the helping professions, in commerce, and even in politics. We also find people speaking of wise executives, salespeople, or even sometimes criminals —people in roles in which the purpose of their actions is the economic, political, or social benefit they derive from their actions.

When we ascribe wise behavior to those in such instrumental roles, we have crossed a line. We can ascribe wisdom to players in instrumental roles, but we should be careful when we do so. Is the experienced salesman wise in recommending to us options on a vehicle when he will sell it to us and then take a profit from the sale? Remember that the slang name for members of certain criminal gangs is wise guys. Wisdom is deeply connected to ethics; we will explore this more carefully later in the chapter.

I will not deal with the kind of wisdom that is merely synonymous with smart or intelligent. Significantly, organizations that are structured or managed in ways that do not encourage (or permit) relationships among its people that are more than exclusively instrumental (e.g., relationships that are not connected to the purposes of the business) will be unable to produce any but the shallowest kinds of wisdom, or being wise in such organizations will simply not be relevant.

Inevitable Goofiness

Over time, all organizations become rigid, fall out of touch with the worlds they were constituted to serve, and behave in goofy or sometimes even criminal fashions. As time passes, every organization accumulates rigidities and practices that lead, inexorably, to these kinds of behaviors. How does this happen? (If we look closely, we will see that organizations that are successful over long periods are periodically reconstructed, sometimes violently, sometimes quietly.)

One of the central mechanisms for accumulating rigidity has this remarkably simple and apparently benign structure of action:

1. Something goes wrong.
2. Those responsible act to repair the situation.
3. At the same time, those responsible put in place mechanisms to prevent the same error from happening again.
4. They do this with rules, new procedures, changes in roles, and so forth.

Ronald Heifetz (1996) points well to the heart of the matter in Leadership Without Easy Answers:

“Living systems seek equilibrium. They respond to stress by working to regain balance. If the human body becomes infected by bacteria, the system responds to fight off the infection and restore health…These responses to disequilibrium are the product of evolutionary adaptations that transformed into routine problems what were once nearly overwhelming threats. Looking backward in time, we marvel at the abundant success of these adaptations and the breadth of exploited opportunities. Yet we tend to notice the successes and innovations more than the failures. By definition, the successes survive while the failures disappear. The roads of evolution are strewn with the bones of creatures that could not thrive in the next environment.” (p. 28)

We are saying that organizations accumulate rigidities as a consequence of the same thing that underlies their faculty as a place for generating wise behavior—they are made up of human beings. What happens in an organization is a lot like what happens when a patient of modern Western medicine has a bunch of prescriptions: the remedies begin to interact badly with each other and produce second and third-order side effects. In organizational life, if we look carefully over time, we will see that as time passes the majority of our prescriptions are dealing with the unintentional side effects of other previously applied prescriptions.

The general situation in human organizations is the same as the case of medicine. The behaviors of the people in the organization are habitual. When we install repairs and modifications to avert future occurrences of an error, if we look carefully, we will see that the conditions that led to the error are often preserved so that the difficulty will arise again but next time in new clothing so that we will not recognize it. Over time, the accumulation of a propensity to goofiness in organizations is inevitable, and periodic reconstruction is required.

ORGANIZATIONS AND AUTHENTIC WAYS OF BEING

One of Churchman's central questions, repeated often in his work, concerned the interplay of the parts of a system and the whole system, understood as a unity. Let me start a new approach to this question. In this chapter, we will come back to this question repeatedly, asking first the question, "who is observing the unity, and on what basis does a person interpret that as a unity?" At this moment, I want to start this process by introducing the notion of authenticity, which I take principally from the philosopher Martin Heidegger.9 Heidegger was convinced that it is impossible for human beings to make good sense of our lives except in the context of a process of continuous reinterpretation of our entire situatedness in the worlds in which we dwell. I think this is more than analogy to the question that Churchman posed; it is a foundational distinction. The question, as I said a moment ago, is this: who is observing the unity? Those who are considering a system and its relationship to ourselves, our work, and our worlds—that is, ourselves—cannot make sense of who we are as observers and speakers unless we have a very specific kind of understanding ourselves. In the process of constructing that understanding, we must have avoided exactly the same trap that Churchman fears—the decontextualization of ourselves—not at the level of the system but at the level of the individual human beings who are conceiving the system and of the individual human beings who will be the beneficiaries of the system.

We understand ourselves well, Heidegger tells us, only in the midst of our worlds, and not abstractly (Dreyfus, 1991, p. 10ff). As we conduct ourselves in our worlds, we are thrown (taken, or swept away, by our normal ways of being) to inauthentic ways of being. Ironically, those inauthentic ways of being provide us with signals inviting us to construct ourselves authentically.

There are two principal inauthentic ways of being. The first is falling into normal everyday busyness—coping with our anxieties and problems by throwing ourselves into activities that are familiar to us from our histories and experience, activities that we hope will suppress or tranquilize our anxieties because we remember that they have worked for us in the past. The second is becoming frozen in fearful patterns of conforming to accepted everyday behavioral norms. Can you see that organizations—with all of the kinds of pressures that we tend to find there to follow rules, not rock boats, not offend people, and so forth, are very often effective places for producing inauthentic ways of being? In contrast, authentic being confronts, in a public way, its anxieties and concerns, and invents new ways of being and acting in the midst of the messes of everyday life. You can see examples of this characteristic in each of the wisdom examples I gave at the beginning of this chapter. Can you think of examples from your own life?

Heidegger (1962) characterized humans as having a way of being the central focus of which is the issue of being:

"... to work out the question of Being adequately, we must make an entity — the inquirer (sic) —transparent in his own being. The very asking of this question is an entity's mode of Being; and as such it gets its essential character from what is inquired about—namely, Being. This entity which each of us is himself and which includes inquiring as one of the possibilities of being, we shall denote by the term 'Dasein.'" (p. 27)

Working in modern organizations may not be a healthy practice for building the kind of observer who can help Churchman with his inquiry. Most of us cannot avoid working in organizations of some size; none of us can avoid interacting with organizations. John Kotter (1990) concludes that training as a manager or executive in a (Western) corporation is not good for building wisdom. (He speaks of leadership, but if you listen carefully, you will see that what he calls leadership is a kind of wisdom-on-the-hoof.)

"For the vast majority of people today, including most of those with leadership potential, on-the-job experiences actually seem to undermine the development of attributes needed for leadership.… managerial careers in many corporations produce individuals who are remarkably narrow in focus and understanding, moderately risk averse, weak in communications skills, and relatively blind to the values of others. They produce people who know little about competitive business strategies, who have limited credibility, and who know more about how to play games with a budget than how to celebrate the real achievements of their people. Four characteristics of managerial careers seem to be particularly important in producing these [negative] results. First, these careers usually begin in centralized and specialized hierarchies and, as such, in jobs that are narrow in scope and tactical in focus.…[Second,] promotions in many firms are almost entirely up a narrow, vertical hierarchy.… [T]he knowledge and relationship base of successful people is often extremely narrow; they understand only one aspect of the business and only one group of people in their corporation.…[Third,] moving through jobs every twelve to eighteen months, these people rarely have an opportunity to learn anything in depth, and never see the longer-term consequences of their actions.… [Fourth, and] perhaps most damaging of all… all too often, people are rewarded almost exclusively for short-term results. As a result, most individuals focus on the process that produces those results-- management. This is especially true for ambitious young people. Because of this, they learn little about leadership. Since developing the leadership potential of others is also not a short-term activity, senior executives are strongly encouraged by such reward systems not to invest time in such an activity. The overall result can be devastating." (p. 119ff)

The question and reflection that I would like to bring to the reader at this moment in the conversation is this. While on the one hand there are obvious reasons that someone could be interested in knowledge or the cultivation of wisdom as Churchman was, on the other hand, the cultivation of wisdom and knowledge is not a mainstream concern in organizational life today. What was it about Churchman's interests that took him in this direction?

CHURCHMAN'S GATHERING OF PHILOSOPHERS

Churchman gathered five philosophers to help him in his work. What was he doing when he did that? What can an exploration of those traditions tell us about what could be important from the work of philosophers for the job of IT designers? Many computer scientists and IT professionals read at least some philosophy; few study it broadly, and few write about it. Churchman put five philosophers into a thought exercise, in which he asked and answered questions—inquired— about how systems might participate in the creation of knowledge.10

Here is my next question: What was Churchman doing with his five philosophers? Why did he bring them to the conversation? Why these five—Gottfried Wilhelm von Leibniz, John Locke, Immanuel Kant, Georg Wilhelm Friedrich Hegel, and Edgar A. Singer, Jr.—and not others? What did he intend we understand in the conversation? How did he intend to alter us, his readers, and students with this thought experiment of his?

There are various ways that we can interpret what he was doing with his five philosophers. I propose the following interpretations for the reader's consideration. I warn in advance that I am not going to claim that any one is right. The point here is to go beyond the standard conversation about using each as emblematic of a member of taxonomy of organizational types. I invite an exploration in which readers get their own answers.

1. Perhaps each philosopher is symbolic of a particular style of inquiry that we can see was important in that philosopher's work and life. Churchman, the argument goes, saw certain virtues and vices of each of the styles he characterized with the help of the philosophers, and he uses their names to compare and contrast these styles. In this sense, the name of each is iconic, representing that style. Leibniz stands for analytic deduction, Locke for consensual induction, and so forth.
2. Perhaps the first four are foils for Singer, Churchman's teacher, whose answers Churchman may have preferred for the questions of how to productively inquire. The role of each of the first four, in this sense, is to help Churchman show dimensions of Singer's propositions that would otherwise be cumbersome to show. In this sense, the name of each of the four stands for an era of incomplete thinking about how to constitute human enterprise, and Singer, though no wiser necessarily than the others, stands on their shoulders, just as Churchman stands on Singers'.
3. Perhaps, as a trained philosopher himself, Churchman gathered around him a gaggle of philosophers to provide a space of conversation through the implicit dialogue, in which certain deep questions could be revealed more richly than they might have been in a straight textual description. In this sense, the entire sensibility of the work of each philosopher is important, and their names point us to the concerns of each in the times in which they worked on those concerns.
4. Perhaps Churchman used the device of introducing an argument among the five philosophers as a way of inviting his students into a richer investigation of the philosophical literature as a foundation for thinking about the design of systems.
5. Finally, perhaps Churchman—not fully resolved himself about the place of inquiry in the operation of organizations—was using the five philosophers' work to inquire into the nature of inquiry in purposeful social interchange.

Churchman chose five philosophers to bring to the party, introduced them and certain aspects of their work to us, and then, through his writings, invited us to go on in conversation with him and with them for as long as the questions he was asking yielded fruit. He did not invite other philosophers whose work we can guess he knew. Why did he do these things? I propose that insufficient attention has been given to this question and invite conversation about it. I do not find in the literature much in the way of additional exploration along the lines that Churchman was exploring.

Let us ask now about a series of themes we can discern in the work of those philosophers Churchman gathered around him. I think that these same themes appear in his questions about knowledge and systems. In the following, I invite you to explore with me three concerns that all six philosophers (I include Churchman himself) grappled with. I will call these concerns (1) the ambitions of philosophy; (2) the problem of what a thing is, objectivity, and the problem of the observer; and (3) the problems of ethics, morality, and value. Obviously, in the limits of this chapter, I will only touch on these questions, but I do so in the spirit of offering a provocation—an invitation to the reader to consider more deeply what Churchman may have intended with his gathering of philosophers. The reader will notice that in order to do this, I have assembled my own group of philosophers with the help of Anthony Kenny,11 and that my group includes some new faces.

The Ambitions of Philosophy

Churchman, a trained philosopher, did not attempt to avoid standing in the middle of traditional philosophical ambitions as he worked in his adopted country—the field of computer systems. My impression is that we can appreciate some of Churchman's thinking by looking at the ambitions of the field of philosophy as a whole. Werner Ulrich, a student of Churchman who is now a professor in his own right, quotes his teacher in "An Appreciation of C. West Churchman," talking about Churchman's (1968) concern with the ignorance of the investigator in critical matters, and the centrality of the unity of the system as a whole: "How can we design improvement in large systems without understanding the whole system, and if the answer is that we cannot, how is it possible to understand the whole system?" (p. 3).

Ulrich (1999) explores Churchman's conviction:

"The systems idea, provided we take it seriously, urges us to recognize our constant failure to think and act rationally in a comprehensive sense. Mainstream systems literature somehow always manages to have us forget the fact that a lack of comprehensive rationality is inevitably part of the conditio humana. Most authors seek to demonstrate how and why their systems approaches extend the bounds of rational explanation or design accepted in their fields. West Churchman never does. To him, the systems idea poses a challenge to critical self-reflection. It compels him to raise fundamental epistemological and ethical issues concerning the systems planner's claim to rationality. He never pretends to have the answers; instead, he asks himself and his readers a lot of thoroughly puzzling questions."

Now we turn to Anthony Kenny (1997), who tells us that this struggle of Churchman's implicitly belongs to philosophy:

"The ambition of philosophy is to achieve truth of a kind which transcends what is merely local and temporal; but not even the greatest of philosophers have come near to achieving that goal in any comprehensive manner. There is a constant temptation to minimize the difficulty of philosophy by redefining the subject in such a way that its goal seems more attainable …even the greatest philosophers of the past propounded doctrines which we can see—through hindsight of the other great philosophers who stand between them and ourselves—to be profoundly mistaken. This should be taken not as reflecting on the genius of our great predecessors, but as an indication of the extreme difficulty of the discipline…But we philosophers must resist [the] temptation [to understate the difficulty]; we should combine unashamed pride in the loftiness of our goal with undeluded modesty about the poverty of our achievement." (p. 368)

Thus, this central question of Churchman's and something important about the form in which he held the question, he shared, in important ways, with philosophy as a tradition. He knew it was a central question to be confronted by any who would dare to think how to think in the domain in which he had chosen to work, and he knew that it would not be easily answered.

What is a Thing, Objectivity, and the Observer

Churchman and his five philosophers were profoundly aware of the danger of assuming the validity of prevailing common senses about the nature of things, objectivity, and the role and capacity of any observer to observe objectively. Philosophers' concerns over these questions have never abated over the last two millennia. To speak in a way that transcends the local about the interplay of designers, organizations, and systems of things supporting people working in organizations, philosophy teaches us that we need to stand on good interpretations about what these things are—people, things, and gatherings of people. To address the question of how organizations might better learn from experience, Churchman was looking for answers to these questions.

Churchman gave center stage to something he called inquiring. What did he mean by this? Who inquires? About what? He was particularly interested in the how part of the question. I take it that he was not calling primarily for a process composed of questions and answers, nor for a narrow questioning style, but instead was looking for something broader—particularly, I suspect, inquiring as a style of openness to different interpretations about the world and the actions we are taking in it. And, he was surfacing the problem of the observer and objectivity. On the other hand, he was calling for the invention of processes, rather than questioning the nature and role of the human being in the center of the puzzle, as we saw Heidegger doing earlier in this chapter. My opinion is that the absence of this element in his questioning marks a serious weakness in his overall project of inquiry.

Churchman speaks of constructing effective powers of observation through the application of diversity: "To deal with such connectedness … Singerian organizations must deploy UST to go well beyond the bounds of the other four organizational styles, by bringing in multiple perspectives or worldviews, and employing a holistic systems approach in their thinking and decision-making processes" (Courtney, 2001, p. 20).

Courtney goes on to show elements of the richness of what Churchman had in mind—ethics, spirituality, and aesthetics—and to show Churchman's dissatisfaction with a strictly scientific orientation:

"The multiple perspectives approach does not end with the technical, organizational, and personal perspectives. It also explicitly brings ethics and aesthetics into play. Many factors in the Industrial Age, the machine metaphor, the desire for "objectivity" and "rigor" in academic work, modeling social science research on "hard science" approaches, and the study of "rational man" to the neglect of our "spiritual" being, have all led to the demise of ethics, morality and aesthetics in decision making today. As we move into the Information Age, or perhaps the Knowledge Age, we seem to be stuck with this legacy of neglecting the factors that make us human." (p. 29)

More than 200 years ago, Kant concluded that the nature of things is inescapably unknown to us: " 'If we take away the subject space and time disappear; these as phenomena cannot exist in themselves but only in us.' The nature of things in themselves is unknown to us" (Kenny, 1997, p. 171).

Arthur Schopenhauer, who followed Kant by a few decades, shifted the place of the observer in the conversation and put the observer under the microscope in a new way:

"The empirical world exists, for the subject, only as representation: 'every object, whatever its origin, is, as object, already conditioned by the subject, and thus is essentially only the subject's representation'... The search for the thing-in-itself behind the representation is futile, so long as we turn our thoughts towards the natural world. Every argument and every experience leads only to the same final point: the system of representations, standing like a veil between subject and thing-in-itself. No scientific investigation can penetrate the veil; and yet it is only a veil, Schopenhauer affirms, a tissue of illusions which we can, if we choose, penetrate by another means."

We are not merely the knowing subject, but that we ourselves are also among those entities we require to know, that we ourselves are the thing-in-itself. Consequently, a way from within stands open to us to that real inner nature of things to which we cannot penetrate from without. [Kenny's emphasis] (Kenny, 1997, p. 212)

At about the same time, others, including Hegel, were moving in the same direction, asking new questions about the observer and how to understand the observer in ways that allow us to responsibly make sense of what he observes.

Churchman, Courtney tells us, puts the Singerian inquirer at a level of extreme abstraction, "above teleological, a grand teleology with an ethical base" (Courtney, 2001, p. 28). We need to give full credit to Churchman for his ambition and the validity of the concerns he brings us, but I am not happy with Churchman's thinking in this regard. Perhaps from his commitment that the observer needs to be looking at systems as a whole, he does something that I regard as a serious mistake and attempts to raise the observer to a lofty position of omniscience. He does not confront the real difficulty at the center of this dilemma.

Singer's better known contemporary Martin Heidegger made important contributions to this discussion that do not appear in Churchman's thought experiment. Following the tradition from Kant, Heidegger distinguished between persons and things and then distinguished further between the ways of being that things are for people when those things are held conceptually and when they are held practically in action. He distinguished between the way of being of things when they are ready-to-hand—having a way of being that is experienced in the middle of their use (as in hammering a nail)—and when they are present-at-hand—experienced as conceptual or abstract objects as when knowledge is contained in a database [my emphasis]. I think this is important when we are considering how to think in regards to building systems.

In Churchman's conversation with his five philosophers, I have the impression that he never escapes the grip of pre-Heideggerian Western analytic philosophy and, under the influence of Singer, moves to ever-more abstract ways of interpreting knowledge, leaving the role of the observer largely unresolved. His worthy ambitions demand more.

The Problem of Ethics, Morality, and Values

Churchman exhorts his readers to put the concerns of ethics, morality, and values in the front rank of their attention, at least alongside rational logic. Courtney (2001) sums up Churchman's understanding of the interplay of knowledge, acting, learning, and moral and ethical values as: "Thus, one might say that knowledge involves the ability to act intelligently and to learn. Wisdom guides knowledgeable actions on the basis of moral and ethical values" (p. 23).

It should be clear from the first and second sections of this chapter that I agree fully with Churchman that the exercise of wisdom and learning are ethical occupations and that architects and designers should put these questions in the center of their concerns. I'll say more about this in the next section of the chapter.

As a provocation, however, I would say that I understand the way that these matters interrelate with each other in a radically different way than does Churchman. Here is how I will put my version of the proposition that Courtney articulates for Churchman just above: People ascribe wisdom and knowledge to actions enacted from embodied structures of ethical behaviors, and learning ensues from repetition of the action together with reflection on those actions and the consequences of the actions.

I will spell out why I say this in the next section of the chapter.

PREPARING THE WAY FOR WISDOM IN ORGANIZATIONS

In this section, I will offer a set of six tiny essays that invite reflection about the construction of the conditions and situations in which wisdom can be cultivated and exercised in organizational settings. The essays are:

- Taking Language and Listening Seriously
- Language-Action and the Constitution of Organizations
- Preparing for Ethical Action
- Learning and Competence
- "Inventing" Waste
- Pain-Free Wisdom?

Taking Language and Listening Seriously

Language, including the misconceptions and confusion that abide in it, underlies everything we understand and know and all our actions. We encounter and invent ourselves in language. What we find desirable and fearsome, our ambitions, doubts, and resignations, the identities in which we make sense of ourselves, those we live and work with, and our worlds, all these live in language. Our problems with things, observers, and ethics all arrive escorted by and clothed in language, and we encounter them only in their clothing, as Schopenhauer pointed out. Heidegger called language "the house of being."

The warp and woof of the tapestry of organizations and the threads that reveal the patterns of that tapestry belong to language. Cars, to take an example, move down assembly lines in the wake of a network of conversations in which an extraordinarily complex set of conversations has set every part of the stage of action, and they move because people are making commitments, to shape, build, sell, and buy. Long before any parts move, design engineers speak instructions telling all concerned how the actors, instruments, and parts will come together into a set of unities that will make sense to all concerned. In operation, production managers lay plans, workers come to work as asked, suppliers deliver materials as promised, and salesmen make offers and customers accept those offers.

All the joys and all the miseries, all the services and all the destruction and waste laid by people working together in organizations begins and is shaped in language. Ethics and values are created, understood or not, passed on, and acted on in language. We speak to each other, and we listen. And, we underestimate, continuously and vastly, the role that language plays in our affairs.

The serious student of wisdom and organizations, I suggest, must put language in the center of his inquiry.

Listening, I propose, is the first prerequisite of wisdom. By the word listening, I point to the biolinguistic process through which we attune ourselves to situations, the concerns of others, our own concerns, and prepare ourselves for action. I distinguish listening from hearing. I use the latter word to point to the mechanics of receiving and decoding disturbances in airwaves, signs, and signals in our worlds—receiving data—what most people refer to as listening. The two are related, but the deaf who were not born deaf listen, just as the blind who were not born blind see. What I call to our attention with the term listening is exemplified by what happens to us when we read poetry or attend a great performance and are touched by it. We are altered by the experience of listening. Listening is partially an automatic process that is out of our control, going on continuously in life, while we are awake and asleep, and the process of listening can be affected, as when "we take a walk" "to collect ourselves" before undertaking a difficult conversation to be responsible for the emotional state in which we will be listening to our conversant. Listening happens all the time and not just when we are listening to spoken language. Here is a partial list of situations in which we can observe listening happening:

- Language spoken and written in our native tongues;
- Distinctions in other languages ranging, for example, from moods and music to finance and marketing;
- Gestures and silence, absorbed and interpreted; and
- Brands, icons, images, art, machinery, offices, and other features of our worlds.

To encounter wisdom in a fresh way, that can give grounding for the work of people preparing tools for working in organizations, we need first to prepare ourselves to get closer to language—to observe some things that happen as we speak and listen to each other.

Listen carefully to the following pair of passages by Gemma Corradi Fiumara (1990) in her book The Other Side of Language, in which she wrestles with the poverty of listening in our time. Neither she, nor Martin Heidegger, whom she quotes, is easy to read. You may have to read each short passage a few times to catch the heart of what she is saying.

"One is often tempted to maintain that the 'richness' of our inner world possesses a guarantee of existence in itself, and that the 'problem' merely consists in knowing how to select the words which are best suited to expressing and representing it in a context of consensus. In this way, we may be tempted to believe that words are 'like a grasp that fastens upon the things already in being and held to be in being' (Heidegger, 1971, p. 68)—a grasp which seizes and compresses. In fact, however, the situation is far more complex, demanding and enigmatic than that. The organization of our innerness seems to exist on condition that it is heard, brought out—in effect brought to be born. It is not just a matter of entities lying there waiting to be linguistically seized and organized in the most diversified expressions." (p. 148)

"To pay heed to what the words say is particularly difficult for us moderns, because we find it hard to detach ourselves from the 'at first' of what is common (e.g., from the common sense that strikes us immediately from what is said); and if we succeed for once (in detaching ourselves from the common sense), we relapse all too easily." (p. 130)

Language-Action and the Constitution of Organizations

For the vast majority of the moments of our lives, including in a great proportion of our sleeping hours, we are doing things in language with each other, and language is doing things to us. The opportunity of this topic is that language-action offers a radically improved path to knowing what we are doing as we are speaking. When we speak, we create new interpretations, moods, possibilities, and futures in the bodies and minds of those with whom we are speaking. Therefore, one of the distinctions that will be essential for us is language-action, observing language as communicative acts.

The English philosopher John L. Austin (1962) was the first to notice the existence of a class of verbs that he called performatives (p. 148)—verbs that, rather than describing actions, perform actions. When someone says "I promise to …," he is performing the action of promising, not reporting that he will, did, or might promise. It turns out that all human languages contain performatives. For the purpose of designing work in organizations, I distinguish six classes of performatives: declarations, offers, requests, promises, assessments, and assertions. The most important and interesting thing about these verbs is that, when we look carefully, we can see that it is with these acts that we human beings invent our futures. Very often we don't actually use the words; people make promises all the time without saying "I promise" and make requests even more often without saying "I request" (for example, "The soup needs salt" and "Don't you think that it is cold in here?"). The roles that the major classes of language-acts play in our invention of our futures?

- With declarations, we create new distinctions—identities, products, roles, services, companies, names, and so forth—with which to take care of our concerns.
- With offers, requests, and promises, we orchestrate new spaces in which we can take action, and we elicit mutual commitment and coordinated action.
- With assessments, we take stock of our world, evaluate our progress, assure that we are prepared for action, and navigate in our projects and worlds.
- With assertions, we build confidence in our judgments and consistent reliable coordination.

Each language action has standard elements which, when recognized, can help guide designers in their specification of systems: speakers, listeners, conditions of satisfaction, time of speaking, time of expected response, time of committed action, and so forth. The implications of Austin's discovery are vast and substantially unrecognized.12 For example, ask the question, "What makes something be an organization?" Within every culture there are a variety of standard modes of business operation that can be observed (sales activities, billing, and so forth) but underneath all of the variety is a more fundamental core. Whether a business is as simple as an individual sitting on the ground with a pile of fruit for sale or it is a multinational conglomerate, and whether it produces tangible goods in factories, provides janitorial services, or operates entirely "on paper," as in many financial businesses,

"A business is created when a person or group of people declares that they will recurrently make certain classes of offers to some population of customers and that they will satisfy the conditions of those offers (deliver what they promised) in exchange for some offer the customer makes in return, or the fulfillment of some request they may make to the customer."

This definition shows several key aspects of how an enterprise is constructed.

- First, it says that the business is created by a declaration. In order to be in business, you have to declare to the appropriate people that you are entering a domain of potential business transactions.
- Second, it says that the business is constituted by classes of offers. If you are in the automobile business, you offer to provide automobiles. If you are in the doctor business, you offer to see and treat patients. A single business may have a variety of different classes of offers but without some public declaration of what they are, the business is not defined.
- Third, to be in business, you must be prepared to satisfy the conditions of the whole transaction: to make offers, recognize acceptance of those offers by customers, complete the conditions of the offers (by providing goods, services, etc.) and recognize that the customer declares the transaction completed to satisfaction.
- Finally and centrally, a business is distinguished from other kinds of enterprises (e.g., charities and governments) by the fact that there is an explicit offer in return from the customer (some form of payment, whether in money or other actions), which is linked to successful completion of the offer made by the business entity.

We can identify these common elements in every business activity we see around the world. Moreover, these structural features of a business belong to how human beings take care of things with each other. The deep structures that we are observing in this conversation have existed since people have been exchanging goods and services, and it is impossible to conceptualize businesses that do not have these underlying structures. In the simplest case, a single individual in verbal communication does them all with customers. In large organizations, each aspect is supported by organizational structures and business processes that have evolved in the ambition to make sure the conditions can be met regularly with a minimum of breakdowns.

Let us take "wise" as an example and look at what it is from the perspective of language-action. Wise, as I said earlier, is an assessment—a judgment or evaluation made by an observer with a particular background, experience, and concerns that shape that judgment. (Examples of assessments: I am late. The cat is sick. The car is behaving strangely. Your hair is getting long. The project is expensive. The new president is not doing well.) Assessments are never true or false; they are effective or not. Assessments help us make sense of our worlds, our place and progress in it, and, most important, they prepare us to take action in those worlds. Judgments about the state of affairs in my world or yours invite us to consider actions to take advantage of opportunities or avoid dangers.

To ascribe wisdom to someone or to some action is to make an evaluation, and that evaluation originally comes from the mouth (or fingers, gestures, silence, written words, etc.) of a particular individual.

Not only is wise an assessment, but it is difficult to be wise (perhaps impossible) without skill at distinguishing assessments from assertions—the class of language action that we call facts—and without the corollary capacity to test assessments by grounding them with facts. (Examples of assertions: The project is late; 60% of the project deliverables are still incomplete one month before its scheduled end.) We may make an assessment shared by many others, even in very large populations. However, even if a measured majority of the French people of France think that Americans have no judgment or taste, it is still an assessment and not a fact. People can ground their interpretations by citing facts that defend the judgment. The evaluation—an assessment—and the facts brought forth to ground it, which are assertions, are two different kinds of language actions, and they have different purposes.

Assertions—facts that can be observed by a universal witness—are true or false. However, the act of making an assertion—stating a fact—does not invite action, except when for the speaker or a listener, the fact elicits a judgment (assessment) of a shift in the expected future and sets up a condition inviting action. (Just look at those black clouds! Implied: The clouds are forbidding. It looks like rain is coming. Let's get under cover.)

Different observers have different assessments about the same phenomena; the source of the difference is that they do not have the same concerns. (One man's meat is another man's poison. A flat tire for a driver is business for a garage.)

Turning to the implications of language-action for the design of systems, Fernando Flores and Terry Winograd (1986) outline a three point theory of management and conversation in their book, Understanding Computers and Cognition, that shows well many of the features of how software designs could embody the insights we are exploring here:

1. Organizations exist as networks of directives and commissives.13 Directives include orders, requests, consultations, and offers; commissives include promises, acceptances, and rejections.
2. Breakdowns will inevitably occur, and the organization needs to be prepared. In coping with breakdowns, further networks of directives and commissives are generated.
3. People in an organization (including, but not limited to managers) issue utterances, by speaking or writing, to develop the conversations required in the organizational network. They participate in the creation and maintenance of a process of communication. At the core of this process is the performance of linguistic acts that bring forth different kinds of commitments. (p. 157)

Flores and Winograd (1986) further claim, and I am convinced that they are right, that the classical idea of decision making is not well supported phenomenologically, and we can usefully substitute a notion of "dealing with irresolution" and supporting people in coming to resolution (p. 144ff).

Preparing for Ethical Action

The concern for action is central to the question of wisdom. Even the extraordinarily rigorous contemplative activities frequently found in the practices of wisdom traditions, when carefully examined, will be found to have to do with getting prepared for taking action.

At the same time that wisdom has more to do with action and less to do with dry abstraction than many traditions would have us believe, as I said before, Churchman is right about the relationship of wisdom and ethics. Here is Heifetz (1996), again putting the case beautifully in the context of effective (i.e., wise) leaders:

Understandably, scholars who have studied "leadership" have tended to side with the value-free connotation of the term because it lends itself more easily to analytic reasoning and empirical examination. But this will not do for them any more than it will do for practitioners of leadership who intervene in organizations and communities everyday.

"We have to take sides. When we teach, write about, and model the exercise of leadership, we inevitably support or challenge people's conceptions of themselves, their roles, and most importantly their ideas about how social systems make progress on problems. Leadership is a normative concept because implicit in people's notions of leadership are images of a social contract. Imagine the differences in behavior when people operate with the idea that 'leadership means influencing the community to follow the leader's vision' versus "leadership means influencing the community to face its problems." (p. 14)

"If a leader personally wants to turn away from the difficulty of problems, and so do his constituents, does he exercise leadership by coming up with a fake remedy? … socially useful goals not only have to meet the needs of followers, they also should elevate followers to a higher moral level." (p. 21)

Similarly, in The Reflective Practitioner, Donald Schon (1983) reported that he found that the most effective professionals' skills are not built on rational structures learned in school but instead result from intuitions and improvisations built through a process of observing themselves in the midst of their practices.14

The reader may be tempted to discard aspects of this discussion as philosophizing or a matter of semantics. I urge you to be patient and follow the thread of this part of the inquiry. This is not a minor theoretical part of the conversation. Recent discoveries in neurophysiology show clearly that the traditional ways of understanding wisdom as a matter of distilling action from abstract conceptions is wrong.

The cognitive scientist Francisco Varela (1999), trained as a neurobiologist, gave a series of three short lectures in 1994 on conclusions about the construction of wisdom in human beings, which he bases on the intersection of recent developments in the science of mind and the teachings of Eastern wisdom traditions. The lectures have been published as a little jewel of a book entitled Ethical Know-How: Action, Wisdom, and Cognition. "As a first approximation," he says, "let me say that a wise (or virtuous) person is one who knows what is good and spontaneously does it" [Varela's emphasis] (p. 4). Quoting the philosopher Charles Taylor, Varela (1999) says:

"Ethics is closer to wisdom than to reason, closer to understanding what is good than to correctly adjudicating particular situations. … the focus [of the current examination of these questions]

has moved away from meta-ethical issues to a much sharper debate between those who demand a detached, critical morality based on prescriptive principles and those who pursue an active and engaged ethics based on a tradition that identifies the good." (p. 3)

Varela (1999) builds his arguments upon current scientific research regarding the functioning of the brain and the human nervous system. Here are three conclusions that bear on our concerns in this chapter:

1. Truly ethical behavior does not arise from mere habit or from obedience to patterns or rules. Truly expert people act from extended inclinations, not from precepts, and thus transcend the limitations inherent in a repertoire of purely habitual responses. This is why truly ethical behavior15 may sometimes seem unfathomable to the untrained eye, why it can be what is called in the Vajrayana tradition "crazy wisdom." (p. 31)
2. We acquire our ethical behavior in much the same way we acquire all other modes of behavior: they become transparent to us as we grow up in society. This is because learning is, as we know, circular: we learn what we are supposed to be in order to be accepted as learners. (p. 24)
3. Contrary to what seems to be the case from a cursory introspection, cognition does not flow seamlessly from one "state" to another, but rather consists in a punctuated succession of behavioral patterns that arise and subside in measurable time. This insight of recent neuroscience—and of cognitive science in general—is fundamental, for it relieves us from the tyranny of searching for a centralized homuncular quality to account for a cognitive agent's normal behavior. (p. 49)

In a passage that sounds as if Varela were right in the middle of the conversation we are having with Churchman and his five philosophers, Varela (1999) says:

"Were we to entertain the idea that there is no hard and fast distinction between science and philosophy, philosophers such as Descartes, Locke, Leibniz, Hume, Kant, and Husserl would take on a new significance: they could be seen as, among other things, proto-cognitive scientists." (p. 25)

In this background, I propose that in the pursuit of systems that support wise organizational action, architects and designers must take careful note of recent developments in some apparently distant parts of the field of cognitive sciences. Along the way, I propose that some treasured wisdoms of the IT and DSS field should be rethought, including for example, the notions that at the heart of the process is a mental model that decision processes begin with the recognition that problems exist and decisions need to be made.

Learning and Competence

When people set out to increase their competence in some domain, they begin by revealing themselves as having a certain level of competence and also incompetence. Our ability to learn depends first upon our acceptance of our incompetence in the domain in which we will learn. In all great wisdom traditions, there are famous stories about masters laughing at what they do not understand and are incompetent for doing (Dreyfus & Dreyfus, 2000, p. 16).

When we speak of a master, we refer to a person of historical excellence, set apart from peers by participation in the ongoing invention of a domain of practices. A master is not only able to act in that domain; a master can produce important innovations in the standard practices of the domain, revolutionizing the history of the domain. Richard Warren Sears of Sears Roebuck invented catalog sales. Sam Walton of Wal-Mart invented another kind of merchandising. Each changed the face of their industry.

Masters do not differ from the competent or virtuoso practitioners in some domain so much by the character of their performance, as by the concerns they bring to the practice. While a competent person attends to the business of the day and a virtuoso explores the limits of invention inside the domain, the master lives in a larger conversation about the meaning of the practice and its place in the larger culture. By focusing on anomalies (situations in which something appears not quite right or violates the expectations the master has built up from long experience), masters find ways to transform the practice of their skill to take on a different meaning in the culture. While a proficient person or even a virtuoso might pass over an anomaly as an exceptional circumstance, a master may become obsessed with an anomaly. Accidental discoveries, such as the discovery of penicillin or the vulcanization of rubber, offer vivid examples of this phenomenon.

"Inventing" Waste

Historic inventions are often built from historic difficulties, and they always involve the invention of new distinctions. At the end of the Second World War, the people of Japan were in terrible trouble, their morale, productive capacity, and international relations demolished. An engineer named Taiichi Ohno, in the enterprise today known as Toyota, began the task of building a new capacity for Japanese production on top of Henry Ford's designs with some important additions. Ford incorporated everything into one plant; Ohno designed for operation in a network. The operational heart of Ford's designs were the way the engineers designed the coordination of the work; Ohno's design was centered in processes that built the capacity of each person on the production floor to take responsibility for the quality and coordination of their work. His invention became the foundation of the quality movement that swept the world starting in the 1970s and 1980s.

To keep the workers thinking, Ohno invented a new collection of wastes for them to observe and eliminate. Waste, like wisdom, is an assessment, an interpretation. For example, inventories, he said, were waste, as was time that workers spent waiting—for parts, others to complete work, and so forth. By inventing these new interpretations, Ohno was able to trigger important revisions in the way the people of Toyota thought and acted. What we in the West now call just-in-time logistics and many other innovations of the last 30 years were born in these inventions.

The organizational wastes with which we have orchestrated our interpretations of work for the last 50 years—wasted movement, wasted time, wasted resources, and so forth—were invented in the traditions of the industrial revolution. I am convinced that they will not be the most important organizational wastes of the next 50 years. Here is my own list of what will be the five most important new waste generators:

1. Not Listening: Tolerating working together in conditions in which people cannot effectively listen to each other in the midst of mistrust, resignation, resentment, and simple incompetence.
2. Bureaucratic Styles: Interacting with each other as if people were machines doing tasks—sequences of movements and activities—in which our concerns, moods, and emotions show up at best only briefly before and after the work but not during it.
3. Worship of Information: Tolerating the illusion that the essential matters of work can be invented, managed, and sustained through the creation, storage, retrieval, display, and publication of information.
4. Suppressing Innovation: Tolerating ways of working in that which is different, unusual,

or new is feared, rejected, or avoided so that it becomes all but impossible to develop flexibility and evolve practices for dealing with a changing world.

5. Work as Toil: Tolerating the interpretation that work consists fundamentally of sequences of things to do. In this interpretation, most people appear to be victims trapped by their needs to make a living, prepare for retirement, support families, and so forth. We ignore, diminish, or distort the ways that most work can bring meaning to people's lives and take care of features of the world for which people care.

Pain-Free Wisdom?

Finally, the kind of wisdom that is involved in historic innovations and longstanding successful leadership of organizations and even that which is required for important reconstructions of organizations does not come from mechanical, procedural, or algorithmic structures. Recently, the Harvard Business Review published a letter that colleagues and I wrote to the editors about an article by Gary Hamel and Liisa Välikangas ("The Quest for Resilience," September 2003), in which we strongly criticized the authors' proposal of what we called "a utopian corporate capacity that adapts to strategic failure without the traumatic wake-up calls of lost market share, protracted earnings slumps, the need for wrenching turnarounds" (Bell et al., 2004). We said to the authors:

"A recipe for pain-free learning could work only if learning were solely about developing valuable new ideas."
"The strategically important innovations that give companies resilience do not come from experiments, less still from multiple bet-hedging experiments—and least of all from people whose careers are protected from the consequences of failed experiments. Instead senior managers need to develop the commitment to risking their careers to develop new ideas. The value of new ideas only becomes real in the midst of failed pilots, funding losses, and heartbreaking rejiggerings."
"Likewise, corporate resilience generally does not come from training senior managers to apply resources, like markets, to a hundred different well-hedged futures. Companies learn to spot difficulties early, invent opportunities in the midst of breakdowns, and fundamentally change how they interact with suppliers and customers by taking a single-minded stand on the core customer concerns they serve. Disconnection from these concerns occurs when managers begin to seek pain-free solutions—such as focusing on one well-understood set of products or segments. Resilience requires reigniting managers' passion and commitment to taking chances and working through them, not pain free experimentation." (Bell et al., 2004)

I agree with Churchman (1968) in his ambition to "create the 'optimal' shatterer of old tablets, a shatterer that does not simultaneously shatter all chance of further progress in the cooperative ideals." (p. 215)

WELL-TOOLED INVESTMENT MANAGEMENT PROCESS

The next several pages recount the process of designing, building, and deploying a software-supported system to help a large institution with the integration of its processes for strategic planning, capital expenditures, and a number of important functions adjacent to those. The reader will see many of the concerns and topics we have discussed in this chapter appearing in the way that the design was done. Here are some of those that I think most relevant and graspable from the written story of what we invented:

1. The example illustrates an important aspect of Churchman's concern with the unity of the system we are designing. The design does not merely integrate many functions, as some software brochure might tout; it would not be possible to do what it does as a function of integration. It is able to do what it does because the design invents a new unity—here called investment management— that did not exist in the language or explicit concerns of the people of the company before we went to work with them.
2. In the example, investment management conversations are managed as interactions among people, paying attention to the interpretations they are making with a system helping keep their attention there, and the articulation of what is handled in the system—the investments—is always held in that context.
3. The design assumes that the participants in the process are ethical actors and does not attempt to police their actions. On the other hand, the system makes their actions visible to other actors and prompts them to act in ways that are coherent with the promises for which they are responsible in the organization (for example, at a high level, for directing operations or for advising others as they direct operations). The system also records everyone's actions for auditors, regulators, and posterity, and it does all that in a way that encourages authentic action.
4. The interpretation of the enterprise that underlies the design of the application is that of a network of commitments, constructed in language-actions, and invented, articulated, and enacted by human beings speaking and listening to each other. All data in the system gets there in that way—by people speaking and listening—and to the extent that a new future is shaped in the process we designed, it is shaped by the human beings and not the data, formulae, and so forth.
5. The design of the system allows the human beings involved to improvise as they invent ways to define their futures under many different kinds of situations and to design structures of coordination that can be adapted to wildly different circumstances that may be encountered. One important effect is to make it possible for new things to emerge rather than only old ones.
6. The way that the system puts a spotlight on the behavior of each participant in the process has the effect of helping the people involved to see their own strengths and weaknesses and thereby encourages and supports learning.

The Situation

During the 1990s, one of my clients was a large and very successful electric utility company (primarily operating coal-fired power plants and a distribution network) that was attempting to shift itself from a style of management suitable to a regulated monopoly in a bounded geographical region to one suited to competition in an open market on a continental or, even eventually, global scale. In the course of several years of work together, we examined and rebuilt many of the company's pivotal processes and ways of working. One of the most important we called their Investment Management process.

Like any modern industrial firm, the company had standard ways of doing a whole variety of things to responsibly prepare to take care of the fact that the future coming to them was not exactly the same as the present, including:

1. Strategic planning,
2. Forecasting demand,
3. Proposing and approving capital budgets,
4. Managing the process of committing to capital expenditures,
5. Managing the actual flows of cash to make capital investments,

6. Managing the execution of capital projects,
7. Accounting for capital expenditures, and
8. Measuring overall returns on capital invested.

As is normally the case with most large firms, these eight processes were related to each other because they all involved money. Indicators of each appeared in the company's accounting system. Also as is normally the case, they had no standard practices for tracking particular investments, nor for measuring the return on any one particular investment, unless a special project was set up to do that. New capital investments once implemented and accepted went into the company's general asset accounts, and their returns were measured along with all other assets.

Anyone with experience in the workings of large enterprises has seen examples of similar collections of processes and can follow as I give a quick critique of them.

- They were slow, expensive, bureaucratic, and generated a lot of paper.
- Most importantly, the processes had the effect of diffusing responsibility, authority, and accountability for one of the most important aspects of the management of an organization's future.
- As a result, the management of the conversation about investing in the company's future moved into a set of essentially unmanageable, highly politicized, back-corridor conversations.
- When proposal packages moved through the organization with their signature lists on the cover, you would hear executives complain, "If all these other people are approving this, of course I am going to go along," "The approval happens in another conversation; this is irrelevant," "This is <so and so's> pet project, and if I don't approve this he'll go after my projects," and the like.
- The processes actually slowed down the speed at which the company's managers were able to think and design how the company moved into the future and pitted people against each other in political contests in the background.

Diagnosis and Design Criteria

In conversation with the company's executives, I characterized their processes as more or less consistent with the processes that I called allowance when dealing with my children. At my request, the children make up stories about what they will need money for in the future, we discuss the stories and arrive at a figure that fits our family finances, fits my wife's and my idea about how much money our children should have access to, and then announce a final number. After that, the children nag us each week for their allowance. We have general anecdotal conversations about what they spend their money on, and at the end of the year when we review the family finances, we discuss how much we spent on allowances.

The difference, as you might guess, was that the allowance process works relatively smoothly, and the collection of eight processes I mentioned above broke, or failed to deliver, the kinds of results that my client's company needed in an agonizingly large proportion of the most important cases. Those processes did not work:

- When the company needed to make a new investment in a hurry.
- When the making of an investment stretched over a long period of time.
- When an unconventional investment was being considered.
- When new ideas were being brought.

In short, they did not work in a lot of the most important investment opportunities.

To cite just one example, in the middle of a scheduled maintenance event, engineers would discover that a turbine blade costing a million dollars needed replacement. The standard processes would all be put aside, as over a period of a few hours a few executives would approve all parts of the purchase, and then people would "fill in the blanks" on the process forms after the fact. The consequence of not acting was far too great to allow action to be constrained by the bureaucratic processes.

In thinking carefully about the diagnosis we would make, I proposed and the client agreed that the support of the intelligence of the people in the company—i.e., wise action—was the critical matter, along with supporting discipline in conversation. We concluded with the client's team that an algorithmic approach (i.e., a fully defined procedure or protocol, possibly supported by mathematical modeling or artificial intelligence tools), which they had been attempting to do for some time, would actually make the situation worse, no matter how sophisticated an approach was taken. For an analogy to understand the claim, think about what is involved in managing the conversation between the pilot and the tower during takeoffs and landings at a major airport. This conversation cannot--nay, must not--be automated. On the other hand, the capacity to have that conversation can be supported with multiple redundant communications channels to mitigate against interruption with radar that allows both to have second opinions about what they observe with their own eyes (or what they cannot see) and other tools.

I proposed criteria for judging a new design:

1. The process should help them manage a unity called "managing our investment in the future of the company" rather than attempting to manage the components that had previously been considered unities.
2. The process should work across a wide spectrum of investment situations, as for example, spanning from an investment where a commitment had to be made in a hurry to investment conversations stretching over a period of years.
3. The process should be organized so that it reveals to managers and executives things going wrong within it as they occur.
4. The roles of participants in the process should be organized in ways that are consistent with the participants' roles in the organization as a whole. For example, senior strategic, operational, and financial managers should have control over the pacing of the process, and senior technical advisors should be able to force their assessments to be heard by all who should listen to them but should not control the pace of the process.
5. The process should automatically generate all the records that will be needed by regulators as a by-product of the participants' work and not require additional processes to complete.

We designed a new process to span all eight component processes, along with a tool implementing the process. The process defined who speaks at which points in the process, whose commitments move the process forward or slow it down, how records are kept, assures that what is happening in the process is transparently visible to all participants, and makes records of everything that happens in the process accessible to all participants. The process could be followed for an investment conversation that lasts only a few hours or for one that lasts years.

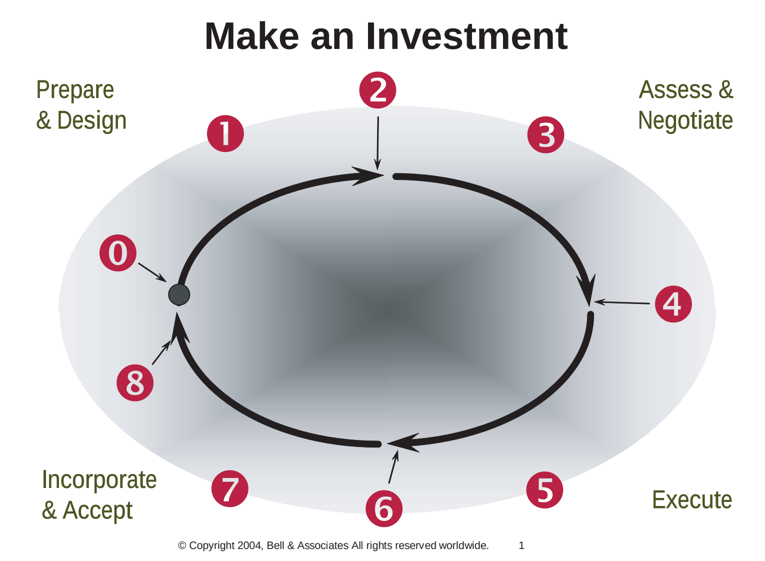
We prototyped and tested the process and tool in the utility company and then implemented it across the company. A year later, we repeated the whole process for the investment management processes of a six billion dollar multinational cement company.

The Design

The process and tool at the center of the design are remarkably simple but also subtle and not intuitive for most system designers. Key elements embodied in the final design are:

1. Participants in the process are assigned to roles during the first phase of the process. Three line roles are defined: Investor, Proposer (who must be a line operational manager), and Manager (the person who implements the investment). An unlimited number of staff roles are defined, covering whatever technical, financial, social, political, or other issues that may need to be topics of conversation for the investment to be properly vetted and designed.
2. The process as a whole is organized, conducted, and recorded as sets of conversations, each set covering a single investment. Each set begins when a potential investment, indicated by the assessment that something important is missing, broken, or in the way, is proposed by a proposer speaking to an investor. After the investor has agreed to make an investment, a manager (who may be the same person as the proposer), promises to implement the investment, does so, and then comes back to the investor to get the latter's declaration of satisfaction. After an investment has been implemented, additional conversations are initiated and managed covering the assessment of its contribution to the enterprise.
3. Every action (transaction) in the process and the system that supports it is structured as a performative. Line roles make requests, offers, promises, and declare investments complete and satisfactory. Staff roles make assessments and recommendations about the investments, including for example, the desirability of a particular investment, conditions for its successful execution, likely costs and returns on investment, assessments of progress, and of the value produced. In this way, each role is being asked to do what "they are paid to do"—line managers for

Figure 1. Make an investment



producing results and staff for providing counsel.

4. Each "investment conversation set" is invoked, conducted, and recorded through four phases of the process: preparation and design; assessment and negotiation; execution; and incorporation and assessment. This process is diagrammed in the figure below.16 The four arcs headed with arrows correspond to the four phases of the process, and the arrowheads correspond to the four critical language-actions that brace the action when an investment is successfully proposed, constructed, and implemented. In the figure, I have numbered the critical moments in each investment conversation. The table explains these moments.
5. Prospective and completed investments are organized into a hierarchy of portfolios matching the current organization chart, with each manager responsible for a portfolio corresponding to his or her role. The senior executives of the company define which investments will be located in each portfolio. Managers can review the progress and performance of all portfolios located below them in the hierarchy through online tools.
6. Schedule objectives are set out at the beginning of each investment process, and requests, offers and promises carry fulfillment dates, which then allow the status of the work in each part of the process to be color-coded.
7. Displays of the progress of each investment show hierarchies of conversations under each phase of the investment process. These displays show in a transparent way the progress of the investment conversation, arguments and difficulties in the process, and so forth. The next figure illustrates what these look like. Entries in the displays are active; clicking on them brings records of the language actions (communications) to the screen.
8. Files and databases supporting the process are organized by the logic of the sets of conversations and integrated with the organization's standard accounting tools.

We built our first prototype of the supporting system (rapidly) with Lotus Notes and later built with more robust platforms.

Benefits

Here are a few of the results that came out of this invention:

- Radical improvement in the organization's capacity to oversee its capital investments, with consequential improvements in the speed of all processes, reduction in the cost of operating all the processes, reduction in the actual risks of investments, increased rates of success in investments, and many other benefits.
- Capacity to couple strategy, capital budgeting, and capital expenditures in ways never before possible.
- Greatly improved and earlier identification of ineffective investments, investment managers, and early warning of investments in trouble.
- A new capacity to cut cycle times for investment decisions and implementation almost at will.
- The approach is tremendously helpful in training young managers and detecting opportunities to improve the skills of senior managers.

CONCLUSION

Having come to the end of this brief inquiry into a question to which some of the best minds in the history of humankind have devoted much, or

Table 1. Critical moments

Step	Action
0	An investment process begins when someone notices an anomaly, or something missing, broken, or in the way and declares an investment opportunity (or the necessity of an investment). Individuals or groups are named to three roles for operational managers ("line") and any number of "staff" roles. A timetable is declared for the conversation, including the moments in which each of the critical actions must be taken.
1	Under the direction of people in the key roles work begins to prepare an investment offer. Conversations among them are conducted through electronic media, in a public space, where people in all roles defined for this particular investment are able to read and observe the conversations.
2	The ***Proposer*** role offers a specific investment to ***Investor*** with ***Manager*** and staff roles observing. Additional staff roles are named at this point for giving assessments in technical, environmental, economic, and other domains as appropriate for the particular investment. In addition, the main operational roles can at this point define process elements in which particular staff roles are compelled to make assessments at particular moments in the process.
3	A very flexible and yet also formal, choreographed conversation now ensues among the key roles, guided by requests from the operational managers. In the conversation the participants answer questions about the value that will be contributed by the investment to the organization, its clients, and others, the costs it will produce, and how it will be evaluated once completed. The governing assumptions (assessments) behind the investment are spelled out in this conversation, in context.
4	The ***Investor*** commits the organization to go ahead with the investment. This commitment is understood by all to have these dimensions: the ***Investor*** is committing the organization (a) to make a specified investment, (b) under specified assumptions, (c) to produce a particular result. At any point in the execution of this investment that any of these "get sideways," the parties understand that the commitment as a whole is in trouble and those responsible at the moment (usually the ***Manager***) must go back to the ***Investor*** and revisit the commitment.
5	The ***Manager*** manages the implementation of the investment, using whatever resources were spelled out in the assumptions at stage 3 above. The other roles are informed about progress and ask questions during the implementation, and those conversations are preserved as part of the record, along with the records of costs during the implementation.
6	The ***Manager*** reports the successful implementation of the investment to the ***Investor*.**
7	Under the direction of the ***Investor,*** the participants in the process evaluate the investment's results, including defining future benchmarks of review and evaluation as appropriate along with accounting standards that will be followed for tracking the investment's results.
8	The ***Investor*** declares him/herself satisfied with the investment on behalf of the organization.

Table 2. Example of the display of the index to an investment management conversation

Date	Who	Act		Subject
Replace blade 110 in Winn Dixie Turbine A				
20040510	Wiseman	OPEN		Trouble with blade 110, no spare available
20040510	Blanquette		Assess	Cost of delays will be $650k/day
20040512	Demasio		Assess	Vendor promises to find replacement
20040512	Wiseman	OFFER		Acquire replacement blade by 5/22
20040512	Demasio		Assess	Vendor wants $12k
20040513	Blanquette		Assess	Bargain! Grab it.
20040513	Demasio		Assess	Committed - in our hands 5/24
20040513	McMaster	COMMIT		Acquisition authorized
20040526	Wiseman	COMPLET		Blade installed
20040528	Wiseman		Assess	Tests passed
20040528	McMaster	SATISF		Thanks, Dwight. Well done all.

sometimes all of their adult working lives, what shall we say?

First, I conclude that to care about wisdom, to ask what it is and how to cultivate it, is, itself, to take an ethical stand. To set the possibility of wise action as a standard for judging the way that we develop management and leadership practices in organizations and as a standard for the design of systems to support action in enterprises, is, itself, to take an ethical stand. To set out to produce the capacity for wisdom is no less than to commit to act in a way that is designed to bring out, make available, the very best that people have to offer. In big and little circumstances that call for wise action, where someone who is in a position to act has not before that moment been prepared to address what is happening, wisdom is possible. In that moment, someone prepared to act with wisdom does not flee or turn away from those circumstances. Instead, they themselves take an ethical stand and use the moment to discover something heretofore undiscovered about themselves, others, and/or the circumstances, as the foundation for building something new. And then they act in a way that is not merely following the rules or repeating what others before them have done.

Then, as a last question, let us ask, "Where, after all, does wisdom come from?" I propose that whatever we may conclude are the essential structures of wisdom, we may be clear that when we say someone is wise, or say that some action was wise, that what we observed is rooted in at least these four places:

1. In the fact that human beings are historical beings, able to remember and continuously reinterpret our experiences, and possessed of practices that allow us to record, read about, and interpret the experience of others.
2. In our capacity to learn from our interactions in our worlds.
3. In our capacity to speak and act from that background.

4. In the biology that gives us the wherewithal for all of the above--cognition, memory, intellect, and language itself, as well as our emotional reactions and predispositions with which we orient ourselves to each other, our experience, and our worlds.

Curiously, in each of these areas, a great deal of new current research is yielding remarkable new insights into what it is that human beings do. I propose these give us a good point of departure and can give us a whole series of places in which to continue Churchman's inquiry and to draw inspiration and ideas for improving the quality of our work on the design and construction of organizational practices and systems to support them.

REFERENCES

Austin, J. L. (1962). *How to do things with words*. Cambridge, MA: Harvard University Press.

Bell, C. (2000). Re-membering the future: Organizational change, technology, and the role of the archivist. *Journal of the Midwest Archives Conference, 25*(1/2), 11-31. [Additional citations to electronic versions of original talks may be found at http://www.chaunceybell.com]

Bell, C., et al. (2004, February). *Harvard Business Review*.

Bell, C., & Bell, S. (2003). *Reflections on listening and anxiety in designing a life*. Unpublished manuscript, available from the author.

Churchman, C. W. (1968). *Challenge to reason*. New York: McGraw-Hill.

Courtney, J. F. (2001). Decision making and knowledge management in inquiring organizations: Toward a new decision-making model paradigm for DSS. *Decision Support Systems, 31*(1), 17-38.

Damasio, A. (1999). *The feeling of what happens: Body and emotion in the making of consciousness*. San Diego: Harcourt.

Dreyfus, H. L. (1991). *Being-in-the-world: A commentary on Heidegger's Being and Time, division I*. Cambridge, MA: MIT Press.

Dreyfus, H. L., & Dreyfus, S. E. (2000). *Mind over machine*. New York: Simon & Schuster.

Fiumara, G. C. (1990). *The other side of language: A philosophy of listening*. London: Routledge.

Flores, F., & Winograd, T. (1986). *Understanding computers and cognition: A new foundation for design*. Norwood, NJ: Ablex.

Goleman, D. (2003). *Destructive emotions: How can we overcome them? … A scientific dialogue with the Dalai Lama*. New York: Bantam Dell.

Heidegger, M. (1962). *Being and time* (J. Macquarrie & E.Robinson, Trans.). New York: Harper and Row.

Heidegger, M. (1971). *On the way to language*. San Francisco: Harper.

Heifetz, R. A. (1996). *Leadership without easy answers*. Cambridge, MA: Harvard University Press.

Kenny, A. (1992). *The metaphysics of mind*. Oxford: Oxford University Press.

Kenny, A. (1997). *The Oxford illustrated history of Western philosophy*. Oxford: Oxford University Press.

Kotter, J. P. (1990). *A force for change: How leadership differs from management* (p.119ff). New York: The Free Press: A Division of Macmillan.

Lown, B. (1996, 1999). *The lost art of healing: Practicing compassion in medicine*. New York: Ballantine Books.

Maturana, H., & Varela, F. J. (1998). *The tree of knowledge*. Boston; London: Shambhala.

Schein, E. H. (1992). *Organizational culture and leadership* (2nd ed.). San Francisco: Jossey-Bass.

Schon, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Spinosa, C., Flores, F., & Dreyfus, H. (1997). *Disclosing new worlds: Entrepreneurship, democratic action, and the cultivation of solidarity*. Cambridge, MA: MIT Press.

Ulrich, W. (1999). *An aprreciation of C. West Churchman*. Retrieved September 26, 2004, from http://www.geocities.com/postfach1/cwc_appreciation.html

Varela, F. J. (1999). *Ethical know-how: Action, wisdom, and cognition*. Stanford, CA: Stanford University Press.

Williamson, O. E. (1996). *The mechanisms of governance*. New York; Oxford: Oxford University Press.

ENDNOTES

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2 http://www.dictionary.com offers the following contributions:

wise:
Having the ability to discern or judge what is true, right, or lasting; sagacious: a wise leader. Exhibiting common sense; prudent: a wise decision. Shrewd; crafty. Having great learning; erudite.Provided with information; informed. Used with to: was wise to the politics of the department. Source: The American Heritage® Dictionary of the English Language, Fourth Edition. Copyright © 2000 by Houghton Mifflin Company. Published by Houghton Mifflin Company. All rights reserved.

wise
\Wise\, a. [Compar. Wiser; superl. Wisest.] [OE. wis, AS. w[=i]s; akin to OS. & OFries. w[=i]s, D. wijs, G. weise, OHG. w[=i]s, w[=i]si, Icel. v[=i]ss, Sw. vis, Dan. viis, Goth. weis; akin to wit, v. i. See Wit, v., and cf. Righteous, Wisdom.] 1. Having knowledge; knowing; enlightened; of extensive information; erudite; learned.They are wise to do evil, but to do good they have no knowledge. --Jer. iv. 22. 2. Hence, especially, making due use of knowledge; discerning and judging soundly concerning what is true or false, proper or improper; choosing the best ends and the best means for accomplishing them; sagacious.When clouds appear, wise men put their cloaks. --Shak.From a child thou hast known the holy scriptures, which are able to make thee wise unto salvation. --2 Tim. iii. 15. 3. Versed in art or science; skillful; dexterous; specifically, skilled in divination.Fal. There was, mine host, an old fat woman even now with me; but she's gone. Sim. Pray you, sir, was't not the wise woman of Brentford? — Shak.4. Hence, prudent; calculating; shrewd; wary; subtle; crafty. [R.] "Thou art . . . no novice, but a governor wily and wise." --Chaucer. Nor, on the other side, Will I be penuriously

wise As to make money, that's my slave, my idol. --Beau. & Fl. Lords do not care for me: I am too wise to die yet. --Ford.5. Dictated or guided by wisdom; containing or exhibiting wisdom; well adapted to produce good effects; judicious; discreet; as, a wise saying; a wise scheme or plan; wise conduct or management; a wise determination. "Eminent in wise deport." --Milton.To make it wise, to make it a matter of deliberation. [Obs.] " We thought it was not worth to make it wise."--Chaucer. Wise in years, old enough to be wise; wise from age and experience; hence, aged; old. [Obs.]A very grave, state bachelor, my dainty one; He's wise in years, and of a temperate warmth. --Ford. You are too wise in years, too full of counsel, For my green experience. --Ford.Source: Webster's Revised Unabridged Dictionary, © 1996, 1998 MICRA, Inc.

wise

\Wise\, a. [OE. wise, AS. w[=i]se; akin to OS. w[=i]sa, OFries. w[=i]s, D. wijs, wijze, OHG. w[=i]sa, G. weise, Sw. vis, Dan. viis, Icel. ["o]?ruv[=i]s otherwise; from the root of E. wit; hence, originally, knowledge, skill. See Wit, v., and cf. Guise.] Wayof being or acting; manner; ode; fashion. ``All armed in complete wise.'' --Spenser.To love her in my beste wyse. --Chaucer. This song she sings in most commanding wise. --Sir P. Sidney. Let not these blessings then, sent from above, Abused be, or spilt in profane wise. --Fairfax.Note: This word is nearly obsolete, except in such phrases as in any wise, in no wise, on this wise, etc. " Fret not thyself in any wise to do evil."--Ps. xxxvii. 8. "He shall in no wise lose his reward." --Matt. x. 42. " On this wise ye shall bless the children of Israel." --Num. vi. 23.Note: Wise is often used as a suffix in composition, as in likewise, nowise, lengthwise, etc., in which words -ways is often substituted with the same sense; as, noways, lengthways, etc.Source: Webster's Revised Unabridged Dictionary, © 1996, 1998 MICRA, Inc.

wise

adj 1: having or prompted by wisdom or discernment; "a wise leader"; "a wise and perceptive comment" [ant: foolish] 2: marked by the exercise of good judgment or common sense in practical matters; "judicious use of one's money"; "a sensible manager"; "a wise decision" [syn: judicious, sensible] 3: evidencing the possession of inside information [syn: knowing, wise(p), wise to(p)] 4: able to take a broad view of negotiations between states [syn: diplomatic] 5: carefully considered; "a considered opinion" [syn: considered] n : a way of doing or being: "in no wise"; "in this wise" [syn: method]Source: WordNet ® 1.6, © 1997 Princeton University

3 I understand organizations as a broad range of human enterprise, including what we construct within the institutions of families, communities, societies, governments, as well as businesses of all sizes and types.

4 http://traditions.skule.ca/articles/ironring/ironringinfo/ironringinfo.html

5 In October 2001, Business Week magazine rated Kotter the #1 "leadership guru" in America based on a survey they conducted of 504 enterprises.

6 The development of wisdom has been a central theme in a number of ancient traditions for millennia. I am thinking of traditions that come to us principally from India, China, Japan, Asian countries, and from Judaism, Christianity, and Islam. These traditions share principles about wisdom, "paths to enlightenment," and styles of learning. I cite a few below. They are relevant to our ambi-

tion for improving systems, but beyond our grasp in such a short work. The names that I give in the following are not universally accepted labels but rather the nomenclature I have given to a short list of topics that can be found in the great books of many traditions.

Transcendence: the principle that meaning, satisfaction, and the organizing principles in life are rarely found first in the phenomenal world of things.

Transformation: the principle that life is far more mutable than any of us is given to suspect in the day-to-day living of it. Our understanding of our lives, our situations, and what we are doing are subject to change rather suddenly. Through our behavior, we can influence how that happens.

Tension: the principle that in life many important things are born in the middle of tensions and that tension, as a result, sometimes needs to be cultivated in order to support invention.

Temporal Structures: the principle that calls for close attention to the temporal horizons in which we conceive and understand life. "Be here now," living in the present, planning and envisioning the future, and care with the processes of recording and accounting for the past are part of this.

The Unity of Existence: John Donne pointed to the center of the question with his Meditation XVII: "All mankind is of one author, and is one volume; when one man dies, one chapter is not torn out of the book, but translated into a better language; and every chapter must be so translated...As therefore the bell that rings to a sermon, calls not upon the preacher only, but upon the congregation to come: so this bell calls us all: but how much more me, who am brought so near the door by this sickness....No man is an island, entire of itself... any man's death diminishes me, because I am involved in mankind; and therefore never send to know for whom the bell tolls; it tolls for thee."

7 I'll say more formally later about assessments. For this moment, take the word in its conventional sense of an interpretation or a judgment.

8 See for example the following from Anthony Kenny, (1992). The Metaphysics of Mind, Oxford: Oxford University Press, p. 17ff, 20.

"To say that I have an intellect is to say that I have the capacity to acquire and exercise intellectual abilities of various kinds, such as the mastery of language and the possession of objective information. To say that I have a will is to say that I have the capacity for the free pursuit of goals formulated by the intellect. My intellect and my will are in essence capacities. What are they capacities of ? Of the living human being, the body you would see if you were here in the room where I write.

"The most important intellectual skill is the mastery of language. Others, such as the knowledge of mathematics, are acquired by human beings through the languages they have mastered. So the study of the acquisition and exercise of language is the way par excellence to study the nature of the human mind. To study knowledge of language you have to consider what the exercise of linguistic knowledge is… for instance, reciting a poem to myself in my head imperceptibly will count as an instance of linguistic behavior."

9 I build a substantial portion of my interpretations about the behaviors of humans and organizations on the work of Kierkegaard, Heidegger, Wittgenstein, and Anthony Kenny. Heidegger is particularly difficult. I use Hubert Dreyfus' Being-in-the-World (see next footnote) as my guide to the Heidegger of Being and Time. I have found Lawrence Vogel's The Fragile "We": Ethical Implica-

tions of Heidegger's "Being and Time" particularly useful in picking my way through the ethical thicket presented by Heidegger's interactions with National Socialism during the time of Hitler. This controversial 20th century philosopher is rapidly becoming, by the measures philosophers use to assess each other's importance, the most important philosopher of all time.

10 The creation of knowledge as a capacity for taking action - I normally speak of it as different kinds of capital that enable one to act skillfully, act in ways that convoke action on the parts of others, and produce satisfaction to those served--is a central issue in my interpretation of what we do with each other in organizations. On the other hand, most speaking in the IT, DSS, and adjacent traditions give the central role in the activities of those leading and managing organizations to what is called decision making. I do not. I think it is important that I note that I have an alternative view of how people in an organization conclude that new actions are possible or called for, come to resolution about how to take those actions, and then put themselves into action. I do not address this difference in this chapter.

11 Anthony Kenny is Warden of Rhodes House, Oxford, and Chairman of the British Library. Until recently, he was Master of Balliol College, Oxford, and President of the British Academy. In The Oxford Illustrated History of Western Philosophy he brought together essays by a series of philosophers covering the epochs of the five Churchman philosophers.

12 Dr. Fernando Flores Labra, currently a Senator in the Chilean government and candidate for President of his country, was the first to point out the importance of performatives for understanding and shaping the behaviors of people in organizations as an underpinning of design in organizations. Flores originally assembled the traditions and many of the thinkers on which I rely in this chapter.

13 Directives and commissives refer to a different categorization of performative verbs than the one I employ in my own work.

14 Donald A. Schon, (1983). The Reflective Practitioner: How Professionals Think in Action. New York: Basic Books.

15 … or, I would say, wise behavior.

16 The ellipse shown is based upon representations of The Conversation for Action copyright by Business Design Associates, Inc., and Action Technologies, Inc. The author of this chapter was the original author of these representations.

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Section 6
Managerial Impact of Knowledge Management

This section presents contemporary coverage of the social implications of knowledge management, more specifically related to the corporate and managerial utilization of information sharing technologies and applications, and how these technologies can be facilitated within organizations. Core ideas such as training and continuing education of human resources in modern organizations are discussed through these more than 35 chapters. Also discussed is strategic planning related to the organizational elements and knowledge sharing program requirements that are necessary to build a framework in order to institutionalize and sustain knowledge management systems as a core business process. Equally as crucial, are the chapters which address the gap between theory and practical implementation within the knowledge sharing community. Directing the reader's focus forward, the final chapters found within this section help to establish a basis for assessing the value of knowledge management while evaluating its results within business enterprises.

Chapter 6.1
Knowledge Management Systems

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INTRODUCTION

As we trace the evolution of computing technologies in business, we can observe their changing level of organizational impact. The first level of impact was at the point work got done and transactions (e.g., orders, deposits and reservations) took place. The inflexible, centralized mainframe allowed for little more than massive number crunching, commonly known as electronic *data* processing. Organizations became data heavy at the bottom and data management systems were used to keep the data in check. Later, the management *information* systems were used to aggregate data into useful information reports, often prescheduled, for the control level of the organization — people who were making sure that organizational resources like personnel, money and physical goods were being deployed efficiently. As information technology (IT) and information systems (IS) started to facilitate data and information overflow, and corporate attention became a scarce resource, the concept of *knowledge* emerged as a particularly high-value form of information (Grover & Davenport, 2001).

Information technology can play an important role in successful knowledge management initiatives. However, the concept of coding and transmitting knowledge in organizations is not new: training and employee development programs, organizational policies, routines, procedures, reports and manuals have served this function for many years. What is new and exciting in the knowledge management area is the potential for using modern information technology (e.g., the Internet, intranets, extranets, browsers, data warehouses, data filters, software agents and expert systems) to support knowledge creation, sharing and exchange in an organization and between organizations. Modern information technology can collect, systematize, structure, store, combine, distribute and present information of value to knowledge workers (Nahapiet & Ghoshal, 1998).

According to Davenport and Prusak (1998), more and more companies have instituted knowledge repositories, supporting such diverse types of knowledge as best practices, lessons learned, product development knowledge, customer knowledge, human resource management knowledge and methods-based knowledge. Groupware and intranet-based technologies have become standard knowledge infrastructures. A new set of professional job titles — the knowledge manager, the chief knowledge officer (CKO), the knowledge coordinator and the knowledge-network facilitator — affirms the widespread legitimacy that knowledge management has earned in the corporate world.

The low cost of computers and networks has created a potential infrastructure for knowledge sharing and opened up important knowledge management opportunities. The computational power, as such, has little relevance to knowledge work, but the communication and storage capabilities of networked computers make computational power an important enabler of effective knowledge work. Through e-mail, groupware, the Internet and intranets, computers and networks can point to people with knowledge and connect those who need to share knowledge independent of time and place.

For example, electronic networks of practice are computer-mediated discussion forums focused on problems of practice that enable individuals to exchange advice and ideas with others based on common interests. Electronic networks make it possible to share information quickly, globally and with large numbers of individuals. Electronic networks that focus on knowledge exchange frequently emerge in fields where the pace of technological change requires access to knowledge unavailable within any single organization (Wasko & Faraj, 2005).

In the knowledge-based view of the firm, knowledge is the foundation of a firm's competitive advantage and, ultimately, the primary driver of a firm's value. Inherently, however, knowledge resides within individuals and, more specifically, in the employees who create, recognize, archive, access and apply knowledge in carrying out their tasks. Consequently, the movement of knowledge across individual and organizational boundaries, into and from repositories and into organizational routines and practices is ultimately dependent on employees' knowledge-sharing behaviors (Bock, et al., 2005).

According to Grover and Davenport (2001), most knowledge management projects in organizations involve the use of information technology. Such projects fall into relatively few categories and types, each of which has a key objective. Although it is possible, and even desirable, to combine multiple objectives in a single project, this was not normally observed in a study of 31 knowledge management projects in 1997 (Davenport & Prusak, 1998). Since that time, it is possible that projects have matured and taken on more ambitious collections of objectives.

Regardless of the definition of knowledge as the highest value of content in a continuum starting at data, encompassing information and ending at knowledge itself, knowledge managers often take a highly inclusive approach to the content with which they deal. In practice, what companies actually manage under the banner of knowledge management is a mix of knowledge, information and unrefined data — in short, whatever anyone finds that is useful and easy to store in an electronic repository. In the case of data and information, however, there are often attempts to add more value and create knowledge. This transformation might involve the addition of insight, experience, context, interpretation or a myriad of other activities in which human brains specialize (Grover & Davenport, 2001).

Identifying, nurturing and harvesting knowledge is a principal concern in the information society and the knowledge age. Effective use of knowledge-facilitating tools and techniques is critical, and a number of computational tools have been developed. While numerous techniques are available, it remains difficult to analyze or compare specific tools. In part, this is because knowledge management is a young discipline. The arena is evolving rapidly as more people enter the fray and encounter new problems (Housel & Bell, 2001).

In addition, new technologies support applications that were impossible before. Moreover, the multidisciplinary character of knowledge management combines several disciplines, including business and management, computer science, cybernetics and philosophy. Each of these fields may lay claim to the study of knowledge management, and the field is frequently defined so broadly that anything can be incorporated. Finally, it is difficult to make sense of the many knowledge management tools available; it is not difficult to perform a search to produce a list of more than one hundred software providers. Each of the software packages employ unique visions and aims to capture its share of the market (Housel & Bell, 2001).

Ward and Peppard (2002) find that there are two dominant and contrasting views of IS/IT in knowledge management: the engineering perspective and the social process perspective. The engineering perspective views knowledge management as a technology process. Many organizations have taken this approach in managing knowledge, believing that it is concerned with managing pieces of intellectual capital. Driving this view is the belief that knowledge can be codified and stored; in essence that knowledge is explicit and therefore is little more than information.

The alternative view is that knowledge is a social process. As such, it asserts that knowledge resides in people's heads and that it is tacit. As such, it cannot be easily codified and only revealed through its application. As tacit knowledge cannot be directly transferred from person to person, its acquisition occurs only through practice. Consequently, its transfer between people is slow, costly and uncertain. Technology, within this perspective, can only support the context of knowledge work. It has been argued that IT-based systems used to support knowledge management can only be of benefit if used to support the development and communication of human meaning. One reason for the failure of IT in some knowledge management initiatives is that the designers of the knowledge management systems fail to understand the situation and work practices of the users and the complex human processes involved in their work.

While technology can be used with knowledge management initiatives, Ward and Peppard (2002) argue that it should never be the first step. Knowledge management is to them primarily a human and process issue. Once these two aspects have been addressed, then the created processes are usually very amenable to being supported and enhanced by the use of technology.

What, then, is knowledge management technology? According to Davenport and Prusak (1998), the concept of knowledge management technology is not only broad but also a bit slippery to define. Some infrastructure technology that we don't ordinarily think of in this category can be useful in facilitating knowledge management. Examples are video conferencing and the telephone. Both of these technologies don't capture or distribute structured knowledge, but they are quite effective at enabling people to transfer tacit knowledge.

Our focus here, however, is on technology that captures, stores and distributes structured knowledge for use by people. The goal of these technologies is to take knowledge that exists in human heads, and partly in paper documents, and make it widely available throughout an organization. Similarly, Alavi and Leidner (2001) argue that information systems designed to support knowledge in organizations may not appear radically different from other forms of IT support, but will be geared toward enabling users to assign meaning to information and to capture some of their knowledge in information. Therefore, the concept of knowledge management technology in this book is less concerned with any degree of technology sophistication and more concerned with the usefulness in performing knowledge work in and between organizations.

Moffett and McAdam (2003) illustrate the variety of knowledge management technology tools by distinguishing between collaborative tools, content management and business intelligence. Collaborative tools include groupware technology, meeting support systems, knowledge directories and intranets / extranets. Content management includes the Internet, agents and filters, electronic publishing systems, document management systems and office automation systems. Business intelligence includes data warehousing, decision support systems, knowledge-based systems and workflow systems. In addition to technologies, we also present techniques in this book. The term technique is defined as a set of precisely described procedures for achieving a standard task (Kettinger, et al., 1997).

KNOWLEDGE MANAGEMENT PROCESSES

Alavi and Leidner (2001) have developed a systematic framework that will be used to analyze and discuss the potential role of information technology in knowledge management. According to this framework, organizations consist of four sets of socially enacted knowledge processes: (1) creation (also referred to as construction), (2) storage and retrieval, (3) transfer and (4) application. The knowledge-based view of the firm represents here both the cognitive and social nature of organizational knowledge and the embodiment of this knowledge in the individual's cognition and practices as well as the collective (i.e., organizational) practices and culture. These processes do not represent a monolithic set of activities, but an interconnected and intertwined set of activities.

Knowledge Creation

Organizational knowledge creation involves developing new content or replacing existing content within the organization's tacit and explicit knowledge. Through social and collaborative processes, as well as individual's cognitive processes (e.g., reflection), knowledge is created. The model developed by Nonaka, et al. (2000) involving SECI, ba and knowledge assets, views organizational knowledge creation as involving a continual interplay between the tacit and explicit dimensions of knowledge, and a growing spiral flow as knowledge moves through individual, group and organizational levels. Four modes of knowledge creation have been identified: socialization, externalization, internalization and combination (SECI), and these modes occur at "ba," which means place.

Nonaka, et al. (2000) suggest that the essential question of knowledge creation is establishing an organization's ba, defined as a common place or space for creating knowledge. Four types of ba corresponding to the four modes of knowledge creation are identified: (1) originating; (2) interacting; (3) cyber; and (4) exercising ba. Originating ba entails the socialization mode of knowledge creation and is the ba from which the organizational knowledge creation process begins. Originating ba is a common place in which individuals share experiences primarily through faceto- face interactions and by being at the same place at the same time. Interacting ba is associated with the externalization mode of knowledge creation and refers to a space where tacit knowledge is converted to explicit knowledge and shared among individuals through the process of dialogue and collaboration. Cyber ba refers to a virtual space of interaction and corresponds to the combination mode of knowledge creation. Finally, exercising ba involves the conversion of explicit to tacit knowledge through the internalization process. Thus, exercising ba involves the conversion of explicit to tacit knowledge through the internalization process.

Understanding the characteristics of various ba and the relationship with the modes of knowledge creation is important to enhancing organizational knowledge creation. For example, the use of IT capabilities in cyber ba is advocated to enhance the efficiency of the combination mode of knowledge creation. Data warehousing and data mining, document management systems, software agents and intranets may be of great value in cyber ba. Considering the flexibility of modern IT, other forms of organizational ba and the corresponding modes of knowledge creation can be enhanced through the use of various forms of information systems. For example, information systems designed for support or collaboration, coordination and communication processes as a component of the interacting ba, can facilitate teamwork and thereby increase an individual's contact with others.

Electronic mail and group support systems have the potential of increasing the number of weak ties in organizations. This, in turn, can accelerate the growth of knowledge creation. Intranets enable exposure to greater amounts of online organizational information, both horizontally and vertically, than may previously have been the case. As the level of information exposure increases, the internalization mode of knowledge creation, wherein individuals make observations and interpretations of information that result in new individual tacit knowledge, may increase. In this role, an intranet can support individual learning (conversion of explicit knowledge to personal tacit knowledge) through provision of capabilities such as computer simulation (to support learning-by-doing) and smart software tutors.

Computer-mediated communication may increase the quality of knowledge creation by enabling a forum for constructing and sharing beliefs, for confirming consensual interpretation and for allowing expression of new ideas. By providing an extended field of interaction among organizational members for sharing ideas and perspectives, and for establishing dialogue, information systems may enable individuals to arrive at new insights and/or more accurate interpretations than if left to decipher information on their own.

Although most information repositories serve a single function, it is increasingly common for companies to construct an internal "portal" so that employees can access multiple repositories and sources from one screen. It is also possible, and increasingly popular, for repositories to contain not only information, but also pointers to experts within the organization on key knowledge topics. It is also feasible to combine stored information with lists of the individuals who contributed the knowledge and could provide more detail or background on it (Grover & Davenport, 2001).

According to Grover and Davenport (2001), firms increasingly view attempts to transform raw data into usable knowledge as part of their knowledge management initiatives. These approaches typically involve isolating data in a separate "warehouse" for easier access, and the use of statistical analysis or data mining and visualization tools. Since their goal is to create data-derived knowledge, the initiatives are increasingly addressed as a part of knowledge management. Some vendors have already begun to introduce e-commerce tools in this area. They serve to customize the menu of available knowledge to individual customers, allowing sampling of information before buying and carrying out sales transactions for knowledge purchases. Online legal services are typical examples where clients can sample legal information before buying a lawyer's time.

For knowledge creation there is the current emergence of *idea-generation software*. Idea-generation software is designed to help stimulate a single user or a group to produce new ideas, options and choices. The user does all the work, but the software encourages and pushes, something like a personal trainer. Although idea-generation software is relatively new, there are several packages on the market. IdeaFisher, for example, has an associative lexicon of the English language that cross-references words and phrases. These associative links, based on analogies and metaphors, make it easy for the user to be fed words related to a given theme. Some software packages use questions to prompt the user toward new, unexplored patterns of thought. This helps users to break out of cyclical thinking patterns and conquer mental blocks.

Knowledge Storage and Retrieval

According to Alavi and Leidner (2001), empirical studies have shown that while organizations create knowledge and learn, they also forget (i.e., do not remember or lose track of the acquired knowledge). Thus, the storage, organization and retrieval of organizational knowledge, also referred to as organizational memory, constitute an important aspect of effective organizational knowledge management. Organizational memory includes knowledge residing in various component forms, including written documentation, structured information stored in electronic databases, codified human knowledge stored in expert systems, documented organizational procedures and processes and tacit knowledge acquired by individuals and networks of individuals.

Advanced computer storage technology and sophisticated retrieval techniques, such as query languages, multimedia databases and database management systems, can be effective tools in enhancing organizational memory. These tools increase the speed at which organizational memory can be accessed.

Groupware enables organizations to create intra-organizational memory in the form of both structured and unstructured information and to share this memory across time and space. IT can play an important role in the enhancement and expansion of both semantic and episodic organizational memory. Semantic memory refers to general, explicit and articulated knowledge, whereas episodic memory refers to context-specific and situated knowledge. Document management technology allows knowledge of an organization's past, often dispersed among a variety of retention facilities, to be effectively stored and made accessible. Drawing on these technologies, most consulting firms have created semantic memories by developing vast repositories of knowledge about customers, projects, competition and the industries they serve.

Grover and Davenport (2001) found that by far the most common objective of knowledge management projects in Western organizations involves some sort of knowledge repository. The objective of this type of project is to capture knowledge for later and broader access by others within the same organization. Common repository technologies include Lotus Notes, web-based intranets and Microsoft's Exchange, supplemented by search engines, document management tools and other tools that allow editing and access. The repositories typically contain a specific type of information to represent knowledge for a particular business function or process, such as:

- "Best practices" information within a quality or business process management function;
- Information for sales purposes involving products, markets and customers;
- Lessons learned in projects or product development efforts;
- Information around the implementation of information systems;
- Competitive intelligence for strategy and planning functions; and
- "Learning histories" or records of experience with a new corporate direction or approach.

The mechanical generation of databases, Web sites and systems that process data are good and have the potential to take us to a higher plane in the organization, help us understand workflows better and aid in dealing with organizational pathologies and problems. The data-to-information transition often involves a low level mechanical process that is well within the domain of contemporary information technologies, though humans are helpful in this transition as well. This information could exist in different forms throughout the organization and could even form the basis of competitive advantage or information products. For example, provision of information to customers about their order or shipment status is something that companies like Baxter and FedEx have been doing for years. But unlike knowledge, mechanically supplied information cannot be the source of sustained competitive advantage, particularly when the architectures on which it is based are becoming more open and omnipresent.

IT in knowledge management can be used to store various kinds of information. For example, information about processes, procedures, forecasts, cases and patents in the form of working documents, descriptions and reports can be stored in knowledge management systems. TietoEnator, a Scandinavian consulting firm, has a knowledge base where they store methods, techniques, notes, concepts, best practices, presentations, components, references, guidelines, quality instructions, process descriptions, routines, strategies and CVs for all consultants in the firm (Halvorsen & Nguyen, 1999).

Knowledge retrieval can find support in content management and information extraction technology, which represent a group of techniques for managing and extracting knowledge from documents, ultimately delivering a semantic meaning for decision makers and learners alike. These types of computer applications are targeted at capturing and extracting the content of free-text documents. There are several tasks that fall within the scope of content management and information extraction (Wang, et al., 2001):

- *Abstracting and summarizing*. This task aims at delivering shorter, informative representations of larger (sets of) documents.
- *Visualization*. Documents can often be visualized according to the concepts and relationships that they play a role among. Visualization can be either in an introspective manner, or using some reference model / view of a specific topic.
- *Comparison and search*. This task finds semantically similar pieces of information.
- *Indexing and classification*. This considers (partial) texts, usually according to certain categories.
- *Translation*. Context-driven translation of texts from one language into another. Language translation has proven to be highly context specific, even among closely related languages. Some kind of semantic representation of meaning is needed in order to be able to make good translations.
- *Question formulation and query answering*. This is a task in human-computer interaction systems.
- *Extraction of information*. This refers to the generation of additional information that is not explicit in the original text. This information can be more or less elaborate.

A group of computational techniques are available to alleviate the burden of these tasks. They include fuzzy technology, neural networks and expert systems. On a more application-oriented level, there are several approaches that apply one or more of the general techniques. The field is currently dynamic, and new advances are made continuously. One novel approach is the CORPORUM system, presented in the section on expert systems.

Knowledge Transfer

Knowledge transfer can be defined as the communication of knowledge from a source so that it is learned and applied by a recipient (Ko, et al., 2005). Knowledge transfer occurs at various levels in an organization: transfer of knowledge between individuals, from individuals to explicit sources, from individuals to groups, between groups, across groups and from the group to the organization. Considering the distributed nature of organizational cognition, an important process of knowledge management in organizational settings is the transfer of knowledge to locations where it is needed and can be used. However, this is not a simple process, in that organizations often do not know what they know and have weak systems for locating and retrieving knowledge that resides in them. Communication processes and information flows drive knowledge transfer in organizations.

Depending on the completeness or incompleteness of the sender and the receiver's information sets, there are four representative types of information structure in knowledge transfer according to Lin, et al. (2005): symmetric complete information, sender-advantage asymmetric information, symmetric incomplete information and receiver-advantage asymmetric information. Lin, et al. (2005) found that because of asymmetry and incompleteness, parties seeking knowledge may not be able to identify qualified knowledge providers, and the appropriate experts may fail to be motivated to engage in knowledge transfer.

Knowledge transfer channels can be informal or formal, personal or impersonal. IT can support all four forms of knowledge transfer, but has mostly been applied to informal, impersonal means (such as discussion databases) and formal, impersonal means (such as corporate directories). An innovative use of technology for transfer is use of intelligent agent software to develop interest profiles of organizational members in order to determine which members might be interested recipients of point-to-point electronic messages exchanged among other members. Employing video technologies can also enhance transfer.

IT can increase knowledge transfer by extending the individual's reach beyond the formal communication lines. The search for knowledge sources is usually limited to immediate coworkers in regular and routine contact with the individual. However, individuals are unlikely to encounter new knowledge through their close-knit work networks because individuals in the same clique tend to possess similar information. Moreover, individuals are often unaware of what their cohorts are doing. Thus, expanding the individual's network to more extended — although perhaps weakerconnections is central to the knowledge diffusion process because such networks expose individuals to more new ideas.

Computer networks and electronic bulletin boards and discussion groups create a forum that facilitates contact between the person seeking knowledge and those who may have access to the knowledge. Corporate directories may enable individuals to rapidly locate the individual who has the knowledge that might help them solve a current problem. For example, the primary content of such a system can be a set of expert profiles containing information about the backgrounds, skills and expertise of individuals who are knowledgeable in various topics. Often such metadata (knowledge about where knowledge resides) proves to be as important as the original knowledge itself. The provision of taxonomies or organizational knowledge maps enables individuals to rapidly locate either the knowledge, or the individual who has the needed knowledge, more rapidly than would be possible without such ITbased support.

Communication is important in knowledge management, because technology provides support for both intra-organizational as well as inter-organizational knowledge networks. Knowledge networks need technology in the form of technical infrastructure, communication networks and a set of information services. Knowledge networks enable knowledge workers to share information from various sources.

Traditional information systems have been of importance to vertical integration for a long time. Both customers and suppliers have been linked to the company through information systems. Only recently has horizontal integration occurred. Knowledge workers in similar businesses cooperate to find optimal solutions for customers. IT has become an important vertical and horizontal interorganizational coordination mechanism. This is not only because of the availability of broadband and standardized protocols. It is also caused by falling prices for communication services and by software programs' abilities to coordinate functions between firms.

One way to reduce problems stemming from paper workflow is to employ document-imaging systems. Document imaging systems are systems that convert paper documents and images into digital form so they can be stored and accessed by a computer. Once the document has been stored electronically, it can be immediately retrieved and shared with others. An imaging system requires indexes that allow users to identify and retrieve a document when needed (Laudon & Laudon, 2005).

Knowledge Application

An important aspect of the knowledge-based view of the firm is that the source of competitive advantage resides in the application of the knowledge rather than in the knowledge itself. Information technology can support knowledge application by embedding knowledge into organizational routines. Procedures that are culturebound can be embedded into IT so that the systems themselves become examples of organizational norms. An example according to Alavi and Leidner (2001) is Mrs. Field's use of systems designed to assist in every decision from hiring personnel to when to put free samples of cookies out on the table. The system transmits the norms and beliefs held by the head of the company to organizational members.

Technology enforced knowledge application raises a concern that knowledge will continue to be applied after its real usefulness has declined. While the institutionalization of best practices by embedding them into IT might facilitate efficient handling of routine, linear and predictable situations during stable or incrementally changing environments, when change is radical and discontinuous, there is a persistent need for continual renewal of the basic premises underlying the practices archived in the knowledge repositories. This underscores the need for organizational members to remain attuned to contextual factors and explicitly consider the specific circumstances of the current environment.

Although there are challenges with applying existing knowledge, IT can have a positive influence on knowledge application. IT can enhance knowledge integration and application by facilitating the capture, updating and accessibility of organizational directives. For example, many organizations are enhancing the ease of access and maintenance of their directives (repair manuals, policies and standards) by making them available on corporate intranets. This increases the speed at which changes can be applied. Also, organizational units can follow a faster learning curve by accessing the knowledge of other units having gone through similar experiences. Moreover, by increasing the size of individuals' internal social networks and by increasing the amount of organizational memory available, information technologies allow for organizational knowledge to be applied across time and space.

IT can also enhance the speed of knowledge integration and application by codifying and automating organizational routines. Workflow automation systems are examples of IT applications that reduce the need for communication and coordination and enable more efficient use of organizational routines through timely and automatic routing of work-related documents, information, rules and activities. Rule based expert systems are another means of capturing and enforcing well-specified organizational procedures.

To summarize, Alavi and Leidner (2001) have developed a framework to understand IS/IT in knowledge management processes through the knowledge-based view of the firm. One important implication of this framework is that each of the four knowledge processes of creation, storage and retrieval, transfer and application can be facilitated by IT:

- *Knowledge creation*: Examples of supporting information technologies are data mining and learning tools, which enable combining new sources of knowledge and just-in-time learning.
- *Knowledge storage and retrieval*: Examples of supporting information technologies are electronic bulletin boards, knowledge repositories and databases, which provide support of individual and organizational memory as well as inter-group knowledge access.
- *Knowledge transfer*: Examples of supporting information technologies are electronic bulletin boards, discussion forums and knowledge directories, which enable a more extensive internal network, more available communication channels and faster access to knowledge sources.
- *Knowledge application*: Examples of supporting information technologies are expert and workflow systems, which enable knowledge application in many locations and more rapid application of new knowledge through workflow automation.

KNOWLEDGE MANAGEMENT SYSTEMS

There is no single information system that is able to cover all knowledge management needs in a firm. This is evident from the widespread potential of IT in knowledge management processes. Rather, knowledge management systems (KMS) refer to a class of information systems applied to managing organizational knowledge for use at the individual, group and organizational level. These systems are IT applications to support and enhance the organizational processes of knowledge creation, storage and retrieval, transfer and application.

Knowledge management systems can be classified as illustrated in Figure 1. Systems are exemplified along the axis of internal support versus external support and along the axis of technology support versus content support for knowledge workers. As an example of a knowledge management system, we find customer relationship management (CRM) systems in the upper left quadrant. CRM systems support knowledge exchange between the firm and its customers.

Figure 1. Classification of knowledge management systems

Tools	**Information**	
Tools for external communications such as customer relationship management services	Information for external electronic cooperation such as Web-based	External
Tools for internal work by knowledge workers	Information for internal work by knowledge workers	Internal

Despite widespread belief that information technology enables knowledge management, and knowledge management improves firm performance, researchers have only recently found empirical evidence of these relationships. For example, Tanriverdi (2005) used data from 250 Fortune 1000 firms to provide empirical support for these relationships.

Knowledge management systems are becoming ubiquitous in today's organizations. Knowledge management systems facilitate the efficient and effective sharing of an organization's intellectual resources. To ensure effective usage, a knowledge management system must be designed such that knowledge workers can readily find high-quality content without feeling overwhelmed (Poston & Speier, 2005).

Requirements from Knowledge Management

The critical role of information technology and information systems lies in the ability to support communication, collaboration and those searching for knowledge, and the ability to enable collaborative learning (Ryu, et al., 2005). We have already touched on important implications for information systems:

1. *Interaction between information and knowledge.* Information becomes knowledge when it is combined with experience, interpretation and reflection. Knowledge becomes information when assigned an explicit representation. Sometimes information exists before knowledge, sometimes knowledge exists before information. One important implication of this two-way direction between knowledge and information is that information systems designed to support knowledge in organizations may not appear radically different from other forms of IT support, but will be geared toward enabling users to assign meaning to information and to capture some of their knowledge in information (Alavi & Leidner, 2001).
2. *Interaction between tacit and explicit knowledge.* Tacit and explicit knowledge depend on each other, and they influence each other. The linkage of tacit and explicit knowledge suggests that only individuals with a requisite level of shared knowledge are able to exchange knowledge. They suggest the existence of a shared knowledge space that is required in order for individual A to understand individual B's knowledge. The knowledge space is the underlying overlap in the knowledge bases of A and B. This overlap is typically tacit knowledge. It may be argued that the greater the shared knowledge space, the less the context needed for individuals to share knowledge within the group and, hence, the higher the value of explicit knowledge. IT is both dependent on the shared knowledge space and is itself an important part of the shared knowledge space. IT is dependent on the shared knowledge space because knowledge workers need to have a common understanding of available information contained in information systems in the organization. If common understanding is missing, then knowledge workers are unable to make use of information. IT is an important part of the shared knowledge space because information systems make common information available to all knowledge workers in the organization. One important implication of this two-way relationship between knowledge space and information systems is that a minimum knowledge space has to be present; IT can contribute to growth in the knowledge space (Alavi & Leidner, 2001).
3. *Knowledge management strategy.* Efficiency-driven businesses may apply the stock strategy where databases and information systems are important; effectiveness-driven businesses may apply the flow strategy where

information networks are important; and Expert-driven businesses may apply the growth strategy where networks of experts, work processes and learning environments are important (Hansen, et al., 1999).

4. *Combination in SECI process.* The SECI process consists of four knowledge conversion modes. These modes are not equally suited for IT support. Socialization is the process of converting new tacit knowledge to tacit knowledge. This takes place in the human brain. Externalization is the process of converting tacit knowledge to explicit knowledge. The successful conversion of tacit knowledge into explicit knowledge depends on the sequential use of metaphors, analogy and model. Combination is the process of converting explicit knowledge into more complex and systematic sets of explicit knowledge. Explicit knowledge is collected from inside and outside the organization and then combined, edited and processed to form new knowledge. The new explicit knowledge is then disseminated among the members of the organization. According to Nonaka, et al. (2000), creative use of computerized communication networks and largescale databases can facilitate this mode of knowledge conversion. When the financial controller collects information from all parts of the organization and puts it together to show the financial health of the enterprise, that report is new knowledge in the sense that it synthesizes explicit knowledge from many different sources in one context. Finally, internalization in the SECI process converts explicit knowledge into tacit knowledge. Through internalization, the explicit knowledge created is shared throughout an organization and converted into tacit knowledge by individuals.

5. *Explicit transfer of common knowledge*. If management decides to focus on common knowledge as defined by Dixon (2000), knowledge management should focus on the sharing of common knowledge. Common knowledge is shared in the organization using five mechanisms: serial transfer, explicit transfer, tacit transfer, strategic transfer and expert transfer. Management has to emphasize all five mechanisms for successful sharing and creation of common knowledge. For serial transfer, management has to stimulate meetings and contacts between group members. For explicit transfer, management has to stimulate documentation of work by the previous group. For tacit transfer, management has to stimulate contacts between the two groups. For strategic transfer, management has to identify strategic knowledge and knowledge gaps. For expert transfer, management has to create networks where experts can transfer their knowledge. These five mechanisms are not equally suited for IT support. Explicit transfer seems very well suited for IT support as the knowledge from the other group is transferred explicitly as explicit knowledge in words and numbers and shared in the form of data, scientific formulae, specifications, manuals and the like. Expert transfer also seems suited for IT support when generic knowledge is transferred from one individual to another person to enable the person to solve new problems with new methods.

6. *Link knowledge to its uses.* One of the mistakes in knowledge management presented by Fahey and Prusak (1998) was disentangling knowledge from its uses. A major manifestation of this error is that knowledge management initiatives become ends in themselves. For example, data warehousing can easily degenerate into technological challenges. The relevance of a data warehouse for decisions and actions gets lost in the turmoil spawned by debates about appropriate data structures.

7. *Treat knowledge as an intellectual asset in the economic school.* If management decides to follow the economic school of knowledge management, then intellectual capital accounting should be part of the knowledge management system. The knowledge management system should support knowledge markets where knowledge buyers, knowledge sellers and knowledge brokers can use the system.
8. *Treat knowledge as a mutual resource in the organizational school.* The potential contribution of IT is linked to the combination of intranets and groupware to connect members and pool their knowledge, both explicit and tacit.
9. *Treat knowledge as a strategy in the strategy school.* The potential contribution of IT is manifold once knowledge as strategy is the impetus behind knowledge management initiatives. One can expect quite an eclectic mix of networks, systems, tools and knowledge repositories in this scenario.
10. *Value configuration determines knowledge needs in primary activities.* Knowledge needs can be structured according to primary and secondary activities in the value configuration. Depending on the firm being a value chain, a value shop or a value network, the knowledge management system must support more efficient production in the value chain, adding value to the knowledge work in the value shop, and more value by use of IT infrastructure in the value network.
11. *Incentive Alignment.* The first dimension of information systems design is concerned with software engineering (error-free software, documentation, portability, modularity and architecture, development cost, maintenance cost, speed and robustness). The second dimension is concerned with technology acceptance (user friendliness, user acceptance, perceived ease-of-use, perceived usefulness, cognitive fit and task-technology fit). The third dimension that is particularly important to knowledge management systems is concerned with incentive alignment. Incentive alignment includes incentives influencing user behavior and the user's interaction with the system, deterrence of use for personal gain, use consistent with organizational goals and robustness against information misrepresentation (Ba, et al., 2001).

EXPERT SYSTEMS

Expert systems can be seen as extreme knowledge management systems on a continuum representing the extent to which a system possesses reasoning capabilities. Expert systems are designed to be used by decision makers who do not possess expertise in the problem domain. The human expert's representation of the task domain provides the template for expert system design. The knowledge base and heuristic rules, which are used to systematically search a problem space, reflect the decision processes of the expert. A viable expert system is expected to perform this search as effectively and efficiently as a human expert. An expert system incorporates the reasoning capabilities of a domain expert and applies them in arriving at a decision. The system user needs little domain specific knowledge in order for a decision or judgment to be made. The user's main decision is whether to accept the system's result (Dillard & Yuthas, 2001).

Decisions or judgments made by an expert system can be an intermediate component in a larger decision context. For example, an audit expert system may provide a judgment as to the adequacy of loan loss reserves that an auditor would use as input for making an audit opinion decision. The fact that the output supports or provides input for another decision does not make the system any less an expert system, according to Dillard and Yuthas (2001). The distinguishing feature of an expert system lies in its ability to arrive at a non-algorithmic solution using processes consistent with those of a domain expert.

Curtis and Cobham (2002) define an expert system as a computerized system that performs the role of an expert or carries out a task that requires expertise. In order to understand what an expert system is, then, it is worth paying attention to the role of an expert and the nature of expertise. It is then important to ascertain what types of expert and expertise there are in business and what benefits will accrue to an organization when it develops an expert system.

For example, a doctor having a knowledge of diseases arrives at a diagnosis of an illness by reasoning from information given by the patient's symptoms and then prescribes medication on the basis of known characteristics of available drugs together with the patient's history. The lawyer advises the client on the likely outcome of litigation based on the facts of the particular case, an expert understanding of the law and knowledge of the way the courts work and interpret this law in practice. The accountant looks at various characteristics of a company's performance and makes a judgment as to the likely state of health of that company.

All of these tasks involve some of the features for which computers traditionally have been noted — performing text and numeric processing quickly and efficiently — but they also involve one more ability: reasoning. Reasoning is the movement from details of a particular case and knowledge of the general subject area surrounding that case to the derivation of conclusions. Expert systems incorporate this reasoning by applying general rules in an information base to aspects of a particular case under consideration (Curtis & Cobham, 2002).Expert systems are computer systems designed to make expert level decisions within complex domains. The business applications of this advanced information technology have been varied and broad reaching, directed toward making operational, management and strategic decisions. Audit expert systems are such systems applied in the auditing environment within the public accounting domain. Major public accounting firms have been quite active in developing such systems, and some argue that these tools and technologies will be increasingly important for survival as the firms strive to enhance their competitive position and to reduce their legal and business risk.

Dillard and Yuthas (2001) find that the implementation and use of these powerful systems raise a variety of significant ethical questions. As public accounting firms continue to devote substantial resources to the development of audit expert systems, dealing with the ethical risks and potential consequences to stakeholders takes on increasing significance. For example, when responsible behavior of an auditor is transferred to an audit expert system, then the system is incapable of being held accountable for the consequences of decisions.

Expert systems can be used in all knowledge management processes described earlier. For knowledge retrieval, content management and information extraction technology represent a useful group of techniques. An example of an expert system for knowledge retrieval is the CORPORUM system. There are three essential aspects of this system (Wang, et al., 2001).

First, the CORPORUM system interprets text in the sense that it builds ontologies. Ontologies describe concepts and relationships between them. Ontologies can be seen as the building blocks of knowledge. The system captures ontologies that reflect world concepts as the user of the system sees and expresses them. The ontology produced constitutes a model of a person's interest or concern. Second, the interest model is applied as a knowledge base in order to determine contextual and thematic correspondence with documents available in the system. Finally, the interest model and the text interpretation process drive an information search and extraction process that characterizes hits in terms of both relevance and content. This new information can be stored in a database for future reference.

The CORPORUM software consists of a linguistic component, taking care of tasks such as lexical analysis and analysis at the syntactical level. At the semantic level the software performs word sense disambiguation by describing the context in which a particular word is being used. This is naturally closely related to knowledge representation issues. The system is able to augment meaning structures with concepts that are invented from the text. The core of the system is also able to extract information most pertinent to a specific text for summary creation, extract the so-called core concept area from a text and represent results according to ranking which is based on specified interest for a specific contextual theme set by the user. In addition, the system generates explanations, which will allow the user to make an informed guess about which documents to look at and which to ignore. The system can point to exactly those parts of targeted documents that are most pertinent to a specific user's interest (Wang, et al., 2001).

Like all software, CORPORUM is continuously improved and revised. The Content Management Support (CMS) was introduced in 2005 (www.cognit.no). It is based on technology that applies linguistics to characterize and index document content. The ontology based approach focuses on semantics rather than shallow text patterns. The software can be applied for intelligent search and indexing, structure content in portals, annotation of documents according to content, summary and compression of information and extraction of names and relations from text.

Another software introduced in 2005, CORPORUM Best Practice, enables organizations to structure their business and work processes and improve value creation. It is a software tool and associated methodology to build organization-wide Best Practice. In operation, the Web part of the system is a work portal. It embraces an ontology based set of templates that helps to publish work-related documentation. Company resources like check lists, control plans, MS Word templates, images and e-learning material that is relevant for any process or activity described can be linked in where it is useful and intuitive (www.cognit.no).

A final software to be mentioned is CORPORUM Intranet Search & Navigation (SLATEWeb), which indexes and categorizes corporate information sources. Featuring language detection and find-related concept search, this tool lets companies find documents that would otherwise be hard to locate. Categories are available to dynamically classify documents into a taxonomy or group structure (www.cognit.no).

Analysis and design necessary for building an expert system differ from those needed for a traditional data processing or information system. There are three major points of distinction that prevent expert systems development being subsumed under general frameworks of systems development (Curtis & Cobham, 2002):

1. *The subject matter is knowledge and reasoning as contrasted with data and processing.* Knowledge has both form and content, which need investigation. Form is connected with the mode of representation chosen — for instance, rules, semantic networks or logic. Content needs careful attention, as once the form is selected it is still a difficult task to translate the knowledge into the chosen representation form.
2. *Expert systems are expert / expertise orientated whereas information systems are decision / function / organization directed.* The expert system encapsulates the abilities of an expert or expertise and the aim is to provide a computerized replica of these facilities.

3. *Obtaining information for expert systems design presents different problems from those in traditional information systems design.* Many expert systems rely, partly at least, on incorporating expertise obtained from an expert. Few rely solely on the representation of textbook or rulebook knowledge. It is difficult generally to elicit this knowledge from an expert. In contrast, in designing an information system, the analyst relies heavily on existing documentation as a guide to the amount, type and content of formal information being passed around the system. In the development of an expert system the experts are regarded as repositories of knowledge.

Expert systems and traditional information systems have many significant differences. While processing in a traditional information system is primarily algorithmic, processing in an expert system includes symbolic conceptualizations. Input must be complete in a traditional system, while input can be incomplete in an expert system. Search approach in a traditional system is frequently based on algorithms, while search approach in an expert system is frequently based on heuristics. Explanations are usually not provided in a traditional system. Data and information is the focus of a traditional system, while knowledge is the focus of an expert system.

Expert systems can deliver the right information to the right person at the right time if it is known in advance what the right information is, who the right person to use or apply that information would be, and, what would be the right time when that specific information would be needed. Detection of non-routine and unstructured change in business environment will, however, depend upon sense-making capabilities of knowledge workers for correcting the computational logic of the business and the data it processes (Malhotra, 2002).

QUESTIONS FOR DISCUSSION

1. What kind of knowledge is created in each primary activity of the value shop?
2. How can expert systems support each primary activity of the value shop?
3. Why is efficient and effective interaction between information and knowledge so important for successful knowledge management systems?

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Ba, S., Stallaert, J., & Whinston, A. B. (2001). Research commentary: Introducing a third dimension in information systems design — The case of incentive alignment. *Information Systems Research, 12*(3), 225-239.

Bock, G. W., Zmud, R. W., & Kim, Y. G. (2005). Behavioral intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly, 29*(1), 87-111.

Curtis, G., & Cobham, D. (2002). *Business information systems: Analysis, design and practice*. Prentice Hall.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge*. Boston, MA: Harvard Business School Press.

Dillard, J. F., & Yuthas, K. (2001). Responsibility ethic for audit expert systems. *Journal of Business Ethics*, 30, 337-359.

Dixon, N. M. (2000). *Common knowledge*. Boston, MA: Harvard Business School Press.

Fahey, L., & Prusak, L. (1998). The eleven deadliest sins of knowledge management. *California Management Review, 40*(3), 265-276.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Halvorsen, K., & Nguyen, M. (1999, 17-19 June). A successful software knowledge base. *Proceedings of the 11th International Conference on Software Engineering and Knowledge Engineering*, Germany: Kaiserslautern.

Hansen, M. T., Nohria, N., & Tierney, T. (1999, March-April). What's your strategy for managing knowledge? *Harvard Business Review*, 106-116.

Housel, T., & Bell, A. H. (2001). *Measuring and managing knowledge*. Irwin, NY: McGraw-Hill.

Kettinger, W. J., Teng, J. T. C., & Guha, S. (1997, March). Business process change: A study of methodologies, techniques, and tools. *MIS Quarterly*, 55-79.

Ko, D. G., Kirsch, L. J., & King, W. R. (2005). Antecedents of knowledge transfer from consultants to clients in enterprise system implementations. *MIS Quarterly, 29*(1), 59-85.

Laudon, K. C., & Laudon, J. P. (2005). *Essentials of management information systems: Managing the digital firm* (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Lin, L., Geng, X., & Whinston, A. B. (2005). A sender-receiver framework for knowledge transfer. *MIS Quarterly, 29*(2), 197-219.

Malhotra, A., Gosain, S., & El Sawy, O. A. (2005). Absorptive capacity configurations in supply chains: Gearing for partner-enabled market knowledge creation. *MIS Quarterly, 29*(1), 145-187.

Moffett, S., & McAdam, R. (2003). Contributing and enabling technologies for knowledge management. *International Journal of Information Technology and Management, 2*(1/2), 31-49.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nonaka, I., Toyama, R., & Konno, N. (2000). SECI, ba and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34.

Poston, R.S., & Speier, C. (2005). Effective use of knowledge management systems: A process model of content ratings and credibility indicators. *MIS Quarterly, 29*(2), 221-244.

Ryu, C., Kim, Y. J., Chaudhury, A., & Rao, H. R. (2005). Knowledge acquisition via three learning processes in enterprise information portals: Learning-byinvestment, learning-by-doing, and learning-from-others. *MIS Quarterly, 29*(2), 245-278.

Tanriverdi, H. (2005). Information technology relatedness, knowledge management capability, and performance of multibusiness firms. *MIS Quarterly, 29*(2), 311-334.

Wang, K., Hjelmervik, O. R., & Bremdal, B. (2001). *Introduction to knowledge management*. Trondheim, Norway: Tapir Academic Press.

Ward, J., & Peppard, J. (2002). *Strategic planning for information systems.* UK: Wiley.

Wasko, M. M., & Faraj, S. (2005). Why should I share? Examining docial vapital and knowledge vontribution in electronic networks of practice. *MIS Quarterly, 29*(1), 35-57.

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Chapter 6.2
Business Processes and Knowledge Management

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INTRODUCTION

Knowledge has been a subject of interest and enquiry for thousands of years, since at least the time of the ancient Greeks, and no doubt even before that. "What is knowledge" continues to be an important topic of discussion in philosophy.

More recently, interest in managing knowledge has grown in step with the perception that increasingly we live in a knowledge-based economy. Drucker is usually credited as being the first to popularize the knowledge-based economy concept, for example, by linking the importance of knowledge with rapid technological change in Drucker (1969). Karl Wiig coined the term knowledge management (hereafter KM) for a NATO seminar in 1986, and its popularity took off following the publication of Nonaka and Takeuchi's book "The Knowledge Creating Company" (Nonaka & Takeuchi, 1995). Knowledge creation is in fact just one of many activities involved in KM. Others include sharing, retaining, refining, and using knowledge. There are many such lists of activities (Holsapple & Joshi, 2000; Probst, Raub, & Romhardt, 1999; Skyrme, 1999; Wiig, De Hoog, & Van der Spek, 1997). Both academic and practical interest in KM has continued to increase throughout the last decade.

In this article, first the different types of knowledge are outlined, then comes a discussion of various routes by which knowledge management can be implemented, advocating a process-based route. An explanation follows of how people, processes and technology need to fit together, and some examples of this route in use are given. Finally there is a look towards the future.

BACKGROUND

Types of Knowledge: Tacit and Explicit

Nonaka and Takeuchi's book (1995) popularized the concepts of tacit and explicit knowledge, as well as KM more generally. They based their thinking on that of Michael Polanyi (1966), expressed most memorably in his phrase "we know more than we can tell".

It is, however, most important to realize that tacit and explicit knowledge are not mutually exclusive concepts. Rather, any piece of knowledge has both tacit and explicit elements, as shown in Figure 1. The size of the inner circle represents the proportion of tacit knowledge: the "tacit core" at the heart of the knowledge that we "cannot tell". Figure 1(a) shows a case where the knowledge is almost entirely tacit, as in riding a bicycle. Figure 1(b) shows mainly explicit knowledge, where the tacit core is very small, for example, how to process a claim for travel expenses in an organization. Figure 1(c) shows an intermediate case, such as making a piece of furniture, where substantial amounts of both tacit and explicit knowledge are involved.

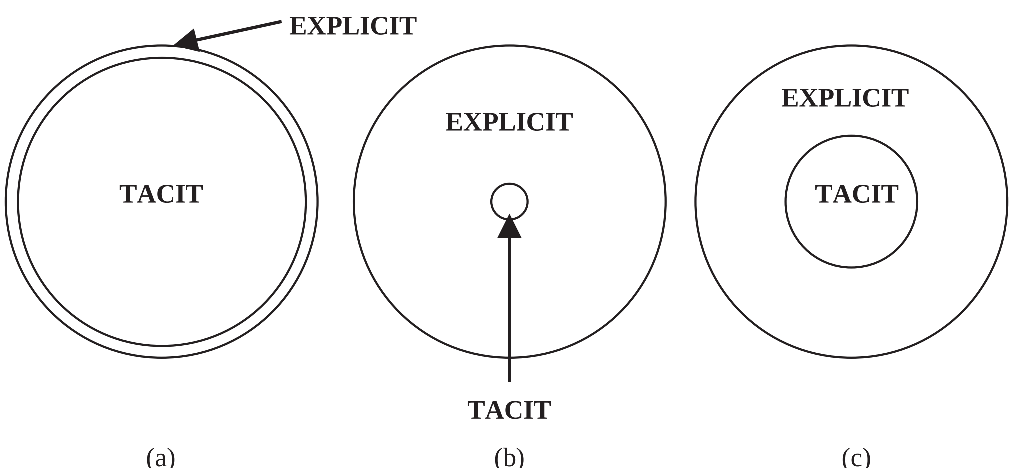
The Role of KM Systems

KM systems represent a deliberate, conscious attempt to manage knowledge, usually in an organization. Hansen, Nohria, and Tierney (1999) identified that there are two fundamental KM strategies, codification and personalization. Codification concentrates more on explicit knowledge (often relying very heavily on information technology), personalization more on tacit knowledge. Again, it is important to realize that these are not mutually exclusive, and that a strategy combining elements of both is likely to be the most successful.

ROUTES TO IMPLEMENTING KM

Many organizations have found it difficult to implement knowledge management systems successfully. Identifying "who", "what", and "why" – who is involved in knowledge manage-

Figure 1. The relationship between tacit and explicit knowledge



ment, what knowledge is being managed, and why is it being managed – can be problematic. The routes they have attempted to follow can be put into five generic categories, which will now be described.

Knowledge World Route

A substantial amount of the literature on knowledge management addresses knowledge at the level of the whole organization, or in a "world of knowledge" that is not specifically linked to the activities that a particular organization carries out. On an abstract level, such discussion of knowledge management can be extremely valuable. However, it has weaknesses in terms of practical implementation. For example, it is necessary not only to understand how individuals learn, but also how they learn in a given organization, and how the organizational systems may help or hinder the individual's learning process. The same issue applies even more forcefully to group learning, since the organization provides a crucial element of the group's context.

The practical focus in Nonaka and Takeuchi (1995) was very much on knowledge creation. As a result, organizations attempting to follow their principles for other aspects of KM, such as sharing or retaining knowledge, have sometimes found it difficult to make a specific connection from abstract ideas about knowledge to what the organization actually does, or could do, or should do. Often only the "why" is present, not the "who" or even the "what". Something more concrete is needed.

IT-Driven Route

This route assumes that the fundamental requirement is for the codification of as much knowledge as possible. Advocates of this approach sometimes refer to this as "extracting" the knowledge from the people who possess it; see for example Johannsen and Alty (1991). This is an inadvisable term to use, for two reasons. First, it is logically incorrect; their knowledge is being shared, not extracted. The people still have the knowledge after the "operation" has taken place. Second, it gives the people the wrong impression – that their knowledge is being taken away. This is not a recipe to encourage their co-operation. For an organization of any size, such a codification task evidently requires IT support, and the thrust of this route is that once the "correct" form of IT support for managing knowledge has been chosen, it is simply a matter of a great deal of hard work.

This technology-driven route only works well in a limited range of situations where the "what" questions are most important, for example, where the main KM task is managing the knowledge held by a company in the form of patents. In other circumstances, it may not achieve any improvement in knowledge management at all. One example of this from the author's experience is of a heavy manufacturing firm. Knowledge management in this organization was seen solely as an information systems issue; the KM group was part of the information systems department. The "solution" was seen in terms of the implementation of a knowledge sharing system based on Lotus Notes™. However, there was no real consideration as to who would share what knowledge or for what specific purpose. Consequently, the eventual use of the installed IT was poor; the only really successful use was by the knowledge management project team itself, where the "who" and "why" questions had been properly addressed, as well as the "what" questions.

Functional Route

An alternative route that has the potential to address the "who", "what" and "why" questions is to organize the implementation around the existing organizational structure. The most commonly found structural elements intended to facilitate learning and knowledge sharing in organizations are departmental groupings based on functions. These have clear advantages in terms of what might be termed professional development and allegiance. Davenport and Prusak (1998) report examples of successful knowledge transfer between groups of surgeons, and groups of tunneling engineers, among others. However, this functional route also has the disadvantage that it encourages the compartmentalization of knowledge. This problem can only worsen over time, as specialisations multiply and sub-divide. In addition, professional divisions can actively prevent sharing of knowledge. It has, for example, taken decades for hospital doctors in the UK National Health Service to allow other professionals such as pharmacists and physiotherapists to participate in decision-making about treatment of individual patients on an equal footing. On a wider scale, modern Western medical science has come to separate "diet" and "drugs", at least until the very recent past, in a way that Chinese medicine, for example, never has done. The problems of running an organization in this manner, and the "functional silos" mentality that tends to result, were recognized by authors such as Hammer (1990) as part of the business process re-engineering movement, when KM was in its infancy.

Therefore, although the functional route to implementation will allow some improvement in KM, progress may be limited by the characteristics of the existing structure, and in the worst cases (for example, where transferring knowledge between functions is the greatest KM issue in the organization) this route may be counter-productive.

People-Centric Route

A people-centric route to KM is the essence of the Hansen et al. (1999) personalization strategy. By definition, such an approach, appropriately implemented, will answer all the "who" questions that might be involved in KM. Thus in organizations where there is general consensus on "what" knowledge is important and "why" it needs to be managed, such a route should prove effective.

However, as was mentioned in the previous sub-section, organizations have become increasingly diverse in their activities, and in the range of specialized knowledge that they need to access. This means that consensus even on what knowledge the organization has, never mind what is important, may be difficult to achieve. On the one hand, it may not be easy for a particular specialist to fully appreciate "what the organization does". Equally, even the most conscientious senior manager will find it literally impossible to understand all the expertise and knowledge possessed by the specialists in his or her organization. To repeat the quotation from Hewlett Packard CEO Lew Platt (Davenport & Prusak, 1998, p. xii), "If HP knew what HP knows, we would be three times as profitable."

Business Processes Route

The managers in an organization have to translate the goals of any strategic program or initiative – whether on knowledge management or something else – into practical, implementable reality. In other words, to connect with "what the organization does". Various management thinkers have presented models of this, for example:

- Porter's (1985) value chain,
- Earl's (1994) view of core processes, the ones that are done directly for external customers,
- Beer's (1985) "System Ones", the systems that make the organization what it is,
- Core competences/competencies as espoused by Hamel and Prahalad (1994).

Although there are some significant differences between them, their common theme is that the effectiveness – indeed, the competitive advantage

– of organizations depends not on how they are structured, or on what resources they have, but on what they do. In the terminology of this article, this means their underlying business processes. Note that the term business processes is used throughout, but such processes exist equally in not-for-profit organizations.

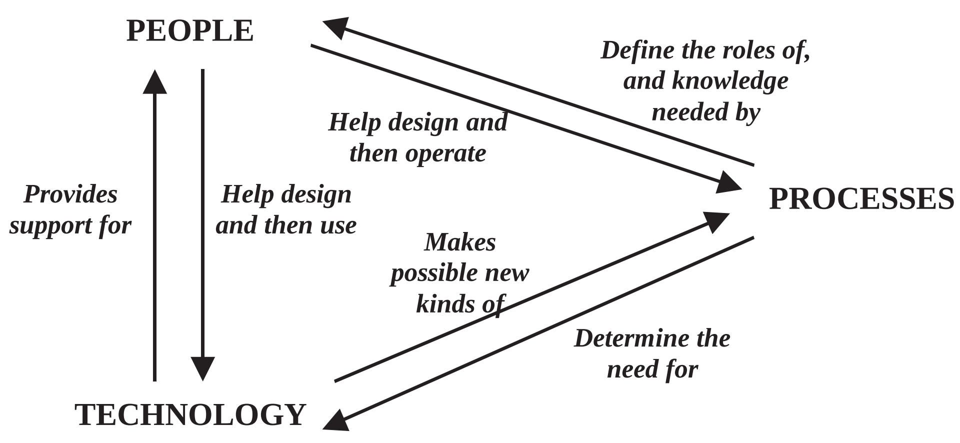
Business processes possess five characteristics that justify their use as a foundation for knowledge management in organizations.

1. Business processes have identifiable customers, whether internal or external. Knowledge is of little relevance unless put to use for a customer of some kind.
2. Business processes cut across organizational boundaries. Knowledge does not need to, and does not, obey the artificial boundaries within an organization.
3. Business processes consist of a structured set of activities. Choosing the appropriate way to structure activities is an important part of the knowledge.
4. Business processes need to be measured. Without some form of measurement as a comparison, knowledge cannot be validated.
5. While the parts of a business process are important, the overriding requirement is that the overall process works. Valid knowledge in an organizational context must take a holistic view.

An additional argument (Braganza, 2001) is that viewing knowledge management in terms of an organization's processes gives a much-needed demand-side view of knowledge. This is complementary to the supply-side view of knowledge that stems, for example, from considerations "of data leading to information leading to knowledge". Beer and Earl particularly concentrate on this demand-side perspective. Beer indeed goes even further, to include the informal processes and activities of the organization as well as the more formalized ones.

Completing this argument for a greater use of the business processes route, the knowledge that an organization requires must, logically, be related not just to what that organization does, but also to how it does it. Thus, people in organizations

Figure 2. People, processes and technology in a KM system



should think about this knowledge, and how to manage it, by reference to that organization's business processes.

PEOPLE, PROCESSES AND TECHNOLOGY

From the earlier discussion, it may be seen that, whichever route is chosen, effective KM requires the consideration of both tacit and explicit knowledge. The need is to coordinate people, processes and technology successfully. The interaction of these three elements is shown in Figure 2.

Not only does a knowledge management system consist of more than technology, it is important to realize that the technology used to support KM does not have to be "KM software". Recent studies have found that generic software such as e-mail or an Intranet may be at least as important as specific software (Edwards, Shaw, & Collier, 2004 (to appear); Zhou & Fink, 2003).

KM BY A BUSINESS PROCESSES ROUTE

As it has so far been less frequently attempted than the other routes, some examples of organizations that have implemented KM by a business processes route will now be given.

Unisys (Wizdo, 2001) have embarked upon a company-wide knowledge management initiative with an explicit process focus. Its objectives include:

- Accelerating the speed and scope of organisational learning,
- Decreasing the time it takes to reach critical mass in new markets,
- Uniting cross-boundary groups,
- Increasing innovation in product and process.

Wizdo identifies three increasingly ambitious categories of "transformation" in business: efficiency, innovation and re-invention. The Unisys knowledge management program regards a focus on processes as essential in achieving the two "higher" categories.

Objective Corporation (Fisher, 2001) changed most of their processes over a period of some five years. They found that such an emphasis not only improved knowledge management within the business, but also had a significant impact on the performance of the business itself. In this case, it was most likely the effect of a coherent training programme, with an emphasis on understanding, increasing the overall organisational performance through the people involved operating more effectively.

Both of these examples involved substantial use of information technology. However, that does not have to be the case. The author's group has been working with a component manufacturer in the aerospace industry, whose KM initiative also has an explicit process focus. Typically, their manufacturing processes use a machine operated by one person. The operators' choice of the best way to retain and share knowledge does not use IT at all (except for a word processor). The agreed best operating procedure, with illustrations, is put on a laminated sheet of paper mounted near the machine, which includes the names of the people who had contributed to designing the procedure. A suitable pen is provided to annotate the laminated sheet. At regular intervals, office staff come round to produce a revised version of any of the "Standard Operating Sheets" that have been annotated.

FUTURE TRENDS

A further justification for the use of business processes as the foundation for implementing knowledge management is that they are now becoming part of the mainstream of management thought. For example, the latest version of the ISO9000 family of standards for Quality Management Systems, including ISO9001: 2000, is constructed on the basis of a "process approach". The ISO9000 term realisation process is equivalent to Earl's core process or Beer's primary activity as discussed earlier. Significantly, the latest editions of strategic management textbooks (Johnson & Scholes, 2001) typically discuss the business process view of organizations, whereas earlier ones did not.

It seems clear, therefore, that the business processes route to implementing knowledge management is likely to become more common in future, and that this will encourage the development of ever more appropriate information technology for supporting it. Equally, new information technologies will enable new types of process. Intelligent agents, smart cards and "picture phones", for example, all offer different possibilities for supporting KM which have only just begun to be considered.

CONCLUSION

This article has considered the implementation of knowledge management systems by looking at five different generic routes towards achieving it: knowledge world, IT-driven, functional, people-centric and business processes. While each of these routes has some merits, it has been argued that the business processes route offers potential for the greatest integration between knowledge management and "what the organization does". It is, thus, likely to be increasingly common in the future.

REFERENCES

Beer, S. (1985). *Diagnosing the system for organisations.* Chichester, UK: Wiley.

Braganza, A. (2001). *Knowledge (mis)management…and how to avoid it. Information Management 2001.* Olympia, London.

Davenport, T.H. (1993). *Process innovation: Reengineering work through information technology.* Boston, MA: Harvard Business School Press.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston, MA: Harvard Business School Press.

Drucker, P.F. (1969). *The age of discontinuity.* London: Heinemann.

Earl, M. J. (1994). The new and the old of business process redesign. *The Journal of Strategic Information Systems, 3*(1), 5-22.

Edwards, J.S., Shaw, D., & Collier, P.M. (2004 (to appear)). Knowledge management systems: Finding a way with technology. *Journal of Knowledge Management.*

Fisher, G. (2001). *A framework for deploying knowledge management in an EDRM environment. Information Management 2001.* Olympia, London.

Hamel, G., & Prahalad, C.K. (1994). *Competing for the future.* Boston, MA: Harvard Business School Press.

Hammer, M. (1990). Re-engineering work: Don't automate, obliterate. *Harvard Business Review, 68*(4 (July/August)), 104-112.

Hammer, M., & Champy, J. (1993). *Reengineering the corporation: A manifesto for business revolution.* London: Nicholas Brealey.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Holsapple, C.W., & Joshi., K.D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information Systems, 9*, 235-261.

Johannsen, G., & Alty, J.L. (1991). Knowledge engineering for industrial expert systems. *Automatica, 27*(1), 97-114.

Johnson, G., & Scholes, K. (2001). *Exploring corporate strategy, text and cases* (6th ed.). Harlow: Financial Times Prentice Hall.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company, how Japanese companies create the dynamics of innovation*. New York and Oxford: Oxford University Press.

Polanyi, M. (1966). *The tacit dimension*. Garden City, NY: Doubleday.

Porter, M.E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York, London: Collier Macmillan.

Probst, G., Raub, S., & Romhardt, K. (1999). *Managing knowledge: Building blocks for success*. Chichester: Wiley.

Skyrme, D.J. (1999). *Knowledge networking: Creating the collaborative enterprise*. Oxford: Butterworth-Heinemann.

Wiig, K.M., De Hoog, R., & Van der Spek, R. (1997). Supporting knowledge management: A selection of methods and techniques. *Expert Systems with Applications, 13*(1), 15-27.

Wizdo, L. (2001, November 8th-9th). *Organisational models for enterprise knowledge management*. Paper presented at the Second European Conference on Knowledge Management, Bled, Slovenia.

Zhou, A.Z., & Fink, D. (2003). Knowledge management and intellectual capital: An empirical examination of current practice in Australia. *Knowledge Management Research & Practice, 1*(2), 86-94.

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Chapter 6.3
Creating Knowledge for Business Decision Making

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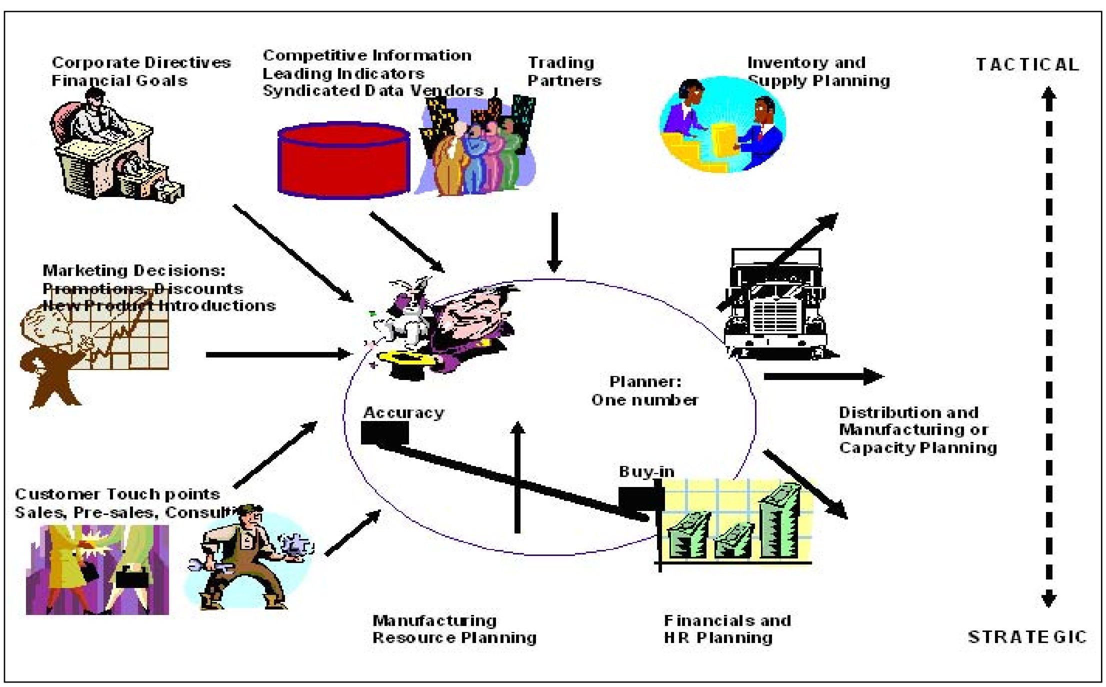
INTRODUCTION

Business forecasts and predictive models are rarely perfect. A paraphrase of the Nobel winning physicist Neils Bohr is apt in this context: Prediction is difficult, especially if it is of the future. However, executives and managers in enterprises ranging from retail and consumer packaged goods to high tech and semiconductors have to resort to forecasting and planning about the future. Phenomenal growth and spectacular failures are associated with organizations depending on their ability to understand market directions and respond quickly to change. Relatively minor improvements in forecast accuracy and predictive modeling at detailed levels can translate to significant gains for the enterprise through better strategic decisions, continuous performance management, and rapid translation to tactical decisions. The key to these processes is the knowledge-based enterprise, which can effectively utilize information from multiple sources as well as the expertise of skilled human resources, to develop strategies and processes for creating, preserving, and utilizing knowledge. These efforts, spanning revenue-generation endeavors like promotion management or new product launch, to cost-cutting operations like inventory planning or demand management, have significant impacts on the top and bottom lines of an enterprise.

Advances in scalable mathematical model-building, ranging from advanced statistical approaches and data mining (DM) to operations research (OR) and data assimilation, can extract meaningful insights and predictions from large volumes of data. Information technologies and e-business applications can enable a degree of process automation and collaboration within and among enterprises. Enterprises of the new millennium can truly take advantage of scalable but cutting-edge data-dictated approaches to understand the past and predict the future, and then focus valuable planner resources on key value drivers or exceptional situations through human-computer interaction, which in turn utilizes tools like online analytical processing (OLAP) and automated or planner-driven decision support systems (DSSs).

Analytic information technologies enable managers of the knowledge-based enterprise to choose the path to new revenues, new markets, good customer service, and competitive advantage over their rivals. The ability to produce "one-number forecasts" that reconcile information from multiple sources and blend disparate points of view is a critical first step for enterprise-scale strategic, operational, and tactical planning (see Figure 1). However, this is a challenging process, especially in recent years owing to short product lifecycles, mass customizations, and dynamic markets, combined with the ever-increasing service expectations of consumers and trading partners on the one hand, versus the need to reduce operating and inventory costs on the other. The need to manage product lifecycles and promotions or pricing decisions, factor in market signals or competitive intelligence, analyze consumer behavior, and achieve buy-in from multiple participants within and across enterprises has fundamentally changed the way the forecast

Figure 1. "One-number forecasting" for an enterprise

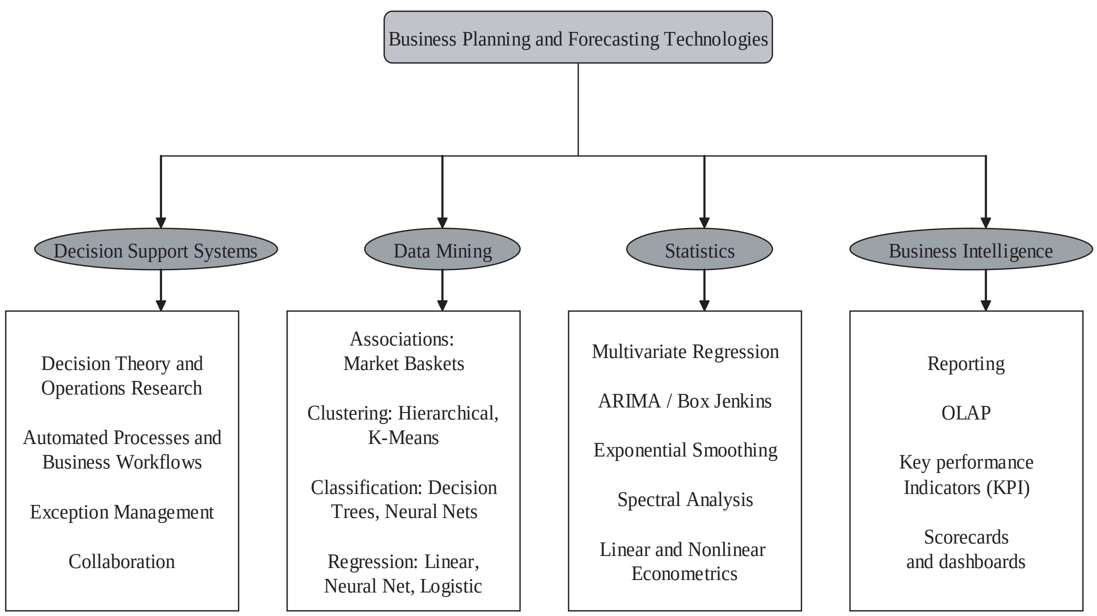


generation process is perceived. Corporate data repositories, collaborative information technologies and processes, syndicated data vendors, and the Internet provide large volumes of historical and real-time information. The challenge is to acquire, manage, analyze, and reconcile the information for knowledge extraction and predictive purposes in an optimal fashion.

BACKGROUND

Data-derived knowledge adds value to a business through products, processes, and better decision making. Davis and Botkin (1994) describe six features of knowledge-based businesses. Manual analysis, evaluation, and interpretation are the most common approaches of creating knowledge from digital data. Volumes of information can grow rapidly, as every communication, interaction, and transaction produces new data. Thus, manual data analysis quickly becomes slow and inexpensive, and is becoming obsolete in applications like retail, telecommunication, health care, marketing, the natural sciences, and engineering. With the advent of analytical information technologies, researchers and engineers have been exploring the possibility of constructing data-dictated models by mining large-scale corporate or scientific data repositories. These approaches combine data management technologies and innovative computational or visualization methods with analytical techniques drawn from the diverse fields of statistics, machine learning, and artificial intelligence (Fayyad & Uthurusamy, 2002; Hand, Mannila, & Smyth, 2001). Many organizations have invested in automated analysis techniques (Ganguly, Gupta & Khan, 2005) to unearth meaningful patters and structures from millions of records with hundreds of attributes. Automated analytical approaches like data mining (DM) and statistics are combined with planner-driven

Figure 2. Examples of technologies used for business planning and forecasting



analytic systems like decision support systems (DSSs) and business intelligence (BI) (see Figure 2). These are being integrated with transactions systems, producing insights into how effectively a company does business, responds to or forecasts trends, understands and reacts to market conditions, and develops customer-focused products and services. The knowledge mined from objective data and generated by human experts is encapsulated through adaptive information systems. This knowledge becomes an asset in current business conditions where supply-driven "push" of products and services has yielded to demand-driven "pull" as well as one-on-one or mass customizations. Management scientists (Aviv, 2001; Cachon & Lariviere, 2001; Chen, Drezner, Ryan, & Simchi-Levi, 2000; Lee & Whang, 1998) have theoretically demonstrated the value of collaborative forecasting on the supply chain and modeled the impact of information sharing among trading partners as well propagation of uncertainty (Gilbert, 2005). A research report by the analyst firm Gartner (Peterson, Geishecker, & Eisenfeld, 2003) indicated the opportunity, need, and confusions surrounding the generation of "one-number forecasts," and highlighted the "opportunity for intra-enterprise forecast improvement."

MAIN FOCUS OF THE ARTICLE: TOOLS AND PROCESSES FOR CREATING KNOWLEDGE FOR BUSINESS DECISION MAKING

Data Management

Data warehousing provides an infrastructure to process vast amounts of data, as well as discover and explore important business trends used for knowledge creation and decision making. Inmon (1992) and Kimball (1996) suggested a data warehouse that integrates data from diverse operational databases to aid in the process of decision making. A data warehouse is the first component of a knowledge system where all available information is acquired from online transactional processing (OLTP) sources, cleansed, stored and processed, and made available for use by knowledge creation systems like business planning and forecasting. The information might range from point of sales (POS) data for the retail industry, to income, marital status, location, demographics, and credit history for a financial or a phone company. A few key data warehousing activities include data cleaning or scrubbing, data transformation, data condensation, data aggregation, data refreshing, data reporting, and metadata synchronization.

Planning and Forecasting Tools

Businesses need to react quickly to evolving market conditions, especially in these days of mass customizations, global competitions, and corporate consolidations. As early as 1999, Forrester Research and Meta Group reported that 30% of firms' data warehouses contained over one trillion characters of data worldwide (Bransten, 1999), and the total sum of data is increasing every hour. Creation of knowledge from this data efficiently through analytical information technologies, and utilizing the knowledge for driving business decisions quickly, is a key requirement.

Data mining (DM) refers to diverse technologies suited for extracting knowledge and insights from vast quantities of data in an efficient manner. Most DM tools use traditional statistical techniques coupled with highly efficient pattern recognition and machine learning algorithms (Breiman, Friedman, Olshen, & Stone, 1984; Ganguly, 2002; Quinlan, 1992). DM methods are used in conjunction with database-centric approaches for knowledge discovery in databases (KDD) (Fayyad, Shapiro, & Smyth, 1996). The type of knowledge created by DM and KDD tasks determines the categories into which these tasks are grouped together (Table 1). Heinrichs and Lim (2003) gave an insight into integrating Web-based DM tools with business models to

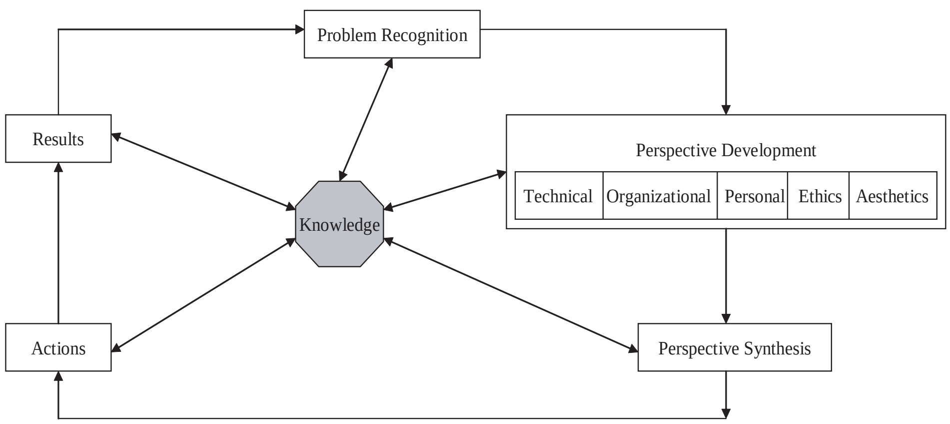
Table 1. A taxonomy of data mining tasks (Shaw, Subramaniam, Tan, & Welge, 2001)

Dependency Analysis • Associations • Sequences *Class Identification* • Mathematical taxonomy • Concept clustering *Deviation Detection* • Anomalies • Changes	*Concept Description* • Summarization • Discrimination • Comparison *Data Visualization* • Pixel oriented • Geometric projection • Graph based

understand changing customer requirements, monitor product performance, uncover market opportunity, and manage customer relationships in real-time. Web-based software tools help skilled knowledge workers identify and understand their competitors' strategy, thus preparing them to respond to potential competitive threat quickly (Lim, Heinrichs, & Hudspeth, 1999).

The ability to anticipate, react, and adapt to market trends and changes, through appropriate business strategies and implementation, are the characteristics of a successful company. Given the uncertainties inherent in the forecasting planners, some companies rely on the "gut feel" of senior decision makers and executives. However, as business conditions are getting more dynamic, it

Figure 3. A new decision paradigm for DSS (Courtney, 2001)



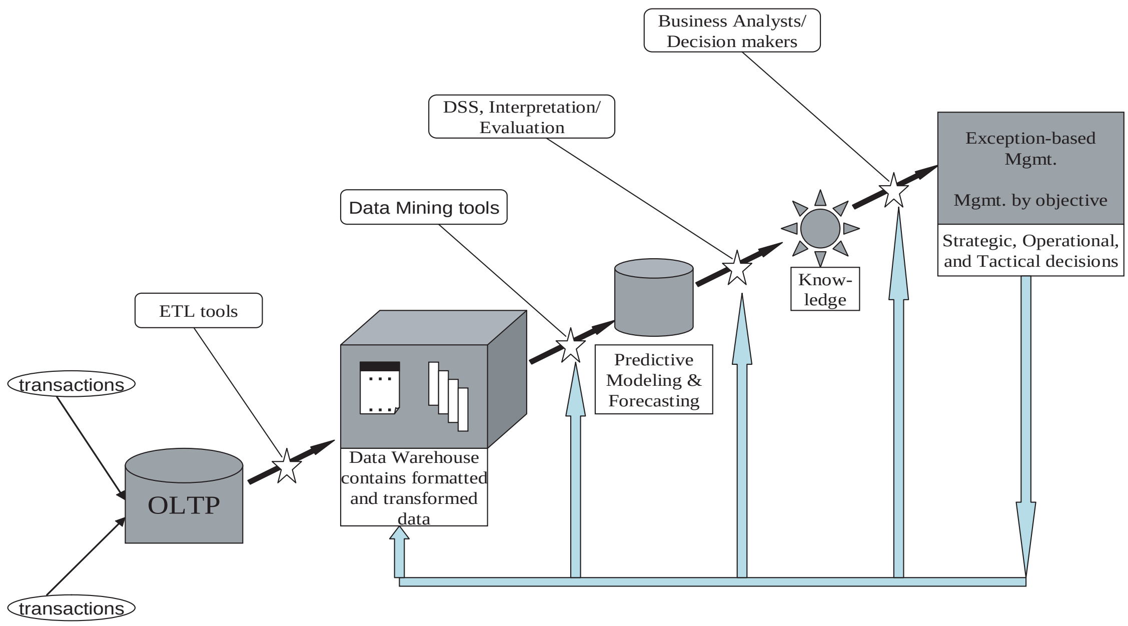
is becoming more and more important to continuously visualize and monitor the state of business through tools like DSS and BI, and to develop predictive modeling capabilities through tools like DM and KDD, for creating knowledge and insights about the future. Originally, the concept of DSS was provided by Gorry and Mortan (1971), who integrated Simon's description of decision types like unstructured, semi-structured, and structured (Simon, 1960) and Anthony's categories of management activities like strategic planning, management control, and operational control (Anthony, 1960). Courtney (2001) described a new paradigm for DSS where a centralized knowledge model is influenced by every step of the process. The model recognizes the problem, creates perspectives to gain insight into the nature of the problem, finds its possible solutions, and continually updates itself. Today, a number of fields like database technologies, management science, operations research, cognitive science, AI, and expert systems (Bonczek, Holsapple, & Whinston, 1981), in addition to software engineering, assist in the design of DSSs. Management science and operations research tools like linear and nonlinear programming, optimization, Monte Carlo simulation, and dynamic programming help to develop mathematical models for use in model-driven DSSs. The use of the Internet and communication technology in DSSs allows organizations to become global and connects suppliers, producers, and customers through collaborative planning, forecasting, and replenishment (CPFR) processes. This helps to achieve full collaboration, develop and share "one-number forecasts" through the extended ("n-tier") supply chain, thus helping in the sales and operations planning (S&OP) process, improving forecasting accuracy, reducing inventory levels, improving customer service levels, designing effective promotions, and maximizing profits through revenue generation and cost cutting.

BI tools like querying or reporting are used to pull information from data stores and present it to end users in the language and structure of a specific business. Key performance indicators (KPIs) are used to monitor critical factors within the business on an ongoing basis. OLAP tools specify fast, consistent, and interactive ways of analyzing multidimensional enterprise data and providing end users analytical navigational activities to gain insights into the knowledge contained in large databases. Drill-down, slice-dice, reach-through, and rotation are the activities of OLAP used for many business applications, including product performance and profitability, effectiveness of a sales program or a marketing campaign, and sales forecasting.

Planning and Forecasting Processes

Extract, transform, and load (ETL) tools extract data from heterogeneous sources like OLTP systems, syndicated data vendors, public domain sources like the Internet, legacy systems, real-time data repositories maintained by business analysts, decision makers, internal or external collaborators, consultants, and executives for business planning and forecasting (see Figure 4) applications (Gung, Leung, Lin, & Tsai, 2002; Peterson et al., 2003; Wang & Jain, 2003; Yurkiewicz, 2003). The data is crunched and transformed into a standard or desired format and then loaded into a data warehouse or a data mart. The data is further processed inside the data warehouse to make them available for online analysis and decision support. DM and KDD tools access the data from the data warehouse to discover new patterns and fit models to predict future behavior. The results of predictive models are presented and utilized in the form of structured business workflows, interactive formatted data models for visualization, graphic models (Pearl, 1988; Whittaker, 1990), planning cycles, and automated predictive and forecasting outputs which can be used as baselines by business planners and decision makers. DSS and BI tools like OLAP (Hammer, 2003) are utilized to interpret and evaluate predictive and forecasting

Figure 4. An overview of the steps involved in business planning and forecasting



models for creating knowledge about the future, which in turn helps analysts and decision makers to make strategic and tactical decisions.

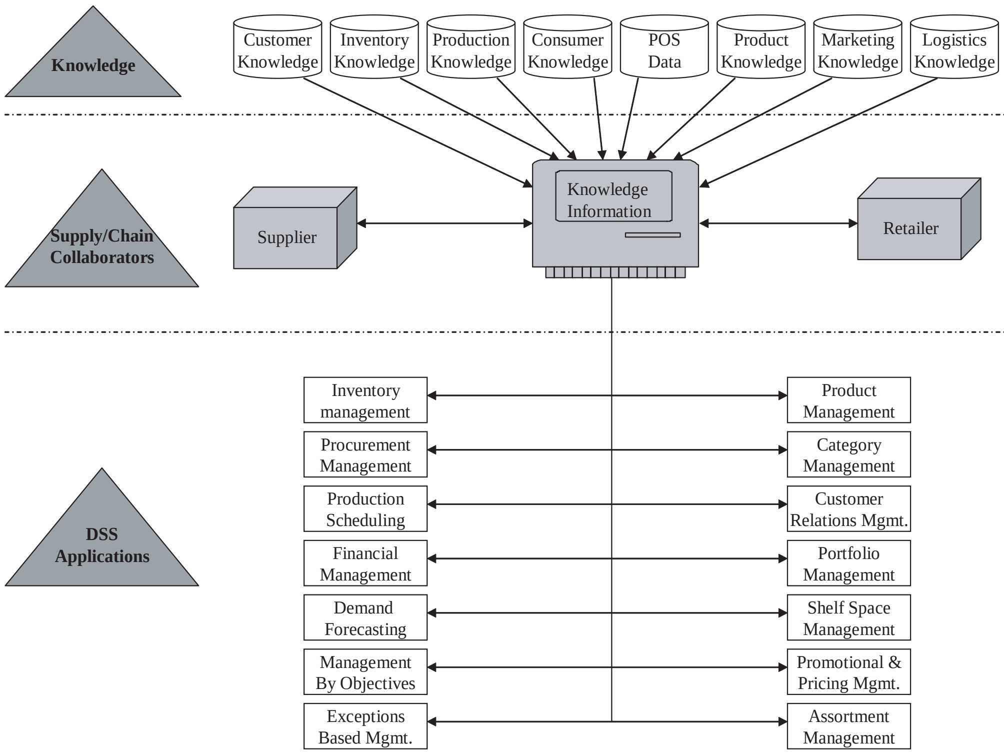
Data Mining Technologies and Decision Support Systems

Managers and business planners use DMT to extract meaningful patterns about their business and customers which can be interpreted as useful or interesting knowledge. Machine learning and pattern recognition algorithms, along with statistical methods like classification, clustering, and regression, are used to fit a model to data, to find structure from data, and derive high-level knowledge from the voluminous data present in the data warehouse.

Predictive and forecasting models generated by DM or KDD tools are interpreted and analyzed by business analysts, planners, and executives using DSS and BI tools to understand trends, manage metrics, align organizations against common goals, develop future strategy, and drive action. In this highly competitive world where different manufacturers offer the same category of products, trade promotions and advertisements can result in larger return on investment (ROI) from the perspective of a CPG company if the marginal increase in promotional sales is caused by increase in brand share. There is a need to distinguish these from natural variability in demand (e.g., seasonal, weather, economic, demographic, or other effects), as well as ancillary effects like cannibalization, drag, or pre- and post-sales dips.

A process described in Figure 5 involves a knowledge information system where all partners can access, view, and modify the same data and knowledge to come up with “one number,” demand forecasts or a common plan that is shared through the extended enterprise, thus resulting

Figure 5. Inter-enterprise DSS in supply chain management

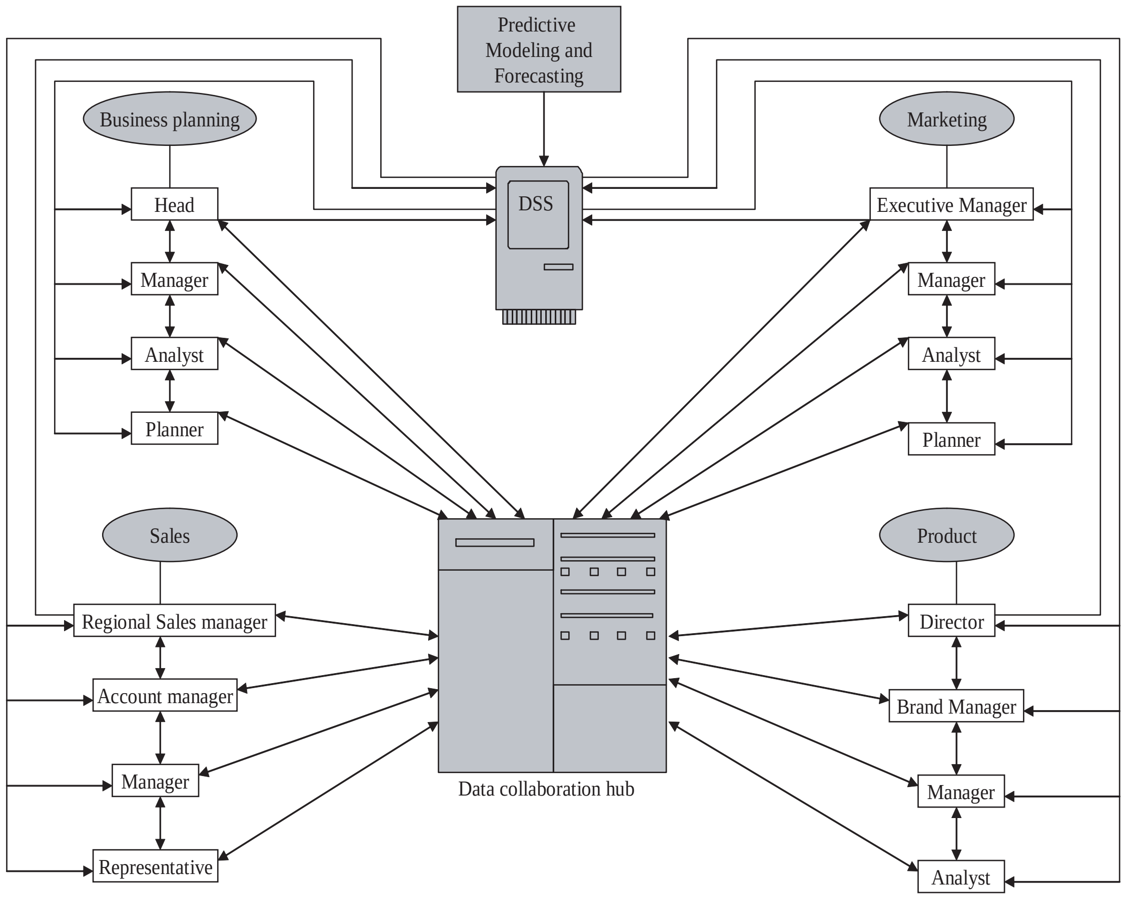


in improvements in forecasting accuracy, shorter lead times, good customer service levels, reduction of inventory levels, and maximum profits.

An intra-enterprise process described in Figure 6 having DSSs used by sales people to understand sales patterns, product people for product lifecycle management, marketing people for managing promotions or introducing new products, and business people for making strategic, operational, and tactical decisions. Each department analyzes and evaluates the information stored in the DSS for creating knowledge about the future and stores this knowledge in the system. A centralized data "collaboration hub" collects every kind of information from business, marketing, product, and sales so that every department can also access other department's information for its own use. The following activities are performed by different departments to create knowledge about the future:

- Marketing: Marketing people want to know: (1) which products need to be promoted, where, when and at what price; (2) which existing products need to be phased out and when; and (3) when and where new products need to be introduced. They might want to interact with sales people to know about historical sales or customer behaviors, product people to know the stage of the product lifecycle, and business people to decide if the promotions would be effective and result

Figure 6. Intra-enterprise DSS in the CPG company



in larger ROI or whether to launch a new product. They perform simulations, 'what if' analysis, and scenario planning to ensure the effectiveness of promotions or advertisements. They can create knowledge in terms of the effectiveness of promotions or advertisements on the sales, and determining the best time to phase out existing products and introduce new products.

- Sales: The sales people might want to interact with product people to understand the behavior of products, marketing people to know about promotions, and business people to understand the impact on sales based on their decisions. The knowledge created by them can be sales variability due to seasonality, customer behaviors, and change of sales patterns due to promotions or advertisements.
- Product: The product people might need to get POS data from sales to know the stage of the product lifecycle, or interact with marketing and business people to know about promotions and new products. They

can create knowledge in terms of the product behaviors at different stages of the product lifecycle.

- Business: Business planners and executives (e.g., in a CPG company) analyze the results of predictive models for promotional and baseline demand forecasts to design promotional strategies that maximize profits and ROI. The definition of maximized profits can differ, depending on whether the promotions are designed from longer-term considerations like brand acceptance or shorter-term considerations like the need to sell excess inventory. They get historical sales data or information about new opportunities from the sales department, product information from the product department, and information about market conditions as well as corporate policies like promotions or advertisements from the marketing department to develop future promotional strategy. They need to know if the promotions would result in lifts (e.g., increased demand due to a promotion on a specified product), drag effects (e.g., increase in sales driving the sales of associated product), and cannibalization (e.g., increase in sales reducing the sales of other products). They need to blend the natural variability of demand (e.g., seasonal and cyclical trends) with market information (e.g., competitive landscape, economic drivers, customer forecasts, demography) with direct and indirect promotional impacts. They use BI tools like querying and reporting for pulling and presenting the data relevant for planning, like past sales patterns, seasonal and cyclic patterns, economic indicators, weather patterns, demographics, and sales patterns of competitive products (and competitive promotions, if such information is available), as well as OLAP for viewing multidimensional data to get a better understanding of the information. OLAP-related activities have been described by the OLAP council (1997). Broadly, OLAP tools are well suited for management by objectives and management by exceptions.

The analysis and evaluation of information through mathematical models and by business analysts and planners produce a wealth of knowledge which can be stored in the system for future use. For example, waterfall accuracy charts can be used to compare forecasts with actual values, as they become available, for continuous evaluation and improvement. Similarly, audit trails and comments entered by planners during manual adjustments can be preserved and mined for evaluation and use in forecasting. The results of prior forecasts and the previous insights of knowledge workers are key building blocks in the process of knowledge creation about the future.

FUTURE TRENDS

The pace of rapid industry consolidations suggests that marketplaces of the future may well be characterized by a few leaders in each vertical, and laggards who run the risk of eventually fading into oblivion. In verticals like retail and CPG where the leaders have probably achieved long-term sustainability, one of the key differentiators between the leaders and the laggards has been the ability to create, retain, and utilize knowledge about the future through forecasting, predictive modeling, and planning efforts. Giants in retail and CPG are known to be superior to their peers in areas like demand forecasting, inventory management, promotion planning, pricing strategies, store and factory placements, as well as product allocations or placement. These leaders have developed the best analytical models, as well as planning and execution systems, in the business, and strive to maintain their superiority. This is indicated by the strong analytical and planning groups in these enterprises, as well as by developments like the use of radio frequency ID (RFID) tags on each product mandated by large retailers. Similar developments are expected in the high-tech industry in the longer term. While innovative newcomers are probably more likely to emerge in these areas even during relatively mature stages, the industry is expected to consolidate around leaders who are not necessarily (or only) the active pioneers and state-of-the-art researchers, but who (also) have the best processes for knowledge creation, retention, and utilization. The advent of globalization will enhance this trend of consolidation around a few large multinationals, who will strive to maintain their superiority by creating knowledge about the future. Mathematical models for extraction of knowledge from vast quantities of information, as well as efficient processes that enable interaction among planners and computers within and among organizations and enterprises, are expected to be ubiquitous in this business scenario. The competition among multinationals to maintain their edge over rivals and innovative challengers may well spawn the age of ubiquitous analytical information technologies, which encapsulates data mining, knowledge discovery, predictive modeling, and decision support.

CONCLUSION

The ability to create, preserve, and utilize knowledge about the future for efficient decision making is a key to competitiveness and survival for a business in this age of globalization, Internet commerce, and rapidly fluctuating economies. Forecasting and predictive modeling is a challenging process and is never perfect. However, even minor improvements can lead to significantly better tactical and strategic decisions, and improve the ability of an enterprise to react quickly to change. The tools, technologies, and processes that enable knowledge creation about the future have been presented in this article. The ability to create knowledge by meaningfully blending data-dictated predictive modeling with the expertise of business planners and executives, as well as retaining and utilizing this knowledge effectively, remains a key requirement for efficient business processes and better decision making, which in turn can make the difference between the leaders and laggards of an industry vertical.

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REFERENCES

Anthony, R.N. (1965). *Planning and control systems: A framework for analysis.* Harvard University Graduate School of Business, MA.

Aviv, Y. (2001). The effect of collaborative forecasting on supply chain performance. *Management Science, 47*(10), 1326-1343.

Bonczek, R.H., Holsapple, C.W., & Whinston, A.B. (1981). *Foundations of decision support systems.* New York: Academic Press.

Bransten, L. (1999). Looking for patterns. *The Wall Street Journal*, (June 21), R16.

Breiman, L., Friedman, J.H., Olshen, R.A., & Stone, C.J. (1984). *Classification and regression trees.* Belmont, CA: AAAI Press.

Cachon, G.P., & Lariviere, M.A. (2001). Contracting to assure supply: How to share demand forecasts in a supply chain. *Management Science, 47*(5), 629-646.

Chen, F., Drezner, Z., Ryan, J.K., & Simchi-Levi, D. (2000). Quantifying the bullwhip effect in a simple supply chain: The impact of forecasting, lead times and information. *Management Science, 46*(3), 436-443.

Courtney, J.F. (2001). Decision making and knowledge management in inquiring organizations: Towards a new decision-making paradigm for DSS. *Decision Support System, 31*(1), 17-38.

Davis, S., & Botkin, J. (1994). The coming of knowledge-based business. *Harvard Business Review,* (September-October), 165-170.

Fayyad, U., Shapiro, G.P., & Smyth, P. (1996). *From data mining to knowledge discovery: An overview. Advances in Knowledge Discovery and Data Mining* (pp. 1-34). AAAI Press and MIT Press.

Fayyad, U., & Uthurusamy, R. (2002). Evolving data mining into solutions for insights. *Communications of the ACM, 45*(8), 28-31.

Ganguly, A.R. (2002). Software review—data mining components. *OR/MS Today,* (October). Institute for Operations Research and the Management Sciences.

Ganguly, A.R., Gupta, A. & Khan, S. (2005). Data mining and decision support for business and science. In J. Wang (Ed.), *Encyclopedia of Data Warehousing and Mining* (pp. 233-238). Hershey, PA: Idea Group Reference.

Gilbert, K. (2005). An ARIMA supply chain model. *Management Science, 51*(2), 305-310.

Gorry, G.A., & Morton, M.S.S. (1971). A framework for management information systems. *Sloan management Review, 13*(1), 50-70.

Gung, R.R., Leung, Y.T., Lin, G.Y., & Tsai, R.Y. (2002). Demand forecasting today. *OR/MS Today,* (December). Institute for Operations Research and the Management Sciences.

Hammer, J. (Ed.). (2003). Advances in online analytical processing. *Data and Knowledge Engineering, 45*(2), 127-256.

Hand, D., Mannila, H., & Smyth, P. (2001). *Principles of data mining.* Cambridge, MA: MIT Press.

Heinrichs, J.H., & Lim, J.S. (2003). Integrating Web-based data mining tools with business models for knowledge management. *Decision Support Systems, 35*, 103-112.

Inmon, W.H. (1992). *Building the data warehouse.* Wellesley, MA: QED Information Sciences.

Kimball, R. (1996). *The data warehouse toolkit.* New York: John Wiley & Sons.

Lee, H., & Whang, S. (1998). *Information sharing in a supply chain.* Research Paper No. 1549, Graduate School of Business, Stanford University.

Lim, J.S., Heinrichs, J.H., & Hudspeth, L.J. (1999). *Strategic marketing analysis: Business intelligence tools for knowledge based actions.* Needham Heights, MA: Pearson Custom Publishing.

Pearl, J. (1988). *Probabilistic reasoning in intelligent systems.* San Francisco: Morgan Kaufmann.

Peterson, K., Geishecker, L., & Eisenfeld, B.L. (2003, May 12). *In search of one-number forecasting.* Gartner Group, USA.

Power, D.J. (2002). *Decision support systems: Concepts and resources for managers.* Westport, CT: Quorum Books.

Quinlan, J. (1992). *C4.5: Programs for machine learning.* San Francisco: Morgan Kauffmann.

Shaw, M.J., Subramaniam, C., Tan, G.W., & Welge, M.E. (2001). Knowledge management and data mining for marketing. *Decision Support Systems, 31*, 127-137.

Simon, H.A. (1960). *A new science of management decision*. New York: Harper Brothers.

Wang, G.C.S., & Jain, C.L. (2003). *Regression analysis: Modeling and forecasting.* Institute of Business Forecasting.

Whittaker, J. (1990). *Graphical models in applied multivariate statistics.* New York: John Wiley & Sons.

Yurkiewicz, J. (2003). Forecasting software survey: Predicting which product is right for you. *ORMS Today,* (February). Institute for Operations Research and the Management Sciences.

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Chapter 6.4
Integrated Modeling

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INTRODUCTION

Modeling is a key task in order to analyze, understand, and improve business processes and organizational structures, and to support the design, implementation, and management of information and communication technologies in general and knowledge management systems (KMSs) in particular. Process-oriented knowledge management (Maier, 2004; Maier & Remus, 2003) is a promising approach to provide the missing link between knowledge management (KM) and business strategy, and to bridge the gap between the human-oriented and technology-oriented views (e.g., Hansen, Nohria, & Tierney, 1999; Zack, 1999). However, existing modeling approaches for business processes, including their extensions for KM, still lack concepts to support knowledge work, which is often unstructured, creative, and learning and communication intensive. Recently, the activity theory has been proposed to provide concepts to analyze knowledge work (e.g., Blackler, 1995), but it has not yet been integrated with business process modeling for designing KM initiatives and KMSs. The following sections analyze the characteristics of knowledge work, distinguish important perspectives for modeling in KM, and discuss extensions of process modeling approaches including activity modeling. Then, the process-oriented and the activity-oriented perspectives on knowledge work are compared and connected by means of the concept of knowledge stance.

BACKGROUND

Knowledge work can be characterized by a high degree of variety and exceptions, strong communication needs, weakly structured processes, an increasing importance on teamwork in the form of project teams, networks, and communities, and it requires a high level of skill and expertise. Inputs and outputs of knowledge work are primarily data, information, or knowledge. Knowledge comprises observations that have been meaningfully organized and embedded in a context through experience, communication, or inference that an actor uses to interpret situations and to accomplish tasks (based on Maier, 2004). Knowledge work consists of a number of specific practices, for example, expressing or extracting experiences, monitoring, translating, and networking (Schulze, 2003).

From an ICT perspective, the main changes in the requirements posed by knowledge work occur due to the considerably higher complexity of data and the focus on organization-wide and interorganizational communication, cooperation, and mobility of knowledge workers. The storage, handling, and sharing of semistructured data require additional ICT systems, such as document , content, and knowledge management systems. Modeling has focused largely on data (entity relationship modeling), objects and classes (object-oriented modeling), and business processes (business process modeling). Knowledge work requires content-, user-, and communication-oriented modeling techniques that show what persons, communities, topics, tools, rules, and other activities and processes are involved, and thus demands concepts and modeling techniques that extend business process modeling to cover these aspects.

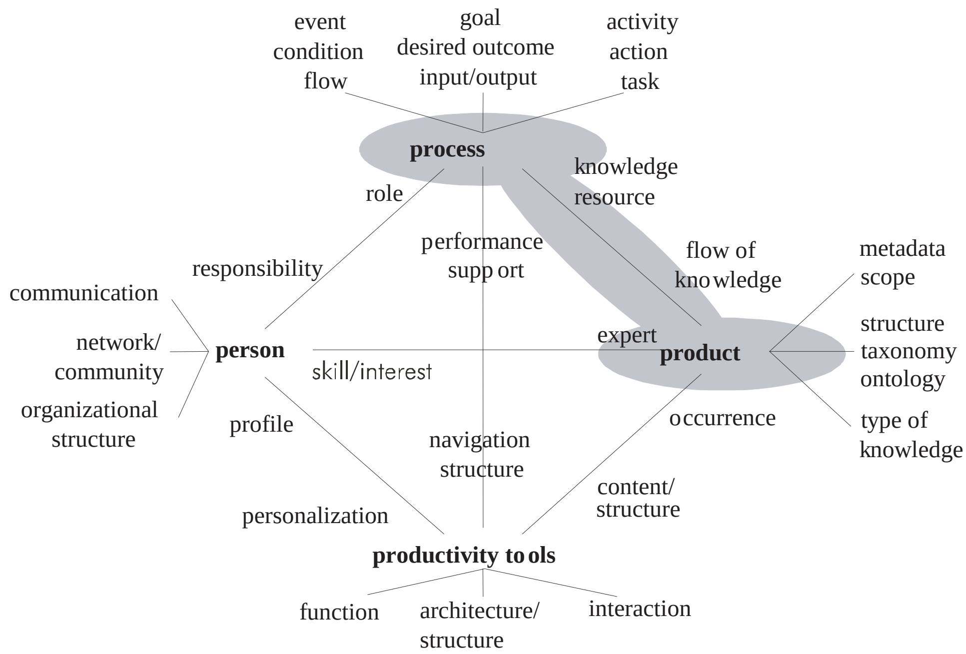
PERSPECTIVES FOR MODELING IN KM

Models are representations of a selected portion of the perceived reality of an individual or a group of observers. The design of KM initiatives requires modeling concepts for (a) processes that describe the organizational design, that is, knowledge tasks, flows, roles, and resources, (b) persons by capturing facts about people, that is, their skills, communication, and cooperation in networks and communities, (c) products, that is, the type of knowledge, structures, taxonomies, ontologies, and metadata, and (d) productivity tools, that is, the architecture, functions, and interaction of ICT tools in support of KM (see Figure 1).

A large number of modeling approaches, methods, and techniques have been developed in the literature (e.g., Balzert, 2001). Each of these approaches predominantly focuses on one of the dimensions in Figure 1. For process-oriented KM, concepts are needed that combine process modeling with the other perspectives, especially with knowledge products and the knowledge-intensive tasks being part of knowledge work.

In recent years, many organizations have applied concepts of business process reengineering (e.g., Davenport, 1993; Hammer & Champy, 1993), and a number of methods and techniques to support business process modeling have been proposed in the literature. Approaches for process modeling distinguish between three levels of granularity that are interconnected: (a) Value chains (Porter, 1985) arrange value-adding activities, (b) business processes connect functions, and (c) work flows orchestrate tasks. As process modeling is a complex task that requires computer support in order to be an economically feasible approach, most methods are applied with the help of a corresponding tool. Examples are ADONIS (Junginger, Kühn, Strobl, & Karagiannis, 2000), ARIS (Scheer, 2001), IEM (Heisig, 2002; Spur, Mertins, & Jochem, 1996), MEMO (Frank, 2002), PROMET (Österle, 1995), SOM (Ferstl & Sinz, 1994), UML-based process modeling (Oestereich, Weiss, Schröder, Weilkiens, & Lenhard, 2003), and the IDEF family of modeling methods (http://www.idef.com). Moreover, there is a number of frameworks and reference models for the definition of work flows that implement business

Figure 1. Perspectives for modeling in knowledge management (based on Maier, 2004)



processes (see, e.g., Kumar & Zhao, 1999; WfMC, 2001). The methods differ in formality, semantic richness, and understandability.

Recently, a number of authors have proposed extensions that model (some of) the specifics of KM. Examples are the extensions to ARIS (Allweyer, 1998), PROMET®I-NET (Bach & Österle, 2000; Kaiser & Vogler, 1999), GPO-WM (Heisig, 2002), KMDL (Gronau, 2003), Knowledge MEMO (Schauer, 2004), and PROMOTE (Hinkelmann, Karagiannis, & Telesko, 2002; Karagiannis & Woitsch, 2003). The main extensions are the introduction of additional object types like knowledge objects, that is, topics of interest, documented knowledge, individual employees, and skills, as well as the introduction of model types like knowledge structure diagrams, communication diagrams, and knowledge maps. More detailed aspects of knowledge-intensive tasks have been implemented in tools for flexible workflow management (Goesmann, 2002). Examples are Bramble (Blumenthal & Nutt, 1995), KnowMore (Abecker, Bernardi, Hinkelmann, Kühn, & Sintek, 1998), MILOS (Maurer & Dellen, 1998, Work-Brain (Wargitsch, Wewers, & Theisinger, 1998), and Workware (Carlsen & Jorgensen, 1998).

The extensions can be classified according to whether they target the abstract level of KM-related organizational design, for example, ARIS and GPO-WM, or whether they target the detailed level of KM-related work flows, for example, PROMOTE and tools for flexible workflow management. None of the extensions provides concepts to model all four perspectives of persons, process, product, and productivity tools, and particularly their relationships. The added concepts describe a portion of the context of knowledge work, but they are not suited to model the often unstructured and creative learning and knowledge practices and their links to business processes.

For example, in the case of ARIS, the added object types “documented knowledge” and “knowledge category,” as well as the model types “knowledge structure diagram,” “knowledge map,” and “communication diagram,” give a rough impression of the knowledge needed and produced in each step of a business process, the general knowledge structure, the required skills of the roles, as well as their communication. However, neither of these concepts indicates which knowledge-related actions are possible or required in the process step, with which communities and other processes or activities. Thus, the concepts only describe a fragment of knowledge work, and it remains unclear when and how knowledge is created and applied, and specifically in what occasions and in what context knowledge-oriented actions should be supported, for example, by KMS functions.

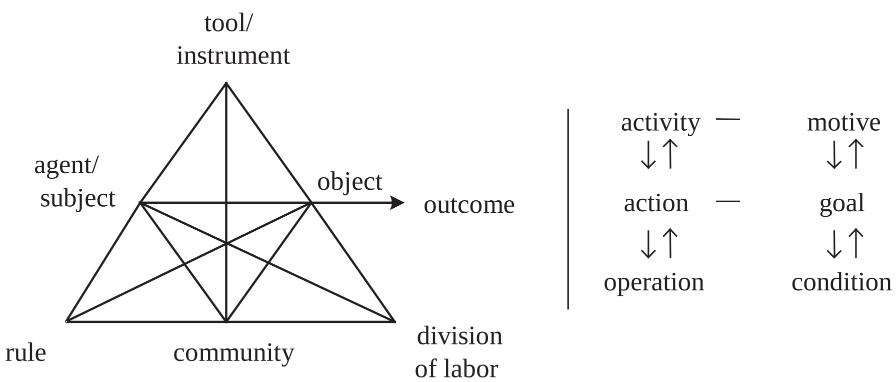
The activity theory has been proposed to guide the analysis of knowledge work (see, e.g., Blackler, 1995) and to design information systems, especially group support systems and KMS (see, e.g., Clases & Wehner, 2002; Collins, Shukla, & Redmiles, 2002; Hasan & Gould, 2003; Kuutti, 1997; Sachs, 1995). It places the focus on activities, not to be confused with activities in Porter’s (1985) value chain and activities in UML.

The core idea of the activity theory is that human activity is a dialectic relationship between individuals (called agents or subjects) and objects (the purpose of human activity) that is mediated by tools and instruments like cultural signs, language, and technologies in so-called activity systems (see Figure 2, left side). The subject is a part of communities and its connection to them is determined by implicit or explicit social rules. A division of labor (e.g., role system) defines the relation of these communities to the object of the activity system (Engeström, 1987). Intended or unintended results are the outcome of the activities’ transformation process.

This is a significant contribution to KM (Hasan & Gould, 2003) since the acquisition of knowledge in modern learning theories is not a simple matter of taking in knowledge, but a complex cultural or social phenomenon (see, e.g., Blackler, 1995).

Activities have a hierarchical structure (see Figure 2, right side). First, the activity is driven by a common motive that reflects a collective need and the reason why the activity exists (Engeström, 1999). Second, an activity is accomplished by

Figure 2. Model and levels of the socially-distributed activity system (Blackler, 1995; Kuutti, 1997)



actions directed to goals coupled with the motive of the activity. Actions consist of an orientation and an execution phase: The first comprises the planning for action, and the latter is its execution by a chain of operations (Kuutti, 1997). Repeated exercise leads to better planning of the action that then can be conducted more successfully. With enough practice, the separate planning phase becomes obsolete, and actions collapse into operations due to learning and routinization. Third, operations are executed under certain conditions. They are the most structured part that is easiest to automate. An important feature of the activity theory is the dynamic relationship between the three levels. Elements of higher levels collapse to constructs of lower levels if learning takes place. They unfold to higher levels if changes occur and learning is necessary.

An example is the activity of learning to drive a car (Leontiev as cited in Hasan & Gould, 2003). The object is being able to drive. For an unaccomplished driver, the handling of the gearbox happens on the action level. A separate planning and execution phase is necessary for changing gears. For an accomplished driver, driving a car merely is an action with the goal to get somewhere in the context of a broader activity. For him or her, the handling of the gearbox happens nearly unconsciously on the level of operations. If he or she has to drive a different car model with a distinctively designed gearbox, these operations can again unfold into actions.

Activity modeling comprises the identification of activity systems and emphasizes the analysis of the mediating relationships and tensions between its constituting components. Compared to process modeling, the contributions of the activity theory are the consideration of individual or group motives, the notion of communities, a way to conceptualize learning by routinization, and the concept of mediation.

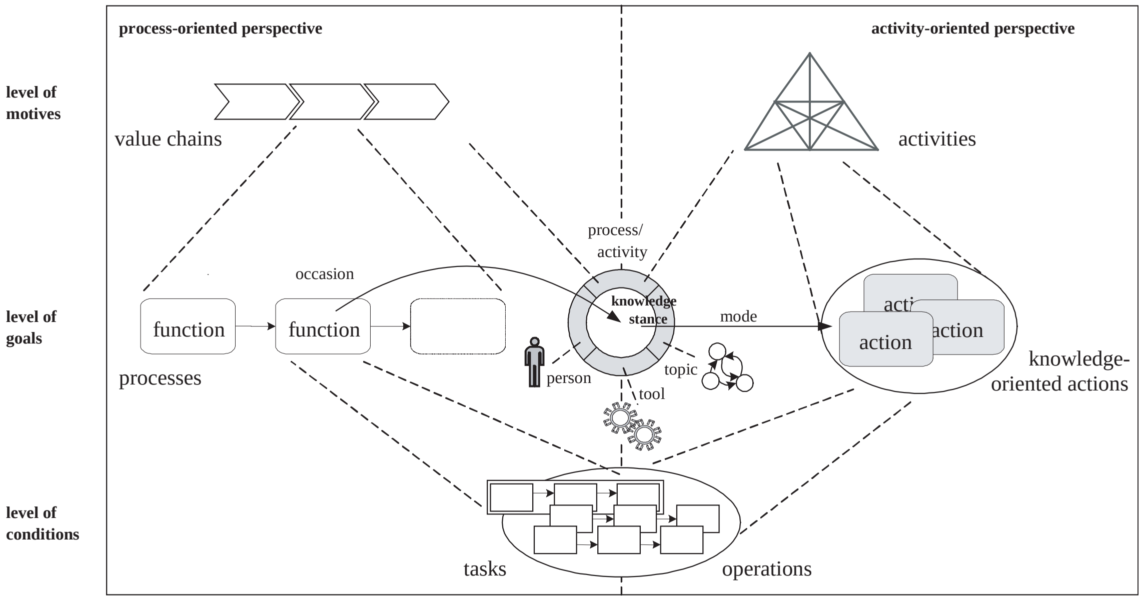
MODELING KNOWLEDGE WORK IN BUSINESS PROCESSES

The concepts provided by the activity theory are well suited to analyze the creative, unstructured, and learning-oriented practices of knowledge work. However, activities primarily aim at the joint creation of knowledge (exploration). Activities lack integration with the value chain and it is not ensured that activities are oriented toward creating customer value (exploitation of knowledge). Therefore, concepts of process and of activity modeling have to be combined in order to get a more comprehensive picture of knowledge work in a business context. This is the aim of the concept of knowledge stance.

A knowledge stance is a class of recurring situations in knowledge work defined by occasion, context, and mode resulting in knowledge-oriented actions (Hädrich & Maier, 2004). It describes a situation in which a knowledge worker can, should, or must switch from a business-oriented function to a knowledge-oriented action (see Figure 3). In a process-oriented perspective, an employee accomplishes functions on the level of goals that belong to a value chain on the level of motives by fulfilling a sequence of tasks on the level of conditions. Simultaneously, he or she can be involved in an activity framing knowledge-oriented actions and corresponding operations. An activity and its corresponding actions and operations can (a) be focused on the business process or (b) pursue a motive not related to the business process (e.g., an effort to build competencies) and thus may make a direct or a more indirect contribution to the process goal.

A business process offers several occasions to learn and to generate knowledge related to the core competencies of the organization. Occasions trigger knowledge stances and are associated with the functions of the business process by offering the opportunity or the need for knowledge-related

Figure 3. Concept of knowledge stance



actions. A knowledge stance is not limited to the generation of knowledge, but may also include the translation and application of knowledge created outside the knowledge stance.

The context comprises all relevant dimensions suitable to describe the actual situation of the worker. It can be structured according to the perspectives for modeling in KM: the process, person, product, and productivity tool. It comprises data about the current process like other subjects involved, desired outcomes, formal rules, or other process steps as well as data about the involved activity like the related community, their objectives, and social rules. Person-related data comprises the level of expertise (e.g., Dreyfus & Dreyfus, 1986), skills, interests, relations to other persons, and position in the organizational structure. The context includes information about what knowledge products and topics are needed, used, or created. Finally, available functions and systems are defined together with privileges to access them.

The mode classifies what actions can be performed and refers to four informing practices (see Schultze, 2000, 2003): (a) Expressing is the practice of the self-reflexive conversion of individual knowledge and subjective insights into informational objects that are independent of the person, (b) monitoring describes continuous, nonfocused scanning of the environment and the gathering of useful just-in-case information, (c) translating involves the creation of information by ferrying it across different contexts until a coherent meaning emerges, and (d) networking is the practice of building and maintaining relationships with people inside and outside the organization.

Context, mode, and occasion are means to specify the set of available, allowed, or required knowledge-oriented actions. Examples for ac-

Table 1. Components of knowledge stances

component	description
occasion	is a type of opportunity to learn and to generate knowledge related to the (core) competencies of the organization within the function of a business process
context	describes the actual work situation, i.e., the process/activity context, personal characteristics, as well as topics and tools
mode	classifies knowledge-oriented actions into expressing, monitoring, translating, and networking
action	refers to an unstructured, knowledge-oriented action and is specified by occasion, context, and mode

tions are (Eppler, 2003) to summarize, prioritize contents, evaluate sources, indicate levels of certitude, compare sources, link content, relate to prior information, add meta-information, notify and alert, ask questions, and offer interaction. In contrast to the clearly defined sequences of functions in the process-oriented perspective, there is no predetermined flow of actions. Table 1 summarizes the components of knowledge stances.

Depending on occasion, context, and mode, it can be decided which KM instruments are suited to support knowledge-oriented actions.

Table 2. Example of a knowledge stance

element	description
function	regular check of gas pipes, to alert and cooperate with service technicians if necessary (in Process 1)
context	**process/activity:** • Process 1 (maintenance of gas pipes): technical and geographical specifics of the gas pipe, problem type, urgency • Process 2 (negotiation with outsourcing partners): regulations and guidelines to formulate a contract, possible cooperation partners • Activity (cooperation with strategic partners): rules like communication patterns, motives, & objectives of the cooperation partners **person:** experience and internal role of maintenance engineer, other people with relevant technical knowledge **tool:** geographical information system, communication systems, access privileges of the worker **topic:** checklists, documented good/best practices
occasion	Damage on a gas pipe or a related component is identified within Process 1 and can only be repaired by a specialist of a company not yet under contract. Process 1 and Process 2 are connected through actions within the scope of the activity.
mode	The worker builds relationships with persons of another company and thus is in the mode of networking.
actions	search for the right partner, negotiate the specifics of the contract, validate the contract, check the skills of the company's workers

When designing KMSs, those knowledge stances are of primary interest that can be supported by ICT. A straightforward approach would be to suggest adequate KMS functions to the user or to automate corresponding operations. This could be accomplished, for example, by offering work flows or user agents known from office applications. The large set of KMS functions available can consequently be tailored to the needs in a stance and thus must obtain information from the context variables as well as the mode and occasion. The context should be derived with as little user effort as possible. The elements and their relation can be represented by a standardized or shared ontology. That way, inference techniques can be applied and the context can be communicated to and translated for other applications.

The following table shows an example of a knowledge stance for a worker consigned with the maintenance of gas pipes within a specific geographic area (see Table 2). The service is fulfilled by specialized companies under contracts that are renegotiated regularly by the purchasing department of the company.

FUTURE TRENDS

The design of KM instruments and of supporting ICT need structured representations of knowledge work in the context of business processes. It is necessary to integrate both process-oriented and activity-oriented elements for the exploration as well as exploitation of knowledge. The concept of knowledge stance, its integration into a modeling method for KM, and the subsequent design and implementation of ICT-supported KM initiatives promise substantial increases in the productivity of knowledge work.

CONCLUSION

This article discussed characteristics of knowledge work and gave an overview of perspectives and approaches for modeling in the context of process-oriented KM. We studied the activity theory as a means to include the dynamic, creative, and often less structured aspects of knowledge work, and proposed the concept of knowledge stance with the following contributions. First, a knowledge stance integrates the process-oriented and the activity-oriented perspectives. The latter is necessary to extend modeling to knowledge-oriented actions. Second, they are a means to design KM instruments and KMSs. The latter could be accomplished, for example, by portals or work spaces that bundle KMS functions and filter contents for knowledge stances, by user agents that guide through an action, and by workflows that routinize parts of actions. To clearly translate into KMS, the concept of knowledge stance needs to be detailed. Overall, the concept seems to be an important step in the quest for adequate extensions of business process modeling to cover aspects of knowledge work.

REFERENCES

Abecker, A., Bernardi, A., Hinkelmann, K., Kühn, O., & Sintek, M. (1998). *Techniques for organizational memory information systems* (DFKI Research Report No. D-98-02). German Research Center for Artificial Intelligence, Karlsruhe, Germany.

Allweyer, T. (1998). Modellbasiertes Wissensmanagement. *Information Management, 13*(1), 37-45.

Bach, V., & Österle, H. (Eds.). (2000). *Customer Relationship Management in der Praxis: Erfolgreiche Wege zu Kundenzentrierten* Lösungen. Berlin, Germany: Springer.

Balzert, H. (2001). *Lehrbuch der Software-Technik* (2nd ed.). Heidelberg, Germany: Spektrum.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Blumenthal, R., & Nutt, G. J. (1995). Supporting unstructured workflow activities in the Bramble ICN system. *Proceedings of the ACM Conference on Organizational Computing Systems (COOCS'95)* (pp. 130-137).

Carlsen, S., & Jorgensen, H. D. (1998). Emergent workflow: The AIS workware demonstrator. *Proceedings of the Workshop "Towards Adaptive Workflow Systems" of the ACM Conference on Computer Supported Cooperative Work (CSCW'98).*

Clases, C., & Wehner, T. (2002). Steps across the border: Cooperation, knowledge production and systems design. *Computer-Supported Cooperative Work, 11*(1), 39-54.

Collins, P., Shukla, S., & Redmiles, D. (2002). Activity theory and systems design: A view from the trenches. *Computer Supported Cooperative Work, 11*(1), 55-80.

Daconta, M. C., Obrst, L. J., & Smith, K. T. (2003). *The semantic Web: A guide to the future of XML, Web services and knowledge management.* Indianapolis, IN: Wiley.

Davenport, T. (1993). *Business process innovation*. Boston: HBS Press.

Dreyfus, H. L., & Dreyfus, S. E. (1986). *Mind over machine: The power of human intuition and expertise in the era of the computer.* New York: Free Press.

Engeström, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki, Finland: Orienta-Konsultit Oy.

Engeström, Y. (1999). Expansive visibilization of work: An activity-theoretical perspective. *Computer Supported Cooperative Work, 8*(1), 63-93.

Eppler, M. J. (2003). *Managing information quality: Increasing the value of information in knowledge-intensive products and processes.* Berlin, Germany: Springer.

Ferstl, O. K., & Sinz, E. J. (1994). *From business process modeling to the specification of distributed business application systems: An object-oriented approach* [Research Paper]. Department of Business Information Systems, University of Bamberg, Germany.

Frank, U. (2002). Multi-perspective enterprise modeling (MEMO): Conceptual framework and modeling languages. *Proceedings of the 35th Hawaii International Conference on System Sciences (HICSS-35),* Honolulu.

Goesmann, T. (2002). *Ein Ansatz Zur Unterstützung Wissensintensiver Prozesse Durch Workflow-managementsysteme*. Retrieved October 15, 2004, from http://edocs.tu-berlin.de/diss/2002/goesmann_thomas.pdf

Gronau, N. (2003). Modellierung von wissensintensiven Geschäftsprozessen mit der Beschreibungssprache K-Modeler. In N. Gronau (Ed.), *Wissensmanagement: Potenziale, Konzepte, Werkzeuge. Proceedings of the 4th Oldenburg Conference on Knowledge Management* (pp. 3-29). Berlin, Germany: Gito.

Gruber, T. R. (1993). A translation approach to portable ontology specifications. *Knowledge Acquisition, 5*(2), 199-200.

Hädrich, T., & Maier, R. (2004). Modeling knowledge work. In P. Chamoni, W. Deiters, N. Gronau, R.-D. Kutsche, P. Loos, H. Müller-Merbach, B. Rieger, & K. Sandkuhl (Eds.), *Multikonferenz Wirtschaftsinformatik (MKWI 2004)* (Vol. 2). Berlin, Germany: Akademische Verlagsgesellschaft.

Hammer, M., & Champy, J. (1993). *Reengineering the cooperation*. New York: Harper Business Publishers.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(3-4), 106-110.

Hasan, H., & Gould, E. (2003). Activity-based knowledge management systems. *Journal of Information & Knowledge Management, 2*(2), 107-115.

Heisig, P. (2002). GPO-WM: Methoden Und Werkzeuge zum Geschäftsprozessorientierten Wissensmanagement. In A. Abecker, K. Hinkelmann, & M. Heiko (Eds.), *Geschäftsprozessorientiertes Wissensmanagement* (pp. 47-64). Berlin, Germany: Springer.

Hinkelmann, K., Karagiannis, D., & Telesko, R. (2002). PROMOTE: Methodologie Und Werkzeug Für Geschäftsprozessorientiertes Wissensmanagement. In A. Abecker, K. Hinkelmann, & M. Heiko (Eds.), *Geschäftsprozessorientiertes Wissensmanagement* (pp. 65-90). Berlin, Germany: Springer.

Junginger, S., Kühn, H., Strobl, R., & Karagiannis, D. (2000). Ein Geschäftsprozessmanagement-Werkzeug fer nächsten Generation. *ADONIS: Konzeption und Anwendungen. Wirtschaftsinformatik, 42*(5), 392-401.

Kaiser, T. M., & Vogler, P. (1999). PROMET®I-NET: Methode für Intranet-basiertes Wissensmanagement. In V. Bach, P. Vogler, & H. Österle (Eds.), *Business Knowledge Management: Praxiserfahrungen Mit Intranet-Basierten Lösungen* (pp. 117-129). Berlin, Germany: Springer.

Karagiannis, D., & Woitsch, R. (2003). The PROMOTE approach: Modelling knowledge management processes to describe knowledge management systems. In N. Gronau (Ed.), *Wissensmanagement: Potenziale, Konzepte, Werkzeuge. Proceedings of the 4th Oldenburg Conference on Knowledge Management* (pp. 35-52). Berlin, Germany: Gito.

Kelloway, E. K., & Barling, J. (2000). Knowledge work as organizational behavior. *International Journal of Management Reviews, 2*(3), 287-304.

Kumar, A., & Zhao, J. L. (1999). Dynamic routing and operational controls in workflow management systems. *Management Science, 45*(2), 253-272.

Kuutti, K. (1997). Activity theory as a potential framework for human-computer interaction research. In B. A. Nardi (Ed.), *Context and consciousness: Activity theory and human-computer interaction* (pp. 17-44). Cambridge, MA: MIT Press.

Leontiev, A. N. (1981). *Problems of the development of the mind*. Moscow: Progress Publishers.

Maier, R. (2004). *Knowledge management systems: Information and communication technologies for knowledge management* (2nd ed.). Berlin, Germany: Springer.

Maier, R., & Remus, U. (2003). Implementing process-oriented knowledge management strategies. *Journal of Knowledge Management, 7*(4), 62-74.

Maurer, F., & Dellen, B. (1998). A concept for an Internet-based process-oriented knowledge management environment. *Proceedings of the Knowledge Acquisition Workshop (KAW98)*, Banff, Canada.

Österle, H. (1995). *Business engineering. Prozeß- und Systementwicklung: Band 1. Entwurfstechniken*. Berlin, Germany: Springer.

Oestereich, B., Weiss, C., Schröder, C., Weilkiens, T., & Lenhard, A. (2003). *Objektorientierte Geschäfts-prozessmodellierung mit der UML*. Heidelberg, Germany: dpunkt.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York; London: Free Press.

Sachs, P. (1995). Transforming work: Collaboration, learning, and design. *Communications of the ACM, 38*(9), 36-44.

Schauer, H. (2005). *Knowledge MEMO: Eine Methode zur Planung, Steuerung und Kontrolle ganzheitlichen betrieblichen Wissensmanagements*. Unpublished PhD thesis, University of Koblenz, Koblenz, Germany.

Scheer, A.-W. (2001). *ARIS: Modellierungsmethoden, Metamodelle, Anwendungen*. Berlin, Germany: Springer.

Schmidt, G. (2002). *Prozessmanagement: Modelle und Methoden* (2nd ed.). Berlin, Germany: Springer.

Schultze, U. (2000). A confessional account of an ethnography about knowledge work. *MIS Quarterly, 24*(1), 3-41.

Schultze, U. (2003). On knowledge work. In C. W. Holsapple (Ed.), *Handbook on knowledge management: Vol. 1. Knowledge matters* (pp. 43-58). Berlin, Germany: Springer.

Sinz, E. J. (2001). Modell/Modellierung. In P. Mertins, A. Back, J. Becker, W. König, H. Krallmann, B. Rieger, A.-W. Scheer, D. Seibt, P. Stahlknecht, H. Strunz, R. Thome, & H. Wedekind (Eds.), *Lexikon Der Wirtschaftsinformatik* (pp. 311-313). Berlin, Germany: Springer.

Spur, G., Mertins, K., & Jochem, R. (1996). *Integrated enterprise modelling*. Berlin, Germany: Beuth.

Wargitsch, C., Wewers, T., & Theisinger, F. (1998). An organizational-memory-based approach for an evolutionary workflow management system: Concepts and implementation. *Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS), I* (pp. 174-183).

WfMC. (2001). *The workflow coalition specification: Interface 1. Process definition interchange process model*. Retrieved October 15, 2004, from http://www.wfmc.org/standards/docs/TC-1016-P_v11_IF1_Process_definition_Interchange.pdf

Zack, M. H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 6.5
Networks of People as an Emerging Business Model

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INTRODUCTION

Networking as a skill is becoming more and more important as traditional ways of doing business continue to change. Many organisations are moving from the industrial model of culture to a more "knowledge"-based culture, changing from having structured hierarchies to flatter structures with distributed responsibility. This has vast implications for how things get done. Instead of receiving instructions or being expected to work to a strict process, the knowledge-based organisations are giving people looser frameworks, and expect them to take responsibility for contributing ideas and sharing their knowledge.

EFFECTIVENESS THROUGH NETWORKING

The most effective way to work in these organisations is to build a network of contacts, colleagues, and teams. This networking approach is different from communities of practice where a group of people come together, formally or informally, to solve particular problems or discuss specific issues. Building a network is wider than just one specific focus; it is a new way of working and indeed a new way of thinking. This will give rise to many questions for organisations including structure, leadership, decision making, and much more. Many are not familiar in working in such an unstructured way.

Traditional communication techniques such as e-mail are also failing to deliver, as they dramatically overload people who have fallen into bad usage habits, thus restricting the techniques' effective use. The preferred way to communicate in the new 'networked organisations' is by using instant messaging and blogs, providing immediate business interactivity and truly engaging people.

Along with these developments, many organisations are downsizing and encouraging more virtual working scenarios. This means that individuals are having to become more self-reliant and build up their networks for support and development purposes. The number of small businesses, independent workers, and those with portfolio careers is also growing, and they are starting to join and form their own online communities to share work, develop business ideas, and to gain profile. With this trend, the skills of networking become critical.

These new online businesses are becoming the 'new corporates', and moving from being efficient networkers to providing infrastructure and benefits to members of the network. An example of this is eBay, which has provided a very successful online world where you can make a living from buying and selling on the company's Web site; but eBay has also developed a huge amount of infrastructure around building a community. eBay promotes its community values as:

- We believe people are basically good.
- We believe everyone has something to contribute.
- We believe that an honest, open environment can bring out the best in people.
- We recognise and respect everyone as a unique individual.
- We encourage you to treat others the way you want to be treated.

Perhaps some of the remaining large corporates could learn from these values. eBay also runs workshops for members of its community, offers a forum facility, and even offers insurance to regular users.

THE FUTURE

Another example of a growing network is Ecademy. This is a business exchange that connects people to knowledge, contacts, support, and business. It is free to join Ecademy, and you can create a profile of yourself, read what is happening within Ecademy, search the site, and receive e-mail newsletters and updates. The idea of Ecademy is to build up a wide range of business contacts. For a small fee, £25 per annum, you can access and contribute to all areas of the site and build a network of up to 20 contacts. At this level you can also generate more awareness of yourself and your business through submitting content onto the Ecademy homepage. There are also a range of specific networking clubs you can join. For £120 per annum, you can have access to a growing list of premium Web site tools, but the ultimate level is the BlackStar level, which costs £2,500 per annum and is available to a limited audience. Benefits include personal introductions, mentoring and promotional opportunities, personal branding, networking tuition, online system training, and much more.

This is a huge support network backed up by regular events where it is not just a case of business cards flying around but real business gets done. They also publish a "Citizens Guide" on how to get the best out of the Ecademy community.

CONCLUSION

Examples like eBay and Ecademy are the beginning of many structured networks that set out to truly help people to do business, as well as provide a support network of value. All this without the company politics, but having true respect for the individual.

These trends are a serious challenge to the traditional corporate environment.

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Chapter 6.6
Bridging the Gap from the General to the Specific by Linking Knowledge Management to Business Processes

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ABSTRACT

A phenomenon common to almost all fields is that there is a gap between theory and practical implementation. However, this is a particular problem in knowledge management, where much of the literature consists of general principles written in the context of a 'knowledge world' that has few, if any, references to how to carry out knowledge management in organisations. In this chapter, we put forward the view that the best way to bridge this gap between general principles and the specific issues facing a given organisation is to link knowledge management to the organisation's business processes. After briefly reviewing, and rejecting alternative ways in which this gap might be bridged, the chapter goes on to explain the justification for, and the potential benefits and snags of, linking knowledge management to business processes. Successful and unsuccessful examples are presented. We concentrate especially on the issues of establishing what knowledge is relevant to an organisation at present, the need for organisational learning to cope with the inevitable

change, and the additional problems posed by the growing internationalisation of operations. We conclude that linking knowledge management in terms of business processes is the best route for organisations to follow, but that it is not the answer to all knowledge management problems, especially where different cultures and/or cultural change are involved.

INTRODUCTION

The main topic of this chapter is the implementation or the application of knowledge management. By this, we mean how the ideas and theories of knowledge management can be made applicable in an organisation. Too often we hear or read the rhetoric of knowledge management without there being any route mentioned to turn these ideas into practical applications. As Americans might say, what happens when "the rubber meets the road?"

We begin by explaining why we believe the application of knowledge management in a specific organisation is problematic. We then propose that the concept of business processes is the most suitable way to help resolve this problem, and go on to review some of the consequences (actual and potential) of rooting knowledge management in an organisation's business processes. We believe that this is the most appropriate way to make the theories of knowledge management applicable. However, the approach is not without its difficulties.

We discuss both the justification and some of the potential snags in the main body of this chapter, with a special emphasis on problems of internationalisation. Our conclusions, however, given the current state of knowledge about knowledge management, are as much in the way of a question as an answer. However, it is clear that while a process orientation may be necessary for successful knowledge management in an organisation, it is not sufficient on its own. For example, an appreciation of cultures and cultural distance is also essential, given that we now live and work in a "global village."

CAN KNOWLEDGE BE MANAGED?

Baseline Definitions

Despite the surge of interest in knowledge management over the past few years, there is no general agreement as to whether knowledge can be "managed" in any meaningful sense. Three views on this topic are apparent to us (others may suggest more):

1. Meaningful knowledge resides only in people's heads, and therefore managing organisational knowledge is an oxymoron (Weick & Westley, 1996).
2. All knowledge can be managed; the principal challenge is to "extract" it from its current location, whether that is a human mind or somewhere else.
3. The statement that "knowledge resides in people's heads" is literally true, but there are knowledge processes in organisations (and elsewhere), and these processes can be managed, even if it is not possible to manage the knowledge itself directly.

View number 1 implies that not only this chapter, but indeed the entire book is a waste of time, and thus need not be discussed further here. Many software vendors may be found advocating view number 2, which has its ancestry, at least in part, in the more mechanistic aspects of the expert/knowledge-based systems field. In our view, the history of that field demonstrates that this view is unlikely to be valid in most domains of knowledge (see for example Gill, 1995). Even the oft-cited Huber has modified his thoughts over a 10-year period to accept that knowledge can be "sticky" and thus difficult to "extract" even from a willing donor (Huber, 1991, 2000).

Most of the literature specifically on knowledge management, not surprisingly, adopts view number 3. This literature often refers to "knowledge processes" or "knowledge management processes." However, the meaning of these phrases is usually only weakly specified, if at all. It is implicitly assumed that "something to do with knowledge" is taking place in organisations.

TOWARDS THE IMPLEMENTATION OF KNOWLEDGE MANAGEMENT

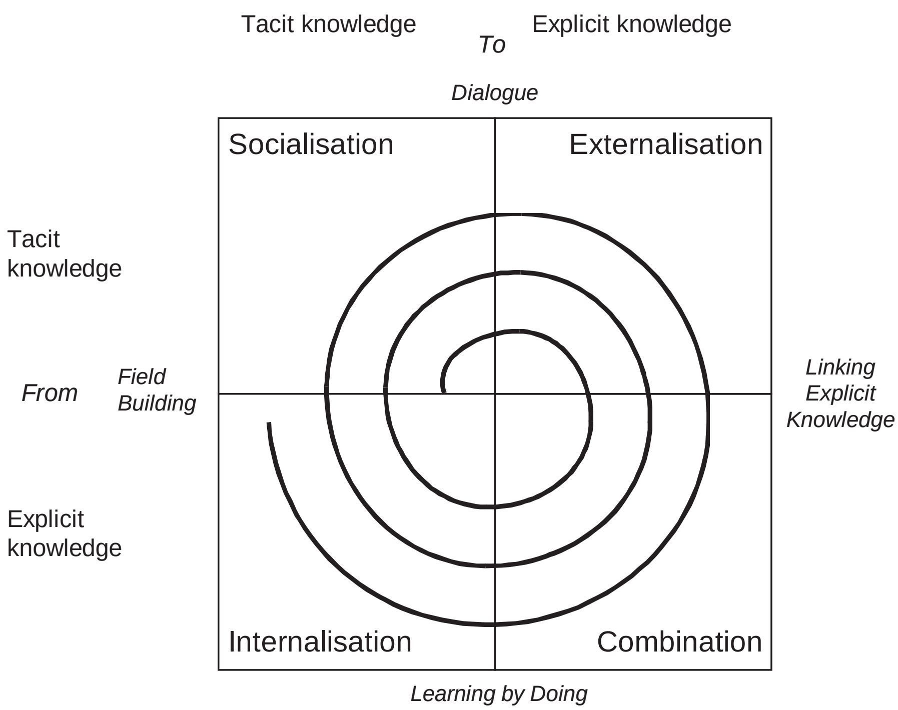
In this section, we consider four routes to the implementation of knowledge management in an organisation. We identify these as follows:

- The "knowledge world" route
- The IT-driven route
- The functional route
- The business processes route

The "Knowledge World" Route

The discussion of the knowledge processes mentioned under view 3 in the previous section is most often considered at the level of the whole organisation, or in a "world of knowledge" that is not specifically linked to the activities that a particular organisation carries out. These features may be seen in the most commonly cited generic model of knowledge processes, that of Nonaka and Takeuchi (1995), as shown in Figure 1. We should make it clear at this point that Nonaka and Takeuchi do go on to consider the practical realities of managing and encouraging these knowledge

Figure 1. Nonaka and Takeuchi's (1995) model of knowledge transfer processes



processes in organisations. However, many of those who cite Nonaka and Takeuchi's models seem to have lost the practical implementation aspects somewhere.

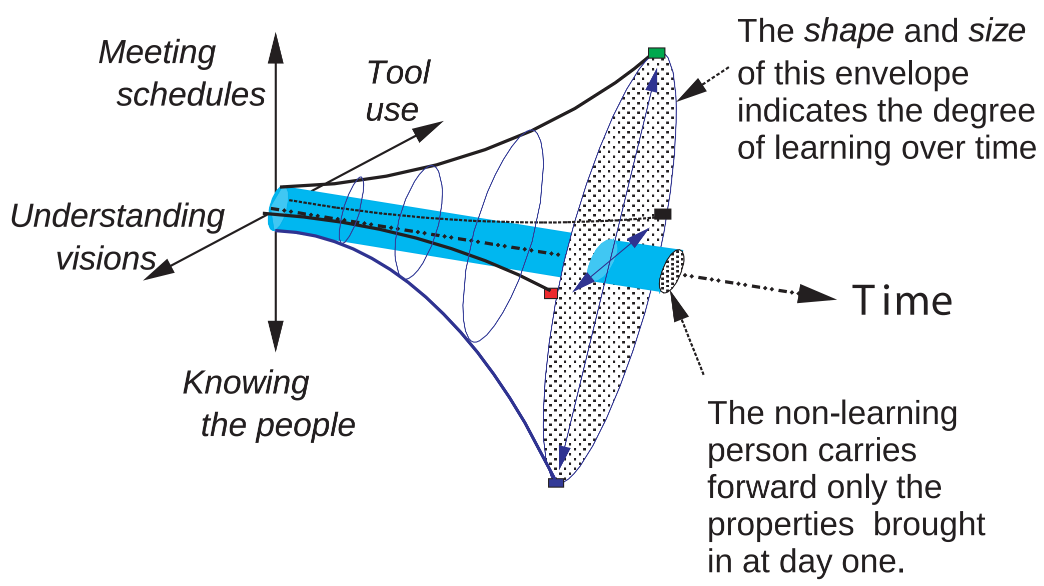
On an abstract level such discussion of knowledge management can be extremely valuable. However, in order for knowledge management to be implemented in an organisation, we believe that such a model has to be "attached" somehow to what the organisation actually does. It is necessary not only to understand how individuals learn, but also how they learn in a given organisation. In other words, we have to understand the processes by which individuals learn to "use their tools, to do what, why and with whom" — and how the organisational systems may help or hinder the individual's learning process. The same issue applies even more forcefully to group learning, since the organisation provides a crucial element of the group's context, whether that group is formal or informal, entirely internal or partly external.

We emphasise these points further in Figure 2. The figure is intended to indicate that a new individual in a firm will initially understand little of his/her new firm and its mores — but we trust he/she has some potential to learn.

As time progresses, they will learn to use the best tools for the job (these might be a telephone or the ubiquitous PC). They will learn that management has provided the best tools possible so they can meet the schedules demanded by the managers, and imposed by customers. They will learn to integrate with the CEO's visions so that all 'do their part and pull together.' Lastly they will learn to commune with others over many business issues. Figure 2 is in part an echo of the schema presented by Nonaka and Takeuchi, though here the focus is on what the individual is doing, whereas Figure 1 focuses on what is happening to the knowledge.

However, none of these ideas, however expressed, provides a specific connection from

Figure 2. The 4-knows of individual/group learning



the abstract ideas about knowledge to what the organisation actually does, or could do, or should do. Something more concrete is needed.

The IT-Driven Route

One possible route that has been adopted by some organisations is a natural progression from "view 2" on whether knowledge can be managed, as set out earlier. This route assumes that the fundamental requirement is for extraction and codification of as much knowledge as possible. For an organisation of any size, such a task evidently requires IT support, and the thrust of this route is that once the "correct" form of IT support for managing knowledge has been chosen, it is simply a matter of a great deal of hard work.

In our opinion, this technology-driven route is unlikely to work well, and may not achieve any improvement in knowledge management at all. One example of this from our own experience is of a heavy manufacturing firm. Knowledge management in this organisation was seen solely as an information systems issue; the knowledge management group was part of the information systems department. The "solution" was seen in terms of the implementation of a knowledge-sharing system based on Lotus Notes. However, there was no real consideration as to who would share what knowledge or for what specific purpose. Matters were not helped by the absence of a prior culture of knowledge sharing in the organisation. Consequently, the eventual use of the installed IT was poor; the only really successful use was by the knowledge management project team itself, where the "who, what and why" questions had been properly addressed!

The Functional Route

An alternative route to the implementation of knowledge management that at least has the potential to address the "who, what and why" questions is to organise the implementation around the existing organisational structure. The most commonly found structural elements intended to facilitate learning and knowledge sharing in organisations are departmental groupings based on functions. These have clear advantages in terms of what we might term professional development and allegiance. Davenport and Prusak (1998) report examples of successful knowledge transfer between groups of surgeons, and groups of tunnelling engineers, among others. However, this functional route also has the disadvantage that it encourages the compartmentalisation of knowledge. This problem can only worsen over time, as specialisations multiply and sub-divide. In addition, the professional divisions can actively prevent sharing of knowledge. It has, for example, taken decades for hospital doctors in the UK National Health Service to allow other professionals such as pharmacists and physiotherapists to participate in decision making about treatment of individual patients on an equal footing. On a wider scale, modern Western medical science has come to separate "diet" and "drugs," at least until the very recent past, in a way that Chinese medicine, for example, never has done.

We believe, therefore, that although the functional route to implementation will allow some management of knowledge to take place, progress may be limited, and in the worst cases this route may be counter-productive.

The Business Processes Route

It is clear that the managers in an organisation have to translate the goals of any strategic programme or initiative — whether on knowledge management or something else — into practical, implementable reality; in other words, to connect with "what the organisation does." Various management thinkers have presented models of this, for example:

- Porter's (1985) value chain;
- Earl's (1994) view of core processes, the ones

that are done directly for external customers;
- Beer's "System Ones" (1985), the systems that make the organisation what it is,
- core competences/competencies as espoused by Hamel and Prahalad (1994).

There are some significant differences in detail between these perspectives. For example, Beer and Porter have substantially different views as to what constitute the primary activities of an organisation. In Beer's view, the primary activities are those that distinguish this organisation from one in a different line of business. Porter, by contrast, sees the activities of all organisations as fundamentally similar. Nevertheless, what these views have in common is that all of their definitions are consistent with looking at the organisation in terms of what it does, rather than how it is structured. From our perspective, this means looking at knowledge learning and exchange in terms of its underlying business processes. Note that we use the term business processes throughout this chapter, but such processes exist equally in not-for-profit organisations, and we believe the concepts discussed here are equally applicable in that context.

Defining 'Business Processes'

There are many definitions of a business process. We prefer that of Davenport:

"A structured, measured set of activities designed to produce a specified output for a particular customer or market." (Davenport, 1993, p.5)

Among the characteristics of business processes that in our opinion justify their use as a foundation for knowledge management in organisations are the following.

1. Business processes have identifiable customers, whether internal or external. Knowledge is of little relevance unless put to use for a customer of some kind.
2. Business processes cut across organisational boundaries. Knowledge does not need to, and does not obey the artificial boundaries within an organisation.
3. Business processes consist of a structured set of activities. Choosing the appropriate way to structure activities is an important part of the knowledge.
4. Business processes need to be measured. Without some form of measurement as a comparison, knowledge cannot be validated.
5. While the parts of a business process are important, the overriding requirement is that the overall process works. True knowledge of the organisation must take a holistic view.

An additional argument, presented by Braganza (2001), is that viewing knowledge management in terms of an organisation's processes gives a much-needed supply-side view of knowledge. This is complementary to the demand-side view of knowledge that stems, for example, from considerations 'of data leading to information leading to knowledge.' Again, this links with our earlier argument; Beer and Earl particularly concentrate on this supply-side perspective. Beer indeed goes even further, to include the informal processes and activities of the organisation as well as the more formalised ones.

A further though indirect justification for the use of business processes in this role is that they are now becoming part of the mainstream of management thought. The new version of the ISO9000 family of standards for Quality Management Systems, including ISO9001: 2000, is constructed on the basis of a "process approach." The ISO9000 term realisation process is equivalent to Earl's core process or Beer's primary activity.

Completing our argument, the knowledge that an organisation requires must, logically, be related not just to what that organisation does, but also to how it does it. Thus we must think about this knowledge, and how to manage it, by reference to that organisation's business processes. But should we be focusing on the current processes, or future, changed processes? Clearly good knowledge management must include both, but this does raise difficulties.

CHANGE AND THE NEED FOR FLEXIBILITY

Types of Change

In looking at how the organisation moves from the present into the future, it is possible to distinguish three fundamentally different sets of circumstances:

- Continuing status quo operation.
- Incremental change or improvement (also called evolutionary change or continuous improvement).
- Radical change or improvement (also called revolutionary, discontinuous or step change).

Note the use of "improvement" as synonymous with "change" here. We do recognise the possibility that change occurs which worsens a particular situation, but in this chapter we take the optimistic view that in a competent organisation such reverses will be only temporary.

Each of these circumstances has different implications for the knowledge the organisation needs, but conversely knowledge drift is itself one of the key drivers for change. One of the main reasons for process change cited in the business process re-engineering (BPR) literature (Hammer, 1990; Hammer & Champy, 1993), is that: "the old ways no longer seem to be effective." In our terms, if old ways are ineffective, this must mean that the knowledge needed to accomplish the activity has changed. Work on knowledge management from an organisational behaviour perspective confirms this view of knowledge as being dynamic. Scarbrough et al. (1999), for example, describe knowledge as relatively transient, in other words changing at different times, even in the same organisation.

The Organisation as a Learning Entity

The requirements for organisational learning are similarly affected by whatever changes the organisation is undergoing. These effects may well permeate through all the human resource management activities of the organisation, right down to recruitment. Elsewhere we have discussed how top-down knowledge management and bottom-up organisational learning must be complementary to each other — changing together to meet the changing circumstances in which the organisation finds itself (Kidd & Edwards, 2000). Again, as most learning relates to the how of the organisation's activities rather than the what, a focus on business processes will be helpful, if not essential.

Knowledge management, organisational learning and business processes are all inextricably linked. Together they require an appropriate combination of human, organisational and IT support. We now go on to consider the issue of change in more detail.

CHANGE AND KNOWLEDGE MANAGEMENT

In considering knowledge, learning and change, we start from the perspective that all those who work in an organisation are thinking beings, capable of reflecting on what they are doing. The principal implication of this is that the "obvious" three-category view of change in the future, as presented in the previous section, is in fact misleading. It may be a valid depiction of change, but it is not the most useful way to consider future needs for knowledge and knowledge management.

In our opinion, there are three scenarios of change to be distinguished:

1. Status quo/continuous improvement: the same processes with perhaps minor changes to the activities.
2. Radical change to one process, with the customers and the organisational boundaries remaining the same.
3. Radical change across the whole organisation, where anything may change, even the nature of the organisation itself. Indeed, as we shall see later, such change may extend well beyond a single organisation, to a sector, region or country.

We argue that the requirements of continuing status quo operation and incremental improvement are effectively the same in terms of knowledge management and organisational learning. It is hard to conceive of a status quo that is enforced so solidly that no improvement ever takes place at all. We will admit that we are aware of some organisations — or at least parts of them — where the type of thinking mentioned at the start of this section is not encouraged, or even positively discouraged. Brief examples are given below.

Examples Within Scenario 1

In the first of these scenarios, we suggest that any learning that takes place must be related to the current process, and will probably be done in the first instance by the actors currently involved in carrying out that process. Thus the management of learning and/or knowledge also involves only incremental change. This does not necessarily mean that it is easy.

We have experience of a situation where even transferring knowledge from workers on one shift to workers on the same equipment on another shift presented serious obstacles. One shift team had developed a clearly superior operating practice, but the other two shifts working on the same production activities refused to adopt their proposed practices. Each shift had its own operational management, and the organisation's middle management were therefore the main communication channel between shift teams. However, this middle layer of managers tended to work "normal office hours," and so had very little involvement with the two of the three shift teams who worked "abnormal" hours. Partly as a consequence of this, the people concerned hardly ever met informally either. The official channels for communicating to and from the non-day shifts were therefore the only ones that could be used. As a result, nothing much happened. Only when a conscious effort was made to exchange management personnel between shifts did matters begin to improve. Changing this management process enabled knowledge sharing about the related business process to take place.

Even in an organisation where development is discouraged, like the archetypal 1930s-style production line environment satirised by Charlie Chaplin in the film Modern Times, change does still occur. Although there may be little scope for an individual to modify the way that they perform their current task while they are performing it, even these organisations would allow "off line" incremental improvement. In the 1950s production line, this might have taken place via work-study investigations, or (in more enlightened cases) a suggestion box scheme.

As a further example of discouraging development, we recall Fred Olsen, the boss of Digital (DEC), who banned conversations about PCs in the 1980s since he believed they were trivia that 'would go away.' As history shows, they did not go away — Olsen left, and eventually Digital was bought by successful PC manufacturer Compaq! Digital's business vision was based on the principle of tailoring the product to fit the customer's needs. This worked very successfully for their main mini-computer market in the 1980s. By the time

Digital (after Olsen) began to produce PCs, their learning curve was at odds with that of their more successful competitors, who had realised that PCs were now commodity items that required being cheaply mass-produced.

Examples Within Scenarios 2 and 3

The remaining two scenarios differ in whether the radical re-engineering is of one process, or of the whole business. Note that it might well be possible to re-engineer most of the processes in a business one after another without really changing the nature of the business overall. There are several examples of organisations that have recently taken a process-based approach to knowledge management with the intention of improving the processes, but not radically changing the business: here we offer three examples — the Unisys Corporation, the Objective Corporation and General Electric.

Unisys (Wizdo, 2001) has embarked upon a company-wide knowledge management initiative, whose objectives include:

- accelerating the speed and scope of organisational learning,
- decreasing the time it takes to reach critical mass in new markets,
- uniting cross-boundary groups,
- increasing innovation in product and process.

Wizdo identifies three increasingly ambitious categories of "transformation" in business: efficiency, innovation and re-invention. The Unisys knowledge management program regards a focus on processes as essential in achieving the two 'higher' categories, although at present the emphasis is on innovation. From our perspective they are re-engineering one process at a time.

Objective Corporation (Fisher, 2001) has adopted a similar process orientation over the past five years. They have found that such an emphasis has not only improved knowledge management within the business, but has had significant impact on the performance of the business itself. Indeed we can refer the reader back to Figure 2 and its discussion. A coherent training programme, with an emphasis on understanding, would be likely to increase the overall organisational performance through the betterment of its constituent personnel.

Probably the largest process-based change initiative, which with the benefit of hindsight can be seen to have had substantial knowledge management aspects as well, is that which has taken place at General Electric (GE) over the last 20 years. Jack Welch, until recently the CEO, completely transformed the company through his strong leadership and by using the knowledge of all its employees — especially those on the shop floor (Lucier & Torsilieri, 2001). GE's "corporate university" at Crotonville has proven to be central to this approach, making the link between Welch's strategy from the top down and the employees' knowledge and learning from the bottom up. They all would seem to understand the rationale of "what, how, who…."

Two Cautionary Tales

It might be easy to conclude from these examples that a process focus always leads to success in knowledge management, or indeed business in general. Unfortunately, this is by no means always the case. Here we present two cautionary tales.

One of the original "success stories" in process re-engineering concerned the application process at Mutual Benefit Life Insurance (Hammer, 1990). The changes to that process were undoubtedly successful, with results such as a reduction in processing time from 5-25 days to 2-5 days. Flow of new business (and funds) in was greatly improved on the basis of an innovative programme including such features as IS professionals and line managers changing roles for a year. However, this did not stop Mutual Benefit Life from first having to file for protection against bankruptcy and then going into administration. They had re-engineered the wrong process; a key one, but not the one that was most problematic for their business. In parallel with all these beneficial changes, the (unchanged) process of investment in real estate and mortgages was making a series of imprudent choices that brought the company to its knees. This was a failure of knowledge management at the management level. Just possibly, company-wide implementation of the change programme would have averted this, but a process focus by itself did not.

Timing of knowledge availability can also be a problem. Robinson et al. (2001) report on the organising of unplanned maintenance (i.e., responding to equipment failures) in an automobile manufacturing facility. Although a process perspective has been taken, the facility being studied is a relatively new one, and therefore has not yet experienced the full range of unplanned maintenance issues. Clearly this gives rise to potential knowledge management problems: how can they know what to do in a situation that has not previously arisen? The transferability of knowledge from other, older, facilities is being investigated as a possible way to overcome the problems. In general, the half-life of knowledge is problematic; however, since there are no easily applicable rules as to what to discard, what data and learning will be unwanted in the new situation, and conversely what will still be valid.

A further potential problem with a process focus is that of over-formalisation, whether of the business processes themselves or the forms of knowledge management in use. There is a risk that too much formalisation will lose the benefits of such means of knowledge sharing and transfer as storytelling and informal communities of practice. A process route to implementing knowledge management will certainly not lessen these risks, and may even increase them compared to the functional route.

INTERNATIONALISATION

One of the most radical changes that an organisation can undertake is to move from a national market and operations to operate on an international scale. Initially, in order to derive cost-cutting benefits, an organisation might venture overseas to access lower cost raw materials or lower cost labour markets to assemble components which are brought back home to satisfy home customers who do not perceive any changes to the vendor's organisational boundaries. Internally the organisation may have grave difficulties in achieving effective learning within the new supply chain. A process view is, in our view, essential to have any chance of success in this, but it is not sufficient and of course the firm must eventually pass beyond these Scenario 1 changes (in our terminology). We now discuss these issues further.

The Concept of 'Distance' and its Effect Within Scenario 2

Space does not permit a deep theoretical development here, but we would argue that 'distance' is a pervasive concept reaching deep into our everyday life. We have our own feelings about "what should be," and when these are broken for whatever reason, we may react at any level — from being mildly puzzled to grossly affronted. Often however we are inconstant in our reactions, and this happens more often in situations where there are cross-cultural issues that leave us bewildered or where there are strong power brokers who distort our ability to cope and react, as is our habit, under normal circumstances.

Research proposes that internationalisation should also be studied as a process (Aharoni, 1966). In consequence a number of different models of the internationalisation process have been developed. One of the most commonly cited models is the "Uppsala model" based on the Nordic studies of Johanson and Wiedersheim-Paul (1975) and Johanson and Vahlne (1977). This suggests that organisations will internationalise in stages as they overcome "psychic distance" (factors which inhibit the flow of information between markets). Johanson and Wiedersheim-Paul (1975) also suggest that organisations will enter countries with successively higher psychic distance. While it is not validated for some industries and markets (Turnbull, 1987; Forsgren, 1989; Erramilli, 1990), the Uppsala model is still put forward as a likely description of the internationalisation process of small, internationally inexperienced organisations (Forsgren, 1989; Johanson and Vahlne, 1990; Buckley et al., 1988). This is important since we note that in all countries the vast majority of firms may be classified as SMEs (Small & Medium Enterprises). In the UK for instance, in 2000, 99% of firms were defined as 'small' although they created 38% of the nations' turnover (DTI Statistical News Release — P/2000/561— 7th August 2000). It follows that some of these firms will venture abroad, and probably will follow the Uppsala model.

Informal support for this 'thesis' was given by Efurth (2001) while discussing aspects of the work of Dzever et al. (2001). The gist of the argument was that the Swedes offer a view of human resource management and entrepreneurship that is clearly distinguished from the Anglo-U.S. or the Asian models. This would correspondingly affect the requirements for knowledge management. Such confirmation is important as process models similar to those above are surfacing in research: such as Brouthers and Brouthers (2001) who review again the cultural distance paradox in joint ventures and mode of entry to another country by single or multi-national organisations; by Larsson et al. (1998) who propose a matrix framework to categorise the issues that 'joint' venture organisations may encounter; and by Kumar and Nti (1998) who note the discrepancies between processes and outcomes. Thus within organisational cultures we may suggest that training be given to help make the intangible more clear in the eyes (and concepts) of the other — and once more we may refer to the subtlety of concepts carried through the learning cycle in Figures 1 and 2. Yet we know from work in knowledge-based systems that knowledge domains have to be well defined and quite restricted, and that effective knowledge management systems need to include links to human knowledge that continues to remain tacit. Thus if the cultural distance (a measure akin to the 'psychic distance') between the parties is too large (Kogut & Singh, 1988), the partners will not achieve (even) a slight congruency.

Although we can envisage organisations moving from Scenario 1 change into Scenario 2 change, and perhaps finally Scenario 3 change, most of this work refers essentially to Scenario 2, that of radical change to one process, with the customers and the organisational boundaries remaining the same. A development of the Larsson matrix by Edwards and Kidd (2001) implies that when a willingness to 'work with the other' goes wrong, there is potential to descend into anomic states rather than cooperate or at least work in a cooperative mode. Equally, when an organisation ventures into a region grossly culturally different (e.g., Anglo-Americans in Asia) they may see the local host organisations employing staff using 'rules' derived from what they see as cronyism, nepotism or simple favouritism, and using working practices they see as somewhat corrupt (Kidd & Li, 2001). Here an understanding of the processes will not be sufficient on its own. The enjoining of radically different cultures may prove too great a threat to the morale of the merging organisation's work force as they fight to retain knowledge. This may mean, for example, that they will not cooperate in any way with those whom they view as 'the enemy.'

It must be conceded that this may be seen to be quite correct historically, at least on some occasions. Entering organisations have taken-over and dissolved indigenous industries; the cotton trade in Manchester, UK, or the UK motorcycle industry after the Japanese 'invasion' are just two cases. Not all foreign direct investment (FDI) is good FDI — Cantwell and Janne (1999), and Driffield and Munday (2000) show that there are benefits accruing from investments which stimulate indigenous organisations; but all is not rosy — they also suggest that local adverse effects can occur, namely that inefficient organisations may be bankrupted under the new competition. The knowledge needed to be successful will have changed, but the organisations do not know about it until too late.

The Problematic Scenario 3

Taking this further, especially in this era of globalisation, brings us back to Scenario 3: radical change across the whole organisation, where anything may change, even the nature of the organisation itself.

Looking back at our five reasons for "thinking of process" in knowledge management, all of them may become problematic.

1. The customer may change in subtle ways, even for the same product or service in a different country.
2. Existing knowledge applied overseas may not be sufficient.
3. Organisational structures — real or virtual — will differ in different countries. Actual and perceived boundaries will multiply when alliances are involved, yet from the point of view of knowledge, all remain artificial.
4. Even transparent measurement can be problematic, especially if the two partners in a joint venture have radically different objectives (perhaps technology transfer for one partner, and access to a new market for the other).
5. Finally, even holism may be interpreted differently in different cultures, although further discussion is beyond our scope here.

We close this section by offering an increasingly important example from international human resources management — the consideration of demographic and economic migrants. Ronås and Ramaurthy (2001) present a powerful description of international labour migration linked to globalisation. Often (they say) there is contract migration when a migrant's sojourn is linked to a specific job and for a specific time. However, there are also many instances where there is an escalator of people from poor countries moving to relatively better developed countries, while that nation's people move onwards to even better developed nations. Sometimes, as in the case of Japan (and soon in Italy), there will be the need to import labour to maintain the local economy. Ronås and Ramaurthy also cite the case of Germany, where even they, over the period from 2000 through 2005, anticipate a need to allow 6,000 migrants annually per million inhabitants simply to maintain the size of the working population. Under these circumstances there may be great cultural distances observed even within one organisation, notwithstanding errors in perception by staff from country A of the workforce of an alliance firm in country B who may in fact be employing many workers from country C.

Radical changes will therefore need to take place across the whole organisation, as nothing in the knowledge exchange and learning systems may be taken for granted. For example, working practices due to local legislation or religious tolerance will have to be observed and absorbed. To overcome some of this effect, we may suggest that the continuing development of and greater familiarity with Information and Communications Technology will facilitate outsourcing and/or teleworking, thereby reducing the need for migration. But this demands earlier infrastructure investment at a national level that just has not taken place in most newly developing regions. This mode will still demand human tolerance, compromise and understanding of "the other" in order to make the processes work well.

CONCLUSIONS

We have explained why we believe that considering knowledge management in terms of business processes is the best route for organisations to follow. We have cited some good examples, but also some indications that a process focus is not the answer to all knowledge management problems, especially where different cultures and/or cultural change are involved.

We conclude with an unanswered question concerning change and knowledge management. In terms of organisational performance, greater potential benefit comes from greater change. But when great change occurs, some of the organisation's existing knowledge, whether it be in stories or systems (or even people) will be less valid in that new context. How does the organisation know, before the change occurs, which of the knowledge that will be?

Returning to the Digital example: in today's purchasing climate, some customers look deeply into an organisation's supply chain to ascertain the ethical and ecological properties of the product's origin, even questioning the origins of its components (Dzever et al., 2001). Thus, ironically enough, Digital, 20 years on, might have been able to retain its marketplace and its original stakeholders' confidence through a continued use of its U.S. design and production chain, and by being perceived to not unethically milk the labour market of developing countries. But hindsight is a wonderful thing!

The key medium- and long-term knowledge challenge is thus "what to keep, and what to throw away." We believe that relating the knowledge to business processes will help, but there will always be an element of, yes, luck, in such matters. Greater change does, after all, involve greater risk. Innovation implies change; change implies lessening the dependence on history as a predictor of the future. Except, that is, in finding those who are adaptable and receptive to change. But will they be forever thus? Who can tell? In the end, as is appropriate, knowledge management is a "people thing" — manageable with care!

REFERENCES

Aharoni, Y. (1966). *The foreign investment decision process.* Boston: Harvard University Press.

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action Perspective.* Reading, MA: Addison-Wesley.

Beer, S. (1985). *Diagnosing the system for organisations.* Chichester: John Wiley & Sons.

Braganza, A. (2001). *Knowledge (mis)management…and how to avoid it.* Presented at Information Management 2001, Olympia, London.

Brouthers, K. D., & Brouthers, L. E. (2001) Explaining the national cultural paradox. *Journal of International Business Studies, 32*(1), 177-189.

Buckley, P. J., Newbould, G. D., & Thurwell, J. (1988). *Foreign direct investment by smaller UK firms.* London: Macmillan.

Cantwell, J. A., & Janne, O. (1999). Technological globalisation and innovative centres: The role of corporate technological leadership and location hierarchy. *Research Policy, 28,* 119-144.

Davenport, T. H. (1993). *Process innovation: Reengineering work through information technology.* Boston: Harvard Business School Press.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Driffield, N. L., & Munday, M. C. (2000). Industrial performance, agglomeration, and foreign investment in the UK. *Journal of International Business Studies, 31*(1), 21-37.

Dzever, S., Quester, P. G., & Chetty, S. (2001, October 31-November 2). Country-of-origin effects on industrial buyer's product perception in the Asia-Pacific region: A comparative study of Australia, New Zealand, Thailand and Cambodia. In *Proceedings of the 18th EAMSA Annual Conference,* Berlin (vol., 2, pp. 221-243).

Earl, M. J. (1994). The new and the old of business process redesign. *The Journal of Strategic Information Systems, 3*(1), 5-22.

Edwards, J. S., & Kidd, J. B. (2001). Knowledge management when 'the times they are a-changin.' In D. Remenyi (Ed.), *Proceedings of the Second European Conference on Knowledge Management* (pp. 171-183). Bled, Slovenia.

Efurth, C. (2001). *Private communication*. 18th EAMSA Annual Conference, Berlin.

Erramilli, M. K. (1990). Entry mode choice in service industries. *International Marketing Review, 7*(5), 50-61.

Fisher, G. (2001). *A framework for deploying knowledge management in an EDRM environment.* Presented at Information Management 2001, Olympia, London, 1-2 November.

Forsgren, M. (1989). *Managing the Internationalisation Process: The Swedish Case*. London: Routledge.

Gill, T. G. (1995). Early expert systems: Where are they now? *MIS Quarterly, 19*(1), 51-81.

Hamel, G. and Prahalad, C. K. (1994). *Competing for the Future*. Boston, MA: Harvard Business School Press.

Hammer, M. (1990). Re-engineering work–don't automate, obliterate. *Harvard Business Review,* (July-August), 104-122.

Hammer, M. and Champy, J. (1993). *Re-Engineering the Corporation–A Manifesto for Business Revolution*. London: Nicholas Brealey Publishing.

Huber, G. P. (1991). Organisational learning: The contributing processes and the literatures. *Organizational Science, 3*(3), 383-397.

Huber, G. P. (2000). Transferring sticky knowledge: Suggested solutions and needed studies. In Edwards, J. S. and Kidd, J. B. (Eds.), Knowledge Management Beyond the Hype: Looking Towards the New Millennium. *Proceedings of KMAC 2000,* Aston Business School, 17-18 July: 12-22.

Johanson, J. and Vahlne, J.-E. (1977). The internationalisation of the firm: A model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies, 8*(1), 23-32.

Johanson, J. and Vahlne, J.-E. (1990). The mechanism of internationalisation. *International Marketing Review, 7*(4), 11-24.

Johanson, J. and Wiedersheim-Paul, F. (1975). The internationalisation of the firm–Four Swedish cases. *Journal of Management Studies,* (October), 305-322.

Kidd, J. B. and Edwards J. S. (2000). Fast-moving global supply chains: How organisational learning may offer bridges in crossing cultures. In Remenyi, D. (Ed.), *Proceedings of the First European Conference on Knowledge Management,* 49-59. Bled, Slovenia. 26-27 October.

Kidd, J. B. and Li, X. (2001). Leaders and transparency: Problems of cronyism in Asia. *Proceedings of the 18th EAMSA Annual Conference,* 37-59. Berlin, 31 Oct–2 Nov: (1).

Kogut, B. and Singh, H. (1988). The effect of national culture on choice of entry mode. *Journal of International Business Studies, 19*(3), 411-432.

Kumar, R. and Nti, K. O. (1998) Differential learning and interaction in alliance dynamics: A process and outcome discrepancy model. *Organizational Science, 9*(3), 356-367

Larsson, R., Bengtsson, L., Henricksson, K. and Sparks, J. (1998). The interorganizational learning dilemma: Collective knowledge development in strategic alliances. *Organizational Science, 9*(3), 285-306.

Lucier, C. E., & Torsilieri, J. D. (2001). Can knowledge management deliver bottom-line results? In I. Nonaka & D.J. Teece (Eds.), *Managing industrial knowledge: Creation, transfer and utilization* (pp. 231-243). London: Sage Publications.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. Oxford: Oxford University Press.

Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. New York: Collier Macmillan.

Robinson, S., Alifantis, A., Edwards, J. S., Hurrion, R. D., Ladbrook, J., & Waller, T. (2001). Modelling and improving human decision making with simulation. In B.A. Peters, J. S. Smith, D. J. Medeiros, & M. W. Rohrer (Eds.), *Winter Simulation Conference 2001.* San Diego, CA: The Society for Computer Simulation.

Ronås, P., & Ramaurthy , B. (2001). International labour migration and globalisation. *Nordic Newsletter of Asian Studies, 3*(October), 3-6.

Scarbrough, H., Swan, J., & Preston, J. (1999). *Knowledge management and the learning organisation: A review of the literature*. London: Institute of Personnel and Development.

Turnbull, P .W. (1987). A challenge to the stages theory of the internationalisation process. In P. J. Rosson & S. D. Reid (Eds.), *Managing export entry and expansion*. New York: Praeger.

Weick, K. E., & Westley, F. (1996). Organisational learning: Affirming the oxymoron. In S.R. Clegg, C. Hardey, & W.R. Nord (Eds.), *Handbook of organisation studies* (pp. 440-458). London: Sage Publications.

Wizdo, L. (2001). Organisational models for enterprise knowledge management. In D. Remenyi (Ed.), *Proceedings of the Second European Conference on Knowledge Management* (pp. 755-766). Bled, Slovenia.

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Chapter 6.7
Knowledge Management: The Missing Element in Business Continuity Planning

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ABSTRACT

This chapter provides a new perspective for Knowledge Management applications within organizations. The relevance of knowledge management components in disaster planning has been underscored by the large-scale terror attacks of September 11, 2001. The objective of the chapter is to provide a different perspective on the risk management category of business continuity planning or disaster recovery. Specifically, the authors show how most plans ignore or downplay the essential requirement for the organization to preserve its critical knowledge resources in the event the possessors of that knowledge are killed. Most proponents of Knowledge Management have neglected this important facet of the field. At the same time, the risk management and disaster recovery fields have ignored the important contributions of Knowledge Management to a viable business continuity plan.

INTRODUCTION

As the horrific events of September 11, 2001 in New York City, Washington, DC, and rural Pennsylvania unfolded, the first thoughts of most were likely for the victims of terror on such a huge scale. In the aftermath of the tragedy and destruction, many survivors had to turn to restoring businesses. Much was written about disaster recovery and business continuity planning as people struggled to regain the essential systems that underlie the modern organization. One aspect of this restoration that has typically been ignored is that of organizational memory management—a crucial part of Knowledge Management (KM). The importance of knowledge as a critical resource continues to gain recognition in the business world. This chapter discusses the need for KM programs in order to cope with large scale disasters such as the World Trade Center attacks.

BACKGROUND

This is really a dual topic as it contains the topics of both KM and risk management. The major focus is on the need for the addition of corporate memory management to complete any business continuity plan. The terrorist attacks of 9/11 have forced many to re-examine their disaster recovery plans.

For the first time, organizations have had to confront the massive loss of intellectual capital. Even if disaster recovery plans had provisions for software, equipment and networking, the plans could not be executed without knowledgeable people. Terrorist attacks have underscored the importance of adding knowledge management or corporate memory management components to make a comprehensive business continuity plan. In order to understand the domains of business continuity planning and KM, it is necessary for us to provide some definitions of the concepts. In the following section, we begin by defining KM.

KNOWLEDGE MANAGEMENT

Unfortunately, KM has a variety of meanings both in the literature and in practice. Some definitions are provided here. Knowledge management is the utilization of "the collective knowledge, experience and competencies available internally and externally to the organization whenever and wherever they are required" (Fearnley, Horder, 1997, p. 25). They have considered KM to be a supportive process comparable to the management of people. It includes the systematic generation, capture and transfer of knowledge and learning for the application and benefit of the whole organization. We believe that knowledge is similar to potential energy in providing the basic competence to perform. A manager's major concern should be centered on the knowledge required to perform the organization's critical processes and tasks. Knowledge Management is the discipline that focuses on capturing, organizing, filtering, sharing and retaining key corporate knowledge as an asset. "KM is the sharing of information and wisdom between global business units and their support organizations" (Griffiths, 1997, p. 62). Dorothy Yu, a global consulting partner at PricewaterhouseCoopers, defines KM as "the art of transforming intellectual assets into business value" (Zerega, 1998, p. 61). Knowledge management is the ability to realize increased returns from business competencies," according to Kirk Klasson, director of knowledge-management solutions at Cambridge Technology Partners (Zerega, 1998, p. 61). The lack of effective management of knowledge could be because most organizations are still struggling to comprehend the KM concept (Holsapple, Joshi, 1997).

To make knowledge work productive will be the greatest management task of this century just as to make manual work productive was the greatest management task of the last century. The gap between knowledge work that is left unmanaged is probably a great deal wider than was the tremendous difference between manual work before and after the introduction of scientific management (Drucker, 1969, p. 272).

Thus, our focus is on the management of the corporate memory that is required for superior performance of those critical processes. This becomes even more important as the world's forces engage in war activities and human knowledge bases leave the organization.

BUSINESS CONTINUITY PLANNING

Business continuity planning is often equated with external forces, such as natural disasters, that present the risk of power disruption, building destruction or worse (McManus, Carr, 2000). Less obvious is the risk inherent with a terrorist attack as devastating as the horrific events experienced by the United States on September 11, 2001. Risk is inherent in any organization, in any operation, in any situation where the goal is continuity.

There are expected situations that cause downtime. However, there are disastrous events that are much more difficult to plan for that can cause total disruption in business. Examples of these interruptions of business are shown in Table 1.

The cost of downtime, whether the result of disastrous or normal situations, has a widely varying impact on the organization depending upon the industry. According to Kelly (2002), the Energy and Telecommunications groups are exceptionally vulnerable to downtime—with revenue at risk of 2.17 million dollars per hour for energy and 2.066 million dollars per hour for telecom companies as displayed in Table 2.

An essential component of any sound Information Resources Management program is that of Business Continuity Planning or, in a more limited sense, Disaster Recovery Planning. These programs are emplaced to ensure that a business can continue to operate after a disaster. From an information technology perspective, the plans deal with restoring capability so that essential IT supported functions can be carried out. An important part of the recovery planning should be on the KM aspects that enable the systems to function. What are these aspects? What are the specific tasks that managers need to perform? How should managers address the KM tasks?

As stated by Dickerson (2001), "In the coming days and weeks, businesses that lost employees in the attack are faced with realities of rebuilding business infrastructure to serve their customers amid the bottomless grieving for their colleagues. The loss of so many people means a catastrophic loss of intellectual capital." Therefore, even companies that have a good disaster recovery plan are struggling to implement that plan. While the total cost of damage to a company's equipment and facilities can easily be determined, intangible

Table 1. A categorization of disasters (Source: Adapted from Aberdeen Group in Kelly, 2002)

	Normal Situation	Disaster Recovery Situation
Time Down	* Minutes per year	* Hours of day per event
Infrastructure Threat	* Disk failure * Network congestion * Application performance	* Earthquake * Blizzard * Fire * Flood
Willful Threat	* Computer viruses * Hacking	* Disgruntled employee * Terrorist attack

Table 2. High cost of downtime (Source: Adapted from Meta Group in Kelly, 2002)

Industry	Revenue/hour	Revenue/employee-hour
Energy	$2,817,000	$589
Telecomm	$2,066,000	$187
Manufacturing	$1,610,000	$134
Finance	$1,495,000	$1,079
Info Tech	$1,344,000	$184
Insurance	$1,202,000	$370
Retail	$1,107,000	$244
Pharmaceutical	$1,082,000	$167
Chemicals	$704,000	$194
Transport	$668,000	$107
Utilities	$643,000	$142
Health Care	$636,000	$142
Media	$340,432	$119
Retail	$1,107,000	$244

damage, such as the cost of downtime and the loss of intellectual capital, are difficult to measure. Not only are companies faced with the loss of employees and loss of the business infrastructure, but also they are struggling with the rebuilding efforts due to a lack of available company employees that can implement the plan. This solidifies the necessity to capture relevant knowledge that can be engaged during such catastrophic disasters as experienced on September 11, 2001.

KM ASPECTS OF CONTINUITY PLANNING

Information technology managers have long advocated certain practices that make a business capable of restoring IT-based aspects of the business in disaster situations. Some of the most basic practices are backup, especially of critical applications. However, most disaster recovery plans that rely on conventional backup, outdated testing, narrow redundancy, etc., are woefully inadequate to comprehensively cover enterprise needs (Grygo et al., 2001). With catastrophic disasters such as massive terrorist attacks, there is a huge human dimension in addition to the technical one. In some cases, the majority of the human resource may be lost in addition to the destruction of IT and facilities. As Kearns (2001) stated, "it is not pleasant to contemplate, but what would your company do in the event that you and your entire department were wiped out?"

One rather recent aspect of KM could be considered the idea of an alumni network for a company. Because talented people do not stay in one organization forever, the alumni network helps to maintain contact with them even when they are gone. The alumni network is designed to engender lifelong affiliation. Eventually, some of the alumni that possess critical organizational knowledge may want to return or may be in the position of being advisors. Therefore, there is a new movement to build alumni networks. Even if the people do not return to the company, the company may be able to bring their knowledge back (Canabou, 2002).

In an interview (Scannell, 2001), the head of IBM's disaster recovery center, Ted Gordon, stated that the basic disaster recovery plan was insufficient when the whole fabric of how the business operated was disrupted, rather than just getting computers back up and running. He said that, "Every company has to take stock of exactly how they do business, where it is most critical for them to keep that part of the business running, and what the processes are that support that…technology is not as big a risk as is the way we use technology to do business—it is the emphasis on the people, and our dependency on them, and how we choose to operate."

Companies must conduct risk assessment and manage the risk potential from all aspects of the company, i.e., personnel, technology. In the traditional disaster recovery plan, it was the responsibility of management to determine where unexpected and undesired consequences were likely to occur. The assessment was often focused on the interruption of technology, process, or procedures. "The technological inability to communicate with customers and suppliers is devastating, which can prevent the company from staying in business. By detecting and recognizing risks, the result of adverse consequences will be less catastrophic" (McManus, Carr, 2000, p. 3).

Johnson (2002) has pointed out that traditional disaster recovery plans are unable to keep up with the speed of doing business today. He advocates continuous processing architecture (CPA). CPA is a complete, high availability concept that allows instant failure recovery as well as storage. Provided adequate separation of the required redundant systems, the systems, applications and data should survive. However, a CPA may be just another piecemeal solution when a comprehensive, complete strategy is needed.

Comprehensive plans are designed to eliminate unnecessary decision-making immediately following the disaster. This plan is only effective if the appropriate personnel are available to invoke the actions necessary to continue the business. The companies in the World Trade Center experienced immediate problems from the terrorist attack and will continue to experience difficulty for months, even years, and potentially may never recovery, because of the tremendous loss of intellectual capital.

Few firms have been so deeply and irrevocably devastated by the World Trade Center attack as KBW. In all, 67 of the firm's 172 New York-based employees died or are still missing. They accounted for nearly a third of KBW's 224 employees. In a stroke, the firm lost more than 400 years of professional experience and much of its leadership. Gone are five of nine board members, including KBW's directors of equity trading, bonds, and research, along with its most prominent and influential financial analysts. Those missing or dead were responsible for 40% of KBW's annual revenues, which reached $125 million last year. In addition to the human loss, the firm lost its headquarters and every shred of paper documentation that existed there (Byrne, 2001).

Many companies in the World Trade Center may have the ability to recover their technological losses quickly, however, not their intellectual losses. In an interview with Howard W. Lutnick, a Cantor Fitzgerald Securities executive, he indicated that 68% of the intellectual assets of the company were lost in the tragedy. "The government bond trader had almost its entire New York staff wiped out on September 11" (Powell, 2001, p. 68). The company did not lose the critical data of the company, however, they did lose customer contact personnel, which will ultimately affect their supply chain management and CRM capabilities. It is apparent that the knowledge of the personnel of Cantor Fitzgerald Securities is a necessity to stay in business.

"Nothing can compare to the enormity of our loss of life," said Mr. Lutnick. "This tragic event has taken from us over one third of our employees (approximately 700), including half of our senior leadership. However, what we have learned from this horrendous act is that it is impossible, to destroy the spirit of our family and together we are forging ahead. We will remain the market leader with the foremost electronic trading platform in the world and in doing so honor the integrity of those employees, executives, family and friends we have lost" (Business Wire, 2001).

Although valuable data was stored in various applications, the employees with the knowledge of creating and using this information were killed in the attack and their knowledge died with them. Therefore, these examples indicate the necessity to store the data in a data warehouse and manage the knowledge for future use. In an effort to replace the personnel, the company will encounter tremendous risk that includes the inability of the new employees to perform at the appropriate level, as well as the risk of a start-up company stealing the business.

"Risk International's Mr. Wellman advised employers to spread staffers around and to 'minimize decision-making' to protect against catastrophes. Businesses that had all or most of their workforce in a single location violated a fundamental risk management principle, 'concentration of risk'" (Bradford, 2001, p. 21). How can survivors restore the firm's presence and ability to do business? "In a disaster, companies may be able to get the IT side up, but what about the rest of the company? What about management and production?" (Kovar, 2001, p. 71). One measure that managers need to address is that of harvesting the crucial knowledge of their best performers and preserving it. This should be a priority undertaking, as it may prove vital for survival in an era where terrorism poses new risks.

KNOWLEDGE MANAGEMENT TASKS

Knowledge management has been a popular concept for several years; however, there are many definitions and controversies about the scope, content, and implementations still clouding the issues. In this regard, we believe that the scope and content may be clarified by delineation of KM tasks that are important for business continuity planning. Consequently, we list tasks that are relevant within this context.

Since managers are interested in capturing relevant knowledge about the key processes of their firms, it is now apparent that this should be part of the strategic goals of the company (Snyder, Wilson, McManus, 2000). An organization's knowledge base and continuity plan needs to contain relevant (expert) knowledge that can be made available during a disaster. Peter Drucker (1993) stated in his book Post Capitalist Society, "The basic economic resource is no longer capital, nor natural resources. It is and will be knowledge." Managers are trying to understand what this means as they move their companies and information technology departments from strategies of data management, to information management, to knowledge management. Organizations are now striving to establish knowledge management systems to assist in the dynamic business environment.

To appreciate the problem with expertise retention, consider the dilemma that suddenly arises when highly valued employees leave the organization unexpectedly, as experienced by many companies on September 11. You want to retain that person's expertise, generally viewed as his or her knowledge (Snyder, Wilson, McManus, 2000).

Corporate Memory Management is an integrated set of processes whereby the hidden insights from top performers are converted into specific, actionable know-how that is able to be transferred to thousands of employees via software (Snyder, Wilson, 1997). The process follows a sort of life-cycle approach (Snyder, Wilson, McManus, 2000). The parts of the process are:

Focus

The first step is to determine the existing explicit knowledge and implicit knowledge that is needed for the focal process. What are the know-how content priorities for this process? Then a formal project plan must be created to capture the information. This capturing process maintains the brain of the organization regardless of downsizing, attrition or resignation of employees.

Find

Another one of the initiating steps involves finding top performing people and their critical activities. The top performers will be identified as a way to determine the source of critical actions. The nature of the person that is being sought and the output of that person's activities create knowledge as opposed to a simple action.

Elicit

Once identified, an understanding of these activities will be elicited from the key individuals. The activities of the top performers are educed and logically mapped in the knowledge harvesting process. KM must uncover the rules of decision within the activities of key performers.

Organize

The knowledge must be arranged in a coherent or systematic form. This procedure of structuring the knowledge into orderly and functional processes allows anyone in the organization to retrieve the necessary information quickly and efficiently. It is this inherent method that allows the organization's knowledge to be carried forward for future use of various applications within the company.

Package

The determination of how to properly package the knowledge so that it can be available when and where needed is a necessity. We must assess the best packaging form, e.g., an Electronic Performance Support System (EPSS). This process collects and preserves information or data on a particular subject within the organization. This is a non-trivial process because the application will have to be expertly structured to glean knowledge from the action of the user and ignore everyday data and information. These knowledge processes are recorded in a database that is accessible through a software package. Software can be used by anyone, increasing the organization's ability to make effective use of all harvested know-how.

Share

Sharing brings different aspects to the value and use of knowledge and will likely lead to the seeking and capturing of other knowledge and uses of previous and new knowledge not formerly considered. This captured knowledge can be distributed throughout the organization to individuals or groups that may require this relevant information. Throughout this sharing process, a corporate repository is developed where tangible “intellectual capital” of an organization can be captured and exchanged. This sharing phase allows individuals to track activities while significantly increasing efficiency and effectiveness of existing groupware for any organization.

Apply

The purpose of a KM system is to allow people other than the key players to use the same decision rules. Once these decision rules have been elicited and captured, they are only of value if we have a way to apply the newly-gained knowledge. It is the employees of the firm that may request or seek assistance, employment or admission of a specific task. By creating these applications through the knowledge harvesting process, these employees can seek that assistance from the database of knowledge that has be gained and stored from the experts of the organization.

Evaluate

Evaluation must be performed in order to determine the effectiveness of the applications. Appraisal of the resulting captured knowledge will occur during its application and sharing. In sharing the knowledge, it will be evaluated—a process that should be continuous so that the total database can be kept up-to-date, relevant and as small as possible. The organization needs to evaluate its learning systems and their contribution to useful knowledge. At the most basic level, learning should be evaluated by assessing the impact on individual performance.

Adapt

The KM system must incorporate the ability to adapt to new knowledge so that it can be refreshed. To maintain this core asset, knowledge, software is utilized to record the knowledge and activities of the company experts. By instantly recording all input information generated during the learning sessions, these processes increase the organization’s ability to make effective use of all harvested know-how. Therefore, when a crisis occurs, the organization’s knowledge can be shared with others. This sharing process allows for a quick recovery. The combination of these harvesting processes can significantly reduce time and result in improved thinking and decision-making when a company is faced with a disaster.

A few case studies were used by Wilson and Frappaolo (2000) to illustrate the application of the approach. One case is of particular interest in the present context. This case is titled “Before A Key Employee Walks Out the Door.” In this case, the firm was forewarned of the imminent departure of one of its key individuals. The firm recognized the importance of capturing his intimate knowledge of a critical process and proceeded to work through the parts of the Knowledge Harvesting process cited above. This is the sort of procedure that all firms need to go through before there is a known loss of knowledge if they are to build survival capabilities.

A MANAGER’S KM CHECKLIST

Companies are already thinking about IT lessons. They “will most likely reconsider centralizing key personnel at a single office—one company lost its entire disaster recovery team of nine people in the attack" (Wagner, 2001, p. 15). Using some of the steps of Knowledge Harvesting, Inc., model as a basis, we have a series of actions for managers. One of the first tasks involves simply identifying the organization's key or critical processes. We would suggest that these processes be evaluated and ranked along a criticality scale in order to determine the areas for priority focus. A checklist can provide a normative model for managers.

1. Identify Key Organizational Processes
2. Rank-Order with Most Critical Processes First
3. Assess Organizational Readiness (From: Assessing Readiness, 1999)
    a. Determine Knowledge Orientation
    b. Assess Climate for KM
    c. Assess Culture
    d. Determine the Degree to Which Daily Operations Support Change
    e. Assess Information Architecture Ability to Support Change
    f. Determine Leadership Support for Change
    g. Determine the Scope and Magnitude of Change
4. Develop KM Plan
5. Select a Proof-of-Concept Process Project
    a. Employ a Proven Methodology
    b. Select a Doable Project
6. Implement Proof-of-Concept Project
7. Evaluate Proof-of-Concept Project
8. Extend KM Implementation to Priority Processes
9. Ensure Integration and Update is Ongoing

These steps can assist managers in their efforts to harvest and preserve essential knowledge surrounding the organization's key processes. The checklist is a suggested model for managers to follow in adding an essential KM element in their business continuity plans. Only by doing this, can firms ensure that they can recover from unexpected disasters such as large-scale terrorism.

FUTURE TRENDS

There are parallel trends that impact this topic. First, the events of September 11, 2001 have caused many firms to reevaluate their business continuity planning because of the scale of disaster caused by terrorists. Firms have had to rethink their total disaster planning and business continuity planning to face the possibility of massive loss of intellectual capital, even if their computing facilities were able to be restored rapidly. The second impact has been the very fact that the loss of intellectual capital can mean that even if all other aspects of computing and telecommunications are backed up, these efforts are futile if firms are without skilled or knowledgeable personnel.

Future research might include building a profile of business continuity plans. An examination of those plans that are executed could determine the impact of inclusion or exclusion of KM facets. Future research would include a study of the knowledge components that should be included in business continuity planning.

CONCLUSIONS

The disastrous effects of the events that occurred on September 11, 2001 will drive companies not only to consider the importance of traditional disaster recovery plans, but also to incorporate a knowledge management component that may have been overlooked in the past. The loss of intellectual capital has virtually crippled some companies, with no recovery possible. In the last ten years, a major disaster has been reported somewhere in the United States as well as the world, every year. The size of the disaster is not the determining factor of staying in business; it is a comprehensive business continuity plan that will determine the success of most companies. Firms must go farther than building a disaster recovery plan in the face of new threats. They need a comprehensive business continuity plan that includes the possibility of massive loss of knowledge. This plan must address organizational memory management. The technology infrastructure can be replaced, the physical facilities can be rebuilt, but it may be impossible to recover the loss of expertise unless there has been a concerted effort to harvest that knowledge and have it packaged so that the essence of the experts' implicit knowledge is preserved.

REFERENCES

Bradford, M. (2001, September 24). Attacks put focus on crisis plans. *Business Insurance, 39,* 18-22.

Business Wire. (2001, October 4). *eSpeed's chairman discusses the company's business.*

Byrne, J. (2001, October 8). How much loss can a firm take? *Business Week, 3752*, p. 68.

Canabou, C. (2002, May). Gone, but not forgotten. *Fast Company, 58,* 28-30.

Dickerson, C. (2001, September 21). Boundless generosity. *InfoWorld, 25.*

Drucker, P. (1969). *The age of discontinuity.* New York: Harper and Row.

Drucker, P. (1993). *Post-capitalist society.* New York: Harper & Collins.

Fearnley, P., & Horder, M. (1997). *What is knowledge management? Knowledge management in the oil & gas industry.* London Conference Proceedings Notes.

Griffiths, E. (1997, February 13). Knowledge management for global operations—and its impact. *Knowledge Management in the Oil and Gas Industry,* 61-70.

Grygo, E., Prencipe, L., Schwartz, E., Scannell, E., & Krill, P. (2001, September 17). IT recovery efforts forge ahead. *Infoworld, 38*, 17.

Holsapple, C.W., & Joshi, K.D. (1997, July, 1-21). *Knowledge management: A three-fold framework*. KIKM Research Paper No. 104.

Johnson, J. (2002). The case for a CPA. *Software Magazine, 22*(1), 16-17.

Kearns, D. (2001, September 24). Disaster recovery: Are you ready? *Network World, 39,* 22-23.

Kelly, D. (2002). Mindset change. Business continuity: Against all odds. *Network World Advertising Supplement*, 8-10.

Kovar, J. (2001, September 10). When disaster strikes. *The Newsweekly for Builders of Technology Solutions, 962*, 70-77.

McManus, D. J., & Carr, H. H. (1999, June). Risk and the need for disaster planning. *Information Systems Management Journal, 1-01-55,* 1-7.

Powell, B. (2001, Oct. 1). New world order: Battered but unbroken. Fortune, 6, pp. 68-80.

Scannell, E. (2001, September 19). *Boss of IBM's disaster recovery center tells what he learned from last week's crisis.* Retrieved from www2.infoworld.com/articles/hn/xml

Snyder, C. A., & Wilson, L. T. (1997). Technology advances supporting electronic performance support systems. *Proceedings, Symposium on Operations Research* (pp. 1-6).

Snyder, C.A., Wilson, L. T., & McManus, D.J. (2000, Spring). Corporate memory management: A knowledge management process model. *International Journal of Technology Management.*

Wagner, M. (2001, September 24). Disaster's aftermath – IT scrambles to restore order – World

Trade Center tenants use lessons from 1993 bombing, quickly switch over to backup systems. *Internetweek, 879,* 15.

Wilson, L., & Frappaolo, C. (2000, April). *After the gold rush or intelligent KM. Implicit knowledge management: Intelligent enterprise*. Retrieved from www.knowledgeharvesting.org/home.htm

Zerega, B. (1998, July 27). Art of knowledge management. *InfoWorld,* p. 61.

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Chapter 6.8
Workflow Systems and Knowledge Management

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INTRODUCTION

The business reengineering movement has left two lasting benefits: One is the identification of an organization as a set of processes (Davenport, 1993); the other is an emphasis on knowledge management (Davenport, 1997). The process orientation finds an expression in workflow systems. Processes have to be supported by knowledge management. Our purpose here is to provide an outline of how knowledge management relates to workflow systems.

The main source of information on workflow systems is the Workflow Management Coalition (WfMC). In 1994, the coalition published a 55-page Workflow Reference Model (available from its Web site www.wfmc.org), which establishes a common vocabulary, a description of key software components of a workflow management system, and interfaces between these components. The WfMC has been publishing an annual workflow handbook, an example being Fischer (2004). This volume contains an evaluation of the Workflow Reference Model (Hollingsworth, 2004). For a textbook with exercises refer to van der Aalst and van Hee (2002). Important pioneering work in this area was done by Schael (1998). A somewhat dated bibliography has been compiled by the ISYS group of the University of Klagenfurt (ISYS, 2000).

We start with a few definitions, based in part on the 65-page WfMC Terminology and Glossary document (also available from the WfMC Web site www.wfmc.org), and on van der Aalst and van Hee (2002). A business process is a set of linked activities that collectively realize a business objective or policy goal, and workflow is the result of automation of this process, in whole or part. A workflow comprises cases and resources. Cases are instances of the business process, and resources support the process. For example, the set of resources of an automated process that provides information about flight arrivals has to include a constantly updated database of flight data and a set of telephones. Every enquiry submitted to this system is a case.

A workflow system (WfS) manages the routing of cases through a workflow: A case "flows" from one station to another, and at each a task is performed on it. The task can be manual, automatic, or semiautomatic, but the definition of workflow as given suggests that the tasks of an ideal WfS should be automatic. It is important to realize that the ideal will not be achieved in the foreseeable future. Most WfSs of today are semiautomatic because they have to deal with unanticipated situations that only a human operator can handle. Moreover, software, the platforms on which it is implemented, and communication links can break down, requiring transfer of control to people. It is therefore important that the skills of these people be maintained by occasionally switching to a totally manual mode of operation.

The term "workflow," which we take to be a way of writing "flow of work," is appropriate because the cases move between workstations connected in a network. Indeed, implementation of workflows would have been difficult before computer networks became commonplace. A workflow management system (WMS) is a software package for the implementation of a WfS; adaptation of the generic WMS to the needs of a specific application turns it into a WfS for this application. This means that the WfS is also a software package. A distinction has to be made between the movement of cases between stations and the tasks performed at the stations. The movement, which is what the WfS controls, is normally fully automated: After a case has arrived at a station, the task is started automatically, or the system prompts a person to start the task; the task is then started at once, or after a delay. The delay may be due to a backup of cases or because the task is to be performed within a specified time window.

In the next section, we present a background survey, namely a discussion of processes that relate to workflows, and a discussion of information and knowledge. Then, we consider the management of knowledge in the context of workflow systems. We look to the future and offer a conclusion.

BACKGROUND SURVEY

Software Processes

In our view, the key concept of workflows is the use of software. With any software system, one has to consider: (a) the processes that create the software; (b) the software being created, which also defines a process; (c) the capabilities needed to implement and manage these processes; and (d) the knowledge resources involved throughout. As regards (a), the software development process can be regarded as a workflow system—this follows from the insight that the software development process is itself software (Osterweil, 1987).

Having established that a WfS is essentially a software system, we need to take a closer look at software development. The software process is made up of people, tools, and procedures. The people have to possess a set of capabilities that are to allow them to understand and make full use of the tools and procedures. For software development, such capabilities are defined by the Capability Maturity Model (CMM-SW) of the Software Engineering Institute (1995), and the more recent CMMI-SW (CMMI Product Team, 2002).

Under CMM-SW there are three types of processes: (1) a generic software development process; (2) processes derived from the generic process for the development of specific applications; and (3) these application processes. In addition, there is a process that assists in the conversion of process (1) into an instance of processes (2). In our context, the WMS would correspond to type (2): a process adapted from a generic software process that takes into account the specialized needs of WfSs. However, the workflow community has been understandably more concerned with business processes than with principles of software development. As a result, WMS is an abstraction of the features of application processes. Nevertheless, the capabilities of the CMM-SW can be of great value in the determination of how best to allocate the resources of an organization in the setting up of a workflow system, and how to modify the system to deal with changing business conditions.

We should also note that an application software system may in principle be developed by a WfS, which is itself an application software system. Rus and Lindvall (2002) and Dingsøyr and Conradi (2002) discuss knowledge management in this context, but software engineering shows that it is difficult to automate all tasks. Although some business processes have been fully automated (e.g., responses to enquiries by telephone), in the software development process not much more can be automated than the transfer of the software system under development from one work group to the next, help with extraction of components from a software reuse library, and prompts that tell developers what they should be doing next.

Information and Knowledge

Three kinds of knowledge are associated with a WfS. The first assists in the setting up of the system. The second is to be accessed by the system in its regular mode of operation. The third allows the system to be adapted in response to changing business conditions. In other words, the first and third kinds relate, respectively, to the implementation and maintenance of the WfS. Since the WfS is a software system, these components are in fact knowledge about the software process. The second kind is specific to a WfS. Its management is to be our primary concern. Note that Davenport (1997) prefers the term information management. In his view, knowledge exists in the human mind and is very difficult to embed in machines. This view is shared by Nonaka and Takeuchi (1995). Based on the seminal work of Polanyi (1958), they distinguish between tacit knowledge, which is personal and hard to formalize, and explicit knowledge that can be expressed in a formal language. We agree in principle. However, the driving force for workflows is the automation of business processes. Hence, we prefer to make the following distinction between information and knowledge: Information for our purposes is embedded in machines and is interpreted (i.e., it is data provided with meaning), and knowledge is information that is being put to use. This implies that we shall refer to information bases rather than knowledge bases, but what is extracted from an information base will be referred to as knowledge. According to Levesque and Lakemeyer (2000), a knowledge base is a collection of symbolic structures representing what a knowledge-based system believes and reasons with during the operation of the system. This view strengthens our distinction between information and knowledge. For Nonaka and Takeuchi (1995), "information is a flow of messages, while knowledge is created by that very flow of information, anchored in the beliefs and commitment of its holder." Fernandes (2000) makes this distinction: Information is obtained by deduction, knowledge by induction. As these examples show, it is difficult to make a clear distinction between information and knowledge, and sometimes we will use the terms interchangeably.

The knowledge that is to support the operation of a WfS can be grouped into five classes: databases, data warehouses, business rules, libraries of cases for case-based reasoning, and external sources. Databases have been extensively studied, and they are well understood. Data warehouses are repositories of archival data. Data mining (Hand, Mannila, & Smyth, 2001) looks for interesting relationships between these data, particularly for cause-effect relationships, with the aim of using these relationships for the improvement of business practices, which in our context means improvement of WfSs. Some WfSs operate on data streams. Thus, data from points of sale in a supermarket can determine policy. Research on mining from data streams is an active research area. A bibliography on this topic (Gaber, 2004) has 63 entries.

Business rules are of the form "if condition, then action." An example: "If the credit rating of the customer is of grade C or below, then demand payment before the order is shipped." Such uncertainty can be intrinsic to any WfS. For example, if the customer is of very long standing, we would be justified to assume some risk, and ship the order even though the credit worthiness may be questionable. To take a broader view, a rule is a trigger for a decision to be made, as it is in our example, or it is an operational definition, for example, "an age is obtained from date-of-birth by applying procedure get-age," or it is a terminological definition, such as "the grandfather of x is the male parent of a parent of x," or it is explanatory as in "the countries that have the euro for their currency are …" We are now in a position to define capability more precisely: It is the potential that an organization or an individual possesses for collecting and making effective use of information, rules, and process definitions.

Case-based reasoning (CBR) allows a system to respond to a situation by modifying a response made to a similar situation in the past (for surveys, see Watson, 1997; Shiu & Pal, 2004). In any software system the most difficult design problem is the treatment of exceptions. Consider a WfS that implements a loan approval process. Most applications can be handled routinely, but in borderline cases, approval or rejection could depend on some exceptional condition that is normally not taken into account. The information base of CBR is a case library of past decisions with the reasons for the decisions. By extracting loan applications similar to the application under consideration, the decisions made in those cases allow a decision to be made for the case being considered, and this decision will be reasonably consistent with the earlier decisions. Note that British law has been for centuries grounded in CBR.

FOCUS: KNOWLEDGE MANAGEMENT AND WORKFLOW SYSTEMS

Information has to be put to use in the operation of a WfS. The structure of the information base is to facilitate access to information, and this is a pragmatic concern. Pragmatics relate signs to their users. These are the people who gather, organize, manipulate, and use the information base. In terms of the distinction between information and knowledge that we made earlier, they convert information into knowledge. A WfS implements a process in a particular domain, and for the implementation to succeed, there has to be adequate knowledge about the domain. Ontologies and design patterns are pragmatic tools for managing domain knowledge.

A widely accepted definition of an ontology is that it is an explicit specification of a conceptualization of a domain. It is important to note that concepts are the basis for the interpretation of data. An ontology makes explicit the set of concepts that characterize a domain. It also indicates how the concepts are related. For example, an ontology for banking would include the concepts of account, account owner, and balance, and would tell that an account has an account owner and that balance is an attribute of an account. Kalfoglou (2001) surveys ontologies and includes a useful list of Web sites.

Software patterns represent general solutions to recurring problems. A pattern has five main components: the problem addressed, the context in which it arises, the solution, several known uses, and related patterns. The known-uses component indicates that patterns are not invented, but are the codification of experience with real projects. Devedzic (2002) surveys software patterns and provides a very useful list of Web addresses to libraries of patterns. There is a similarity to CBR. Under CBR, a search is made in a library of cases for a solution to a similar problem, and this solution is modified to suit present conditions. A pattern is an abstraction that has to be refined to make it correspond to the new situation. This means that a library of cases could be reduced to a limited number of patterns by merging similar cases. However, the advantage of CBR is precisely the details that would be lost in a pattern: The details help to achieve consistency in decision-making.

Most of the patterns to be found in libraries of patterns are very general, for example, requirements gathering, finding and defining domain objects, and user interface requirements. At this level of abstraction workflow itself is a pattern. What we need is a set of templates for the tasks of a WfS. This is investigated in Berztiss (1997) for the general class of rentals. Rentals relate to cars, formal wear, and library books. Even restaurant visits and airline flights have the characteristics of rentals: You "rent" a restaurant table or a seat on a flight. The rental processes for different types of rentals differ, and the different varieties of the process are obtained by refinement of the templates. Some of the templates for rentals include reservation, cancellation, handover, return, damage assessment, overdue item, payment, and inventory management. As a first step, each task is described as natural language text. Our example is the reservation template:

- Reservation: A customer makes a reservation of a rental object for a length of time starting at an indicated date and/or time. Variants of the basic task include (a) group reservations, (b) indication of just the starting point and not the duration, (c) no indication of a starting time, as in the case of a library book currently out on loan, (d) confirming of the reservation, (e) overbooking in anticipation of cancellations, (f) return site differs from rental site.

The description of a task of a specific rental WfS has to follow a definite format, but it is still expressed in natural language. From these refinement templates a decision can be reached regarding what is to be automated, and what is to be done by people. The format of the specialization templates includes:

- "Triggered by" establishes how the task is initiated.
- "Activities" gives an outline of all the activities that are part of the task, an indication under what conditions an activity is to be performed, and the order in which they are to be performed.
- "Information base changes" indicates those parts of the information base supporting the WfS that are to be affected.
- "Affects" identifies all tasks that can be affected by this task and states the conditions under which this task would interact with other tasks. This establishes flow patterns for a WfS.
- "Notes" contains any information thought to be relevant by the author of the template, for example, an explicit indication of what is not to be part of this task.

The Triggered by and Affects components define the flowlines of a workflow. Thus, specialization templates define both the tasks and the flow structure of a WfS.

A LOOK TO THE FUTURE

The biggest challenge to the manager of a WfS is keeping the system up-to-date. The business world of today is very volatile, and managers of

WfSs that are interacting with the world have to adapt their systems in response to changes taking place in this world. It is not enough merely to react to changes that have already taken place. There also has to be proactive adaptation of a WfS in response to analysis of business process data, such as the extrapolation of trends. We regard the determination of what existing and anticipated changes should lead to a modification of a WfS, what form the modification should take, and how the modification is to be implemented as very important research topics in knowledge management as it relates to WfSs. Totally new knowledge management problems arise when a workflow spans more than one organization (Schmidt, 2004).

The updating of a WfS is to be triggered by information that can come in various guises. But this creates a problem: How reliable is a particular item of information? Techniques such as data quality control (Tayi & Ballou, 1998), computing with words (Wang, 2001), and fuzzy techniques (Klir & Yuan, 1995) can be used to deal with data that are not crisp or reliable; Berztiss (2002) is a general survey. Methods have to be found for the determination of the level of unreliability of knowledge used in the estimation of business risks, and for the configuring a WfS in a way that reduces the risk associated with business process changes based on such knowledge.

A fairly recent development is the view that knowledge management can be purchased as a service (Woitsch, 2003). Workflow systems have become products, marketed by companies such as SAP. It remains to be seen to what extent the knowledge required to support these systems can become a service.

CONCLUSION

Workflow is a representation of a business process as software, but with the understanding that exceptional situations, and even some normal ones, require human intervention. Both the software system and human operators base their decisions on knowledge. Our main focus has been on the use of templates for the representation of this knowledge.

REFERENCES

Aalst, W.v.d., & Hee, K.v. (2002). *Workflow management: Models, methods, and systems.* Cambridge, MA: MIT Press.

Berztiss, A.T. (1997). Domains and patterns in conceptual modeling. In *Information Modelling and Knowledge Bases VIII* (pp. 213-223). Amsterdam: IOS Press.

Berztiss, A.T. (2002). Uncertainty management. In S.K. Chang (Ed.), *Handbook of software engineering and knowledge engineering* (Vol. 2, pp. 389-417). Singapore: World Scientific.

CMMI Product Team (2002). *Capability Maturity Model Integration, Version 1.1* (CMMI-SW, V1.1) Staged Representation. CMU/SEI-2002-TR-029. Retrieved from www.cmu.edu/sei

Davenport, T.H. (1993). *Process innovation: Reengineering work through technology.* Cambridge, MA: Harvard Business School Press.

Davenport, T.H. (1997). *Information ecology.* New York: Oxford University Press.

Devedzic, V. (2002). Software patterns. In S.K. Chang (Ed.), *Handbook of software engineering and knowledge engineering* (Vol. 2, pp. 645-671). Singapore: World Scientific.

Dingsøyr, T., & Conradi, R. (2002). A survey of case studies of the use of knowledge management in software engineering. *International Journal of Software Engineering and Knowledge Engineering*, *12*, 391-414.

Fernandes, A.A.A. (2000). Combining inductive and deductive inference in knowledge management tasks. In *Proceedings of the 11th International Workshop on Database and Expert Systems Applications (DEXA'00)* (pp. 1109-1114). Los Alamitos, CA: IEEE CS Press.

Fischer, L. (Ed.) (2004). *The workflow handbook 2004*. Mississauga, Ontario: Future Strategies, Inc.

Gaber, M.M. (2004). *Mining data streams bibliography*. Retrieved from www.csse.monash.edu.au/~mgaber/WResources.htm

Hand, D., Mannila, H., & Smyth, P. (2001). *Principles of data mining*. Cambridge, MA: MIT Press.

Hollingsworth, D. (2004). *The workflow reference model: 10 years on*. In (Fischer, 2004) (pp. 295-312).

ISYS (2000). *Workflows technology bibliography*. Retrieved from www.isys.uni-klu.ac.at/ISYS/JE/Projects/Workflow/bibliobis2k.doc

Kalfoglou, Y. (2001). Exploring ontologies. In S.K. Chang (Ed.), *Handbook of software engineering and knowledge engineering* (Vol. 1, pp. 863-887). Singapore: World Scientific.

Klir, G.J., & Yuan, B. (1995). *Fuzzy sets and fuzzy logic: Theory and applications*. Englewood Cliffs, NJ: Prentice Hall.

Levesque, H.J., & Lakemeyer, G. (2000). *The logic of knowledge bases*. Cambridge, MA: MIT Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. Oxford University Press.

Osterweil, L. (1987). Software processes are software too. In *Proceedings of the 9th International Conference of Software Engineering* (pp. 2-12). Los Alamitos, CA: IEEE CS Press.

Polanyi, M. (1958). *Personal knowledge*. London: Routledge & Kegan Paul.

Rus, I., & Lindvall, M. (2002). Knowledge management in software engineering. *IEEE Software 19*(3), 26-38.

Schael, T. (1998). *Workflow management systems for process organizations*, (2nd Ed.) Berlin: Springer.

Schmidt, R. (2004). Enactment of inter-organizational workflows using aspect-element-oriented Web services. In *Proceedings of the 15th International Workshop on Database and Expert Systems Applications (DEXA'04)* (pp. 254-258). Los Alamitos, CA: IEEE CS Press.

Shiu, S., & Pal, S.K. (2004). *Foundations of soft case-based reasoning*. New York: Wiley.

Software Engineering Institute (1995). *The capability maturity model: Guidelines for improving the software process*. Reading, MA: Addison-Wesley.

Tayi, G.K., & Ballou, D.P. (1998). Examining data quality (editorial introduction). *Communications of the Association for Computing Machinery 41*(2), 54-73.

Wang, P.P. (Ed.) (2001). *Computing with words*. New York: Wiley.

Watson, I. (1997). *Applying case-based reasoning: Techniques for enterprise systems*. San Francisco: Morgan Kaufmann.

Woitsch, R. (2003). Knowledge management services as a basic concept for enterprise knowledge management systems. In *Proceedings of the 3rd International Conference on Knowledge Management (I-Know03)* (pp. 523-531).

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Chapter 6.9
Integrating Knowledge Management with Programme Management

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ABSTRACT

Knowledge reuse has long been an issue for organisations. The management, reuse and transfer of knowledge can improve project management capabilities (i.e., learning, memory, cycle time) resulting in continuous learning. Although knowledge management has been recognised as a critical success factor in programme management very little research has been conducted to date (Lycett, Rassau, & Danson, 2004; Soderlund, 2004). A framework is discussed that demonstrates how knowledge is created, transferred, captured and reused within project and programme management, resulting in improved project management maturity. The framework utilises a task based approach to knowledge management and assumes that knowledge is created, transferred and reused as a result of an individual performing a specific task, which in this context is a project at the project level and a programme at the programme level.

INTRODUCTION

Organisations use projects to implement their strategy and change (Cleland, 1999). To achieve this, organisations need to utilise knowledge gained from earlier projects or project phases and not reinvent the wheel. One method of achieving this is for an organisation to develop a knowledge management strategy. A knowledge management strategy articulates how the organisation creates, values, preserves and transfers knowledge critical to its operations. As a way of ensuring that knowledge is effectively reused across projects they are often allocated to programmes. A programme is a group of projects managed together allowing added benefit and control that would not normally be achieved from managing projects individually (Project Management Institute, 2004; Turner, 1999).

Although knowledge management has been recognised as a critical success factor in programme management very little research has been conducted to date (Lycett et al., 2004; Soderlund, 2004). The focus of current research covers knowledge management in project management from intra- and inter-project learning (Kotnour, 1999) where it is important to capture knowledge as lessons learned where a full description of the project is captured allowing it to be used on other projects (Disterer, 2002). There has been a lack of formal knowledge exploitation in project management organisations.

A framework has been developed to demonstrate how knowledge is created, transferred, captured and reused within project and programme management. The framework utilises a task based approach to knowledge management and assumes that knowledge is situated within a specific context. Knowledge is created, transferred and reused as a result of an individual performing a specific task, in this context the task is a project at the project level and a programme at the programme level (Burstein & Linger, 2003). The framework shows how knowledge management can be integrated with project management.

The paper is structured as follows, a background to knowledge management within project and programme management grounded in relevant literature is provided, including actor network theory (ANT). ANT describes the way that a project team can be viewed (Parkin, 1996) in terms of comprising both humans and nonhumans (machines, procedures, processes and documents) and how knowledge can be created, transferred and reused (Latour, 1987, 1999). The next section provides a framework for how knowledge is developed at the task level and is embedded into the project methodology of an organisation allowing knowledge to be linked and reused in future projects and programmes. A description of a case study and a discussion of how knowledge management issues in the case study relate to the framework are then provided.

THE IMPORTANCE OF INTEGRATING KNOWLEDGE MANAGEMENT INTO PROJECT MANAGEMENT

The Project Management Institute (2000) defines a project as:

…a temporary endeavour undertaken to create a unique product or service. Temporary means that every project has a definite beginning and a definite end. Unique means that the product or services is different in some distinguishing way from all other products or services. (p. 4)

This definition offered by the Project Management Institute and widely used in both industry and academia focuses on project management as a tool rather than including project objectives, business performance (portfolio and programme management) that are fundamentally linked to project success (Morris, 2003). Morris (2003) offers an alternative definition:

Project management has to be about delivering business benefits through projects, and this necessarily involves managing the project definition as well as the downstream implementation. (p. 3)

Project success involves project management taking into account the traditional areas of project control and organisation, as well as the softer issues of stakeholder success, portfolio and programme management, project strategy, technology, and communication management (Morris, 2003). To achieve this, there needs to be a greater understanding of the integration of knowledge management into project management.

Different forms of knowledge exist in the project management environment — predominantly procedural (including tools) and contextual. While procedural knowledge is important, in larger or more complex projects contextual knowledge plays a key role both in learning and project success (Morris, 2003). Conversely if this procedural and contextual knowledge is not fully exploited the cost to an organisation could potentially be large in terms of time and dollars, reinventing the wheel and not reusing existing knowledge.

As project teams are temporary organisations need to ensure that knowledge from one project is available for use on future projects to reduce rework. Damm and Schindler (2002) argue that knowledge needs to be captured and indexed for future retrieval, however while it is important to capture explicit knowledge in a usable form it is also important to ensure that tacit knowledge can be tapped into (either personal knowledge or via a network)

Snowden (2002) argues that context is important in knowledge transfer because at one level people exchange knowledge personally based on trust and experience, while at the other level knowledge is coded for an unknown audience whose specific experience is unknown.

A knowledge management strategy is developed by organisations, including project organisations, for improving the way it develops, stores, and uses its corporate knowledge. Both tacit and explicit knowledge are important in the creation and reuse of knowledge. Organisational memory forms the basis of intellectual capital that is held in an organisation. Intellectual capital is the knowledge and capability to develop that knowledge in an organisation (Nahapiet & Ghoshal, 1998).

If an effective knowledge management strategy is not developed and managed by an organisation valuable intellectual capital can be lost, causing rework and lost opportunities. Better identification, transfer and management of knowledge allows intellectual capital to be effectively retained within the organisation, allowing it to be reused on other projects, reducing the time staff spend recreating what has already been learned.

For a project management organisation to be competitive Project Managers need to build knowledge and improve project performance (Cooper, Lyneis, & Bryant, 2002). In a structured organisation the learning process is important as it helps Project Managers to build on their experience by delivering not just one but a succession of successful projects, and to develop the right sorts of capabilities, that is, the project management process, the product development process and the knowledge management process (Kotnour, 1999).

In a project management organisation learning is important as it helps project managers deliver not just one but a succession of successful projects, and to develop the right sorts of capabilities, that is, the project management process, the product development process, and the knowledge management process. Learning within (intra-project) and between (inter-project) projects is required for this (Kotnour, 1999). Knowledge needs to be developed within a project, where it is used and tested, before it can be transferred to other projects. The challenge within some projects, particularly long-term, is to look at the process for the capture and reuse of knowledge in future projects (or phases of the same project) and to ascertain how intra and inter project learning occur (McLoughlin, Alderman, Ivory, Thwaites, & Vaughan, 2000).

Four key factors are critical to a project organisations capacity to learn, and these in turn are influenced by:

- A culture that encourages learning,
- A strategy that allows learning,
- An organisational structure that promotes innovative development, and
- The environment (Fiol & Lyles, 1985).

These factors contribute to individuals creating, transferring and reusing knowledge leading to organisational learning (Argyris & Schon, 1978). For a project organisation to continually learn and develop organisational learning needs to occur. Organisational learning is the capacity or process within an organisation to maintain or improve performance based on experience (Nevis, DiBella, & Gould, 1995). Organisational learning is dependent on individuals improving mental models (representing a person's view of the world). To develop new mental models the existing models need to be captured allowing organisational learning to occur independently of any specific individual (Kim, 1993). Organisational learning occurs when:

… members of the organization act as learning agents for the organization, responding to changes in the internal and external environments of the organization by detecting and correcting errors in organizational theory in use and embedding the results of their inquiry in private images and shared maps of organization. (Argyris & Schon, 1978, p. 29)

A key component of this mapping process is the recording of organisational memory. Organisational memory comprises the sum of participating individual's knowledge (Argyris & Schon, 1978). Organisational memory is distributed across an organisation rather than in one central area. There are six repositories, five internal and one external: individuals, culture, transformations, structures, ecology, and external archives. Once this body of knowledge is created new people can use it and it survives people leaving the organisation (Walsh & Ungson, 1991). The sum of an organisation's knowledge exceeds the sum of the individuals (Nelson & Winter, 1982).

At a project level knowledge is created by individuals and groups building on existing knowledge and creating new knowledge (adapting McElroy's [2003] definition of knowledge production at an organisational level). This knowledge can either be coded in project documentation or is stored with the project member.

PROGRAMME KNOWLEDGE

Knowledge Management is an important aspect of programme management. Programmes are the central point for the capture of knowledge such as project management policies, procedures and templates (Kerzner, 2003; Project Management Institute, 2004). Effective programme management allows for an enterprise or programme view of projects to be obtained via reporting and communication (Lycett et al., 2004) allowing for the more effective and efficient utilisation of schedules, resourcing, interface management, prioritisation, risk identification, mitigation, and management and forecasting (Lycett et al., 2004; Kerzner, 2003; Turner 1999).

At the programme level knowledge is shared, reused and created via training, mentoring, benchmarking, and capturing of lessons learned (Kerzner, 2003; Project Management Institute, 2004). In addition knowledge from previous projects can be stored and shared in a knowledge management system allowing for contextual searches for items such as lessons learned, financial data, processes, and procedures (Project Management Institute, 2004).

Project team members are often under pressure to move onto the next project rather than having time to reflect or transfer learning. Organisations need to develop a culture that allows knowledge to be captured and transferred (Lycett et al., 2004). It is suggested that it is a key role for programme management to foster this culture.

Knowledge management at the enterprise or programme level contributes to a learning organisation approach (Szymczak & Walker, 2003). Learning loops occur at regular review periods throughout a programme allowing benefits to be achieved (Thiry, 2002). These learning loops are a key point in knowledge creation, reuse, and transfer.

Successful organisations continually respond to change and reinvent themselves to maintain their competitiveness. Learning and knowledge management are key elements of the transformation and success (Thiry, 2002). Extending this it could be argued that learning and knowledge are embedded into the organisation (people, policies, and procedures).

ACTOR NETWORK THEORY

Project teams are temporary in nature with project team members moving back into operational roles, or onto another project, at the completion of a project or project phase (Cross, Nohria, & Parker, 2002; Blackburn 2002). Project management is associated with human and nonhuman machines, tools, and artefacts) in temporary organisations, as in actor network theory (ANT) (Blackburn, 2002). ANT comprises heterogeneous actors comprising both humans and nonhumans, for example, machines, procedures, processes, and documents (Latour, 1987, 1999a). The creation of knowledge occurs within a network. Within a network, sucha as a project team, a situation is framed and structured according to the actors existing knowledge, skill sets and competencies, and the nonhuman actors present in the network. It is a dynamic situation and changes as actors come and go within the network (Callon, 1998). Knowledge is gained by interacting with actors within a network and in understanding how and why they have behaved in a particular way (Latour, 1993, 1999a). Programme and project teams are networks based on the concept of ANT. Knowledge within a project is unstable as knowledge is continuously built on and created as new situations emerge and project team members enter and leave the network (Callon, 1998).

An important element of a given network is the boundary of the network that is set and the links within the network. These links have properties via which actors can collaborate within the network (Law & Hassard, 1999). Both the actor and the network rely on the other (Callon & Latour, 1981). Networks are constantly redefined as situations change and actors enter and leave the network (Latour, 1999b).

Actors (both human and nonhuman) within ANT are linked to the external environment (including networks), which is constantly changing and existing knowledge is constantly being built on and created (Callon, 1998). Based on Callon's (1998) work it is argued that a programme or project has a network of connections with the outside world, usually with resources or actors (human and nonhuman) both within and outside the organisation. Overflows occur when an actor enters or leaves the network. Actors continually reconfigure their networks as they change and adapt.

The changing nature of the networks allows knowledge to be reused as the "black box" concept (Callon & Latour, 1981). Decisions that are made/adopted within networks utilise the concept of the "black box", allowing people to take known, accepted and established work of others as a resource and build on this work rather than reproducing and questioning it (Callon & Latour, 1981; Latour, 1987). Within a programme this is most likely artefacts such as processes, methodologies, and documentation.

THEORETICAL FRAMEWORK

Project Management

Projects typically have subject matter experts or application area specialists who are required to manage a project or input specialist knowledge into a project to ensure that it runs effectively and efficiently (Dinsmore, 1999; Project Management Institute, 2004). Activities are the specific tasks that must be performed to produce the various project deliverables (Project Management Institute, 2004). Deliverables are any measurable, tangible, verifiable outcome in a project that must be produced to complete a project or a phase of a project (Project Management Institute, 2004). These outputs (usually in explicit form) are organisational process assets that are embedded into the corporate knowledge base (Project Management Institute, 2004). As a number of different project team members may be involved in completing the same task tacit knowledge is created, transferred and reused at each deliverable (Owen et al., 2005).

As an individual conceptualizes the task and reuses and reapplies past knowledge and experiences it can be argued that organizational memory is accessed and built on at the work breakdown structure/activity level. Also, knowledge is created, transferred and reused as a result of performing a specific task (Burstein & Linger, 2003).

An output of a project, that is often required at regular review points throughout the project, is performance reporting. Performance reporting involves progress and status reporting and forecasting. This reporting provides details of actual performance/progress against projected progress. Measures cover scope, project schedule and quality. At these review points the method of reporting varies depending on the organisation (including industry and methodology used) and the type of project. Knowledge is captured and transferred at these performance reports at the explicit level through reporting and at the tacit level in the form of project review meetings (Project Management Institute, 2004).

Organisations have formal or informal methodologies in place (depending on the type of organisation and their level of project maturity) to allow a project to be managed on time and budget and develop appropriate risk mitigation strategies (Kerzner, 2001b; Project Management Institute, 2000). These methods are often linked to other processes within the organisation (Kerzner, 2001b). Knowledge is embedded and captured within the methodology (Project Management Institute, 2004). As identified earlier regular review points identified within the methodology allow knowledge to be captured and reused at the tacit and explicit level.

As a project moves into latter phases, past the initial scoping, the project can be planned in greater detail (including risks) it can be understood what resources in terms of manpower, facilities, proprietary knowledge, special expertise, and knowledge of the business and financials are required. People provide the knowledge, skills, capabilities, and talents of the firm's employees in terms of knowledge of the business, special expertise, and proprietary knowledge (Kerzner, 2001a). This progress inputs into an organisation's capability.

In order to sustain a competitive edge an organisation needs to continually develop capability, that is the ability to achieve a desired effect or outcome in a specific operating environment and be in a constant state of readiness (applying the military definition) (Hinge, 2000). Lessons learned need to be embedded into the way a firm does its work. Within the project environment improving capability is to deliver successful projects and develop a competitive edge. This could be extended to knowledge creation where knowledge is embedded and made available for reuse and sharing thereby developing capabilities. To be competitive or retain competitiveness an organisation needs to continually develop its capabilities. In order to be competitive, an organisation needs to improve its level of project management maturity (Kerzner, 2001a). As capability improves, the appropriate resources can be supplied improving project maturity (Kerzner, 2001a). Project Management capabilities can only improve if continuous learning occurs. Learning occurs via knowledge creation, transfer, and reuse. If knowledge is lost, an organisation's project management maturity can decline (Kerzner, 2001a).

Where issues cannot be resolved within the normal project environment and intervention is required, an escalation process is used identifying when, how and the issue will be resolved (Project Management Institute 2004). As well as resolving the issue in the short term a decision needs to be made if the project methodology should be improved. To develop and maintain a competitive advantage an organisation needs to embrace continuous improvement rather than becoming complacent allowing competitors to catch up or overtake (Kerzner 2001a).

Knowledge is embedded throughout the project lifecycle at both the tacit and explicit level. Tacit knowledge is captured and reused at the project level in the form of personal knowledge (utilisation of knowledge from earlier projects), networks (informal to obtain specialist knowledge), and informal lessons learned. At the performance reporting level tacit knowledge is captured via mentoring (formal mentoring at regular review points). At the capability level, tacit knowledge is transferred and reused via mentoring. Explicit knowledge is reused at the explicit level in terms of documentation, while at the performance reporting level it is captured in the form of action and issues (Owen et al., 2005). Project templates and the project methodology allow for consistent reporting and for lessons learned to be captured (Project Management Institute, 2004). Knowledge creation, capture, transfer, and reuse occur throughout different phases of the model, learning occurs at all of these points. Based on Beer's (1981) concept of sympathetic and parasympathetic flows where knowledge is created at the sympathetic flow, it is reused in the parasympathetic flow (Owen 2004).

Programme Management

Following Beer's (1981) concept of recursiveness this model can be linked to the programme level. Related projects are aligned to a programme to allow benefits to be gained that would not be achieved if the project was managed individually (Lycett et al., 2004).

Programmes of work focus on effectiveness and efficiency goals and business goals (Lycett et al., 2004). Key common areas for programme management are typically planning and resource management, monitoring and control, configuration management and change control, risk and issue management, benefits management, and stakeholder management. Programme management allows for consistent reporting and communication (Lycett et al., 2004). Knowledge is reused, created, and transferred via consistent reporting and communication.

Interfaces amongst projects are managed and aligned at the programme level. Alignment allows for a more efficient and effective use of resources, especially scarce and limited resources (Turner, 1999). In addition managing the interdependencies between projects can reduce the amount of rework between projects therefore reducing project delays and eliminating risks that arise between the interfaces of projects (Lycett et al., 2004).

Monitoring of the programme usually occurs within a project or programme management office (PMO). The PMO oversees the management of projects within a programme. Resources are shared and coordinated and a common set of tools and techniques are used allowing knowledge to be embedded within the PMO (Kerzner, 2003). As well as standardising processes, the PMO allows for an improvement in resource allocation and a more realistic prioritisation of work (Kerzner, 2003). The PMO is responsible for ensuring that knowledge is maintained and disseminated throughout the programme. Relevant tools and processes need to be available for the capturing of and dissemination of knowledge including: risk data, lessons learned, project plans, team meeting minutes, and subject matter experts (Kerzner, 2003). Organisational process assets allow knowledge to be embedded within the methodology. Organisational process assets can vary depending on the type of industry and application area but are often templates, processes, guidelines, standards, communication requirements, and change control procedures (Project Management Institute, 2004). A challenge is to ensure that the knowledge is distributed in a timely manner (Kerzner, 2003). In addition, knowledge can be transferred to Project Managers via programme management meetings.

One output of programme monitoring (and the PMO) is prioritised projects. Prioritisation of projects can be based around resource requirements, the length of the project, interdependencies of projects and the strategic and business initiatives (Turner, 1999). As a programme of work progresses and more knowledge about the programme (and projects within the programme) is gained, a greater level of project prioritisation can occur. The prioritisation of projects inputs into a programme's capability.

Within the programme environment improving programme capability is to deliver a successful programme of work. This could be extended to knowledge creation where knowledge is embedded and made available for reuse and sharing thereby developing capabilities. To be competitive or retain competitiveness, an organisation needs to continually develop its programme capabilities. In order to be competitive, an organisation needs to improve its level of project management maturity (Kerzner, 2001a). Capabilities must be improved over time allowing repeatable successes in programme management.

As capabilities are improved effective resource utilisation can occur (Lycett et al., 2004). There is an improvement in the effectiveness and efficiency of resources, including justification for allocating specialist and scarce resources to particular projects. Resources would be allocated based on project prioritisation (Lycett et al., 2004).

Improved monitoring of the programme leads to effective benefits realisation, including benefits associated with the delivery of key organisational capabilities and the associated outcomes over time (Thorp, 1998). Benefits can be the elimination of risks arising from effective interface management, successful completion of projects and effective resource utilisation (Turner, 1999).

Effective capabilities of the programme lead to improved project and scope definition (Lycett et al., 2004). Where issues cannot be resolved within the normal programme environment a programme escalation is used identifying when, and how the issue will be resolved (Project Management Institute, 2004).

Framework

The theoretical framework provides a structure for linking programme management to knowledge management and mutually exploiting it (see Figure 1). The framework is a theoretical construct that represents the link between knowledge management and programme management.

As highlighted earlier, I choose to look at knowledge management using a bottom-up approach where knowledge is created, transferred, and reused as a result of a knowledge worker completing a task. Knowledge work is created, transferred and reused within a community of practice supported by a knowledge management system (Burstein & Linger, 2003).

A task is defined as:

…a substantially invariant activity with outcomes that include tangible output, central to the organization's viability and internal outcomes that are potential drivers of change. (Burstein & Linger, 2003, p. 290)

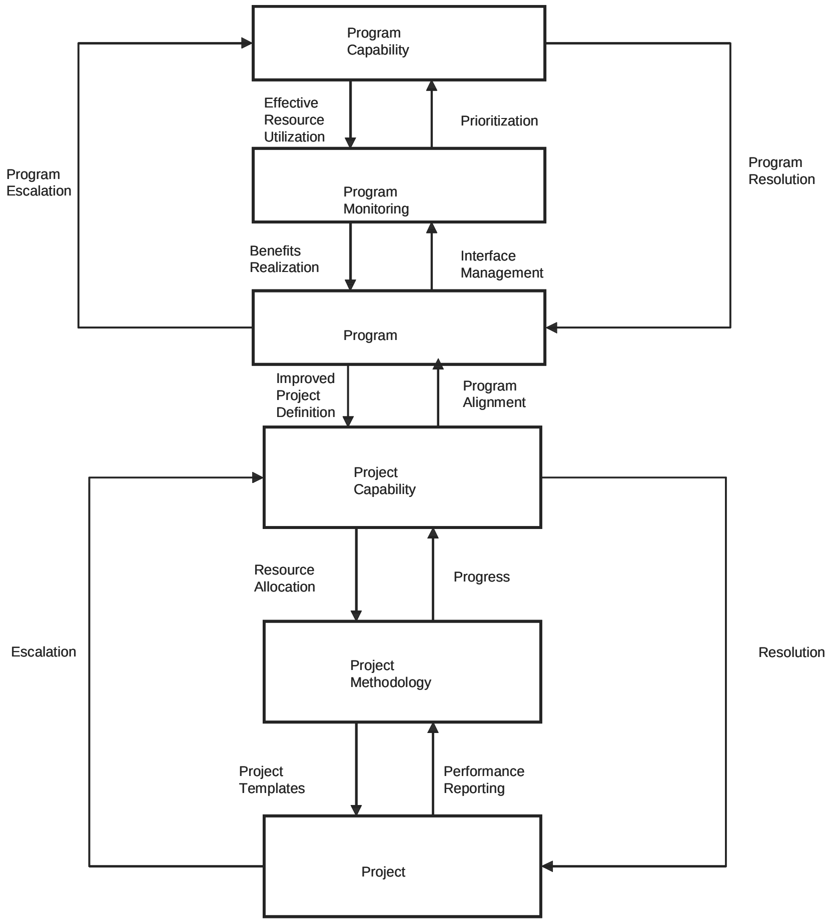
A project can be defined as a task where knowledge is created as the result of the activities that are carried out in a project by project teams and project team members (Owen et al., 2005).

Project team members create, transfer, and reuse knowledge in a community of practice (in this case it is most likely the project team) supported by a knowledge management system.

This framework (Owen et al., 2005) caters for the fact that when completing the task project team members will be able to conceptualise the task, reuse and apply past knowledge and experiences. Their knowledge work is supported via a knowledge management system (Burstein & Linger, 2003). The framework shows how knowledge is developed at the task level, is embedded into the project methodology, and improves the capability of an organisation.

This framework has alternative channels — sympathetic and parasympathetic flows. In order to maintain a stable environment where there is an input channel (sympathetic), there is an alternative channel (parasympathetic) which reports different information (Beer, 1981). The framework utilises the concept of recursiveness and as such is extended from the project to the programme level (refer to Figure 1) (Beer, 1981).

Figure 1. Knowledge management and project/programme management linked



CASE STUDY

Methodology

To initially test the project management component of the theoretical framework comprehensively within an organisation an exploratory case study, methodology was used allowing an insight to be gained into how knowledge was created, reused and transferred within and between projects (Owen et al., 2005). Data was analysed to look at emerging patterns to the research questions. Two analytical techniques were used in the research: document analysis, and unstructured interviews, with project team members, from both projects were conducted; both providing different perspectives and enabling crosschecking (Sabherwal et al., 2001).

A framework was developed for recording and analysing the relevant project documentation. In addition an interview guide was developed for conducting in-depth interviews. Both instruments were mapped to the theoretical framework.

Relevant project documentation was studied, assessed, and analysed during the case study research. Nine in-depth interviews, each taking approximately one hour, were conducted from a random sample of project team members across both projects. Project team members were interviewed from all work streams, seniority levels, and permanent versus contract staff.

The theoretical framework provides a structure for showing how knowledge management can be applied to project management. This model identifies four main areas of research:

1. Intra-project/programme learning and knowledge creation;
2. Knowledge transfer and reuse across projects and programmes;
3. Whether project and programme knowledge becomes part of organisational memory or is retained as individual knowledge; and
4. Management of project and programme knowledge.

The Case Study Site

A case study was conducted in an engineering project management consulting organisation. Two linked projects from planning to implementation and closure were chosen in conjunction with the organisation and studied. The organisation treated the projects as two separate projects with separate deliverables and have been analysed as such. The projects were analysed at the completion of the projects with no intervention from the researcher.

The organisation studied for the project management component is a global consulting company and is recognised as a leader in the market place. The organisation is employee owned and has grown organically and via strategic mergers with organisations with similar cultures and values. Their mission is to focus on valued client relationships to achieve remarkable success for them. The firm has a commitment to service, quality, and high standards of safety and business ethics. Management of the organisation follows a global management structure. The management structure reflects the regional, business and functional unit structure. A wide range of knowledge workers including project managers, engineers and scientists are employed by the organisation.

The corporate vision is to deliver solutions to clients which create exceptional value. The strategy is a global approach through our local offices. The projects analysed for this research supported the strategy to deliver exceptional service for and create an ongoing relationship and reputation with key clients. A key strategy of the organisation is to invest in the future of the business; knowledge management has been recognised as a key contributor to the future of the business. To assist with this strategy there has been the appointment of a

Knowledge Manager and the implementation of a knowledge management system. The knowledge management strategy is people centric rather than technology driven.

FINDINGS

Project

At the project level there is a reliance on both the existing network and actors in other networks (overflows). Documentation is usually in the form of a "black box", that is documentation that has been developed by others and is accepted as a resource, the documentation is built on rather than reinventing the wheel (Callon & Latour, 1981).

You use information that other people have worked on, particularly if you are running a project which is not like what you've done before. You ask around to find out who has the knowledge for that type of project and perhaps use their assistance.

Documents are stored on a server via job number, making it impossible to search contextually for documents (the organisation is in the process of implementing a knowledge management system) so explicit knowledge is often obtained from earlier projects that a person has worked on or obtaining the information from an expert. Documents are used as a starting point while more complex and detailed knowledge (such as financials and methodology) are obtained via tacit means, usually via human networks, that is, asking someone for the information.

It's a lot more efficient if you know who produced the file last time and you can go and ask them where it is…

Project Templates and Project Methodology

The organisation has a robust project management methodology with strong links to the methodology developed by the Project Management Institute (2000, 2004) Project Management Body of Knowledge (PMBOK). Each project follows a methodology based on: initiation, planning, execution, and closing phases. Business processes and project management systems also support the project and are aligned with the PMBOK methodology.

The project methodology has regular review points embedded into it allowing for performance to be reported against plan and allows for forecasting. The templates used cover scope, risk management and mitigation, project schedule, and quality. There is a reliance on existing templates and project methodology.

The critical steps in the process are signed off by the project manager and project director … we register them with a budget … and we monitor progress on a monthly basis we calculate earned value on the project online.

Performance Review and Reporting

Performance reporting occurs at regular review points of the project, using project templates; the performance of the project is measured against the project plan. Project templates that are used for performance reporting cover risk management, quality assurance, progress, performance against plan, and change management requests. The review points are identified by the project methodology.

As part of the reporting there is a review process (between the project director and project manager or an external reviewer and project manager/project team member), linked to the project methodology, where knowledge gained from one phase is incorporated into the next phase of the process. In this instance I would argue that the external reviewer, usually a quality assurance manager, is part of the external environment (including networks), which is constantly changing as they bring new knowledge into the project network during the review (Callon 1998).

Quality Assurance requirements are set up at the start of a project. Documents tend go through informal reviews to begin with, and then after changes are made, go back to the original reviewer for a formal review and sign off.

Capability

Mentoring is a key way of improving project capability, and is used within the existing network and via external networks (see Table 1). A Project director is appointed to mentor a project manager during the project. Mentoring occurs via regular review points.

The system of having a project director and project manager is one way that we reuse knowledge, because generally the director has more experience than the project manager. It's partly a mentoring system where the project director passes on knowledge to the project manager.

In addition more senior people (in terms of hierarchy and experience) external to the project mentor more junior project managers.

We've got a good mix of very senior guys and we try and get our junior guys to run projects and the senior guys feed the knowledge into the project…

Table 1. Knowledge use in project management

Phase of Model	Artefact	Actor
Project	• Informal lessons learned • Documentation • Informal networks	• Project team • "Black box" documentation and experience • Specialists (informal and formal)
Performance Reporting	• Project review process • Mentoring • Review points	• Programme manager/ project director • Project director • QA manager
Project Templates	• Project plans • Scope documents • Review documents	• "Black box" documentation
Project Methodology	• Methodology/ documentation	• Project team utilise "Black box" methodology
Progress	• Monitoring/mentoring	• Project director/project manager monitoring and mentoring at regular review points
Project Capability	• Mentoring	• Project director/project manager • Knowledge transfer from experienced employees to junior project managers
Resolution/Escalation	• Alliance project meetings	• Project director and project manager alliance meetings with their alliance counterparts

Escalation/Resolution

Typically issues that cannot be resolved within the project are resolved by external networks. The project director and project manager meet with their alliance counterparts, and the client issues that cannot be resolved by the project team or the project manager/project director can be resolved.

There's an alliance leadership team (ALT) and an alliance management team (AMT). The ALT meeting is at a higher level than the AMT and takes a broad overview of issues. If the project team cannot resolve an issue, there is a process whereby the issue gets escalated for a decision up to the AMT or ALT. It's a case of using the experience of senior alliance members to resolve issues using a best for project approach.

DISCUSSION

Knowledge is embedded and reused throughout the model. Knowledge creation, capture, transfer, and reuse, as stages of the implementation of a knowledge management strategy, occur throughout different phases of the model, learning occurs

Table 2. Project phases—How knowledge is managed and used

Knowledge Element	Type of Artefact	Existing Network/ Overflow (Based on Callon, 1998)	Phase of Project Component of Framework
Knowledge Creation	• Personal tacit knowledge • Collaborative tacit knowledge within project network • Tender/technical documentation • Tacit/explicit knowledge via external networks (informal/formal)	• Network • Network • Network • Overflow	• Project • Performance reporting • Progress • Project capability • Escalation • Resolution
Knowledge Capture	• Lessons learned (formal/ informal • Meeting minutes • Files • Project documentation	• Network/ overflow • Network • Network • Network	• Project • Performance reporting • Project methodology • Progress • Project capability • Escalation
Knowledge Transfer	• Collaborative tacit knowledge within project network • Project documentation – Explicit • Tacit/explicit knowledge via external networks (informal/formal)	• Network • Network • Overflow	• Project • Project templates • Project methodology • Resource allocation • Resolution
Knowledge Reuse	• Project review documentation • Earlier project documentation/ methodology/ templates • Personal experience • Subject matter experts – informal/formal	• Network – black box • Network – black box • Network/overflow • Overflow	• Project • Project templates • Resource allocation • Project capability • Resolution

at all of these points. Based on Beer's (1981) concept of sympathetic and parasympathetic flows where knowledge was created at the sympathetic flow it was reused in the parasympathetic flow (see Table 2).

Networks

Networks, based on the concept of ANT, play a crucial role in the creation, capture, transfer and reuse of knowledge. The project manager and senior project team members initially relied on personal knowledge and then "overflowed" into their informal external networks throughout the project when external expertise was required (Callon, 1998). Formal networks (e.g., as established in the corporate e-mail system) were only tapped into if the relevant knowledge could not be obtained from the other sources. In most cases as well as utilising tacit knowledge people utilised informal networks when seeking explicit knowledge, that is, black box documentation that was accepted and established of others (Callon & Latour, 1981). People interviewed said it was quicker to ask the person who knew where the relevant documentation was rather than searching for it on the server or in folders.

Knowledge Creation

While there is a reliance on personal knowledge, explicit knowledge and collaboration within the projects external networks play a crucial role in terms of knowledge creation. These networks tend to be the informal networks of project team members and "overflow" (Callon, 1998) into the network when external knowledge or expertise is required.

Build up relationships with people over a period of time. You work with them and find out who the specialists are in areas of the company. You talk to a specialist call that person and ask questions on how they have approached something a relationship is established. As you build personal relationships you know who to call.

Knowledge Capture

Knowledge capture predominantly occurs within the project team, both formally and informally, usually at regular review points during the methodology. Formal lessons learned are stored by project (each project is allocated a project number) on the network server, or in individual paper-based files. While this network server can be accessed by more than one office it does not allow for contextual searches. As a result there has tended to be a reliance on informal knowledge capture and reuse.

Knowledge Reuse

Knowledge is embedded and reused throughout the model. Knowledge is informally reused or re-created from one project to another as the culture and system is not in place to formalise it. Several project team members have worked with the organisation for a number of years, and given the length of time that they have been with the organisation they have created informal networks (usually people that they have worked with on previous projects).

The project team manager and senior project team members initially relied on personal knowledge and then their informal networks. Formal networks (e.g., as established in the corporate e-mail system) were only tapped into if the relevant knowledge could not be obtained from the other sources. In most cases, as well as utilising tacit knowledge people sought out explicit knowledge, that is, people interviewed said it was quicker to ask the person who knew where the relevant documentation was rather than searching for it on the server or in folders.

At the more senior levels of the organisation formal networks (across the distributed enterprise) also played a crucial role. In addition there was one exception where one team member relied predominantly on informal knowledge transfer but also documented everything so that if he was not in the organisation any longer another person could access the information, the only issue is that as everything (including all e-mails) were stored in hardcopy it would be difficult to find the most appropriate knowledge.

During project implementation a key reason that knowledge is reused, from documented lessons learned (explicit knowledge) and informal lessons learned (obtained from informal networks), is to deliver a solution where any potential pitfalls are known in advance allowing them to be overcome.

You remember the projects you've worked on the most, so you are more inclined towards them. But a lot of the time you pick up cost estimates and specifications and use information from projects other people have worked on, particularly if you are running a project which is not like what you've done before. You ask around to find out who has the knowledge for that type of project and perhaps use their assistance.

The knowledge derived from the formal lessons learned can form content for a knowledge-management system. An immature knowledge management system had been implemented within the case study site, however as project documentation was stored on a network server, a key question for the future is as the

knowledge management system is utilized within the organisation will there still be the same reliance on informal lessons learned or will people start to rely on formal lessons learned that are stored in the system.

Knowledge Transfer

Knowledge is transferred from the project level to business unit and organisational levels contributing to the creation of organizational memory. Mentoring played a key role in knowledge transfer from the project director to the project manager at regular reviews/meetings throughout the project. In addition as part of the development of more junior project managers and in recognition that a lot of experience and knowledge was held by more senior people one business unit developed a system whereby a senior staff member of retirement age mentored and transferred knowledge to more junior project managers.

CONCLUSION

This paper has established a theoretical framework for knowledge reuse based on a review of relevant literature. The literature is mainly concerned with how knowledge is integrated at both the programme and project level. Networks (both human and nonhuman) play a key role in knowledge creation, reuse, and transfer.

At both the project and programme level knowledge plays a crucial role in delivering successful projects and programmes of work. The paper builds on Burstein and Linger's (2003) concept of task based management where the project is the task and knowledge is created as a result of project team members completing a task within the project team environment. The model shows that in order for an organisation to deliver successful projects, develop its project management maturity, and improve its capability continuous learning needs to occur.

This research is grounded by the principles of task based management where knowledge is created in a project by the project team member or project team completing the task. This article contributes to the overall body of knowledge by exploring the contribution of learning and knowledge to a project organisation's development in terms of capability. The framework will also make a substantial practical contribution in terms of developing guidelines for creating, sharing, and reusing knowledge in a project management environment.

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REFERENCES

Argyris, C. & Schon, D. A. (1978). *Organizational learning: A theory of action perspective*. Addison Wesley Publishing Company.

Beer, S. (1981). *Brain of the firm*. Chichester, New York, Brisbane, Toronto: John Wiley & Sons.

Blackburn, S. (2002). The project manager and the project-network. *International Journal of Project Management, 20*(3), 199-204.

Burstein, F. & Linger, H. (2003). Supporting postfordist work practices: A knowledge management framework for supporting knowledge work. *Information Technology and People, 16*(3).

Callon, M. (1998). An essay on framing and overflowing: Economic externalities revisited by sociology. In M. Callon (Ed.), *The laws of the markets.* Oxford and Keele, Blackwell and the Sociological Review.

Callon, M. & Latour, B. (1981). Unscrewing the big Leviathan: How actors macrostructure reality and how sociologists help them to do so. In K. D. Knorr-Cetina & A. V. Cicourel (Eds.), *Advances in social theory and methodology: Toward an integration of micro and macro-sociologies*. Boston: Routledge.

Cleland, D. (1999). *Project management strategic design and implementation*. McGraw-Hill.

Cooper, K. G., Lyneis, J. M., & Bryant, B. J. (2002). Learning to learn from past to future. *International Journal of Project Management, 20*(3), 213-219.

Cross, R., Nohria, N., & Parker, A. (2002). Six myths about informal networks and how to overcome them. *Sloan Management Review, 43*(3), 67-75.

Damm, D. & Schindler, M. (2002). Security issues of a knowledge medium for distributed project work. *International Journal of Project Management, 20*(1), 37-47.

Dinsmore, P. C. (1999). *Winning in business with enterprise project management.* New York: AMA Publications.

Disterer, G.. (2002). Management of project knowledge and experiences. *Journal of Knowledge Management, 6*(5), 512-520.

Fiol, C. M. & Lyles, M. A. (1985). Organizational learning. *Academy of Management Review, 10*(4), 803-813

Hinge, A. (2000). *Australian defence preparedness: Principles, problems, and prospects.* Australian Defence Studies Centre Canberra ACT.

Kerzner, H. (2001a). *Strategic planning for project management using a project management maturity model*. New York: John Wiley and Sons.

Kerzner, H. (2001b). *Project management: A systems approach to planning, scheduling and controlling.* New York: John Wiley and Sons.

Kerzner, H. (2003). Strategic planning for a project office. *Project Management Journal, 34*(2), 13-25.

Kim, D. H. (1993). The link between individual and organizational learning. *MIT Sloan management Review, 35*(1).

Kotnour, T. (1999). A learning framework for project management. *Project Management Journal, 30*(2), 32-38.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society.* Cambridge, MA: Harvard University Press.

Latour B. (1993). *The pasteurisation of France.* Cambridge, MA: Harvard University Press.

Latour, B. (1999a). *Pandora's hope: Essays on the reality of science studies.* Cambridge, MA: Harvard University Press.

Latour B. (1999b). On recalling ANT. In J. Law & J. Hassard (Eds.), *Actor network theory and after* (pp. 15-25). Oxford: Blackwell.

Law, J. & Hassard, J. (Eds.). (1999). *Actor network theory and after.* Oxford and Keele: Blackwell and the Sociological Review.

Lycett, M., Rassau, A., & Danson, J. (2004). Programme management: A critical review. *International Journal of Project Management, 22*, 289-299

McElroy, M. (2003) *The new knowledge management.* Butterworth-Heinemann

McLoughlin, I. P., Alderman, N., Ivory, C. J., Thwaites, A., & Vaughan, R. (2000). Knowledge management in long term engineering projects. In *Proceedings of the Knowledge Management: Controversies and Causes Conference.* Retrieved May 19, 2003 from, http://bprc.warwick.ac.uk/km065.pdf

Marshall, C. & Rossman, G. B. (1995). *Designing qualitative research* (2nd ed.). London: Sage Publications.

Morris, P. W. G. (revised 2003). *The validity of knowledge in project management and the challenge of learning and competency development.* Retrieved May 23, 2005, from http://www.bartlett.ucl.ac.uk/research/management/Validityofknowledge.pdf

Nahapiet, J. & Ghosal, S. (1998) Social capital, intellectual capital, and the organizational advantage. *Academy of Management. The Academy of Management Review, 23*(2), 242-266.

Nelson, R. R. & Winter, S. G. (1982). *An evolutionary theory of economic change.* Cambridge, MA: Belknap Press of Harvard University Press.

Nevis, E. C., DiBella, A. J., & Gould, J. M. (1995). Understanding organizations as learning systems. *MIT Sloan Management Review, 36*(2).

Owen, J. (2004, November). *Developing program management capabilities: A knowledge management perspective.* Paper presented at the 7th Australian Conference on Knowledge Management and Intelligent Decision Support (ACKMIDS 2004).

Owen, J., Burstein, F., Linger, H., & Mitchell, S. (2005, January). *Managing project knowledge: The contribution of lessons learned.* Paper presented at IPSI-2005, Hawaii.

Owen, J., Burstein, F., & Mitchell, S. (2005). Knowledge reuse and transfer in a project management environment [Special issue]. *Journal of Information Technology Cases and Applications (JITCA), 6*(4).

Parkin, J. (1996). Organizational decision making and the project manager. *International Journal of Project Management, 14*(5).

Project Management Institute. (2000). *A guide to the project management body of knowledge.* Project Management Institute USA.

Project Management Institute. (2004). *A guide to the project management body of knowledge.* Project Management Institute USA

Sabherwal, R., Hirschheim, R., & Goles, T. (1998). The dynamics of alignment: A punctuated equilibrium model. *Organization Science, 12*(2), 17.

Scymczak, C. & Walker, D. H. T. (2003). Boeing — A case study example of enterprise management from a learning organisation perspective. *The Learning Organization, 10*(3), 125-137.

Snowden, D. (2002). Complex acts of knowing: Paradox and descriptive self awareness. *Journal of Knowledge Management, 6*(2), 100-111.

Thiry, M. (2002). Combining value and project management into an effective programme management model. *International Journal of Project Management, 20,* 221-227.

Thorp, J. (1998). *The information paradox, Realizing the business benefits of information technology.* Toronto: McGraw-Hill Ryeson.

Turner, J. R. (1999). *Handbook of project-based management: Improving the processes for achieving strategic objectives.* London: McGraw-Hill.

Walsh, J. P. & Ungson, J. R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

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Chapter 6.10
Alignment of Business and Knowledge Management Strategies

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INTRODUCTION

The role of knowledge as a crucial asset for an enterprise's survival and advancement has been recognized by several researchers (e.g., von Krogh, Ichijo & Nonaka, 2000). Moreover, by having knowledge (intellectual resources), an organization can understand how to exploit and develop its traditional resources better than its competitors can, even if some or all of those traditional resources are not unique (Zack, 1999).

However, realizing the importance of organizational knowledge and its management in creating value and in gaining competitive advantage is only the first and the easiest step in any knowledge management (KM) initiative. The second and almost as important step is to answer how and where to begin questioning (Earl, 2001). In fact, "many executives are struggling to articulate the relationship between their organization's competitive strategy and its intellectual resources and capabilities (knowledge)" (Zack, 1999). As Zack (1999) argued, they need pragmatic yet theoretically sound model. It has been highly accepted that a pragmatic and theoretically sound model should meet at least two criteria. First, it should explicitly include the external domains (opportunities/threat) and internal domains (capabilities/arrangements) of both business (B-) and knowledge (K-) strategies and the relationships between them. Second, it should provide alternative strategic choices.

In order address this issue a KM strategic alignment model (KMSAM) is presented. It stems from the premise that the realization of business value gained from KM investment requires alignment between the business (B-) and knowledge (K-) strategies of the firm and is based on the Henderson-Venkatraman SAM for IT (Henderson & Venkatraman, 1993).

Overview of the Henderson-Venkatraman Strategic Alignment Model

The KM strategic alignment model is based on the theoretical construct developed by Henderson and Venkatraman (1993). In their model business success is viewed as the result of the synergy between four domains. The first two, the external domains, are business strategy and information technology (IT) strategy. The strategy domains are described in terms of (business/technology) scope, (distinctive business/IT systemic) competencies and (business/IT) governance. The second two, the internal domains, are organizational infrastructure and processes and IT infrastructure and processes. Both internal domains are described in terms of (administrative/IT) infrastructure, (business/IT) processes and (business/IT) skills. This synergy is achieved through two types of relationship:

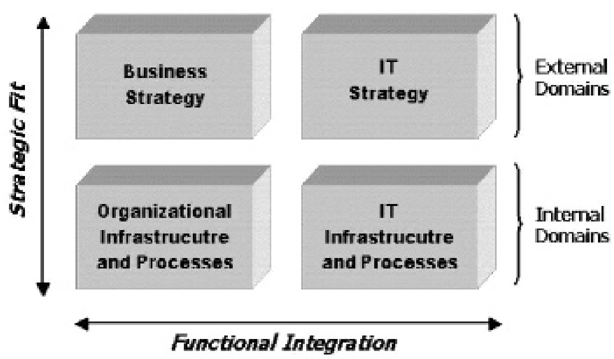
- Strategic fit emphasizes the need for consistency between strategy (external domain) and its implementation (internal domain).
- Functional integration, which has two modes, extends the strategic fit across functional domains. The first mode, strategic integration, deals with the capability of IT functionality both to shape and to support business strategy. The second mode, operation integration, focuses on the criticality of ensuring internal coherence between organizational infrastructure and processes and IT infrastructure and processes.

Figure 1 shows the elements of the IT strategic alignment model (ITSAM).

KM Strategic Alignment Model (KMSAM)

The premise of the original ITSAM is that ”the effective and efficient utilization of IT requires the alignment of IT strategies with business strategies” (Henderson & Venkatraman, 1993). In parallel way, the premise of KMSAM, in which knowledge strategy replaces IT strategy, is that “the effective and efficient use of organizational

Figure 1. IT strategic alignment model (Henderson & Venkatraman, 1993)



knowledge requires the alignment of knowledge strategies with business strategies". Since strategy, whether business (B)-strategy or knowledge (K)-strategy, can be seen as a balancing act between the external domain (opportunities/threats) and the internal domain (capabilities/arrangements) of the firm (strengths and weaknesses) (Henderson & Venkatraman, 1993; Zack, 1999), the external and internal domains of K strategy have first to be defined.

K-Strategy External Domain

In the case of K-strategy, the external domain involves three dimensions: K-scope (what the firm must know), K-systemic competencies (what are the critical characteristics of the required knowledge) and K-governance (how to obtain the required K-competencies). The first dimension, K-scope, deals with the specific domains of knowledge that are critical to the firm's survival and advancement strategies. Survival strategies aim at securing current enterprise profitability, while advancement strategies aim for future profitability (von Krogh et al., 2000).

Determining the K-scope can be achieved by constructing a business (B-) domain/ Knowledge (K-) thing matrix that documents the current and required state of organizational knowledge concerning some or all business domains. The first group of elements that constitute this matrix includes the list of B-domains (Bi). The second group of elements includes the K-things (Kj) that describe the current state of knowledge associated with each of the relevant B-domains. To relate this knowledge to enterprise business strategies, K-things are further classified according to the roles they play in such strategies. Von Krogh et al. (2000) have suggested that there are two types of strategies: survival and advancement. Survival strategies aim at securing current enterprise profitability, while advancement strategies aim for future profitability. Therefore, organizational knowledge, and consequently K-things, is classified into two categories: survival (KS) and advancement (KA). Figure (2) shows the generic form of this matrix.

The second dimension of the K-strategy external domain is K-systemic competencies. The focus of this dimension is the set of utilization-oriented characteristics of knowledge that could contribute positively to the creation of new business strategy or better support of existing business strategy. This set includes characteristics such as:

- Accessibility, the extent to which organizational knowledge is made available to its members regardless of time or location (Buckman, 1998);

Figure 2. Generic form of B-things/K-things matrix (Abou-Zeid, 2002)

Survival Knowledge				**Advancement Knowledge**		
B_1	K_{S11} (Current/ Required States)	….	K_{S1n} (Current/ Required States)	K_{A11} (Current/ Required States)	….	K_{A1m} (Current/ Required States)
B_2	K_{S21} (Current/ Required States)	….	K_{S2k} (Current/ Required States)	K_{A21} (Current/ Required States)	….	K_{A2l} (Current/Required States)
….	….	….	….	….	….	….
B_N	K_{SN1} (Current/ Required States)	….	K_{SNk} (Current/ Required States)	K_{AN1} (Current/ Required States)	….	K_{ANl} (Current/ Required States)

- Transferability, the extent to which the newly acquired knowledge can be applied in other contexts, for example organizational, cultural (Grant, 1996);
- Appropriability, the extent to which knowledge can be imitated. Things are said to have "strong" appropriability if they are difficult to reproduce by another organization. The converse is "weak" appropriability. A related concept is that of "sticky/slippery"; that is, sticky knowledge is such an integral part of a regime that it cannot be extracted in a meaningful whole (Grant, 1996; Narasimha, 2000);
- Depth and breadth (Narasimha, 2000);
- Compositionality, the amenability of knowledge to be synthesized from existing knowledge; and
- Integrateability, the extent to which the newly acquired knowledge can be integrated with existing knowledge.

Finally, K-governance dimension deals with the selection and use of mechanisms for obtaining the required K-competencies. The following are examples of some "acquisition mechanisms" (Probst, Raub & Romhardt, 2000):

- Bringing experts to the firm by recruiting specialists as full-time or temporary staff. Temporary hiring is becoming an increasingly interesting alternative.
- Tapping knowledge held by other firms through different inter-organizational co-operation forms such as joint ventures or strategic alliances.
- Utilizing the knowledge of stakeholders, for example, customers, suppliers, employees and owners. For example, involving customers early in the product-development process could generate valuable information about their needs.
- Acquiring knowledge products such as software, patents, and CD-ROMs.

K-Strategy Internal Domain

In the case of K-strategy, the internal domain involves three dimensions: knowledge (K)-processes, knowledge (K)-infrastructures, and knowledge (K)-skills.

Knowledge (K)-processes, the first dimension of the K-strategy internal domain, can be classified into two main categories: K-manipulating processes and K-enabling processes. The first category, K-manipulating processes, includes all the organizational processes needed to change the state of organizational knowledge such as K-generation, K-mobilization and K-application (Abou-Zeid, 2003). The second category, K-enabling processes, includes organizational processes that support K-manipulating processes such as managing conversation, mobilizing knowledge activists, creating the right context, and globalizing local knowledge (von Krogh et al., 2000).

Organizational knowledge processes are socially interaction-intensive. They involve social interactions and direct communication and contact among individuals and among members of "communities of practice". Therefore, they require the presence of social capital. Social capital is "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by a social unit" (Nahapier & Ghoshal, 1998). Recognizing the importance of social capital, Gold et al. (2001) have identified three key K-infrastructures, the second dimension of the K-strategy internal domain, that is, technical, structural and cultural, that enable social capital. The K-technical infrastructure includes IT-enabled technologies that support KM activities such as business intelligence, collaboration and distributed learning, K-discovery, K-mapping, opportunity generation and security. The K-structural infrastructure refers to the presence of enabling formal organization structures and the organization's system of rewards and incentives. Finally, the K-cultural infrastructure involves elements such as corporate vision and the organization's system of values (Gold et al., 2001).

The last dimension of the K-strategy internal domain is K-skills. KM processes are by their very nature multifaceted. They involve many dimensions such as technical, organizational and human. This characteristic of KM processes reflects on the nature of skills required to perform them. For example, Malhotra (1997) defines a senior knowledge executive, such as a chief knowledge officer (CKO) or an organizational knowledge architect, as the person who should have the combined capabilities of a business strategist, technology analyst, and a human resource professional. The ability to facilitate the ongoing process of knowledge sharing and knowledge renewal, the ability to develop the human and cultural infrastructure that facilitates information sharing, and the ability to utilize the available technologies for serving the creation, sharing and documentation of knowledge are some examples of the required skills.

The Dynamics of KM Strategic Alignment Model (KMSAM)

Effecting a change in any single domain may require the use of three out of the four domains to assure that both strategic fit and functional integration are properly addressed. Therefore, applying KMSAM requires the identification of three domains: pivot, anchor and impacted (Luftman, 1996). The pivot domain is the weakest and offers the greatest opportunity for improvement. The anchor domain is the strongest and will be the driver of change. Finally, the impacted domain is the area affected by a change to the pivot domain. Figure 3 shows the dynamics of the strategic alignment process.

Based on this distinction, different perspectives of strategic alignment can be identified. Each perspective represents a pattern of linkages between at least three elements of the four elements of KMSAM, that is, the two external domains (business strategy and knowledge strategy) and the two internal domains (organizational infrastructure and processes and knowledge infrastructure and processes). By identifying the strongest (anchor) domain and the adjacent weakest (pivot) domain, it becomes possible to identify the area that will be affected by the changes (the impacted domain). The direction the perspective flows is based on which domain is the strongest and which is the weakest.

For example, Figure 4 shows knowledge potential perspective in which business strategy, the strongest domain, derives changes to the adjacent

Figure 3. The dynamics of the strategic alignment process

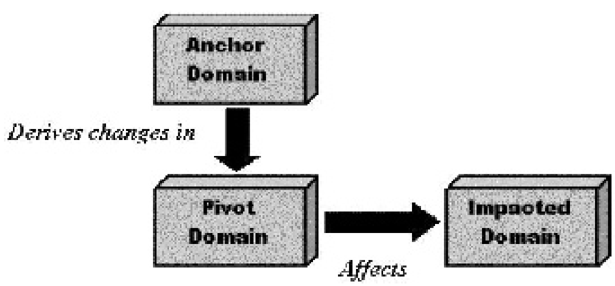


Figure 4. Knowledge potential perspective

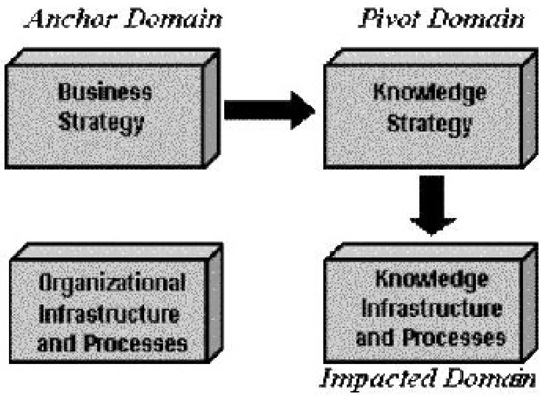
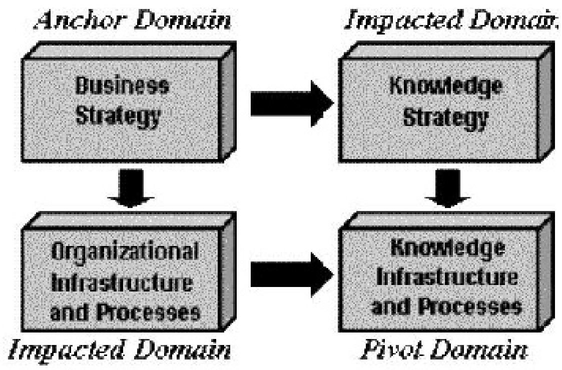


Figure 5. K-infrastructure fusion perspective



weakest domain, knowledge strategy, and these changes will impact knowledge infrastructure and processes. In general, each alignment perspective has to include two types of relationships. The first is between external and internal domains of its business and knowledge components, that is, strategic fit. The second is the functional integration between business and knowledge domains. Eight single-path alignment perspectives can be then identified, namely: from anchor domain to adjacent pivot domain to impacted domain.

When the pivot and the anchor domains are not adjacent to one another, but rather across from each other on the diagonal, there will be two possible "paths" from the anchor domain to the pivot domain. This yields four fusion perspectives that result from fusing two of the eight single-path perspectives (Luftman, 1996). For example, Figure 5 shows K-infrastructure fusion perspective in which business strategy derives changes to the K-infrastructure and processes domain through organizational infrastructure and processes, and K- strategy domains.

Table 1 summarizes the 12 alignment perspectives.

CONCLUSION

Based on the premise that the realization of business value from KM investments requires alignment between the business and knowledge strategies and on the IT strategic alignment model (SAM) developed by Henderson and Venkatraman (1993), a KM strategic alignment model (KMSAM) is developed. Moreover, it provides executives with a logical framework for analyzing and assessing alternative strategic choices with regard to aligning K-strategy and B-strategy.

Extension of this work would move in two directions. The first would be to use KMSAM in cross-sectional study of KM initiatives in order to identify the dominant patterns of K-strategy and B-strategy alignment. As "strategic alignment is not an event but a process of continuous adaptation and change" (Henderson & Venkatraman, 1993), the second direction would be a longitudinal study of each enterprise cycle around the alignment perspectives and how the adopted perspective is related to the degree of maturity of the KM initiative.

Table 1. KM strategic alignment perspectives

	Domain / Strategic Perspective	Anchor Domain	Pivot Domain	Impacted Domain
1	**Strategy Execution**	Business Strategy	Organizational Infrastructure and processes	K-Infrastructure and processes
2	**Knowledge Potential**	Business Strategy	K-Strategy	K-Infrastructure and processes
3	**Competitive Potential**	K-Strategy	Business Strategy	Organizational Infrastructure and processes
4	**Service Level**	K-Strategy	K-Infrastructure and processes	Organizational Infrastructure and processes
5	**K-/Organizational Infrastructure**	K-Infrastructure and processes	Organizational Infrastructure and processes	Business Strategy
6	**K-Infrastructure/ K-Strategy**	K-Infrastructure and processes	K-Strategy	Business Strategy
7	**Organizational/ K-Infrastructure**	Organizational Infrastructure and processes	K-Infrastructure	K-Strategy
8	**Organizational Infrastructure/ Business Strategy**	Organizational Infrastructure and processes	Business Strategy	K-Strategy
9	**K-Infrastructure Fusion** (Perspectives 4 + 7)	Business Strategy	K-Infrastructure and processes	• Organizational Infrastructure and processes • K-Strategy
10	**Organizational Infrastructure Fusion** (Perspectives 1 + 5)	K-Strategy	Organizational Infrastructure and processes	• Business Strategy • K-Infrastructure and processes
11	**Business Strategy Fusion** (Perspectives 3 + 8)	K-Infrastructure and processes	Business Strategy	• Organizational Infrastructure • K-Strategy
12	**K-Strategy Fusion** (Perspectives 2 + 6)	Organizational Infrastructure and processes	K-Strategy	• Business Strategy • K-Infrastructure and processes

REFERENCES

Abou-Zeid, E. (2002). A knowledge management reference model. *Journal of Knowledge Management, 6*(5), 486-499.

Abou-Zeid, E. (2003). Developing business aligned knowledge management strategy. In E. Coakes (Ed.), *Knowledge management: Current issues and challenges* (pp. 156-172). IRM Press.

Buckman, R. (1998). *Lions, tigers and bears: Following the road from command and control* *to knowledge sharing.* White Paper. http://www.knowledge-nurture.com/

Earl, M. (2001). Knowledge management strategies: Toward a taxonomies. *Journal of Management Information Systems, 18*(1), 215-233.

Gold, A., Malhotra, A., & Segars, A. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Grant, R. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(Winter Special Issue), 109-112.

Henderson, J., & Venkatraman, N. (1993). Strategic alignment: Leveraging information technology for transforming organization. *IBM Systems Journal, 32*(1), 4-16.

Luftman, J. (1996). Applying the strategic alignment model. In J. Luftman (Ed.), *Competing in the information age* (pp. 43-69). Oxford University Press.

Malhotra, Y. (1997). *Profile of the ideal knowledge manager/architect.* http://www.brint.com/wwwboard/messages/273.html

Nahapier, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*, 242-266.

Narasimha, S. (2000). Organizational knowledge, human resource management and sustained competitive advantage: Toward a framework. *CR*, *10*(1), 123-135.

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing knowledge: Building block for success.* John Wiley.

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation.* Oxford University Press.

Zack, M.H. (1999). Developing knowledge strategy. *California Management Review, 41*(3), 125-145.

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Chapter 6.11
Developing Business Aligned Knowledge Management Strategy

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ABSTRACT

With the growing awareness of the crucial role that knowledge can play in gaining competitive advantage, several issues with regard to knowledge management (KM) initiatives have challenged executives. The articulation of the relationship between an organization's competitive strategy and its knowledge strategy is the most eminent. This chapter addresses the issue of how to align knowledge strategy with enterprise business strategy. Based on the premise that the realization of business value from KM investments requires alignment between business and knowledge strategies, the issue is addressed by developing a strategic alignment model for KM. This model, which is based on the Henderson-Venkatraman strategic alignment model, includes the external domains (opportunities/threat) and internal domains (capabilities/arrangements) of both business (B-) and knowledge (K-) strategies and the relationships between them. Furthermore, it provides alternative strategic choices. The model is used to study a KM initiative at Buckman Laboratories.

INTRODUCTION

The role of knowledge as a crucial asset for an enterprise's survival and advancement has been recognized by several researchers (e.g., Von Krogh, Ichijo, Nonaka, 2000). Moreover, by having knowledge (intellectual resources), an organization can understand how to exploit and develop its traditional resources better than its competitors can, even if some or all of those traditional resources are not unique (Zack, 1999a).

However, realizing the importance of organizational knowledge and its management in creating value and in gaining competitive advantage is only the first and the easiest step in any knowledge management (KM) initiative. The second, and almost as important, step is to answer how and where to begin questioning (Earl, 2001). In fact "many executives are struggling to articulate the relationship between their organization's competitive strategy and its intellectual resources and capabilities (knowledge)" (Zack, 1999a). As Zack (1999a) argued, they need a pragmatic, yet theoretically sound, model. The required model has to meet at least two criteria. First, it must explicitly include the external domains (opportunities/threat) and internal domains (capabilities/arrangements) of both business (B-) and knowledge (K-) strategies and the relationships between them. Second, it must provide alternative strategic choices.

This chapter stems from the premise that the realization of business value gained from KM investment requires alignment between the business (B-) and knowledge (K-) strategies of the firm. Therefore, it addresses the aforementioned issues by developing a "strategic alignment model (SAM)" for KM initiatives. It is based on the Henderson-Venkatraman SAM for IT (Henderson & Venkatraman, 1993).

The remainder of this chapter is organized as follows: The Henderson-Venkatraman SAM for IT (ITSAM) is first presented. Next, the KM Strategic Alignment Model (KMSAM) is developed and used to study the KM initiative at Buckman Laboratories. The paper then concludes by discussing the implications of the proposed metamodel and future research.

OVERVIEW OF THE HENDERSON-VENKARTAMAN STRATEGIC ALIGNMENT MODEL

The strategic alignment model (SAM), the framework for this study, is based on the theoretical construct developed by Henderson and Venkatraman (1993). In this model, business success is viewed as the result of the synergy between four domains. The first two, the external domains, are business strategy and information technology (IT) strategy. The strategy domains are described in terms of (business/technology) scope, (distinctive business/IT systemic) competencies and (business/IT) governance. The second two, the internal domains, are organizational infrastructure and processes and IT infrastructure and processes. Both internal domains are described in terms of (administrative/IT) infrastructure, (business/IT) processes and (business/IT) skills. This synergy is achieved through two types of relationship:

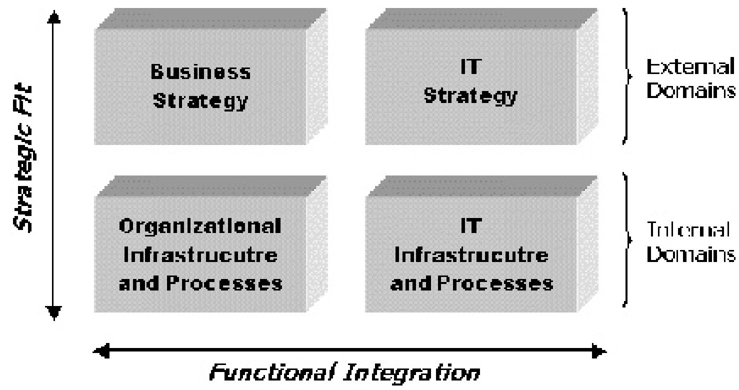
- Strategic fit emphasizes the need for consistency between strategy (external domain) and its implementation (internal domain).
- Functional integration, which has two modes, extends the strategic fit across functional domains. The first mode, strategic integration, deals with the capability of IT functionality both to shape and to support business strategy. The second mode, operation integration, focuses on the criticality of ensuring internal coherence between organizational infrastructure and processes and IT infrastructure and processes.

Figure (1) shows the elements of the IT Strategic Alignment Model (ITSAM).

KM Strategic Alignment Model

Whereas the premise of the original ITSAM is that, "the effective and efficient utilization of IT requires the alignment of IT strategies with business strategies" (Henderson & Venkatraman, 1993), the premise of knowledge management SAM (KMSAM), in which knowledge strategy replaces IT strategy, is that, "the effective and efficient use of organizational knowledge requires the alignment of knowledge strategies with business

Figure 1. IT strategic alignment model (Henderson & Venkatraman, 1993)



strategies." Since strategy, whether business (B)-strategy or knowledge (K)-strategy, can be seen as a balancing act between the external domain (opportunities/threats) and the internal domain (capabilities/arrangements) of the firm (strengths and weaknesses) (Henderson & Venkatraman, 1993; Zack, 1999a), the external and internal domains of K-strategy first have to be defined.

K-Strategy External Domain

In the case of K-strategy, the external domain involves three dimensions: K-Scope (what the firm must know), K-Systemic Competencies (what are the critical characteristics of the required knowledge) and K-Governance (how to obtain the required K-competencies). The first dimension, K-Scope, deals with the specific domains of knowledge that are critical to the firm's survival and advancement strategies. Survival strategies aim at securing current enterprise profitability, while advancement strategies aim for future profitability (Von Krogh et al., 2000).

In order to identify the required knowledge, two concepts are introduced. First, is the concept of the enterprise's cognitive domain, which is composed of all relevant things, together with the set of possible relationships between them, toward which thought or action is directed or is communicated by the members of the enterprise, i.e., business (B-) things. Examples of B-things include: business outcomes, business processes, resources, business rules (Davenport, Sbort, 1990; Eriksson, Penker, 2000; McDavid, 1999), consumer, supplier, competitors, and partners (e.g., distributors, vendors, banks, …).

Second, is the concept of knowledge (K-) thing. A K-thing describes the knowledge about the knowledge associated with a B-thing, i.e., the meta-knowledge. Each B-thing in the enterprise's cognitive domain is associated with certain knowledge that is needed to deal with it or to act upon it (Grant, Baden-Fuller, 1995). For example, STEP (The Standard for the Exchange of Product Model Data) data architecture recognized three categories of knowledge to be associated with a product, i.e., classification, marketing and technical (Fowler, Boyle, 1997). Classification knowledge is concerned with how the product is classified or categorized. Marketing knowledge is concerned with how the product is presented to the market. Finally, technical knowledge is the technical description of the product for the purpose of design, engineering, manufacturing, operations, maintenance, etc. This knowledge is characterized in terms of one or more knowledge thing (K-thing). Such a distinction between B-things and K-things is important, since the knowledge associated with a B-thing is in constant change and is context-dependent. For example, the knowledge required to manufacture certain product may change because of the introduction of new technology or the emergence of new marketing demands. Table (1) shows examples of a K-thing's attributes that characterize the knowledge associated with a B-thing.

Based on the concepts of B-thing and K-thing, determining the K-scope can be achieved by constructing a B-things/K-things matrix that documents the current and required state of organizational knowledge concerning some or all of the constituents of the enterprise cognitive domain. The first group of elements that constitute this matrix includes the list of B-things in the enterprise cognitive domain. The second group of elements includes the K-things that describe the current state of knowledge associated with each of the relevant B-things. To relate this knowledge to enterprise business strategies, K-things are further classified according to the roles they play in such strategies. Von Krogh et al. (2000) have suggested that there are two types of strategies: survival and advancement. Survival strategies aim at securing current enterprise profitability, while advancement strategies aim for future profitability. Therefore, organizational knowledge, and consequently K-things, are classified into two categories: survival (KS) and advancement (KA). Figure (2) shows the generic form of this matrix.

The second dimension of the K-strategy external domain is K-systemic competencies. The focus of this dimension is the set of utilization-oriented characteristics of knowledge that could contribute positively to the creation of new business strategy or to better support of existing business strategy. This set includes characteristics such as:

- Accessibility, the extent to which organizational knowledge is made available to

Table 1. Examples of the attributes of a k-thing

Attribute	Description
Actualization	The list of products, services, or processes in which the available or the required knowledge is/will be used.
Convertibility	The ability and the feasibility of converting knowledge from one form to another.
Compositionality	The amenability of knowledge to be synthesized from existing knowledge.
Currency	The recentness of knowledge.
Form	The form of the available/required knowledge: tacit, explicit.
Mode of Generation	The way by which the new knowledge is generated, i.e., acquisition, externalization, discovery, synthesis, creation.
Mode of Mobilization	The way in which the organizational knowledge, whether explicit or tacit, is distributed or shared.
Mode of Preservation	The way in which the organizational knowledge, whether explicit or tacit, is preserved.
Ownership	The bearers or the sources of available or required knowledge.
Value	The business value of actualized knowledge.
Visibility	The list of individuals and collectives who can access the knowledge.

Figure 2. The generic form of b-things/k-things matrix (Abou-Zeid, 2002)

Survival Knowledge				**Advancement Knowledge**		
B_1	K_{S11} (Current/Required States)	….	K_{S1n} (Current/ Required States)	K_{A11} (Current/Required States)	….	K_{A1m} (Current/Required States)
B_2	K_{S21} (Current/Required States)	….	K_{S2k} (Current/ Required States)	K_{A21} (Current/Required States)	….	K_{A2l} (Current/Required States)
….	….	….	….	….	….	….
B_N	K_{SN1} (Current/ Required States)	….	K_{SNk} (Current/ Required States)	K_{AN1} (Current/ Required States)	….	K_{ANl} (Current/Required States)

its members, regardless of time or location (Buckman, 1998);

- Transferability, the extent to which the newly acquired knowledge can be applied in other contexts, e.g., organizational, cultural (Grant, 1996);
- Appropriability, the extent to which knowledge can be imitated. Things are said to have "strong" appropriability if they are difficult to reproduce by another organization. The converse is "weak" appropriability. A related concept is that of "sticky/slippery", i.e., sticky knowledge is such an integral part of a regime that it cannot be extracted in a meaningful whole (Grant, 1996; Narasimha, 2000);
- Depth and breadth (Narasimha, 2000);
- Compositionality, the amenability of knowledge to be synthesized from existing knowledge; and
- Integrateability, the extent to which the newly acquired knowledge can be integrated with existing knowledge.

Finally, the K-governance dimension deals with the selection and use of mechanisms for obtaining the required K-competencies. The following are examples of some "acquisition mechanisms" (Probst, Raub, Romhardt, 2000):

- Bringing experts to the firm by recruiting specialists as full-time or temporary staff. Temporary hiring is becoming an increasingly interesting alternative.
- Tapping knowledge held by other firms through different inter-organizational co-operation forms, such as joint ventures or strategic alliances.
- Utilizing the knowledge of stakeholders, e.g., customers, suppliers, employees and owners. For example, involving customers early in the product-development process could generate valuable information about their needs.
- Acquiring knowledge products, such as software, patents, and CD-ROMs.

K-Strategy Internal Domain

In the case of K-strategy, the internal domain involves three dimensions: Knowledge (K)-infrastructures, Knowledge (K)-processes and Knowledge (K)-skills. Organizational knowledge processes are socially interaction-intensive. They involve social interactions and direct communication and contact among individuals and among members of "communities of practice." Therefore, they require the presence of social capital. Social capital is "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships possessed by a social unit" (Nahapier, Ghoshal, 1998). Recognizing the importance of social capital, Gold et al. (2001) have identified three key K-infrastructures, i.e., technical, structural and cultural, that enable social capital. The K-technical infrastructure includes IT-enabled technologies that support KM activities, such as business intelligence, collaboration and distributed learning, K-discovery, K-mapping, opportunity generation and security. The K-structural infrastructure refers to the presence of enabling formal organization structures and the organization's system of rewards and incentives. Finally, the K-cultural infrastructure involves elements, such as corporate vision and the organization's system of values (Gold et al., 2001).

The second dimension of the K-strategy internal domain, Knowledge (K)-processes, deals with the processes that change the states of K-things. While things in the cognitive domains of the enterprise (B-things) are relatively stable, the associated K-things are in a state of continual change. For example, during its life cycle K-things can exist in different states that correspond to the states of the knowledge associated with B-things. The life cycle of a K-thing starts with the "Being identified" state. This state occurs whenever the necessity of having certain knowledge relevant to a B-thing becomes obvious, and the form of the required knowledge, together with its owner/bearer, is identified. After being identified the K-thing may have many states, such as "Being created," "Being acquired," "Being discovered," "Being synthesized," "Being externalized," "Being preserved," "Being actualized," "Being justified," "Being updated," "To be evaluated," "Being evaluated," "Being mobilized," and "Being visible." Some of these states are composite; for example, the state "Being justified" contains nested states such as "Being conceptually justified" and "Being commercially justified" (Abou-Zeid, 2002). The state transitions of a K-thing are caused by performing one or more K-manipulating processes. Based on the literature review (e.g., Firestone, 1999; Nissen, Kamel, Sengupta, 2000; Nonaka, 1994; Probst et al., 2000; Zack, 1999b) and on analysis of several KM initiatives (e.g., Davenport, 1998; Elliott, 1997, 1998), K-manipulation processes can be classified into three main categories, i.e., K-generation, K-mobilization and K-application.

K-Generation Processes

The knowledge generation process includes all activities by which new knowledge is generated within the organization. There are several types of knowledge generation, namely:

- Acquisition, where the new knowledge is acquired from external sources;
- Externalization, where the convertible tacit knowledge of the members of the organization is conceptualized and articulated;
- Discovery, where the knowledge hidden in the data sources of the organization (e.g., databases, data warehouses) is discovered (O'Leary, 1998);
- Synthesis, where the new knowledge is generated either by integrating the newly generated and validated knowledge with the existing knowledge or by combing the existing knowledge;
- Production (creation), where the new knowledge is produced by interacting with the things in the cognitive domains of the enterprise (Cook, Brown, 1999).

K-Mobilization Processes

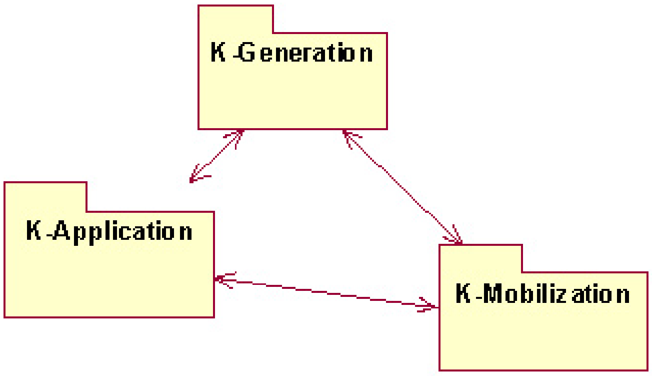
Knowledge mobilization means increasing the visibility of knowledge by sharing it or transferring it from one bearer (the knowledge provider, owner or source) to another (the knowledge seeker or target) through space or time. The knowledge bearer could be an artifact, such as technical documents or best practice databases, or human, such as experts in a certain domain. Based on the nature of the provider/source and seeker/target, four K-mobilization types can be distinguished, i.e., human-human, human-artifact, artifact-human and artifact-artifact.

- Human-human: Mobilizing knowledge among individuals depends on its form. In the case of tacit knowledge, this mode can be realized through activities such as socialization, which results in the creation of common perspectives and shared experience (Nonaka, 1994) or informal and semi-formal learning, e.g., mentorship and apprenticeship. In the case of explicit knowledge, it can be realized through activities such as formal learning, i.e., professional training. Moreover, through these activities individual knowledge will be preserved by extending its ownership range.
- Human-artifact: Two processes are needed in order to transfer the explicit knowledge and store it in physical media, i.e., knowledge (K-) refinement and knowledge (K-) preservation processes. K-refinement process consists of all the knowledge activities intended to refine existing or newly generated explicit knowledge, e.g., testing, labeling, indexing, abstracting, restructuring, and to maintain (update) the existing explicit knowledge (Zack, 1999b). The refined knowledge is then preserved. The K-preservation process includes activities, such as formalizing, codifying, organizing, and storing in different media.
- Artifact-human: This type of K-mobilization includes the processes that aim at increasing the visibility of the preserved explicit knowledge that is stored in physical media, i.e., K-delivery and K-presentation. An example of such processes is K-delivery process, which includes activities such as pushing/pulling, searching/retrieving. However, as knowledge and knowledge use are context-dependent, whether this context is related to the individual user or to the business process in which it will be used, the effective use/re-use of knowledge depends upon the degree to which the presented knowledge matches its context-of-use. From this perspective, the K-presentation process aims to develop the capabilities for presenting explicit knowledge "with sufficient flexibility to render it meaningful and applicable across multiple contexts of use" (Zack, 1999b).
- Artifact-artifact: The main purpose of the processes of this type of K-mobilization is to develop and implement machine-processable representations of the semantics of the preserved knowledge. For example, the Resource Description Framework (RDF) specifications provide a lightweight ontology system to support the exchange of knowledge on the Web. It provides interoperability between applications that exchange machine-understandable information on the Web (Harmelen, Fensel, 1999; W3C, 1999).

K-Application Processes

During K-application processes, knowledge is embodied in various forms. Knowledge can be used to develop new product/service/business processes or to improve existing ones. Associated with the processes of K-application are the processes of K-evaluation, which includes all the activities that aim at justifying and measuring the business value of the knowledge. Von Krogh et al. (2000) have identified three types of knowledge justification. The first type, strategic justification, includes justifying the newly generated knowledge against the advancement and survival strategies of the company. The second type, stakeholders' justification, focuses on evaluating the stakeholders' attitudes towards the newly generated knowledge. The final type, emotional justification, concerns the aesthetic value of the newly generated knowl-

Figure 3. K-manipulating processes



edge (Von Krogh et al., 2000). The K-evaluation process may initiate a K-identification process, which includes all the activities that develop the awareness of the need to create new K-things or to update existing ones. It also includes activities that determine the form, the convertibility, and the owner(s) of the required knowledge. The following are examples of such activities:

- Determining the knowledge gap by comparing knowledge needs with the existing knowledge.
- Identifying the form and convertibility of the required knowledge.
- Identifying the possible internal and external sources of the required knowledge.

Figure (3) shows the cyclical nature of K-manipulating processes.

However, knowledge processes are characterized by their dual nature. On the one hand, there are K-manipulating processes, i.e., processes such as acquiring knowledge, converting it into a useful form, applying it, and protecting it. On the other hand, it has been identified that cultural and organizational issues are crucial in the successful deployment of KMS (Alavi, Leider, 1999; Von Krogh et al., 2000). Therefore, each K-manipulating process should be associated with one or more K-enabling process. The following are examples of K-enabling processes (Von Krogh et al., 2000):

Managing Conversation

This process includes setting the guiding principles for holding fruitful conversations with respect to encouraging active participation, establishing conversational etiquette, editing, and fostering innovative language.

Mobilizing Knowledge Activists

The principal activities of this process consist of triggering K-manipulating activities throughout the different parts of an enterprise, coordinating them, and providing overall directions for them. These activities are performed by the "knowledge activist," which could be an individual, group or function.

Creating the Right Context

As K-manipulating activities are crucially dependent on social interactions among the organizational members, this process aims at setting "shared spaces" - physical, cyber, and mental - that enhance existing interactions and foster new ones. This involves creating the organizational structures that foster solid and effective collaboration.

Globalizing Local Knowledge

This process aims at supporting the creative approach to knowledge mobilization. Since knowledge is context-sensitive, it cannot be treated as a "commodity" that can be packaged and shipped to another location, within or outside the organization, to be readily re-used. Rather, to be effective, it must be reshaped by local experience and expectations, and justified by local values. In other words, it must be re-created.

Table (2) is an extension of the von Krogh et al. (2000) knowledge enabling grid. It shows the links between K-manipulating processes and K-enabling processes, and to what degree each K-enabling process affects the related K-manipulating process.

The last dimension of the K-strategy internal domain is K-skills. KM processes are by their very nature multifaceted. They involve many dimensions, such as technical, organizational

Table 2. K-manipulating processes and the associated k-enabling processes

	K-Enabling Processes				
K-Manipulating Processes	**Instilling K-Vision**	**Managing Conversation**	**Mobilizing Knowledge Activists**	**Creating the Right Context**	**Globalizing Local Knowledge**
K-Generation					
K-Acquisition	✓				
K-Externalization	✓	✓✓	✓	✓	
K-Discovery	✓				
K-Synthesis	✓	✓✓	✓	✓	
K-Production (creation)	✓	✓✓	✓	✓	
K-Mobilization					
K-Human-human		✓✓	✓	✓✓	
K-Preservation (K-Human-artifact Mobilization)	✓			✓	
K-Presentation (K-Artifact-human Mobilization)	✓	✓		✓	
K-Artifact-artifact Mobilization	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**
K-Application					
K-Utilization				✓	✓✓
K-Evaluation	✓✓	✓✓	✓		
K-Identification	✓✓				

and human. This characteristic of KM processes reflects on the nature of skills required to perform them. For example, Malhotra (1997) defines a senior Knowledge Executive, such as a Chief Knowledge Officer (CKO) or an Organizational Knowledge Architect, as the person who should have the combined capabilities of a business strategist, technology analyst, and a human resource professional. The ability to facilitate the ongoing process of knowledge sharing and knowledge renewal, the ability to develop the human and cultural infrastructure that facilitates information sharing, and the ability to utilize the available technologies for serving the creation, sharing and documentation of knowledge are some examples of the required skills.

The Dynamics of KMSAM

Affecting a change in any single domain requires the use of three out of the four domains to assure that both strategic fit and functional integration are properly addressed. Therefore, applying KMSAM requires the identification of three domains: pivot, anchor and impacted (Luftman, 1996). The pivot domain is the weakest and offers the greatest opportunity for improvement. The anchor domain is the strongest and will be the driver of change. Finally, the impacted domain is the area affected by a change to the pivot domain. Figure (4) shows the dynamics of the strategic alignment process. Based on this distinction, 12 perspectives of strategic alignment can be identified (see Table (3)). Among the 12 perspectives, the last four are fusion perspectives that result from fusing two of the eight single-path perspectives. In the fusion perspectives, the pivot domain is not directly adjacent to the anchor domain (Luftman, 1996).

KMSAM AT BUCKMAN LABORATORIES

In order to illustrate its interpretive power, KMSAM it will be used to study one of the KM initiatives at Buckman Laboratories (Buckman, 1998; Fulmer, 1999; Pan, Scarbrough, 1999; Rifkin, 1996). The first KM initiative, global knowledge sharing, was introduced when Robert Buckman, who became the new chairman and CEO in 1978, was convinced that the company was too "product driven" and not sufficiently

Figure 4. The dynamics of the strategic alignment process

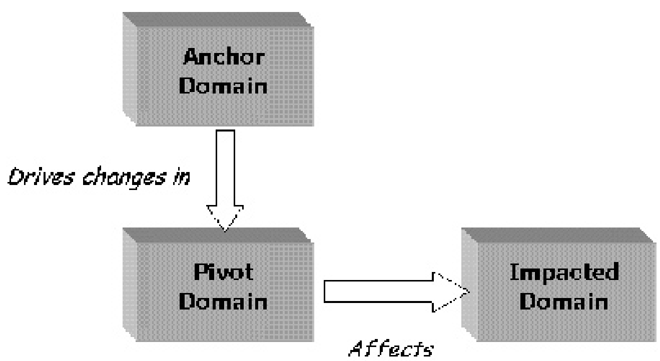
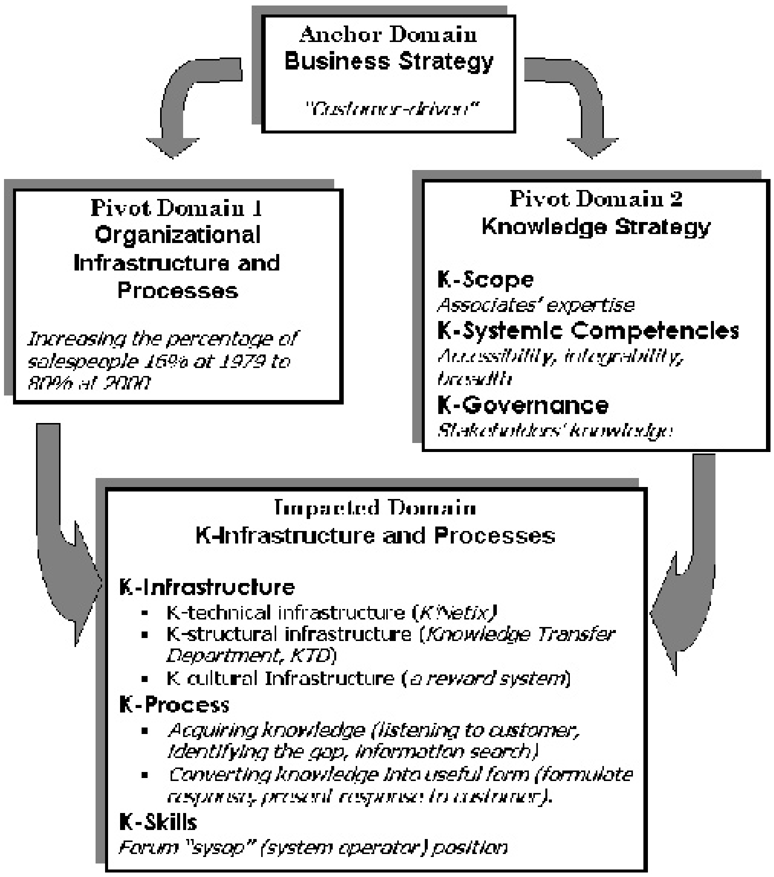


Table 3. KM strategic alignment perspectives

	Domain / Strategic Perspective	Anchor Domain	Pivot Domain	Impacted Domain
1	**Strategy Execution**	Business Strategy	Organizational Infrastructure	K-Infrastructure
2	**Technology Potential**	Business Strategy	K Strategy	K-Infrastructure
3	**Competitive Potential**	K-Strategy	Business Strategy	Organizational Infrastructure
4	**Service Level**	K-Strategy	K-Infrastructure	Organizational Infrastructure
5	**K-/Organizational Infrastructure**	K-Infrastructure	Organizational Infrastructure	Business Strategy
6	**K-Infrastructure/ K-Strategy**	K-Infrastructure	K-Strategy	Business Strategy
7	**Organizational/ K-Infrastructure**	Organizational Infrastructure	K-Infrastructure	K-Strategy
8	**Organizational Infrastructure/ Business Strategy**	Organizational Infrastructure	Business Strategy	K-Strategy
9	**K-Infrastructure Fusion** (Perspectives 1 + 2)	Business Strategy	• Organizational Infrastructure • K- Strategy	K-Infrastructure
10	**Organizational Infrastructure Fusion** (Perspectives 3+ 4)	K-Strategy	• Business Strategy • K-Infrastructure	Organizational Infrastructure
11	**Business Strategy Fusion** (Perspectives 5+ 6)	K-Infrastructure	• Organizational Infrastructure • K- Strategy	Business Strategy
12	**K-Strategy Fusion** (Perspectives 7+ 8)	Organizational Infrastructure	• Business Strategy • K-Infrastructure	K-Strategy

"customer driven." This shift reflected Buckman's belief that "cash flow is generated on the front line with customers, by associates…who have built relationships of continuity and trust, face-to-face with the customer" (Fulmer, 1999). To realize such a strategic shift, the percentage of salespeople, i.e., those employees "effectively engaged with the customer," was increased from 16% in 1979 to 80% by 2000 (Rifkin, 1996). Moreover, salespeople must provide fast and correct answers to customers by deploying the company's tacit knowledge, carried in the heads of the company's associates, at the points of sale. The new K-strategy that emerged from this strategic business shift was characterized by its emphasis on associates' expertise (K-scope), accessibility, integrateability and breadth of knowledge - "replace the depth of knowledge offered in a multi-tiered hierarchy with the breadth of knowledge that is the sum of the collective experience of employees" (Fulmer, 1999) - (K-systemic competencies) and "utilizing stakeholders' knowledge" as the main mechanism for acquiring knowledge (K-governance).

Figure 5. "K-infrastructure fusion" perspective at Buckman Laboratories



The implementation of this new K-strategy was accomplished by developing K-infrastructures, K-processes and K-skills. The first component of K-infrastructures, K-technical infrastructure, is K'Netix, a global corporate intranet consisting of e-mail, seven forums, files of company knowledge and databases of 'fluid' knowledge. K'Netix's forums are "open spaces" where anyone can post a message, question, and/or request for help. The second component, K-structural infrastructure, is the Knowledge Transfer Department (KTD) which is formed by merging three departments: IS, Telecommunication and Technical Information Center. The last component, K-cultural Infrastructure, includes a reward system, "the most powerful people are those who become a source of knowledge by sharing what they know" (Rifkin, 1996) and Buckman's Code of Ethics that "provides the basis for the respect and trust that are necessary in a knowledge sharing environment" (Fulmer, 1999). As both Buckman's B-strategy and K-strategy are customer driven, the K-sharing flow includes processes such as K-acquisition (listening to customer), K-externalization (formulating response), and K-presentation (presenting response to customer). Finally, the K-skills at Buckman Laboratories are exemplified by the forum "sysop" (system operator) position, which has been established to facilitate discussion, promote usage, track requests and make sure that they were fulfilled and to assist users.

From the previous discussion, one can identify the "K-infrastructure fusion" strategic alignment perspective adopted by Buckman Laboratories. In this perspective, B-strategy is the anchor domain that drives the change, K-strategy and organizational infrastructure are pivot domains and K-infrastructure and processes are the impacted domain. Figure (5) shows the "K-infrastructure fusion" perspective at Buckman Laboratories.

CONCLUSION

Based on the premise that the realization of business value from KM investments requires alignment between the business and knowledge strategies and on the IT strategic alignment model (SAM) developed by Henderson and Venkatraman (1993), a KM strategic alignment model (KMSAM) is developed. The interpretive power of KMSAM is illustrated by studying the KM initiative at Buckman Laboratories. Moreover, it provides executives with a logical framework for analyzing and assessing alternative strategic choices with regard to aligning K-strategy and B-strategy.

Extension of this work would move in two directions. The first would be to use KMSAM in a cross-sectional study of KM initiatives in order to identify the dominant patterns of K-strategy and B-strategy alignment. As "strategic alignment is not an event, but a process of continuous adaptation and change" (Henderson, Venkatraman, 1993), the second direction would be a longitudinal study of each enterprise cycle around the alignment perspectives and how the adopted perspective is related to the degree of maturity of the KM initiative.

REFERENCES

Abou-Zeid, E. (2002). A knowledge management reference model. *Journal of Knowledge Management, 6*(5), 486-499.

Alavi, M., & Leider, D. (1999). Knowledge management systems: Issues, challenges, and benefits. *Communication of the AIS, 1*(7).

Buckman, R. (1998). *Lions, tigers and bears: Following the road from command and control to knowledge sharing.* White Paper. Retrieved from http://www.knowledge-nurture.com/

Cook, S., & Brown, J. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational learning. *Organization Science, 10*(4), 381-400.

Davenport, T. H. (1998). *Teltech: The business of knowledge management case study.* Retrieved from http://www.bus.utexas.edu/kman/telcase.htm

Davenprot, T., & Sbort, J. (1990, Summer). The new industrial engineering: Information technology and business process redesign. *Sloan Management Review,* 11-27.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Elliott, S. (1997). Case corporation's pilot effort proves value of knowledge management. *Knowledge Management in Practice,* (10).

Elliott, S. (1998). Broderbund builds stong 'case' for internal, external knowledge sharing. *Knowledge Management in Practice,* (14).

Eriksson, H., & Penker, M. (2000). *Business modeling with UML*. John Wiley.

Firestone, J. (1999). *Enterprise knowledge management modeling and distributed knowledge management systems*. Retrieved from http://www.dkms.com/EKMDKMS.html

Fowler, J., & Boyle, A. (1997). *From product to product knowledge modelling in STEP*. Retrieved from http://www.pdtsolutions.co.uk/standard/papers/pdtag/paper.htm

Fulmer, W. (1999). *Harvard Business School case study on knowledge sharing at Buckman Laboratories* (N9-899-175).

Gold, A., Malhotra, A., & Segars, A. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Grant, R. (1996, Winter Special Issue). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17,* 109-112.

Grant, R., & Baden-Fuller, C. (1995). A knowledge-based theory of inter-firm collaboration. *Academy of Management Journal, Best Papers Proceedings,* 17-21.

Harmelen, F., & Fensel, D. (1999). *Practical knowledge representation for the Web.* Paper presented at the IJCAI-99 Workshop on Intelligent Information Integration, Held on July 31, 1999 in conjunction with the Sixteenth International Joint Conference on Artificial Intelligence, Stockholm, Sweden. Retrieved from http://citeseer.nj.nec.com/202021.html

Henderson, J., & Venkatraman, N. (1993). Strategic alignment: Leveraging information technology for transforming organizations. *IBM Systems Journal, 32*(1), 4-16.

Luftman, J. (1996). Applying the strategic alignment model. In J. Luftman (Ed.), *Competing in the information age* (pp. 43-69). Oxford University Press.

Malhotra, Y. (1997). *Profile of the ideal knowledge manager/architect*. Retrieved from http://www.brint.com/wwwboard/messages/273.html

McDavid, D. (1999). A standard for business architecture description. *IBM Systems Journal, 38*(1), 12-31.

Nahapier, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23,* 242-266.

Narasimha, S. (2000). Organizational knowledge, human resource management and sustained competitive advantage: Toward a framework. *CR, 10*(1), 123-135.

Nissen, M., Kamel, M., & Sengupta, K. (2000). Integrated analysis and design of knowledge systems and processes. In Y. Malhotra (Ed.), *Knowledge management and virtual organizations* (pp. 214-244). Hershey, PA: Idea Group Publishing.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

O'Leary, D. (1998). Knowledge management systems: Converting and connecting. *IEEE Intelligent Systems, 13*(3), 30-33.

Pan, S., & Scarbrough, H. (1999). Knowledge management in practice: An exploratory case study. *Technology Analysis & Strategic Management, 11*(3), 359-374.

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing knowledge: Building block for success*: John Wiley.

Rifkin, G. (1996). Buckman Labs is nothing but net. *FC,* (3), 118.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*. Oxford University Press.

W3C. (1999). *Resource description framework (RDF) model and syntax specification*. Retrieved from http://www.w3.org/TR/1999/REC-rdf-syntax-19990222/#intro

Zack, M. H. (1999a). Developing knowledge strategy. *California Management Review, 41*(3), 125-145.

Zack, M. H. (1999b). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 6.12
Competitive Advantage of Knowledge Management

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INTRODUCTION

Knowledge management has been proposed as a fundamental strategic process and the only sustainable competitive advantage for firms (Grant, 1996; Davenport, 1998). A key to understanding the success and failure of knowledge management efforts within organizations is the ability to identify the relevant knowledge to manage and to extract value out of this knowledge. In the last decade past research has focused heavily on defining what knowledge is and on using different typologies (e.g., tacit vs. explicit knowledge, individual vs. collective) to characterize the different types of knowledge available to firms (e.g., Polanyi, 1967; Spender, 1996). In addition, researchers have described the processes through which knowledge is created, developed, retained, and transferred in firms (e.g., Argote, 1999; Nonaka & Takeuchi, 1995), and the role played by leadership (Bryant, 2003; Vera & Crossan, 2004) and decision-making styles (Kalling, 2003) in influencing these processes. Unfortunately, despite the growing interest in knowledge management, little specific has been said about the mechanisms firms use to identify key knowledge areas and to gain competitive advantage out of knowledge management investments. The recognition of the important knowledge resources for a firm is critical, because the effectiveness of knowledge and learning can only be assessed on the basis of its utility in guiding behavior relative to the firm's relevant domain (Crossan, Lane, & White, 1999; Cepeda, Galán, & Leal, 2004; Zack, 1999). Knowledge for the sake of knowledge is not useful to firms.

We define knowledge management as the formalized, integrated approach of managing an enterprise's articulated and tacit knowledge assets. Knowledge assets include systems, documents, policies, and procedures, as well as unarticulated expertise and experience across the individuals, groups, organizational, and inter-organizational domains. We discuss how a knowledge management infrastructure enables the generation, acquisition, use, and transfer of knowledge, and most importantly, the identification of the critical knowledge areas for a firm. Moreover, we argue that competitive advantage consists of two dimensions: the value created to the customer and the ability to differentiate (through cost, innovation, or both) from competitors. The framework describes specific mechanisms through which knowledge management contributes to these two processes. Building on a resource-based view of the firm (Barney, 1991, 1995, 2001) and the knowledge management and organizational learning literatures (Grant, 1996; Hall, 1992, 1993; Spender, 1996), we develop a framework to address how critical knowledge areas can enable competitive advantage sources through customer approach and competitor approach.

This article integrates knowledge management and strategic management fields by taking a fine-grained look at the connection between knowledge resources and competitive advantage. We are explicit about how firms can identify key knowledge areas that impact competitive advantage, and how they can implement market (value creation) and competitor (differential capabilities) mechanisms that are instrumental in obtaining competitive advantage. Our integrative approach provides a fresh perspective on knowledge management from which we generate important insights for management practice. Only relevant and available knowledge impacts competitive advantage, thus top management needs to proactively engage in identifying this knowledge and extracting value out of it.

BACKGROUND

The relevance and importance of knowledge is becoming increasingly critical in business as we transition from an industrial era into an information and knowledge era.

With the arrival of the knowledge and information age as well as the service economy, the importance of effective knowledge and management has been emphasized by several scholars and industry analysts (Quinn, 1992; Toffler, 1990; Nonaka, 1991; Glazer, 1991; Leonard-Barton, 1992; Bohn, 1994; Klein & Prusak, 1994; Winslow & Bramer, 1994; Davis & Botkin, 1994; Peters, 1992). Drucker (1994) argues that the world is witnessing a great transformation, which he calls the "post-capitalist society," in which the basic economic resources will no longer be the traditional production input factors, but that the primary resource for both organizations and the economy will be knowledge.

Organizational knowledge management (KM) as a source of competitive advantage is now widely recognized (Nonaka, 1991; Bohn, 1994; Davis & Botkin, 1994). KM holds key implications for virtually all industries. Research indicates that knowledge and knowledge work has infiltrated deep into the value chain of most businesses (Quinn, 1992). Some of the reasons for this infiltration, such as product differentiation, creating "best in class" capabilities, and setting high entry barriers, provide important insights in the area of organizational knowledge and its impact on core business processes and functions. According to Quinn (1992) the majority of all public and private organizations are rapidly shifting to become repositories and coordinators of knowledge-based activities.

As we transition from an industrial/manufacturing economy to a more service-driven economy, we see the emergence of knowledge-intensive service organizations emerging alongside the more traditional capital-intensive and labor-intensive organizations (Bonora & Revang, 1993). Examples of knowledge-intensive service organizations include consulting, software engineering, law firms, and health care.

Actually, the challenge posed to contemporary businesses, particularly knowledge-intensive firms, is to remain competitive in a highly volatile and competitive knowledge environment in which markets quickly shift, technologies rapidly proliferate, competitors multiply, and products and services become obsolete almost overnight. Increasing customer needs and demands for immediate high value at low cost mandates the harnessing of knowledge coupled with the flexibility to meet changing needs. Achieving this goal in the information age requires the implementation of different strategies from those that were effective in the industrial age. For traditional organizations, it is no longer adequate to only achieve production and manufacturing efficiency. Knowledge-intensive firms, as well as traditional organizations, now increasingly compete because of knowledge and information. As a result, the issue of ownership and control of knowledge as a source of power in business has also become increasingly important. Both industry and academia are looking for approaches and methods to capture, organize, and leverage knowledge for increased competitiveness.

A set of publications (Stewart, 1994; Sveiby & Risling, 1987; Sveiby, 1990; Starbuck, 1990) indicates that several organizations are learning how to capture, manage, store, and leverage knowledge, and are making significant investments in KM. In this way, increasingly, firms are implementing KM, which is not surprising, since several types of firms, such as consulting and law firms, have the primary business of the application of their knowledge. Some authors include the idea of demonstrating accrued knowledge and experience in their area of service to customers, thereby retaining current customers and gaining new business by quickly delivering high-value solutions at low cost (faster, better, cheaper than their competitors). To leverage knowledge and intellectual capital in a more cost- and time-efficient manner, the firms develop employee competencies by sharing leading practices in their service areas, and capture and preserve knowledge that may be lost as a result of individuals leaving the firm.

A review of literature in the area of knowledge and information management reveals that many scholars have highlighted the importance of knowledge and information management.

MAIN FOCUS OF THE ARTICLE

An Organizing Framework Linking KM and Sustainable Competitive Advantage

Knowledge and Competitive Advantage

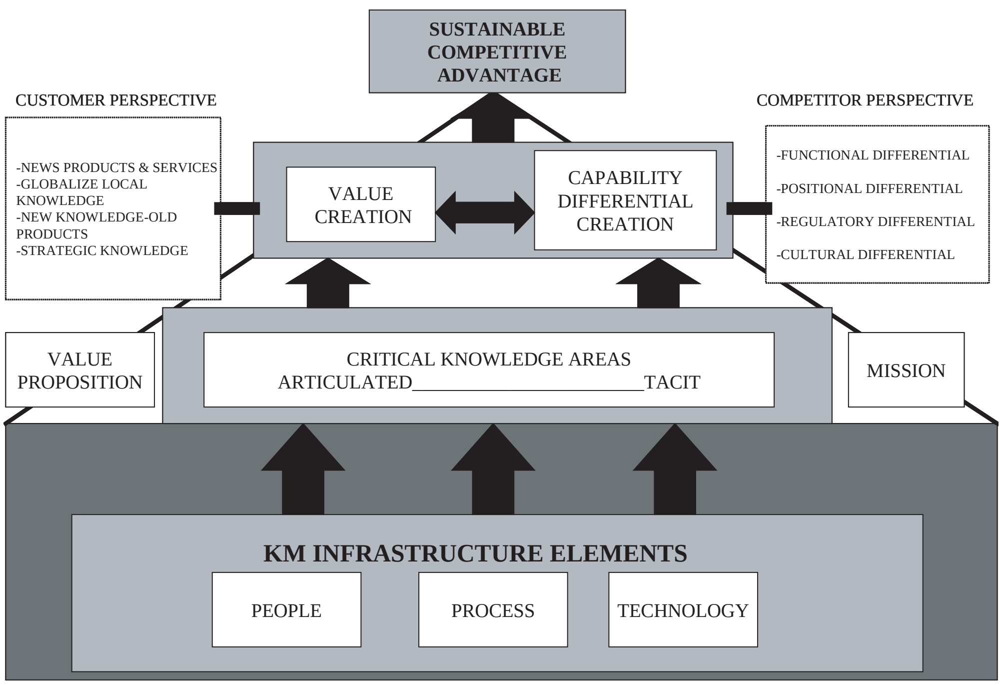
Knowledge activities in organizations have increased in significance over the past few years (Davenport & Klahr, 1998). In fact, knowledge has been proposed as the primary source of wealth creation (Cole, 1998), and knowledge protection has been suggested as critical to generate and preserve competitive advantage (Porter-Liebeskind, 1996). Davenport and Prusak (1998) also note that the only sustainable competitive advantage a firm has comes from what it collectively knows, how efficiently it uses what it knows, and how readily it acquires new knowledge.

Our conceptual development builds on the resource-based view (RBV) of the firm, an influential theoretical framework for understanding the creation and sustainability of competitive advantage (Barney, 1991; Nelson, 1991; Peteraf, 1993; Teece, Pisano, & Shuen, 1997). In this perspective, firms are conceptualized as bundles of resources. Resources are heterogeneously distributed across firms; resource differences might persist over time (Amit & Schoemaker, 1993). Resources are defined as all assets, capabilities, organizational processes, or firm attributes which are controlled by a firm, and which enable it to conceive of and implement strategies that improve its efficiency and effectiveness (Barney, 1991; Daft, 1983). When the resources are valuable, rare, inimitable, and non-substitutable (VRIS), firms can achieve sustainable competitive advantage by implementing strategies that leverage their resources in unique ways (Dierickx & Cool, 1989; Barney, 1991; Grant, 1996; Amit & Schoemaker, 1993).

One of the few resources that can pass the VRIS test is knowledge. Consequently, several authors have argued for a knowledge-based view (KBV) of the firm as a specialized case of RBV (Conner, 1991; Conner & Prahalad, 1996; Ghoshal & Moran, 1996; Grant, 1996b). KBV presents firms as social communities (Kogut & Zander, 1992) with the primary role of integrating the specialist knowledge resident in individuals into goods and services, so that organizational capabilities are the manifestation of this knowledge integration (Grant, 1996). Knowledge is embedded in multiple entities within the firm, such as the organizational culture, routines, policies, systems, and documents, as well as individuals and teams (Crossan et al., 1999; Nelson & Winter, 1982; Grant, 1996; Spender, 1996). Knowledge shapes the firm's core competences (Prahalad &Hamel, 1990) and therefore determines value creation (Grant, 1996). Furthermore, tacit knowledge, social knowledge, and complex knowledge are difficult to imitate (Leonard & Sensiper, 1998; Helfat & Raubitschek, 2000; McEvily & Chakravarthy, 2002). Hence, competences based on these types of knowledge cannot be easily duplicated by competitors, and strategies based on these competences are likely to lead to sustainable competitive advantage.

A contentious aspect of knowledge is its definitional domain. Researchers have engaged in a

Figure 1. Critical knowledge areas, value creation, capability differentials, sustainable competitive advantage, and infrastructure elements (people, process, technology)



passionate debate about what knowledge is and what forms or types of it are available (Collins, 1993; Drucker, 1994). Knowledge has been defined as information whose validity is established through test of proof (Porter-Liebskind, 1996), and as relevant and actionable information based at least partially on experience (Leonard & Sensiper, 1998). While the positivist view ("knowledge as justified true belief") is the predominant one in Western culture and a generally accepted assumption in organizational theory (Nonaka & Takeuchi, 1995), it has been increasingly complemented by authors arguing that knowledge cannot be conceived independently from action (Blackler, 1995; Cook & Brown, 1999; Polanyi, 1967). These views shift the notion of knowledge as a commodity that people acquire to the study of knowing as something that they do.

For the purpose of this article, we define knowledge as familiarity with or understanding of a phenomenon. Knowledge can be contained in subjects such as individuals, groups, and organizations, and in objects such as systems, products, and processes. We view knowledge as a higher form of information, which is elevated by the specific nature and purpose of the organization to provide an opportunity that the firm can exploit for its advantage (Beckett, Wainwright, & Bance, 2000). Hence, the challenge for many firms is to identify that knowledge, which is relevant to their goals and strategies.

Figure 1 shows interrelationships between knowledge management infrastructure, critical knowledge areas, and various elements leading to sustainable competitive advantage. These relationships between these elements ensure the leading and enhancing sustainable competitive advantage. In the next sections, we discuss the factors that influence the identification of critical knowledge areas and the mechanisms through which critical knowledge areas have an impact on competitive advantage.

Identifying Critical Knowledge Areas

Critical knowledge areas are specific bodies of knowledge or key resource capabilities that are unique to an enterprise and reside at the core of their business (Thompsen, Ibarra, & Center, 1997). Given that "the most important context for guiding knowledge management is the firm's strategy" (Zack, 1999, p. 125), every strategic position is linked to some set of intellectual resources and capabilities. In order to implement knowledge management processes (e.g., data analysis and information communication) that support a firm's strategy, managers need to consider several issues. First, they need to assess what the firm must do to compete and what the firm can actually do (strategic gap) (Zack, 1999). Second, they should establish what the firm must know to compete and what the firm actually knows (knowledge gap) (Zack, 1999). Third, organizations need to recognize what their knowledge management infrastructure needs to be and what it currently is. While the first two issues focus on linking knowledge management efforts to strategic goals, the third point acknowledges that knowledge is a path-dependent resource (Teece et al., 1997) and that future knowledge configurations will be constrained by previous investments in a knowledge infrastructure. In the next sections we describe in further detail the role of two tangible components of a firm's strategy—its mission and value proposition—and that of the existing knowledge management infrastructure in helping organizational members to identify the firm's critical knowledge areas.

- Business mission: The starting point for business strategy is some underlying idea of why the business exists; this is typically comprised in a firm's mission, which includes a statement of the company's purpose and overarching goal (Grant, 2002). Some mission statements, such as that of Skandia, are explicit about the role of knowledge. For example, "Skandia creates unique skills around the world that allow us to provide the best financial solutions for our customers and enduring value for our shareholders. We build special relationships, engage the energy of our employees, and transfer knowledge with pride." If a statement of corporate purpose embodies or embraces knowledge, it becomes a "knowledge business vision" (Earl, 2001). Otherwise, when a business mission, such as that of America Online ("To build a global medium as central to people's lives as the telephone or television…and even more valuable") is not explicit about knowledge, the question firms need to answer is, what is the contribution that knowledge can make to the attainment of the firm's purpose?

Because a mission defines the basic functions the firm has decided to perform in society, it provides organizational members with initial strategic guidelines about the knowledge they require (Bailey & Clark, 2000; Beckett et al., 2000). The firm's goals and purpose create a roadmap that helps the company to define its core activities and the knowledge creation and knowledge sharing processes that will support those activities. For example, in an in-depth case study at a European Innovation and Technology Center, Cepeda et al. (2004) showed that the preparation of a mission statement—one that emphasized the promotion of innovation and research activities among companies in the industry—helped the firm to guide its knowledge management efforts. Given that their mission was the promotion of innovation efforts, organizational members identified knowledge areas such as training and development and industry social networks as critical for their success.

- Value proposition: A business' value proposition is a statement of the fundamental benefits it has chosen to offer in the marketplace; it answers the question: How does the business intend to attract customers? (Crossan, Fry, & Killing, 2002). A value proposition communicates to employees what the business is trying to do for its customers and, by inference, the requirements of their particular role. It represents the attributes that firms provide, through their products and services, to achieve satisfaction and build loyalty with their targeted customers (Thompsen, 1999). The choice of a value proposition is perhaps the most obvious way in which a business attempts to differentiate itself from competition (Crossan et al., 2002). For example, Microsoft and Harley-Davidson have a product-leadership value proposition; they offer one-of-a-kind products and services, state-of-the-art features, and innovative solutions that customers often cannot get anywhere else. In contrast, firms such as IBM and Nordstrom have a customer-relationship value proposition, choosing to focus on the quality of their relationships with clients and offering them "complete solutions." A third case is that of Wal-Mart and Southwest Airlines, which have an operational-excellence value proposition. These firms opt to excel at attributes such as price, quality, on-time delivery, selection, and availability that their rivals cannot match.

  To deliver a value proposition, a business needs to make choices about the core activities it intends to perform and the knowledge needed to perform those activities (Furlong, 2000). Furthermore, by comparing the value proposition to the current performance of the company, performance gaps can be detected (Earl, 2001). There could be quality problems, customer service issues, or a deficit in product innovation efforts. Analyzing the gap between the current and the desired value proposition is a way of discovering the critical knowledge needed. From this perspective, knowledge management supports strategy when it enables the firm to implement solutions based on the unique needs of the client.

- Knowledge management infrastructure: To implement knowledge management successfully, it is important to understand the infrastructure required to support the acquisition, generation, transfer, and storage of tacit and explicit knowledge resources. Knowledge management involves the coordination and integration of multiple knowledge-based activities, structures, systems, processes, and individuals with diverse roles in the organization. These elements are frequently grouped into three categories—people, processes, and technology—and constitute what scholars call a knowledge management infrastructure (Gold, 2001; Muzumdar, 1997).

  While knowledge management solutions are a rising phenomenon, many firms manage knowledge in an implicit way and have elements of a knowledge infrastructure without calling it so. For example, Volvo has extensive databases and core experts in lifecycle analysis; Sony has training cells on product disassembly and ensures knowledge sharing with designers; BMW design teams have permanent members from the recycling function to ensure lessons from previous experiences be incorporated into product design. The existence of implicit or explicit knowledge management elements (people, processes, and technology) creates awareness about the importance of knowledge and facilitates the identification of critical knowledge areas (Thompsen, 1999; Muzumdar, 1997; Cepeda et al., 2004).

  Furthermore, an existing knowledge infrastructure affects the identification of critical knowledge areas because knowledge resources are path dependent, which is to say that "a firm's previous investments and its repertoire of routines (its 'history') constrain its future behavior" (Teece et al., 1997, p. 522). Resources are specific to a firm, embedded in their routines or assets, and accumulated over time (Dierickx & Cool, 1989). Consequently, an existing knowledge infrastructure (people, processes, and technology) may constraint the process of identifying critical knowledge areas. Independent of the firm's strategy, the current infrastructure elements might create boundaries and mental models within which managers will evaluate their knowledge needs. In this circumstance, it may appear faster and easier to develop a new strategy that leverages the current knowledge management infrastructure than it would be to create a new knowledge infrastructure to leverage the desired strategy.

Relationship Between Critical Knowledge Area and Competitive Advantage

Having discussed factors that facilitate the identification of the critical knowledge areas that support a firm's strategy, we now discuss two processes that mediate the impact of critical knowledge areas on competitive advantage: value-creation ways and capability differentials. Value-creation ways address how knowledge contributes to competitive advantage through the satisfaction of customer needs (customer perspective). In contrast, capability differentials address how knowledge contributes to competitive advantage through differentiation from competitors (competitor perspective).

- Value-creation ways: An emphasis on customer value and value creation is an intangible asset that has been posited to positively influence business performance and competitive advantage (Narver & Slater, 1990; Deshpandé et al., 1993; McNaughton, Osborne, & Imrie, 2002). The ultimate test of value creation is whether customers are willing to pay for a firm's products and services under conditions of wide competitive choices available to them (Rastogi, 2003). Knowledge is at the origin of most improvements in customer value (Novo, 2001; Rowley, 2002). Companies create value by instilling knowledge in products and services (Rastogi, 2003), by applying new knowledge to old problems (and in the process displacing existing knowledge), and by synthesizing discrete kinds of existing knowledge (Hamel, 2000). Another way to create value to customers is by globalizing deeply embedded local knowledge (Hamel, 2000). This implies transferring knowledge in the form of products that are easily moved worldwide, but also the more subtle effort of transferring knowledge in the form of services. In addition, firms create value by converting knowledge to strategic knowledge and enhancing shareholder wealth (Hamel, 1996, 2000). Because organizations grow or decline as their value-creation possibilities expand or contract, the richer, wider, and more varied the knowledge resources, the larger the value-creation opportunities open to the enterprise (Rastogi, 2003). Thus, a firm's capacity for sustained and superior value-creating ability may lie in the richness of its knowledge.

- Capability differentials: Coyne (1986) identifies the sources of sustainable competitive advantage as being four types of capability differentials, which Hall (1992, 1993) labels functional capabilities, cultural capabilities, positional capabilities, and regulatory capabilities. While functional and cultural capabilities involve competences and processes such as advertising and manufacturing, positional and regulatory capabilities refer to assets that the firm owns such as brands and reputation. By including assets and processes, the notion of capability differentials encompasses the concepts of resources and capabilities as described by RBV (Barney, 1991) and the dynamic capabilities perspectives (Teece et al, 1997; Eisenhardt & Martin, 2000). Because knowledge is the cornerstone of resources and capabilities, competitive advantage depends on the speed at which organizations can generate, capture, and disseminate knowledge, and use it to develop new resources and capabilities that competitors cannot easily imitate (Sharkie, 2003).
  Zack (1999) stresses the importance of concentrating on the development of unique and valuable capabilities, rather than exclusively focusing attention on the production of products and services. A concentration of products and services can provide, at best, short-term advantages because, as Schumpeter (1934) argues, organizations that engage in invention, innovation, and imitation in a continual basis render current products and services obsolete. Long and Vickers-Koch (1995) also argue that organizations that wish to improve their performance need to develop underlying skills and expertise, and channel them into process improvements. These skills and expertise include capability differentials such as know-how of employees, suppliers, and distributors (functional); learning ability and quality perception (cultural); reputation and networks (positional); and contracts, licenses, and trade secrets (regulatory). The building up of these internal capabilities results in sustainable competitive advantage because of the difficulty in imitating competences that are based on knowledge,

skills, and attitudes; built into processes; and developed over time in a particular organizational context (Long & Vickers-Koch, 1995; Quinn, 1992).

FUTURE TRENDS

On the basis of the issues in this article, specific recommendations are made for further research.

- Multiple case studies are recommended to establish the basis for cross-case analysis and the potential for even more compelling evidence and conclusions. Multiple case studies also provide greater probabilities for external validity and generalizability of the theory.
- A quantitative study is also recommended. Such a study could be designed to establish baseline strategic decisions, measures, and competitive comparisons. Other procedures could be designed to isolate specific decisions that incorporate deliberation of the critical knowledge area and to track the relative measurable impact upon the business results and competitive position of an enterprise.
- Additional research is recommended to establish financial valuation measures for a critical knowledge area and the creation of a theoretical foundation for a business formula to identify a measurable return on critical knowledge.

To summarize, the results of these recommendations would be expected to build upon the theoretical foundation. This additional research would extend and enrich this framework.

CONCLUSION

Several conclusions are derived from the description of this framework. These are presented as follows.

The eventual isolation of a unique body of knowledge, the identity of a critical knowledge area can create a new perspective on the enterprise and how it contributes value to its customers. The framework can support management's intent in creating and using a business planning framework of competitive analysis, strategy formation, and identification of critical success factors for decision making and measurement. Such a business framework is designed to create a managerial mindset that is predisposed to focus upon certain factors. The practitioners could find this predisposition as a source of difficulty in reframing their perspective of the organization. These conclusions align with the research of Penrose (1959), Mahoney (1995), Leonard (1998), and Thompsen (1999) on the impact of mental models on the identification and selection of key resource-capabilities that can serve in the best interest of the firm.

A critical knowledge area can be considered as another critical success factor and important for management decision making and the formation of competitive strategy. By examining the connections between the critical knowledge area and the points of competitive differentiation (differential capabilities and value creation ways), specific actions can be identified to leverage those points and enhance competitive advantage. A critical knowledge area can be a unifying factor in the development of an integrated strategy for enhancing competitive advantage. It can also be used to align infrastructure, policies, practices, systems, and processes to achieve fulfillment of competitive strategies.

Consistent deployment of a critical knowledge area is expected to produce positive impact on business results and relative competitive position. The development of benchmarking data and subsequent measurement are required to confirm such results. These findings and conclusions build on the research of Hall (1993) and Kamoche (1996), which concluded that resource-capabilities have important implications in management practice.

To summarize, the described framework could be aligned with the theoretical proposition that the identification of key resource-capabilities, or critical knowledge areas, in a firm can serve as an important and practical foundation for management decision making and enhancing competitive advantage.

The identification of key resource-capabilities or a critical knowledge area is an essential step in defining competitive forces and determining strategy. A critical knowledge area is another critical success factor that can be used in conducting situational and competitive analysis, formulating differentiating strategies, making strategic decisions, and aligning the organization infrastructure for strategy fulfillment.

The consideration of a critical knowledge area in management deliberations in a variety of scenarios can enhance competitive advantage and the potential for positive business results. The structure of an organization, its processes, systems, policies, and practices can be examined and adjusted to achieve greater leverage with the critical knowledge area. Some of these processes and systems include: acquisition/generation, store/retrieval, transfer, application, and protection.

A critical knowledge area can also used as a benchmarking measure for comparison of practices. Asset valuation and ownership policies can be more intentionally applied to the critical knowledge area. All of these are examples that demonstrate ways in which the identification and measurement of a critical knowledge area can impact management decision making and contribute to the economic value of a firm.

REFERENCES

Amit, R., & Schoemaker P.J. (1993). Strategic assets and organizational rent. *Strategic Management Journal, 14,* 33-46.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge.* Boston: Kluwer Academic.

Bailey, C., & Clarke, M. (2000). How do managers use knowledge about knowledge management? *Journal of Knowledge Management, 4*(3).

Barney, J.B. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17,* 99-120.

Barney, J.B. (1995). Looking inside for competitive advantage. *Academy of Management Executive, 9,* 49-61.

Barney, J.B. (2001). Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review, 26,* 41-56.

Beckett, A.J., Wainwright, E.R.C., & Bance, D. (2000). Knowledge management: Strategy or software? *Management Decision, 38*(9), 601-606.

Blackler, F. (1995). Knowledge, knowledge work and organizations: An overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Bohn, R. (1994). Measuring and managing technological knowledge. *Sloan Management Review, 36,* 61-72.

Bonora, E., & Revang, O. (1993). *A framework for analysing the storage and protection of knowledge in organizations: Strategic implications and structural arrangements. Implementing strategic processes: Change, learning and cooperation* (pp.190-212). Cambridge: Basil Blackwell.

Bryant, S.E. (2003). The role of transformational and transactional leadership in creating, sharing and exploiting organizational knowledge. *Journal of Leadership & Organizational Studies, 9,* 32-42.

Cepeda, G., Galán, J.L., & Leal, A. (2004). Identifying a key knowledge area in the professional services: A case study. *Journal of Knowledge Management, 8*(6), 131-150.

Cole, R. (1998). Introduction. *California Management Review, 40*(3), 15-21.

Collins, H. (1993). The structure of knowledge. *Social Research, 60,* 95-116.

Conner, K.R. (1991). A historical comparison of resource-based theory and five schools of thought within industrial organization economics: Do we have a new theory of the firm. *Journal of Management, 17,* 121-154.

Conner, K.R., & Prahalad, C.K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science, 7*(5), 477-501.

Cook, S., & Brown, J. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organization knowing. *Organization Science, 10*(4), 381-400.

Coyne, K.P. (1986). Sustainable competitive advantage—what it is and what it isn't. *Business Horizons,* 54-61.

Crossan, M., Fry, J.N., & Killing, J.P. (2002). *Strategic analysis and action* (5th ed.). Toronto: Prentice-Hall Canada.

Crossan, M.W., Lane, H.W., & White, R.E. (1999). An organizational learning framework. From intuition to institution. *Academy of Management Review, 24,* 522-537.

Daft, R.L. (1983). Learning the craft of organizational research. *Academy of Management Review, 8*(4), 539-547.

Davenport, T., & Klahr, P. (1998). Managing customer support knowledge. *California Management Review, 40,* 195-208.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Davenport, T.H. (1998). *Some principles of knowledge management.* Retrieved March 23, 2003, from http://www.bus.utexas.edu/kman/kmprin.htm

Davis, S., & Botkin, J. (1994). The coming of knowledge-based business. *Harvard Business Review,* (September-October), 165-170.

Deshpande, R., Farley, J.U., & Webster, F. (1993). Corporate culture, customer orientation, and innovativeness in Japanese firms: A quadrad analysis. *Journal of Marketing, 57,* 23-37.

Dierickx, I., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science, 35,* 1504-1511.

Drucker, P.F. (1994). *Post-capitalist society.* New York: Harper Business.

Eisenhardt, K.M., & Martin, J. (2000). Dynamic capabilities: What are they? *Strategic Management Journal, 21,* 1105-1121.

Furlong, G. (2000). *Knowledge management and the competitive edge.* Working Paper University of Greenwich, UK.

Ghoshal, S., & Moran, P., (1995). Bad for practice: A critique of the transaction cost theory. *Academy of Management Review, 21,* 13-47.

Glazer, R. (1991). Marketing in an information intensive environment: Strategic importance of knowledge as an asset. *Journal of Marketing, 55,* 1-19.

Gold, A.H. (2001). *Towards a theory of organizational knowledge management capabilities.*

UMI Dissertations, University of North Caroline at Chapel Hill, USA.

Grant, R.M. (1996). Toward a knowledge-based view of the firm. *Strategic Management Journal, 17,* 109-122.

Grant, R.M. (2002). *Contemporary strategy analysis* (4th ed.). Oxford, UK: Blackwell.

Hall, R. (1992). Strategic analysis and intangible resources. *Strategic Management Journal, 13,* 135-144.

Hall, R. (1993). A framework linking intangible resources and capabilities to sustainable competitive advantage. *Strategic Management Journal, 14,* 607-618.

Hamel, G. (1996). Keynote speech. *Proceedings of the Strategic Management Society Conference,* University of Arizona Tech, Phoenix, AZ.

Hamel, G. (2000). Knowledge strategy. *Executive Excellence, 17,* 7.

Helfat, C.E., & Raubitschek, R.S. (2000). Product sequencing: Co-evolution of knowledge, capabilities and products. *Strategic Management Journal, 21*(10-11), 961-979.

Kalling, T. (2003). Organization-internal transfer of knowledge and the role of motivation: A qualitative case study. *Knowledge and Process Management, 10,* 115-126.

Kamoche, K. (1986). Strategic human resource management within a resource-capability view of the firm. *Journal of Management Studies, 33,* 213-233.

Kelly, D., & Amburguey, T.L. (1991). Organizational inertia and momentum: A dynamic model of strategic change. *Academy of Management Journal, 34,* 591-612.

Klein, D., & Prusak, L. (1994). *Characterizing intellectual capital.* CBI Working Paper. Boston: Ernst and Young.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

Law, K., Wong, C., & Mobley, W. (1998). Toward a taxonomy of multidimensional constructs. *Academy of Management Review, 23,* 741-753.

Leonard-Barton, D. (1992). Core capabilities and core rigidities: A paradox in managing new product development. *Strategic Management Journal, 13,* 111-126.

Leonard, D., & Sensiper, S. (1998). The role of tacit knowledge in group innovation. *California Management Review, 40,* 112-132.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the source of innovation.* Boston: Harvard Business School Press.

Long, K., & Vickers-Koch, M. (1995). Using core capabilities to create competitive advantage. *Organizational Dynamics, 24*(1), 6-22.

Mahoney, J.T. (1995). The management of resources and the resource of management. *Journal of Business Research, 33,* 91-101.

McEvily, S., & Chakravarthy, B. (2002). The persistence of knowledge-based advantage: An empirical test for product performance and technological knowledge. *Strategic Management Journal, 23,* 285-305.

McNaughton, R.B., Osborne, P., & Imrie, B. (2002). Market-oriented value creation in service firms. *European Journal of Marketing, 36*(9), 990-1012.

Muzumdar, M. (1998). *Organizational knowledge management frameworks and a case study.* UMI dissertation, Kent State University, USA.

Narver, J.C., & Slater, S. (1990). The effect of market orientation on business profitability. *Journal of Marketing, 54,* 20-35.

Nelson, R.R. (1991). Why do firms differ, and how does it matter? *Strategic Management Journal, 12*(Special Issue), 61-74.

Nelson, R.R., & Winter, S.G. (1982). *An evolutionary theory of economic change*. Cambridge: Harvard University Press

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review,* (November-December), 96-104.

Nonaka, I., & Takeuchi, H. (1995) *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Novo, J. (2001). *The source of customer value—customer knowledge*. Retrieved from www.crm-forunm.com

Penrose, E.T. (1959). *The theory of the growth of the firm.* Oxford: Basil Blackwell.

Peteraf, M.A. (1993). The cornerstones of competitive advantage: A resource-based view. *Strategic Management Journal, 14,* 179-191.

Peters, T. (1992). *Liberation management: Necessary disorganization for the nanosecond nineties.* New York: Ballantine Books.

Polanyi, M. (1967). *The tacit dimension*. London: Routledge and Kegan Paul.

Porter-Liebeskind, J. (1996). Knowledge, strategy, and the theory of the firm. *Strategic Management Journal, 17*(Special Issue), 93-107.

Prahalad, C.K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review, 40*(3), 79-91.

Quinn, J.B. (1992). *Intelligent enterprise: A knowledge and service based paradigm for industry.* New York: Maxwell Macmillan.

Rastogi, P.N. (2003). The nature and role of IC: Rethinking the process of value creation and sustained enterprise growth. *Journal of Intellectual Capital, 4*(2), 227-248.

Rowley, J.E. (2002). Reflections on customer knowledge management in e-business. *Qualitative Market Research: An International Journal, 5*(4), 268-280.

Schumpeter J. (1934). *The theory of economic development: An inquiry into profit, capital, credit, interest, and the business cycle*. London; Oxford; New York: Oxford University Press (reprint 1974).

Sharkie, R. (2003). Knowledge creation and its place in the development of sustainable competitive advantage. *Journal of Knowledge Management, 7*(1), 20-31.

Spender, J.C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17,* 45-62.

Starbuck, W.H. (1990). Knowledge-intensive firms: Learning to survive in strange environments. In L. Lindamark (ed.), *Kunskap som kritisk resurs, en artikel sampling om Kunskapsforetag* (pp. 10-20). Handelshigskolan I Umea: Umea University.

Stewart, T.A. (1994). Your company's most valuable asset: Intellectual capital. *Fortune, 3,* 68-74.

Sveiby, K.E. (1990). *The new organizational wealth: Managing and measuring knowledge-based assets.* San Francisco: Berrett-Koehler.

Sveiby, K.E., & Risling, A. (1987). *Kunnskapsbedriften-arhundrets storste lederut fordring?* Kunskapsforetag, Cappelen, Oslo: Liber Forlag.

Teece, D.J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18,* 509-533.

Thompsen, J., Ibarra, R., & Center, J. (1997). Extending critical knowledge areas: Learn, innovate, propagate. In D.F. Kocaoglu, & T.R. Anderson (Eds.), *Innovation in technology management: The key to global leadership*. Portland International Press.

Thompsen, J.A. (1999). *A case study of identifying and measuring critical knowledge areas as key resources-capabilities of an enterprise*. UMI Dissertation, Walden University.

Toffler, A. (1990). *Powershift: Knowledge, wealth and violence at the edge of the 21st century*. New York: Bantam Books.

Vera, D., & Crossan, M. (2004). Strategic leadership and organizational learning. *Academy of Management Review, 29*, 222-240.

Winslow, C.D., & Bramer, W.L. (1994). *Future work: Putting knowledge to work in the knowledge economy*. New York: The Free Press.

Zack, M. (1999). Developing a knowledge strategy. *California Management Review, 41*, 125-145.

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Chapter 6.13
An Exploratory Analysis of Information and Knowledge Management Enablers in Business Contexts

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ABSTRACT

This chapter explores the factors limiting organizational information and knowledge management (IKM) through the perceptions of IKM practitioners. The authors propose that a number of organisational factors – which for them are enablers – have the ability to influence IKM project outcomes. It follows that explication of these enablers in an integrated framework could, therefore, be beneficial for practitioners. This chapter itemises 10 candidate enablers identified from a review of the literature and explored in previous research work. The authors discuss the findings of two exploratory surveys, which indicated that all ten enablers were perceived as important to the performance of IKM. However, the amount of management attention required by each enabler appears to be IKM project specific.

INTRODUCTION

Information systems, business professionals and academics have become increasingly fascinated with a seemingly new phenomenon1, knowledge management. While some authors believe KM to be merely a reinterpretation of information management (IM), and others believe it to be just another management fad2, independent writers with a business focus, such as Senge (1990), Peters and Waterman (1992) and Drucker (1993), and the IT research organisation – Gartner – have articulated sensible reasons to explain why organisations should embark on knowledge management (KM) projects. The reasons given for these projects are based on a premise that knowledge and the capability to manage it are the most crucial elements in sustaining or improving organisational performance.

Regard for knowledge as a strategic resource is well documented (for example, von Krogh, Roos, Kleine, 1998) and corroborates Nonaka and Takeuchi's 1995 theoretical framework, which as Magalhaes (1998, 101-102) puts it, is based on an understanding that business advantage arises from the ability of an organisation to create new knowledge. Several case studies have been reported that show support for this idea, [for example, the Skandia AFS case (Marchand, 1998) and Nonaka, Umenoto and Sasaki (1998)]. Although the overall number of empirical studies in KM is low, recent quantitative evidence has further substantiated these cases by showing a direct relationship between effective information and knowledge management (IKM) practices and corporate performance (Marchand, Kettinger, Rollins, 2000). Furthermore, well-organised IM and KM are seen to be complementary (Blumentritt, Johnston, 1999; Marchand, 1998) with both required to operate effectively to ensure adequate supply of both "old and new knowledge" (Stephens, 2000).

The purpose of this chapter is to present the results of some exploratory research that aimed to understand which organisational factors IKM practitioners believe are enablers for IK activities. This work is part of a larger research project, which aims to develop a multidimensional integrated framework for IM and KM, and to test the application of this framework within business contexts.

BACKGROUND

Integrated Information and Knowledge Processes

The relationship between data, information and knowledge existing at various points along a continuum (leading to wisdom) has been discussed and debated for some time. Although there is some confusion in the use of these terms, most authors agree that knowledge is the ultimate result of the capture of raw facts (data), applying specific context and purpose to it to produce information, and finally applying one's own terms of reference to produce knowledge within the minds of individuals. Tuomi (1999) challenges this view, and proposes that knowledge comes first and is used to create data. His view is that individual knowledge is represented in the design of databases and, as such, information is derived from the data contained within these repositories.

Some authors find that making a distinction between the three information stages is unwarranted and does not provide any benefit. Others, although they agree that making a distinction is largely unnecessary, create boundaries for their work in a specific area by providing definitions. Still others (including the authors of this paper) believe that effective IM and KM activities rely on a sound understanding of these stages and what they mean. We have, therefore, adopted definitions from Marchand (1998) for this paper:

- Data are context free and can always be shared because the receiver cannot or does not interpret them (e-mail is data to those who do not share the context for its interpretation).
- Information includes all documents and verbal messages that make sense or can be interpreted by organisational members and is never context or value-free. Information always encompasses an act of transfer or sharing among people and involves inter-

preting representations of our own or others knowledge and is context specific for use and application.

- Knowledge is always personal – it resides inside peoples' heads. Knowing means not only to understand or believe, but also to use or apply that knowledge. In an organisational context, knowledge conversion processes depend on human-to-human or human-to-technology interactions (Nonaka, Takeuchi, 1995). Knowledge use emphasizes personal interpretation and understanding and is context specific for expressing beliefs and commitments.

According to Marchand (1998), knowledge is converted to information for communication and transfer, which means the two are inextricably linked in a complementary and co-dependent relationship. Therefore, in practice, it is not enough to talk about KM as an isolated construct, but that effective management of knowledge should be based on sound information management and knowledge management processes, as well as addressing elements of the information environment, such as culture, behaviour, information politics and technology. Therefore, information management focuses on the acquisition, capture, sharing and use of essentially tangible information, while knowledge management focuses on the creation and identification of intangible information so it can be shared with others, or for conversion to tangible information. The approach used for managing knowledge in organisations reflects a focus on either sharing or conversion, and these approaches are known respectively as personalisation or codification strategies (Hansen, Nohria, Tierney, 1999; Davenport, Grover, 2001).

Issues, Controversies, Problems

Information, knowledge and their application within organisational or enterprise contexts are the subject of a large (and ever-increasing) number of publications (Davenport, Prusak 1998; Dixon 2000; Housel, Bell, 2001; Marchand, Kettinger, Rollins, 2001). A recurring theme is that a number of "factors" are critical for successful implementation of IM and KM initiatives. A review of literature in both the IM and KM areas revealed the range of elements that are regarded by academics and practitioners as constituent parts (our candidate enablers) of IM and KM frameworks3. These candidate enablers often include, but are not limited to: information and information technology architectures (McGee, Prusak, 1993), individual behaviours (Bonner, Casey, Greenwood et al., 1998) organisational culture, policy and strategy and information politics (Davenport, Eccles, Prusak, 1992; Davenport, 1997; Norton, 1994; Orna, 1999; Strassman, 1995), people management (including roles and responsibilities) (Ichijo, von Krogh, Nonaka, 1998; Broadbent, 1997; Standards Australia, 1999), and processes (Marchand, Kettinger, Rollins 2000). Some authors have addressed various groupings of enablers because it is believed to be "unlikely that the adoption of new titles, procedures or technology alone will produce sustainable competitive advantage" (Nonaka, Umenoto, Sasaki, 1998). Davenport (1997) presented a holistic view of organisational information environments in his model of an information ecology, which incorporated many, but not all, of the enablers mentioned above.

These candidate enablers, each with a scope statement and examples of the sources in which they were identified, are provided in Table 1. The scope statements in this table derived to set boundaries for the purpose of defining the categories in the practitioner surveys. These statements are not intended to limit the interaction and co-dependencies that may exist between many of the enablers.

Ideally, each key enabler in an information environment would be designed and operate optimally to facilitate effective IKM, but this aim is difficult and impractical to achieve. Not only

Table 1. Candidate IM and KM enablers from the literature

Candidate IM & KM Enabler (& Code)	Scope	Examples of Reference to Enabler in Literature
Information Architecture (IA)	Elements that define what information the organisation has, what it needs to achieve its goals, and what should be done with information and / or knowledge. (Tools include: information maps, directories, yellow pages etc.)	McGee and Prusak 1993, Orna 1999; Davenport 1997.
Information Behaviour (IB)	How individuals behave and are encouraged to behave in respect to information, for example how information sharing, exchange, use and communication occurs between individuals.	Davenport 1997; Bonner, Casey and Greenwood et al 1998; Orna 1999
Organisational Culture (OC)	How "the way things are done" effects IM and KM.	Brooking 1999, 112; Bertels and Savage 1998; Davenport 1997; Ichijo, von Krogh and Nonaka 1998; Orna 1999; Standards Australia 2000; Norton 1994
IM Processes (IMP)	Activities focussed on managing tangible information.	Orna 1999; Marchand et al 2000; Davenport 1997; Standards Australia 2000
IT Practices (ITP)	Management of IT to support IM and KM.	Marchand et al 2000; Brooking 1999; Orna 1999; Standards Australia 2000
KM Processes (KMP)	Activities focussed on the capture and sharing of knowledge held within the minds of individuals.	Marchand et al 2000; Standards Australia 2000; Ichijo, von Krogh and Nonaka 1998
People Management (PM)	Interventions to create environments that enable and encourage people to create, share and use knowledge, for example dynamic teams, role rotation, reward and recognition programs, training and education.	Broadbent 1997; Brooking 1999; Ichijo, von Krogh and Nonaka 1998; Standards Australia 2000
Information Policy and Strategy (IP&S)	High-level formal statements that explicitly assert the organisation's intent for information and or knowledge and provide guidance about the overall approach to information and or knowledge.	Strassman 1995; Davenport 1997; Orna 1999; Standards Australia 2000
Information Politics (IP)	Organisational activities and behaviours specifically related to the power information instils and how these are managed to ensure effective information and knowledge use.	Marchand et al 2000; Strassman 1995; Davenport, Eccles and Prusak 1992, Davenport 1994, 1997
Organisational Structures (OS)	Formal roles, responsibilities and authority for IM and KM.	Bertels and Savage 1998; Blacker, Crump and McDonald 1998; Ichijo, von Krogh and Nonaka 1998; Davenport 1997; Orna 1999;

do these enablers constitute a substantial portion of the fabric of organisations but, also, the ubiquitous nature of IK means that their management need permeates all business processes. This ideal position is further complicated by potential co-dependencies between the enablers (for example, strategy, politics, organisational structure and people management) and the need to manage resistance to change when attempting to transform enablers, such as culture and behaviour. Yet, the need to address some of these enablers seems inherent in any IKM initiative.

Solutions and Recommendations

Firstly, an understanding of the emphasis IKM practitioners place on each of the candidate enablers would assist refinement of a proposed IKM framework. Secondly, a comparison of management attention required for these enablers and the situation in a sample of organisations would be informative regarding awareness and progress towards the ideal situation described above.

Two exploratory surveys were used in this study to explore practitioners' perceptions of the candidate IKM enablers. Both surveys required qualitative and quantitative responses and were pre-tested, piloted and administered by e-mail to a group of individuals unknown to the authors, but who were members of an active KM forum.

Survey 1 consisted of nine questions. Questions 1-7 requested qualitative information such as occupation, professional affiliation, employer type, and some demographics (age and gender). Question 8 contained a series of 50 principle statements, which the respondents were asked to rate on a 5-point Likert scale to indicate their perceived importance to IKM. The 50 items were made up of five descriptive statements for each enabler. These statements were derived from the literature and were seen as adequately describing each enabler in the pre-test and pilot stages. The participants were not aware of the list of candidate enablers at this stage and, as such, the links between the statements and enablers were not made visible in the survey. In addition, the five statements for each enabler were distributed throughout the question. Question 9 invited respondents to include additional principles that they thought were important and had not been addressed in Question 8.

Survey 2 consisted of seven questions. Question 1 presented the list of ten candidate enablers (accompanied by scope statements) and required respondents to indicate their significance to IM and KM effectiveness (using a 7-point Likert scale). Question 2 asked respondents to rank the relative importance of the enablers from 10 (most important) to 1 (least important), while Question 3 requested additional enablers. In Question 4, the set of 50 principles used in Survey 1 was reused and this time respondents were asked to indicate (again, using a 7-point Likert scale) how well the statement reflected the situation in their organisation. Questions 5 and 6 focused on position titles and organisational size, while Question 7 asked for descriptions of IM and KM projects.

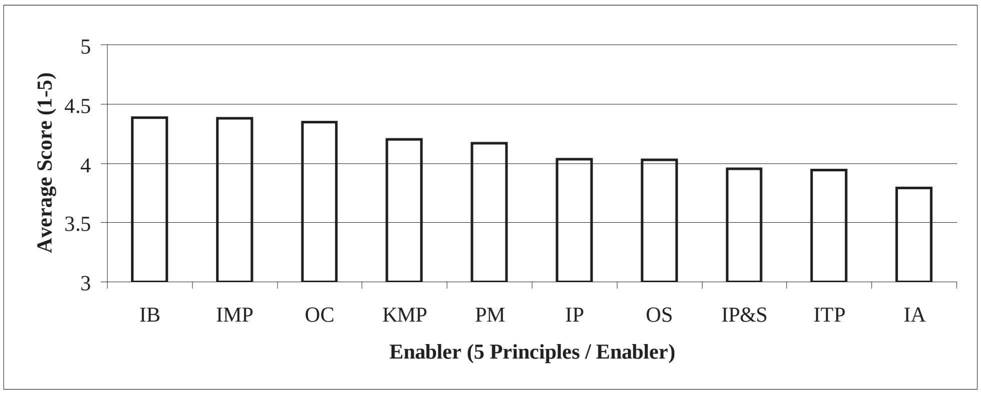
These exploratory surveys did not attempt to derive factor interrelationships. Rather, questions were associated with the perceptions of specific enablers. Copies of the survey forms are available from the authors.

Survey 1 Results

There were six respondents in the pilot group (100% response rate) and 20 respondents in the sample group (21% response rate), which was a low response rate, but, for the purposes of this exploratory work, we felt adequate. The pilot and sample group were assessed separately and as no differences were found, the results were pooled (26% response). The ten most important principles, their average score (out of five) and the enabler that they represent are listed below.

- Sharing information (4.77) - IB.
- Identifying the information needed to meet business objectives (4.73) - IMP.
- Demonstrating appropriate information behaviours at senior levels (4.69) - IB.
- Making key business information accessible throughout the enterprise (4.65) - IP.
- Open communication between people (4.58) - OC.

Figure 1. Enabler importance by principle statement



- A strong affinity between the espoused and experienced culture (4.58) - OC.
- Meeting the information needs of core processes (4.54) - IMP.
- Capturing learning from past experiences (4.50) - KM.
- Investing in employee training, skill enhancement or education (4.50) - PM.
- Making decisions that support the firm's mission or goals / Encouraging collaboration between IT, content and HR managers (4.46) – OC/OS.

The data collected about the importance of principles allowed us to extrapolate the enabler rankings from this initial survey. The values in this figure were calculated by averaging all the statement scores for each of the enablers. Figure 1 illustrates that the aggregated average for all enablers was over 3.5 on the 5-point scale used, with the scores ranging from 4.39 for information behaviour to 3.79 for information architecture.

Survey 2 Findings

The second survey was pre-tested for accuracy and then piloted with the survey one pilot group before being distributed to the 21 respondents from the previous survey. Fifteen responses were obtained (71% response rate).

The importance ranking of the enablers is shown in Figure 2. The most highly ranked enablers were information behaviour, organisational culture and people management. The least highly ranked enablers were information technology practices, information policy and strategy, and organisational structure.

Two sets of data are shown in Figure 3, significance and organisational alignment. Firstly, the respondents saw that nine of the 10 enablers were seen as significant to the ultimate success of IKM, and that these organisational aspects required some type of planned attention to ensure IKM initiative success. It was only seen necessary to pay attention to organisational structures when problems arose. Secondly, Figure 3 shows

Figure 2. Ranking of IM and KM enablers

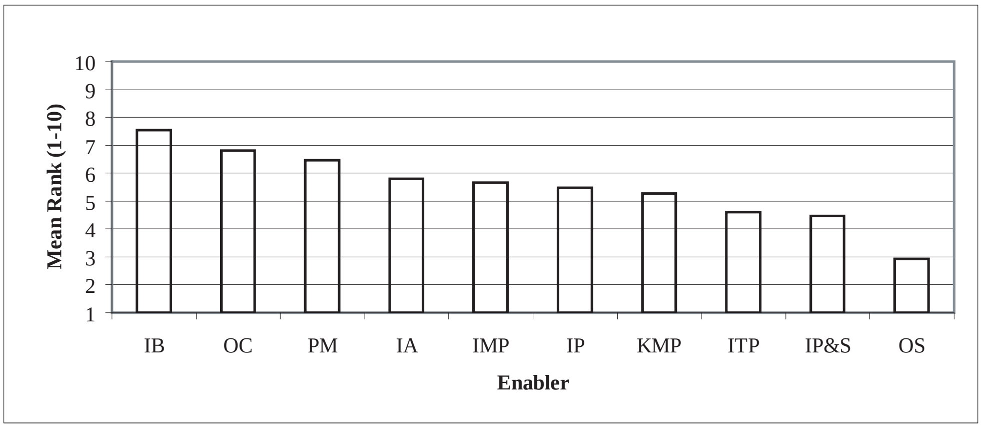
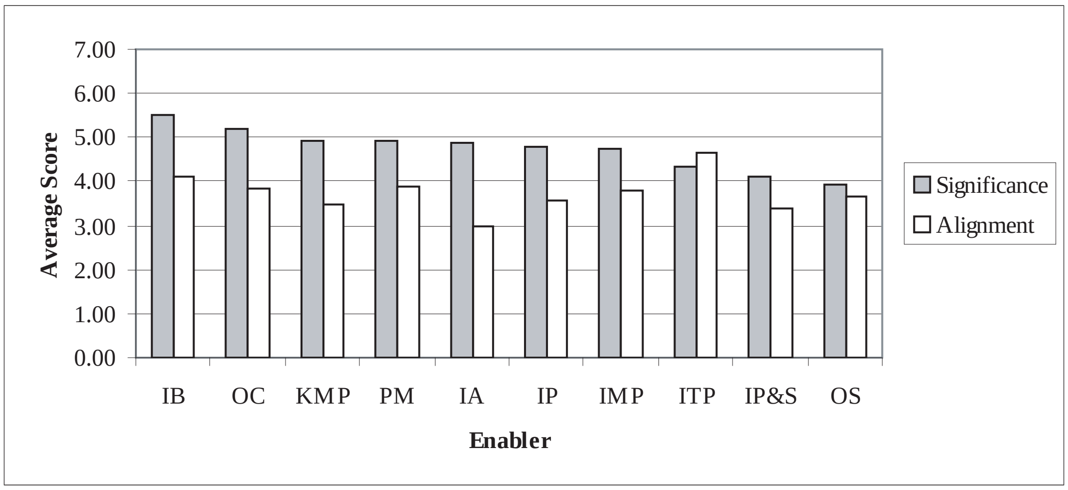


Figure 3. Comparison of enabler significance and organisational "state of practice"



the degree of alignment between the IM and KM enablers and the actual situation in the sample group of organisations. Alignment was assessed using a seven-point Likert scale where a seven meant that the principle statement was highly aligned with the organisation's circumstances and one indicated no alignment between the organisation and the statement. Responses from

14 organisations were used to provide the alignment score for each enabler (no data was received from one organisation for this question). For the organisations surveyed, an average score of close to five indicates good alignment with the enabler, while scores nearer to three indicate some degree of alignment between the organisation and the enabler.

Figure 3 allows a visual comparison between (1) the significance of each enabler and (2) the organisational "state of practice" for that enabler.

DISCUSSION

The results of Survey 1 indicated that practitioners recognised the relevance of 50 principles seen to be important to IKM. The data, when aggregated for each enabler, shows a ranking of enablers from most to least important in terms of IKM; however, the small number of responses precludes any statistical inference. Another limitation of this first survey is that the statements used to gauge the importance of each enabler were derived from the literature and, as such, were contrived to correspond to a single candidate enabler. Despite these limitations, we believe this data indicates that all ten candidate enablers were seen as important for the facilitation of sound IKM, and this initial exploratory assessment provided us with a foundation on which to base further research activities.

Although the response rate for survey two was quite high (71%), the sample size once again prohibits statistical data analysis. However, the main purpose of Survey 2, which was to inform the researchers prior to embarking on interview and case study processes, was achieved. Although the order of enablers in Figure 1 (importance of enabler by principle), Figure 2 (ranking of enablers), and Figure 3 (significance of enablers) differs, the data does indicate that all ten enablers are seen as having an important role to play in the overall performance of organisational IKM activities. Furthermore, practitioners were able to distinguish between what is theoretically ideal (Question 8 in Survey 1) and the actual "state of practice" regarding that principle in their organisation (Question 4 in Survey 2). We have shown the alignment data alongside the significance data to indicate the gap between the ideal and actual situations in our sample organisations. Further interpretation of this data could be used to show the fit against an aggregated benchmark for each organisation and enabler. This data could be then used by organisations to focus their IKM strategies. The data also suggest that a large quantitative data collection and analysis may produce some significant differences between theory and practice in this area.

FUTURE TRENDS AND CONCLUSION

This exploratory analysis of IKM frameworks in business contexts has provided answers to the two issues questions posed. The data from the two exploratory surveys confirmed that participants saw ten organisational factors as having a role in enabling information and knowledge management activities. The surveys also indicated that there are gaps between the significance of IKM enablers and the actual situation in our sample of Australian organisations. The true value in these findings lies in the opinions, understandings and experiences of the IKM practitioners underpinning the quantitative data. So, the quantitative data proved useful to inform the authors before engaging the respondents to the second survey in an interview and case study process.

As expected, this study raises a number of further challenges that we will be pursuing. Firstly, a clear distinction between the processes required to manage information and knowledge is needed. Secondly, we need to gather more data to confirm the integrated framework and its component enablers. Thirdly, we will elaborate on the characteristics of the candidate enablers. Fourthly, we will describe the impact of each key enabler on IKM initiatives after organisational assessment in further case studies. Finally, (for now) we plan to describe the role of each enabler within IKM.

The overall goal of this on-going research is to provide practical guidelines to assist organisations to optimize their environments so that the outcomes of IKM projects are beneficial to them. This exploratory study has provided the foundation to achieve this goal.

REFERENCES

Bertels, T., & Savage, C. (1998). Tough questions on knowledge management. In G. von Krogh, J. Ross, & D. Kleine (Eds.), *Knowing in firms: Understanding, managing and measuring knowledge* (pp. 7-25). London: Sage.

Blacker, F., Crump, N., & McDonald, S. (1998). Knowledge, organisations and competition. In G. von Krogh, J. Ross, & D. Kleine (Eds.), *Knowing in firms: Understanding, managing and measuring knowledge* (pp. 67-86). London: Sage.

Blumentritt, R., & Johnston, R. (1999). Towards a strategy for knowledge management. *Technology Analysis and Strategic Management, 11*(3), 287-300.

Bonner, M., Casey, M-E., Greenwood, J., Johnstone, D., Keane D., & Huff, S. (1998). Information behaviour: A preliminary investigation. In M. Khosrow-Pour (Ed.), *Proceedings of IRMA 1998, Effective Utilisation and Management of Emergent Technologies* (pp. 68-79). Idea Group Publishing.

Broadbent, M. (1997). The emerging phenomenon of information management. *Newsletter of the Arts Libraries Society of Australia and New Zealand, 45,* 16-32.

Brooking, A. (1999). *Corporate memory: Strategies for knowledge management.* London: Thomson International Business Press.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organisations manage what they know.* Boston: Harvard Business School Press.

Davenport, T. H. (1997). *Information ecology: Mastering the information and knowledge environment.* New York: Oxford University Press.

Davenport, T. H., Eccles, R.G., & Prusak, L. (1992). Information politics. *Sloan Management Review, 34*(1), 53-65.

Davenport, T. H., & Grover, V. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Dixon, N. (2000). *Common knowledge: How companies thrive by sharing what they know.* Boston: Harvard Business School Press.

Drucker, P. (1993). *Post capitalist society.* Oxford: Butterworth-Heinemann.

Hansen, M., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge. *Harvard Business Review, 77*(2), 106-116.

Housel, T., & Bell, A. (2001). *Measuring and managing knowledge*. Boston: McGraw-Hill.

Ichijo, K., von Krogh, G., & Nonaka, I. (1998). Knowledge enablers. In G. von Krogh, J. Ross, & D. Kleine (Eds.), *Knowing in firms: Understanding, managing and measuring knowledge* (pp. 173-203). London: Sage.

Marchand, D. (1998). Competing with intellectual capital. In G. von Krogh, J. Ross, & D. Kleine (Eds.), *Knowing in firms: Understanding, managing and measuring knowledge* (pp. 253-268). London: Sage.

Marchand, D., Kettinger, W., & Rollins, J. (2000). Information orientation: People, technology and the bottom line. *Sloan Management Review, 41*(4), 69-81.

Marchand, D., Kettinger, W., & Rollins, J. (2001). *Information orientation: The link to business performance*. Oxford: Oxford University Press.

Magalhaes, R. (1998). Organisational knowledge and learning. In G. von Krogh, D. Kleine & M. Venzin (Eds.), *Knowing in firms: Understanding, managing, and measuring knowledge* (pp. 87-112). London: Sage.

McGee, J., & Prusak, L. (1993). *Managing information strategically,* New York: John Wiley & Sons.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. London: Oxford University Press.

Nonaka, I., Umenoto, K., & Sasaki, K. (1998). Three tales of knowledge-creating companies. In G. von Krogh, J. Ross, & D. Kleine (Eds.), *Knowing in firms: Understanding, managing and measuring knowledge* (pp. 146-172). London: Sage.

Norton, R. (1994). Organizational cultures and their relevance to the information organization. *ASLIB Proceedings, 46*(4), pp. 173-176.

Orna, E. (1999). *Practical information policies* (2nd ed.). Aldershot, Gower.

Peters, T., & Waterman, R. (1992). *In search of excellence: Lessons from America's best run companies,* New York: Warner Books.

Polanyi, M. (1966). *The tacit dimension*. New York: Doubleday.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organisation*. Milsoms Point, NSW: Random House Australia.

Standards Australia. (1999). *National knowledge management framework - Preliminary draft,* Sydney: Standards Australia International Ltd.

Stephens, D. (2000). *Knowledge management in the Australian Public Service: A stocktake and a prospectus*. IPAA Conference 'Five + years of reform', Canberra.

Strassman, P. (1995). *The politics of information management: Policy guidelines*. New Canaan, CT: The Information Economics Press.

Tuomi, I. (1999). Data is more than knowledge: Implications of the reversed knowledge hierarchy for knowledge management and organisational memory. *Journal of Management Information Systems, 16*(3), 103-107.

von Krogh, G., Roos, J., & Kleine, M. (1998). *Knowing in firms: Understanding, managing and measuring knowledge*. London: Sage.

ENDNOTES

1. Although this interest does seem relatively recent, philosophical discussions about knowledge and knowing engaged Plato and Aristotle and many scholars since. The potential of untapped knowledge within peoples minds was succinctly stated by Polanyi (1966) who said "we know more than we can tell," thereby emphasizing the current challenge for business.
2. Another view is that the current popularity of KM is largely driven by the commercial imperatives of software vendors and consulting firms.
3. Further discussion about IM and KM framework development is the subject of another paper by Nelson and Middleton (2001) currently under development.

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Chapter 6.14
Managing Information Technology Component of Knowledge Management:
Outsourcing as a Strategic Option in Developing Countries

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ABSTRACT

Information technology and social-cultural, organizational variables are considered major components to support knowledge processes in knowledge management. These components have to be carefully managed and be supported in balanced proportion for organization to create and retain greater value from their core competencies. The peculiar situation of developing countries, where there is lack of adequate information technology infrastructure, emphasizes the importance of strategic management of organizational information technology. Using a case study, we discuss the possibility of outsourcing the management of the information technology in order to have more focus on the other components in knowledge management.

INTRODUCTION

Knowledge management (KM) could be defined as the ability to create and retain greater value from core business competencies (Duffy, 2000; Bhatt, 2001; CIO, 2000). IT is one of the enablers of knowledge management. Its availability, management, and right application could increase the success rate of knowledge management efforts of organizations. Due to lack of human resources with required skills and lack of adequate IT infrastructure (ITI) in sub-Saharan Africa, IT outsourcing could be a better approach to IT management for an organization considering KM. In this chapter, we present part of the outcome of an empirical research and an in-depth analysis of a case organization where IT outsourcing seems to contribute to a high performance in knowledge management efforts. We suggest that organizations in sub-Saharan Africa that are considering knowledge management could look at the possibility of outsourcing the management of the information technology component in order to have more focus on the other enablers of KM

Information technology is one of the enablers of knowledge management and its management could have a great effect on the knowledge management efforts of organizations. IT management in sub-Saharan Africa is posing problems to some organizational activities in the face of low resources and expertise (Odedra et al. 1993; Moyo, 1996). Outsourcing IT has attracted a lot of attention in IT literature (e.g., Lacity and Hirschheim 1993; McFarlan and Nolan, 1995; Hirschheim and Lacity 2000). It could allow organization to focus more on development efforts such as reengineering process, just-in-time, total quality management, benchmarking, etc. For these reasons, IT outsourcing has become very popular. There is much evidence of its success after the understanding of the problems associated with earlier agreements (Shepherd, 1999). Firms focus on their core capabilities to have competitive advantage especially in today's dynamic, volatile business environment. When a firm focuses on core businesses that add unique value to its customers, it may outsource activities for which it lacks core capabilities (Quinn and Hilmer, 1994).

In our empirical study of six research organizations on ITI and KM in sub-Saharan Africa, two organizations presented exceptions to our assumption that organizations with high ITI capability are also likely to have effective knowledge management. In one organization, high level of IT infrastructure capability was not accompanied by high KM efforts while in another research institute, there were high KM efforts at instance of low IT infrastructure capability. Upon closer inspection of the later, the IT outsourcing strategy of the organizations with low ITI seems to be responsible for the high performance in knowledge management activities. Could the IT outsourcing strategy directly relate to the performance in KM efforts? We examine KM from core competence perspective and argue about the difference between the strategic and operational view of organizational IT. We illustrated this with a case organization upon which we will draw our conclusions and suggestions for further studies.

IT OUTSOURCING

Outsourcing is the transfer or delegation of the operation and day-to-day management of a business process to an external service provider. IT outsourcing can be regarded as the practice of transferring IT assets, leases, staff, and management responsibility for delivery of services from internal IT functions to third-party (Hirschheim and Lacity, 2000). According to Hitt et al. (1999), outsourcing is a strategic concept, a way to add value to the business that converts an in-house cost center into a result oriented service operation. The motivation for IT outsourcing is widely discussed in the literature. Shepherd (1999) provides a summary where he included financial restructuring, reduction or stabilization of costs, overcoming cultural and organizational problems, concentrating on core competencies, access to world class expertise, concern with economies of scale and scope, and possibly growth expectation. Generally, virtually all organizations are seeking the strategic value that can be captured through effective outsourcing.

IT outsourcing evolved from the early 1960s data processing service bureau to the contract programming approach of 1970s. The 1980s witnessed more focused efforts on vertical integration and internal control and a slowdown in outsourcing (Ketler and Willems, 1999). The 1990s are characterized by a renewed interest in outsourcing, following Eastman Kodak's much written-about outsourcing deal of 1989. At turn of the century, with various IT related problems (e.g., Y2K, skill demands, etc.) and developments (e.g., e-commerce) and the need for organizations to be more competitive and responsive, IT outsourcing has become a generally acceptable practice in various forms and scopes. Both small and large-sized organizations are taking advantage of outsourcing opportunities.

Since only few organizations if any, possess the resources and capabilities required to achieve competitive superiority in all primary and support activities, more especially with respect to information technology which required keeping with the dynamism of the industry and changing expertise (Hitt et al., 1999). IT outsourcing enables an organization to focus on their core competence and it provides possibility to make a right strategic decision that directly affects the work. It enables access to new technology and keeping up with the trends in the ever-changing world of IT (Ketler and Willems, 1999; Goo et al., 2000). In a situation where there is low availability of human resources, it relieves the organization of the burden of continuous recruiting due to the high turnover rate in the sector (Slaughter and Ang, 1996). Thus, we also agree that IT outsourcing could be a good decision for an organization that does not use IT for strategic purposes, but mostly for operational functions (Currie and Pouloudi, 2000), especially in a region where there is lack of adequate expertise to support in-house IT management.

According to Ang and Straub (1998), organizations apply selective outsourcing analysis in which outsourcing relationships are focused on specific IT activities where external providers supply expertise that is currently lacking. Also, organizations apply selective outsourcing analysis is applied where outsourcing relationships are focused on external providers that furnish assets or competencies for which they have a comparative advantage in terms of economies of scale. Analysis is also applied to external providers that take on responsibilities for IT activities not considered mission critical so that the organization can deploy released resources into strategic activities. Using the last option could enable an organization to nurture few core competencies and thus, increase the organizations probability of developing a competitive advantage or a tremendous improvement in a particular process (Chesebrough and Teece, 1996).

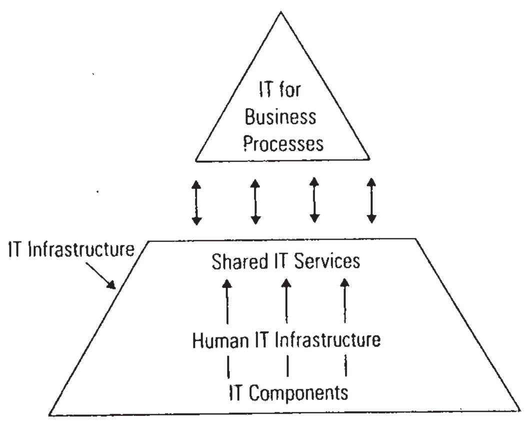
Although outsourcing IT to India and other developing countries has attracted attention, the outsourcing arrangements within developing countries are less written about. In the case of non-profit research organizations, IT could be viewed as a set of operational tools. The scientists are mainly interested in getting their work done and they may have little interest in state-of-the-art-IT. Their core competence is far from IT, though in the modern world where they operate, IT use appears essential. In as much as they are able to carry out their primary duties with IT, the kind of IT installed or the style of its management might not in any direct way provide competitive advantages to them. In fact, these non-profit organizations do not consider other organizations as competitors, but rather collaborators. They need IT to support the process of their work, communication, collaboration and coordination. For these reasons, it could be convenient for the research organizations to outsource their entire IT management functions.

INFORMATION TECHNOLOGY INFRASTRUCTURE (ITI)

IT infrastructure is a major business resource and a source for attaining sustainable competitive advantage (Broadbent et al., 1999; Keen, 1991;

McKenney, 1995). It is increasingly seen as a fundamental differentiator in the competitive performance of the organizations, its investment leads to new competitive strategies and progression through higher levels of organizational transformation. IT infrastructure capabilities enable the emergence of new organization forms, facilitate electronic commerce and knowledge management; it is critical to globally competing firms (Broadbent et al., 1999). Strategically, the importance of an organization's information technology infrastructure capability is increasingly recognized as critical to an organization's competitiveness. These infrastructures are important for organizations going through dynamic change, for organizations reengineering their business processes, managing individual and organizational knowledge and for those with multiple business units or extensive international or geographically dispersed operations (Broadbent et al. 1999). IT infrastructure, according to Broadbent and Weill (1997) is the base foundation of information technology capability, delivered as reliable services shared throughout the firm.

Figure 1. Elements of IT infrastructure (Broadbent and Weill, 1997)



ITI is coordinated centrally, usually by the information systems group or external people when outsourced. They use a pyramid to illustrate the different components of information technology infrastructure (see Figure 1).

At the base of the pyramid there are components such as computer and communications technologies (hardware and software), that are largely commodities and readily available for purchase and hire. The second layer comprises of a set of shared services such as management of large-scale data processing, provision of electronic data interchange (EDI) capability, groupware, Internet or management of firm-wide databases. The human resources turn the components into reliable, shared information technology infrastructure services. Each of these components could be outsourced completely or in part, the decision depends on the factors already described above.

They also identified four views of IT infrastructure with different benefits and investments: none, utility, dependent, and enabling. None view implies that an organization does not invest in IT infrastructure at a firmwide level. The utility view primarily considers investment in IT infrastructure as a way to reduce costs through economies of scale. The dependent view ties the investment in IT infrastructure to the current organizational strategies and the enabling view is a dependent view with extra investment to cater for long-term goals and developments (Broadbent and Weill, 1997). It has earlier been recognized that ITI can be a significant barrier or enabler in the practical options available to planning and changing organization processes like KM (Broadbent et al., 1999), thus adequate support of enabling technologies and platforms is an important factors in the success of organizational changes. Therefore, organizations that consider IT as part of their core strategies are likely to take the dependent and/or enabling views. On the other hand, while organizations that consider IT as operational tools are likely to take the none and /or utility view, thus, they are likely to outsource their IT without fear of losing knowledge and have more time to concentrate on core capabilities.

KNOWLEDGE MANAGEMENT (KM)

Several authors acknowledge that the ultimate goal of KM is to improve organizations efficiency and productivity, hence profitability (APQC, 1996; Davenport and Prusak, 1998). For the purpose of this chapter, we lean towards the definition that KM is the ability to create and retain greater value from core business competencies (CIO, 2000) and a practice that finds valuable information and transforms it into necessary knowledge critical to decision making and action (Beveren, 2002). This could be achieved by various strategies to provide the right knowledge for the right people at the right time (APQC, 1996). Organizations are using various approaches to achieve these goals. Some are focusing on management of people and others on the management of information (Sveiby, 1996).

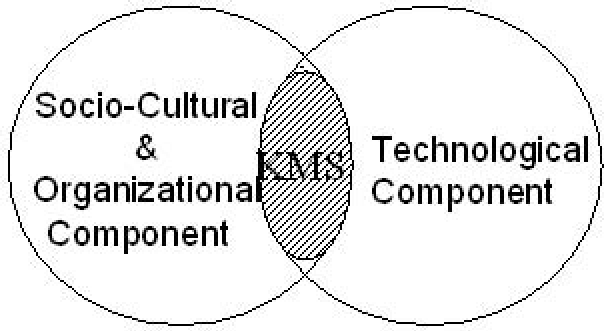
Tyndale (2000) further explained Sveiby's view, using the terms codification and personalization. He used codification to explain KM that is IT focused. This strategy includes attempts to codify knowledge and carefully store it in a database where it can be accessed and used easily by anyone in the company. This approach considers knowledge as objects that can be identified and handled in information systems. Personalization was used to explain KM that is people-focused. This approach regards knowledge as a process that is closely tied to the person who developed it. This kind of knowledge is shared mainly through direct person-to-person contacts. In this approach, technology is only used as the infrastructure that enables the capture, storage, and delivery of contents to those who need it when they need it. Bhatt (2001) also suggested that exclusive focus on codification or personalization does not enable the firm to sustain its competitive advantages but rather it is the interaction between technology, techniques and people that allow an organization to manage its knowledge effectively.

KM AND IT OUTSOURCING

The focus of previous studies on the relationship between IT outsourcing and KM has been on the knowledge issues between the contracting parties. For example Currie and Pouloudi (2000) relate the outsourcing decision to the value the organization attaches to their knowledge-based assets, they conclude that consideration of the value of knowledge-based assets, knowledge creation, growth, and retentions could affect the outsourcing decision. Their conclusion also supports the view that organizations that considered IT as core competence are likely to insource while organization that think otherwise may likely outsource. However, they did not elaborate further on whether the outsourcing decision allows the organizations to focus more on their core competency. Although it is the core competencies that really distinguish a company competitively and reflect its personality. According to Hitt et al. (1999), core competencies emerge over time through an organizational process of accumulating and learning how to deploy different resources and capabilities. Like in product development where organization can focus on their core competency, organization could also focus on the issues that they understand better in a dynamic organization change like knowledge management.

Although KM is currently being viewed as a combination of the technological component and the social-cultural, organizational component, relatively little attention has been paid to the issue of outsourcing the IT component. Balancing these components could yield effective KM and improve productivity, efficiency, innovation and competence of an organization. In the knowledge management components described by Alavi

Figure 2. Knowledge management components (Alavi, 1997)



(1997), effective KM occurs at the intersection of the technological component and social-cultural and organization component (Figure 2).

Therefore, for an organization to have an effective KM practice, there should be a balance between the technological component and the social-cultural, and organizational component. Technology is often considered to be the easier component. Dan Holthouse in his foreword to Information technology for Knowledge management (Borghoff and Pareschi, 1998) remarked on this: "Technology is the easier piece of the problem to solve, it's far more challenging to change people's behavior and to create a learning environment that fosters the expansion of individual's personal knowledge. Therefore, organization could do better if the internal resources [were] focused on the people aspect and allow an external organization that has the adequate [expertise], to handle the (easier piece of) technology."

THE EMPIRICAL STUDY

As part of a study to investigate how information technology infrastructure generally affects knowledge management efforts of research organizations in sub-Saharan Africa, we conducted a multiple case study (Yin, 1994) using six different organizations in two countries in sub-Saharan Africa (Okunoye and Karsten, 2001). Three of the organizations are international: International Institute of Tropical Agriculture (IITA), Nigeria, Medical Research Council (MRC) Laboratories, and International Trypanotolerance Center in The Gambia. Three are national: National Agricultural Research Institute (NARI) in The Gambia, Nigeria Institute of Social Economic Research (NISER) and Nigerian Institute of Medical Research (NIMR) in Nigeria.

The national organizations are primarily dependent on the national government for their basic funding. Usually the international organizations enjoy supports from various sources around the world. They have a substantial number of expatriates working in them and have better support for the IT. The multiple-case study was conducted between January and March 2001. We interviewed, observed and presented questionnaires to research scientists, management staff, librarian, and IT staffs on knowledge management and use of ICTs. We interviewed the head of IT where applicable and the people responsible for IT department. KM was evaluated using the knowledge management diagnostic (KMD) created by Bukowitz and Williams (1999) and ITI was assessed using the approach developed by Broadbent and Weill (1997) where IT infrastructure is linked to the business by maxims, which reflect the company's strategic context. The KM assessment and ITI capability has been fully described in Okunoye and Karsten (2002).

INFLUENCE OF IT ON KNOWLEDGE MANAGEMENT

Four of the organizations appear to correspond to our expectations on the influence of IT on KM: In NARI in the Gambia and in all Nigerian organizations, the ranking in IT is similar to ranking in KM. Two exceptions to this consistency were found. In MRC, a high level of ITI existed with low level of KM. In ITC, a high level of KM existed despite low level of ITI capability.

The ranking of IITA and NISER in both KM process assessment and their IT infrastructure capability tallied and reflects the way they have been able to apply the available IT infrastructure in supporting their knowledge management efforts. IITA had a well-developed IT infrastructure. NISER had a reasonable level of infrastructure, which is put into proper usage. In these two organizations, people have been able to put the IT infrastructure into proper use for the purpose of their work. NIMR and NARI had low IT infrastructure rank and they were also low in their KM assessment, thus showing the relationship between IT infrastructure and KM processes similar to IITA and NISER. MRC needs to be studied further to find out their specific deterrents to efficient KM despite high ITI capability. The performance of ITC in KM efforts could be explained by their strong focus on organizational efficiency and on research, leaving all the IT management of the small organization to be taken care of by an outside vendor (see Table 1).

ITC is the smallest among the case organizations, with about 122 staff members and attracts visitors and researchers from major agricultural research laboratories with interest in tropical agriculture. Due to their small size and their view towards IT, they do not see the need for running in-house IT department, as remarked by one interviewee. Hence they outsource the management of the IT unit to local companies.

"If your staff strength is not high, the cost benefit is not there…We have IT support from ITS and other ISP, that is better for us, because again of critical mass, there is no point hiring a permanent staff, if no computer breaks down in a month then

Table 1. Nature of IT management, IT infrastructure capability and KM rankings

Name	IT Unit	Status of the Head	Outsourced services	IT Staff No.	Est. expenditure on IT per year (in US dollars)	Total Staff Strength	ITI capabilities ranking	KM efforts ranking
MRC	Yes	Expatriate	Some	7	$ 142 243	600	2	5
NARI	Yes	Local	Some	2	Not known	211	5	4
ITC	No	N/A	All	N/A	Not known	122	4	2
IITA	Yes	Expatriate	Some	10	$ 200 000	1400	1	1
NISER	Yes	Local	Some	8	$ 8 900	500	3	3
NIMR	Yes	Local	Some	4	Not known	130	5	6

he sits down idle. If there is a problem, then we call our engineers."

The Gambia is one of the smallest countries in the sub-region. There is a shortage of IT personnel. It also shares other difficulties facing the countries in the sub-region in the areas of training and low expertise. Nevertheless, there are a few IT companies serving the needs of local businesses. We do not go into detail of the kind of agreements ITC have with the outsourcing partners. However, they tried to avoid opportunism and monopolistic bargaining by using multiple competing vendors strategy (Ngwenyama and Bryson, 1999). From our interview, we are aware that they use at least two different outsourcing partners, the Internet service provision is from one company while the regular IT management services are from another.

"Now it is difficult and we have asked for a network and we are hoping, a man was just here from QuantumNet or ITS to make a budget for Network."

IT OUTSOURCING – A STRATEGIC CHOICE FOR KM

Even though ITC had a low infrastructure services, they performed well in their knowledge management efforts. Their outsourcing decision is likely to be responsible for it. They were able to concentrate on the particular infrastructure required for their work. In ITC, the Internet is enabling collaboration among the staff and connecting them to external sources of knowledge that used to require travelling abroad in the past.

"That used to be quite a difficult thing, it was a problem, the only way you could get access to journals would be either to go to Europe in person and then do a literature search. I normally go to Wageningen every year, that's my almamater, but now I can liase with the Royal Tropical Institute in Amsterdam. I only send keywords of research topic and they will do the relevant search and send back to me abstracts. I will request the document I am interested in and they will send it to me… I get table of contents of recent journals and if something is of interest to me, I send to them by email and they send it back to me."

ITC have extended their computing infrastructure by using the Internet to exchange files even to next door.

"…we don't want to go into the cost of having a LAN, so even for me to send things next door, I go through the Internet."

Technology is seen to a vital role in knowledge management, but that technology on its own cannot make knowledge management happen (Hibbard, 1997). This was evident with ITC: their low ranking in IT infrastructure capability did not affect their KM efforts, because knowledge actually resides in people, technology can only assist in making things work more efficiently. Moreover, there was a presence of a minimum IT infrastructure supported by their outsourcing partner, which they were able to balance with other variables as suggested by Leavitt (1965). While the availability of IT infrastructure is important, support for its applications, usage, and technical components can significantly lower its usefulness.

CONCLUSION

We have discussed how IT outsourcing appeared to be having a positive effects on KM efforts of a research organization in sub-Saharan Africa. As an exception to a consistency that the availability of IT infrastructure has a direct relationship with KM efforts, we examined the concerned organization further. The outsourcing of the IT management seems to enable them to put the available IT infrastructure into proper usage and the main success factor in their KM efforts. It would be appropriate to study several organizations that have a similar arrangement to see if a similar pattern could be found before we could make any generalization. Nevertheless, there is an implication of this finding for the organizations in sub-Saharan Africa considering knowledge management as part of their strategy. This chapter implies that they might fare well by focusing on the social, cultural and organizational issues while outsource the technological component. For the researchers with interest in IT outsourcing and knowledge management, this chapter raises additional issues to be considered in the IT outsourcing and knowledge management relationship.

REFERENCES

Alavi, M. (1997, December 14-17). Knowledge management and knowledge management system. In *Proceedings of 18th International Conference on Information Systems,* Atlanta, GA.

American Productivity and Quality Center (APQC). (2000). *Knowledge management: Consortium benchmarking study final report 1996.* Retrieved April 3, 2000, from http://www.store.apqc.org/reports/Summary/know-mng.pdf

Ang, S., & Straub, D. (1998). Production and transaction economies and IS outsourcing: A study of the U.S. banking industry. *MIS Quarterly, 22*(4), 535-552.

Beveren, J. (2002). A model of knowledge acquisition that refocuses knowledge management. *Journal of Knowledge Management, 6*(1), 18-22.

Bhatt G. (2001). Knowledge management in organizations: Examining the interaction between technologies, techniques, and people. *Journal of Knowledge Management, 5*(1), 68-77.

Borghoff, U., & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management.* Berlin: Springer- Verlag.

Broadbent, M., & Weill, P. (1997). Management by Maxim: How business and IT managers can create IT infrastructures. *Sloan Management Review, 38*(3), 77-92.

Broadbent, M., Weill, P., & Neo, B. (1999). Strategic context and patterns of IT infrastructure capability. *Strategic Information Systems, 8,* 157-187.

Bukowitz, W.R., & Williams, R.L. (1999). *The knowledge management fieldbook*. London: Pearson Education Limited.

Chesbrough, H., & Teece, D. (1996). When is virtual virtuous? Organising for innovation. *Harvard Business Review, 74*(1), 70.

CIO (2000). *Knowledge management: Collaborating for a competitive edge.* CIO White Paper Library 2000. Retrieved July 26, 2001, from http://www.cio.com/sponsors/0600_km/index.html

Currie, W., & Pouloudi, A. (2000). IT outsourcing: A challenge for the management of knowledge as a resource. In J. Edwards & J. Kidd (Eds.), *The Proceedings of the Knowledge Management Conference* (pp. 364-375). The Operation Research Society, Birmingham, UK.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal, 34*(2), 62.

Goo, J., Kishore R., & Rao, H. (2000). A content-analytic longitudinal study of the drivers for information technology and systems outsourcing. *Proceedings of 21st International Conference on Information Systems (ICIS)* (pp. 601-611). Brisbane, Australia.

Hibbard, J. (1997). Knowing what we know. *InformationWeek,* October 20, 46-64.

Hirschheim, R., & Lacity, M. (2000). The myths and realities of information technology insourcing. *Communications of the ACM, 43*(2), 99-107 .

Hitt, M., Ireland, R., & Hoskisson, R. (1999). *Strategic management: Competitiveness and globalisation*. OH: South Western College Publishing.

Keen, P. (1991). *Shaping the future: Business design through information technology*. NA: Harvard Business School Press.

Ketler, K., & Willems, J. (1999). A study of the outsourcing decision: Preliminary results. In *Proceeding of ACM SIGCPR 99* (pp. 182-189). New Orleans, LA.

Lacity, M., & Hirschheim, R. (1993). *Information systems outsourcing myths, metaphors and realities*. Chichester, UK: John Wiley & Sons.

Leavitt, H.J. (1965). Applied organisational change in industry: Structural, technological, and humanistic approaches. In J. March (Ed.), *Handbook of organisations* (pp. 1144-1170). Chicago: Rand McNally & Co.

McFarlan, E., & Nolan, R. (1995, Winter). How to manage an IT outsourcing alliance. *Sloan Management Review, 36*(2), 9-26.

McKenney, J. (1995). *Waves of change: Business evolution through information technology*. MA: Harvard Business School Press.

Moyo, L. M. (1996). Information technology strategies for Africa's survival in the twenty-first century: IT all pervasive. *Information Technology for Development, 7,* 17.

Ngwenyama, O., & Bryson, N. (1999). Making the information systems outsourcing decision: a transaction cost approach to analyzing decision problems. *European Journal of Operational Research, 115*(2), 351-367.

Odedra, M., Lawrie, M., Bennett, M., & Goodman, S. (1993). International perspectives: Sub-Saharan Africa: A technological desert. *Communications of the ACM, 36*(2), 25-29.

Okunoye, A., & Karsten, H. (2001, June 10-12). *Information technology infrastructure and knowledge management in sub-Saharan Africa: Research in progress*. Second Annual Global Information Technology Management (GITM) World Conference, Dallas, TX.

Okunoye, A., & Karsten, H. (2002, January). ITI as enabler of knowledge management: empirical perspective from research organizations in sub-Saharan Africa. In *Proceedings of the 35th Hawaii International Conference on System Sciences HICSS*.

Quinn, J., & Hilmer, F. (1994, Summer). Strategic outsourcing. *Sloan Management Review, 35*(4), 43-55.

Shepherd, A. (1999), Outsourcing IT in a changing world. *European Management Journal, 17*(1), 64-84.

Slaughter, S., & Ang, S. (1996). Employment outsourcing in information systems. *Communications of The ACM, 39*(7), 47-54.

Sveiby, K. (1996). *What is knowledge management?* Retrieved March 4, 1996, from http://www.sveiby.com.au/KnowledgeManagement.html

Tyndale, P. (1997). The knowledge development cycle: from knowledge creation to knowledge distribution. In *Proceedings of the 1st European Conference On Knowledge Management,* Bled, Slovenia, 2000. Retrieved July 31, 2001, from http://www.mcil.co.uk/2a-eckm-papers2000.htm

Yin, R. K. (1994). *Case study research: Design and methods,* (2nd ed.) Newbury Park, CA: Sage Publications.

Chapter 6.15
Small Business Transformation Through Knowledge Management

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INTRODUCTION

In the last decade, the importance of knowledge as a source of sustainable competitive advantage has gained widespread acceptance. Business practitioners and academics alike recognize that what is "between the ears" (Tiwana, 2000) of their employees represents the source of creativity and innovation that nourishes and sustains the organization. Furthermore, the ability to harness the intellectual capital in an organization probably represents the most important aspect relating to the creation of an intelligent enterprise.

However, most research on the topic of knowledge management (KM) and intellectual capital has focused on larger organizations. Because small businesses account for a major portion of the total number of businesses, jobs, and growth in many world economies (Wong & Radcliff, 2000), it is important to understand the impact of knowledge management on small businesses as well. We need to understand the correlation between knowledge management practices, the ability of a small business to transform itself into an intelligent enterprise and any resulting performance or competitive improvements KM may provide.

Because a "build it and they will come" approach to knowledge management usually does not work, this article discusses and integrates the concepts of adoption and diffusion of innovations with knowledge management theories to help transform a small business into an intelligent enterprise. The ultimate goal of this chapter is to provide small businesses with some consistent theories and practices that may help improve their competitiveness in a turbulent world.

KNOWLEDGE MANAGEMENT IN SMALL BUSINESS

What is Knowledge Management?

Karl Wigg is credited with coining the term "knowledge management" (KM) at a 1986 Swiss Conference sponsored by the United Nations International Labor Organization. He defined KM as "the systematic, explicit, and deliberate building, renewal, and application of knowledge to maximize an enterprise's knowledge-related effectiveness and returns from its knowledge assets" (Wigg, 1999). Thus, KM represents an organization's ability to capture, organize, and disseminate knowledge to help create and maintain competitive advantage. It is becoming widely accepted as a key part of the strategy to use expertise to create a sustainable competitive advantage in today's business environment. It enables the organization to maintain or improve organizational performance based on experience and knowledge. It also makes this knowledge available to organizational decision-makers and for organizational activities (Beckman, 1999; Pan & Scarbrough, 1999). Therefore, we can assert that knowledge management represents a key strategy in creating and sustaining an intelligent enterprise, capable of outperforming its competitors.

Using KM in Small Business

Why is it important for small businesses to use knowledge management to become "learning organizations" or "intelligent enterprises"? According to Wong et al. (1997), "Many of the factors which have promoted the growth of SMEs also require their managers to acquire new skills. In fast-growing small firms, the management team will be constantly developing and the skills needed will change as both cause and effect of the development of the firm itself." The bottom line is that for a small business to succeed and thrive in a changing world, it must continually learn and adapt better and faster than its competitors. Knowledge management provides the tools and strategies to achieve this (Anderson & Boocock, 2002).

Guimaraes (2000) further suggests that small businesses face greater pressures from chains owned by large corporations, increased regulations and politics, and greater competition due to increasing business globalization. He asserts that innovation, facilitated by knowledge management, may be the key to their survival and success in difficult times. Chaston et al. (2001) support this view in their statement: "Organizational learning [knowledge management] is increasingly being mentioned in the literature as a mechanism for assisting small firm survival". It is "the most effective and practical way through which to increase Small and Medium-Size Enterprise (SME) sector survival rates during the early years of the new millennium". They contend that by assisting employees and facilitating their learning and knowledge sharing, they can creatively develop new products, better and more efficient processes, and identify new ways of building better relationships with customers. Thus, it appears that knowledge management techniques of acquiring, sharing and effectively using knowledge may represent a crucial means of transforming a small business into an intelligent enterprise, resulting in improved performance by facilitating innovation, idea creation, and operating efficiencies.

Influence of Adoption and Diffusion

How do adoption and diffusion factors influence KM in small businesses and their goal of becoming an intelligent enterprise? By understanding factors that facilitate the adoption and diffusion of innovations, small businesses may improve their chances of success in a knowledge management initiative. Based on many years of adoption and diffusion of innovations research, Rogers (1995) developed a model often considered the foundation for the adoption and diffusion of innovations. We include strategies and processes in the definition of "innovations" in the context of this chapter. This model proposes three main elements influencing the adoption and diffusion of innovations, including: the innovation, communication channels, and social systems.

Based on the research of Rogers and others, the factors that appear to significantly influence adoption and diffusion include the relative advantage of an innovation (the degree to which the innovation is perceived as better than what it supercedes), which is positively related to its rate of adoption and continued and effective use and the influence of culture and social systems. The social systems similarly influence people's attitudes and willingness to adopt new processes or technologies. Finally, communication channels such as mass communication and interpersonal channels have been found to be effective promotional avenues to facilitate the successful awareness and use of a new process or technologies. Other studies propose that technological change within organizations represents a cumulative learning process where firms will seek to improve and diversify their technology in areas that enable them to build upon their current strategies in technology (Alange et al., 1998). Thus, prior experience appears to influence the willingness to adopt and the rate of adoption and diffusion in addition to Rogers' variables. The concept of absorptive capacity (Cohen & Levinthal, 1990) further suggests that an organization's ability to absorb new knowledge or for an innovation to diffuse throughout is based on its prior experience with this knowledge or innovation. In terms of creating a learning organization or an intelligent enterprise, this theory says that the greater the absorptive capacity of the organization, the greater is the ability of its employees to absorb and use new knowledge effectively.

APPLICATIONS TO SMALL BUSINESS

How can these theories be applied to a small business for transformation into an intelligent enterprise? First, relying on Rogers' classic theories, a small business can easily communicate the advantages of these new technologies and practices using mass media channels, such as company newsletters, e-mail, or company meetings. After making people aware of the new KM system, the business can use interpersonal channels to effectively persuade people to try them and continue using them. By using homophilous colleagues (individuals with similar attributes such as common beliefs, education, social status and values), a small business can more effectively persuade people to adopt and then use the KM systems. These "knowledge champions" represent very important motivators and influencers because they are trusted and respected by their peers (Jones et al., 2003). This is very important because the literature is replete with cases of companies investing in new technologies and new management strategies, which are simply viewed with skepticism as the "latest fad". However, by carefully selecting peers who are trusted and respected, the adoption and diffusion process can be greatly facilitated.

Similarly, the literature describes the huge influence of culture on the effectiveness of KM systems and the development of a learning organization (intelligent enterprise). Rogers' theories can be effectively applied to the cultural aspect as well. The effect of norms, opinion leaders, and change agents can exert a profound influence on the adoption and diffusion of an innovation throughout a social system. This is because norms (culture) can exert a powerful influence on people's willingness to accept or reject an innovation depending on whether it is compatible with their existing values and norms. Therefore, by using change agents as cultural influencers, small businesses can greatly enhance the transition to becoming a learning organization/ intelligent enterprise while using knowledge management systems to provide competitive advantages. Finally, in an organizational social system, such as within a small business, a powerful individual within the organization, such as the business owner, can also exert a strong influence on the adoption and diffusion of a KM system as well as facilitating a cultural shift to becoming a learning organization. Table 1 summarizes these factors.

FUTURE TRENDS

As mentioned, small businesses often face major challenges of coping with resource deprivation. This includes not only fewer technological resources, but also less focused expertise to enable them to make critical decisions or improve

Table 1. Contributing factors to the adoption & diffusion of innovations

Success Factor	Characteristic
Innovation:	
o Relative advantage	o The perceived benefit from the innovation that makes it superior to existing tools or processes.
o Compatibility	o How well the innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters.
o Complexity	o How difficult it is to understand and use.
o Triability	o Ability to experiment with the innovation.
o Observability	o Ability to see tangible results from using it.
Communication Channels:	
o Type of communication channel	o **Communication Type:** Mass media: used for initial awareness of innovation versus interpersonal: used to persuade potential people about benefits.
o Type of individual	o **Individual Type:** Homophilous; opinion leader, knowledge champion.
Social Systems (Culture):	
o Organizational Leaders (Change Agents)	o People in a position of authority who can make the adoption decision.
o Opinion Leaders (Peers)	o Those individuals who can exert a positive influence on others to adopt and use an innovation; individuals who have similar attributes such as common beliefs, education, social status and values, who can persuade their peers to adopt the new system and change values and norms within the culture.
o Prior knowledge/ experience/ attitude towards innovation	o Attitudes and prior experience and knowledge may influence the adoption and diffusion of an innovation. The theory of absorptive capacity tells small businesses that the more knowledge they provide their employees, the greater their capacity to absorb more and become a more proactive learning organization/intelligent enterprise.

products or processes. They need to learn how to learn, change, and adapt better and faster than their competitors and better meet the needs of their customers. By understanding how they can facilitate a knowledge sharing initiative, a small business may be able to make better use of scarce resources and become more intelligent than their competitors; become better at learning, innovation and creativity. For a small business to increase the speed and effectiveness of the diffusion process for a knowledge management initiative or other processes/technologies, it may be important for them to understand the components of an innovation, communication channels, and/or social systems within the context of a small business environment.

Therefore, incorporating a knowledge management strategy holds some promise as a mechanism for small businesses to improve performance. However, the "build it and they will come" philosophy may be simplistic and an investment in knowledge sharing technologies may be wasteful if the systems are not used effectively. Therefore, small businesses should be aware of the issues associated with adoption and diffusion of knowledge management practices.

Similarly, small businesses should understand that creating a learning organization/ intelligent enterprise potentially involves huge cultural changes. Thus, a major challenge is whether a small business owner is interested in fundamentally changing the culture of the organization, including the reward and recognition structures. For example, Pan and Scarbrough (1999, 2000) found that the major challenge to implementing a knowledge management initiative was successfully overcome when the CEO initiated cultural changes that actively promoted and rewarded knowledge acquisition, knowledge sharing, and knowledge use. This led to significant performance improvements such as considerably reduced time in process for product development, reduced costs and improved customer satisfaction. However, this involved a complete commitment to cultural change by a new CEO, who made dramatic changes in the culture and the reward/recognition structures and company policies.

CONCLUSION

With respect to opportunities and challenges for SMEs, knowledge management appears to represent a mechanism for survival, growth and prosperity. As knowledge management continues to diffuse throughout the global business world, the competitive pressures may necessitate some form of KM as a pre-requisite for survival. Therefore, implementing these diffusion methods should prove beneficial to small business owners and operators.

Small businesses can benefit from understanding the factors associated with diffusion, including Roger's five major elements. Another important consideration for small businesses is the cultural issues surrounding their organizations and resources issues that will prove important to employees. By understanding these issues, small businesses may be able to tailor the adoption and diffusion of technologies or a knowledge sharing system to their unique situation, thus improving their chances for success.

While the small business studied represents only one situation, it is interesting that several consistencies with the literature emerged, lending some possible connections and conclusions between the effective diffusion of knowledge management systems and a causal relationship with improved performance. The implication is that knowledge management can facilitate the creation of a learning organization or an intelligent enterprise. This improves creativity and innovation that further enhances productivity, problem solving and customer satisfaction. By promoting a culture that continually learns and improves, organizations can develop a sustainable competitive advantage that is not easily imitated by competitors.

REFERENCES

Advocacy, O. (2001). *Small business economic indicators for 1999: Executive summary*. Washington, DC: U.S. Small Business Administration.

Alange, S., Jacobsson, S., & Jarnehammar, A. (1998). Some aspects of an analytical framework for studying the diffusion of organizational innovations. *Technology Analysis and Strategic Management, 10*(1), 3-21.

Anderson, V., & Boocock, G (2002). Small firms and internationalisation: Learning to manage and managing to learn. *Human Resource Management Journal, 12*(3), 5-24.

Beckman, J. (1999). The current state of knowledge management. In J. Liebowitz (Ed.), *Knowledge management handbook*. Boca Raton: CRC Press.

Chaston, I., Badger, B., & Sadler-Smith, E. (2001). Organizational learning: An empirical assessment of process in small U.K. manufacturing. *Journal of Small Business Management, 39*(2), 139-151.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-153.

Daugherty, P.J., Germain, R., & Droge, C. (1995). Predicting EDI technology adoption in logistics management: The influence of context and structure. *Logistics and Transportation Review, 331*(4), 309-325.

Davenport, T.H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Guimaraes, T. (2000). The impact of competitive intelligence and IS support in changing small business organizations. *Logistics Information Management, 13*(3), 117-130.

Holland, R. (1998). *Planning against a business failure*. Agricultural Extension Service, University of Tennessee, ADC Info #24.

Jones, N., Herschel, R., & Moesel, D. (2003) Using "knowledge champions" to facilitate knowledge management. *Journal of Knowledge Management, 7*(1), 49-63.

Karahanna, E., Straub, D.W., & Chervany, N.L. (1999). Information technology adoption over time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly, 23*(2), 183-213.

Kolle, C. (2001). SMEs are the 'backbone of the economy'. *Asian Business, 37*(3), 68-69.

Kwon, B. (2001). The post-WTC economy: How long a slump? *Fortune Small Business, 11*(9), 18-24.

Mcgee, M.K. (1999). Lessons from a cultural revolution- Proctor & Gable is looking to IT to change its entrenched culture- and vice versa. *Information Week*, 46-50.

McGregor, J., & Gomes, C. (1999). Technology uptake in small and medium-sized enterprises: Some evidence from New Zealand. *Journal of Small Business Management, 37*(3), 94-102.

Pan, S.L., & Scarbrough, H. (1998). A socio-technical view of knowledge-sharing at Buckman Laboratories. *Journal of Knowledge Management, 2*(1), 55-66.

Pan, S.L., & Scarbrough, H. (1999). Knowledge management in practice: An exploratory case study. *Technology Analysis & Strategic Management, 11*(3), 359-374.

Puccinelli, B. (1998). Overcoming resistance to change. *Inform, 12*(8), 40-41.

Reisenberger, J.R. (1998). Executive insights: Knowledge— the source of sustainable competitive advantage. *Journal of International Marketing, 6*(3), 94-107.

Rogers, E.M. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Scheraga, D. (1998). Knowledge management competitive advantages become a key issue. *Chemical Market Reporter, 254*(17), 3-6.

Thong, J.Y.L. (1999). An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems, 15*(4), 187-214.

Tiwana, A. (2000). *The knowledge management toolkit*. Upper Saddle River, NJ: Prentice Hall PTR.

Wigg, K.M. (1999). Introducing knowledge management into the enterprise. In J. Liebowitz (Ed.), *Knowledge management handbook*. Boca Raton: CRC Press.

Wong, C., Marshall, N., Alderman, N., & Thwaites, A. (1997). Management training in small and medium sized enterprises: Methodological and conceptual issues. *International Journal of Human Resource Management, 8*(1), 44-65.

Wong, W.L.P., & Radcliffe, D.F. (2000). The tacit nature of design knowledge. *Technology Analysis & Strategic Management, 12*(4), 493-512.

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Chapter 6.16
Transforming Small Businesses into Intelligent Enterprises through Knowledge Management

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ABSTRACT

As small businesses struggle to survive in the face of intense competitive pressures, an emerging strategy to help them involves using knowledge management tactics to harness their intellectual capital and improve their sustainable competitive advantage. This chapter discusses the issues involved with the transformation of small businesses into intelligent enterprises via knowledge management tools and strategies. However, because a "build it and they will come" approach usually leads to failed initiatives, this chapter further addresses the issues of how small businesses can successfully incorporate adoption and diffusion theories to help them effectively transform themselves into successful learning organizations or intelligent enterprises. Finally, a case study from one small business is presented to validate some of the theories.

INTRODUCTION

In the last decade, the importance of knowledge as a source of sustainable competitive advantage has gained widespread acceptance. Business practitioners and academics alike recognize that what is "between the ears" (Tiwana, 2000) of their employees represents the source of creativity and innovation that nourishes and sustains the organization. Furthermore, the ability to harness the intellectual capital in an organization probably represents the most important aspect relating to the creation of an intelligent enterprise.

However, most research on the topic of knowledge management (KM) and intellectual capital has focused on larger organizations. Because small businesses account for a major portion of the total number of businesses, jobs, and growth in many world economies (Wong & Radcliff, 2000), we need to understand the impact of knowledge management on small businesses as well. We need to understand the correlation between knowledge management practices, the ability of a small business to transform itself into an intelligent enterprise and any resulting performance or competitive improvements KM may provide.

The fact that small businesses impact world economies is well documented. In the United States, The U.S. Small Business Administration's "Small Business Economic Indicators for 1999 (2001) states, "Small businesses continued to employ more workers than large companies; they employed 68.2 million people in 1999 or 58% of the private-sector workforce." In Australia, there are about 951,000 small businesses in the private nonagricultural sector, employing 3.1 million people (Shaper & Raar, 2001). Kolle (2001) similarly states, "SMEs are the backbone of what makes Hong Kong special in world trade." Small and medium sized enterprises (SMEs) similarly account for a large percent of businesses and are responsible for the net job creation in many economies (Wong & Radcliffe, 2000).

However, the failure rate for small businesses is staggering. According to Dun & Bradstreet reports, "Businesses with fewer than 20 employees have only a 37% chance of surviving four years (of business) and only a 9% chance of surviving 10 years" (Holland, 1998). Why are small businesses so susceptible to failure? According to Wong & Radcliffe (2000), "SMEs must contend with challenges that are not as pressing in large organizations. First, they are susceptible to 'resource poverty' in technology and recruitment. They are also susceptible to external forces such as competition and changes in government regulations. They often have limited access to capital and money markets and sometimes are forced to make critical decisions without the aid of internal specialists." In addition, if knowledge is concentrated in a few key employees, the company becomes vulnerable to resource deprivation if these people leave and take their valuable knowledge with them.

Because a "build it and they will come" approach to knowledge management usually does not work, this chapter also discusses and integrates the concepts of adoption and diffusion of innovations with knowledge management theories to help transform a small business into an intelligent enterprise. It does so by presenting the results from the study of one small business. The ultimate goal of this chapter is to provide small businesses with some consistent theories and practices that may help improve their competitiveness in a turbulent world.

The rest of the chapter is organized as follows. First, the role and importance of knowledge management in a small business to create an intelligent enterprise is discussed. This discussion includes the ways a small business can enhance the adoption and diffusion of knowledge management systems to facilitate competitive advantage. Second, existing research on relationships between knowledge management and a sustainable competitive advantage in small businesses is examined to identify some challenges inherent in the process of developing successful knowledge management systems. A case study is then presented to substantiate or refute the offered theories in the context of a small business. This case study is also used to understand the process required to obtain sustained performance improvements in a small business and to transform it into an intelligent enterprise. Finally, the chapter concludes with a summary and limitations of the study findings and some fruitful directions for future research.

ROLE OF KNOWLEDGE MANAGEMENT IN SMALL BUSINESS

Why is it important for small businesses to use knowledge management to become "learning organizations" or "intelligent enterprises?" According to Wong et al. (1997), "Many of the factors which have promoted the growth of SMEs also require their managers to acquire new skills. In fast-growing small firms, the management team will be constantly developing and the skills needed will change as both cause and effect of the development of the firm itself." The bottom line is that for a small business to succeed and thrive in a changing world, they must continually learn and adapt better and faster than their competitors. Knowledge management provides the tools and strategies to achieve this (Anderson & Boocock, 2002).

What is Knowledge Management?

Karl Wigg is credited with coining the term, "knowledge management" (KM), at a 1986 Swiss Conference sponsored by the United Nations International Labor Organization. He defined KM as "the systematic, explicit, and deliberate building, renewal, and application of knowledge to maximize an enterprise's knowledge-related effectiveness and returns from its knowledge assets." Thus, KM represents an organization's ability to capture, organize, and disseminate knowledge to help create and maintain competitive advantage. It is becoming widely accepted as a key part of the strategy to use expertise to create a sustainable competitive advantage in today's business environment. It enables the organization to maintain or improve organizational performance based on experience and knowledge. It also makes this knowledge available to organizational decision-makers and for organizational activities (Beckman, 1999; Pan & Scarbrough, 1999). Therefore, we can assert that knowledge management represents a key strategy in creating and sustaining an intelligent enterprise, capable of outperforming its competitors.

Karl Wigg (1999) also described the benefits of a knowledge management system as reducing costs due to benchmarking and sharing best practices between different groups inside and outside the organization, decreasing time-in-process, reducing re-work and increasing customer satisfaction and quality. Innovations in products, services and processes can increase due to sharing of knowledge among different functional areas. Increased knowledge of customers often results in the ability to better satisfy their needs, resulting in increased market penetration and increased profit margins (Reisenberger, 1999).

In other words, if an organization can collect and store the knowledge (both tacit and explicit) of its employees in an easily accessible and searchable organizational memory mechanism, when an employee leaves the organization, all their knowledge, skills, and expertise do not necessarily leave with them. With an effective knowledge management system, the firm can prevent knowledge gaps when they lose their employees, who represent valuable sources of knowledge. Rather, that expertise and knowledge can be retained in the organizational memory. In a small business, this represents a crucial asset. Finding a way to leverage a small business' intellectual capital represents a means of lessening the problem of resource poverty and employee resignations.

Using KM in Small Business

Guimaraes (2000) further suggests that small businesses face greater pressures from chains owned by large corporations, increased regulations and politics, and greater competition due to increasing business globalization. He asserts that innovation, facilitated by knowledge management, may be the key to their survival and success in difficult times. Chaston et al. (2001) support this view in their statement, "Organizational learning [knowledge management] is increasingly being mentioned in the literature as a mechanism for assisting small firm survival." It is "the most effective and practical way through which to increase SME sector survival rates during the early years of the new millennium." They contend that by assisting employees and facilitating their learning and knowledge sharing, they can creatively develop new products, better and more efficient processes, and identify new ways of building better relationships with customers. Thus, it appears that knowledge management techniques of acquiring, sharing and effectively using knowledge may represent a crucial means of transforming a small business into an intelligent enterprise, resulting in improved performance by facilitating innovation, idea creation, and operating efficiencies.

Influence of Adoption and Diffusion

How do adoption and diffusion factors influence KM in small businesses and their goal of becoming an intelligent enterprise? By understanding factors that facilitate the adoption and diffusion of innovations, small businesses may improve their chances of success in a knowledge management initiative. Because these theories emerged from research on both large and small organizations, they serve as initial models for research in most organizations. It has been shown repeatedly that a "build it and they will come" approach usually will not work. Therefore, if small businesses understand the factors that motivate executives and associates within a small business to adopt or reject these KM practices and philosophies, KM champions can plan and implement a KM initiative with greater success.

Based on many years of adoption and diffusion of innovations research, Rogers (1995) developed a model often considered the foundation for the adoption and diffusion of innovations. We include strategies and processes in the definition of "innovations" in the context of this chapter. This model proposes three main elements influencing the adoption and diffusion of innovations including: the innovation, communication channels, and social systems.

The primary success factors are related to the innovation. According to Rogers, five main attributes of innovations can predict an innovation's rate of adoption and diffusion including: (a) the relative advantage of an innovation (the degree to which the innovation is perceived as better than what it supersedes) is positively related to its rate of adoption and continued and effective use. (b) The perceived compatibility (the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters) of an innovation is positively related to its rate of adoption and continued and effective use. Furthermore, if the technology can be standardized in its use, the rate of adoption and diffusion will increase (Alange et al., 1998). (c) The perceived complexity (the degree to which an innovation is perceived as relatively difficult to understand and to use) of an innovation is negatively related to its rate of adoption. (d) The perceived triability (the degree to which an innovation may be experimented with on a limited basis) is positively related to its rate of adoption. (e) The perceived observability (the degree to which the results of an innovation are visible to others) is positively related to its rate of adoption.

Other studies propose that technological change within organizations represents a cumulative learning process where firms will seek to improve and diversify their technology in areas that enable them to build upon their current strategies in technology (Alange et al., 1998). Thus, prior experience appears to influence the willingness to adopt and the rate of adoption and diffusion in addition to Rogers' variables. The concept of absorptive capacity (Cohen & Levinthal, 1990) further suggests that an organization's ability to absorb new knowledge or for an innovation to diffuse throughout is based on its prior experience with this knowledge or innovation. In terms of creating a learning organization, or an intelligent enterprise, this theory says that the greater the absorptive capacity of the organization, the greater is the ability of its employees to absorb and use new knowledge effectively.

Applications to Small Business

How can these theories be applied to a small business for transformation into an intelligent enterprise? First, relying on Rogers' classic theories, a small business can easily communicate the advantages of these new technologies and practices using mass media channels, such as company newsletters, e-mail, or company meetings. After making people aware of the new KM system, the business can use interpersonal channels to effectively persuade people to try them and continue using them. By using homophilous colleagues (individuals with similar attributes such as common beliefs, education, social status and values), a small business can more effectively persuade people to adopt and then use the KM systems. These "knowledge champions" represent very important motivators and influencers because they are trusted and respected by their peers (Jones et al., 2003). This is very important because the literature is replete with cases of companies investing in new technologies and new management strategies, which are simply viewed with skepticism as the "latest fad". However, by carefully selecting peers who are trusted and respected, the adoption and diffusion process can be greatly facilitated.

Similarly, the literature describes the huge influence of culture on the effectiveness of KM systems and the development of a learning organization (intelligent enterprise). Rogers' theories can be effectively applied to the cultural aspect as well. The effect of norms, opinion leaders, and change agents can exert a profound influence on the adoption and diffusion of an innovation throughout a social system. This is because norms (culture) can exert a powerful influence on people's willingness to accept or reject an innovation depending whether it is compatible with their existing values and norms. Therefore, by using change agents as cultural influencers, small businesses can greatly enhance the transition to becoming a learning organization/ intelligent enterprise while using knowledge management systems to provide competitive advantages. Finally, in an organizational social system, such as within a small business, a powerful individual within the organization, such as the business owner, can also exert a strong influence on the adoption and diffusion of a KM system as well facilitating a cultural shift to becoming a learning organization.

Both leaders and opinion leaders often need to help workers unlearn or abandon earlier, often deeply entrenched practices in order to break the status quo inertia before a new technology or system will be fully adopted and used. Subordinates will often observe the behavior of their managers to find out what is really important, emphasizing the need for involvement by managers and top executives in this process. The CEO's innovativeness and IS knowledge were also found to contribute positively to the adoption decision (Alange et al., 1998; Thong, 1999; Daugherty et al., 1995).

In several studies on small business (Thong, 1999; Daugherty et al., 1995), results showed that businesses with a positive attitude toward technology were more likely to adopt, emphasizing the importance of relative advantage, compatibility, and complexity. The CEO's innovativeness and IS knowledge were also found to contribute positively to the adoption decision. In addition, the greater the employee knowledge and experience with technology, the more likely was the adoption decision as well as continued use of the technology. In a study of technology uptake in small businesses in New Zealand (McGregor &

Gomes, 1999), they found that small businesses required extensive external sources of information to facilitate first the awareness of need for the adoption of new technologies. Therefore, in terms of relevance to creating an intelligent enterprise via KM systems, the moral of the story for small businesses is to provide a compelling reason for employees to create an intelligent enterprise, have strong leadership support and a culture that facilitates this endeavor. Table 1 summarizes these factors.

Inherent Challenges

As mentioned, small businesses often face major challenges in coping with resource deprivation. This includes not only fewer technological resources, but also less focused expertise to enable them to make critical decisions or improve products or processes. They need to learn how to learn, change, and adapt better and faster than their competitors and better meet the needs of their customers. By understanding how they can

Table 1. Contributing factors to the adoption and diffusion of innovations

Success Factor	Characteristic
Innovation:	
o Relative advantage	o The perceived benefit from the innovation that makes it superior to existing tools or processes.
o Compatibility	o How well the innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters.
	o How difficult it is to understand and use
o Complexity	o Ability to experiment with the innovation
o Triability	o Ability to see tangible results from using it.
o Observability	
Communication Channels:	
o Type of communication channel	o **Communication Type**: Mass media: used for initial awareness of innovation vs. Interpersonal: used to persuade potential people about benefits.
o Type of individual	o **Individual Type**: Homophilous; opinion leader, knowledge champion.
Social Systems (Culture):	
o Organizational Leaders (Change Agents)	o People in a position of authority who can make the adoption decision
o Opinion Leaders (Peers)	o Those individuals who can exert a positive influence on others to adopt and use an innovation; individuals who have similar attributes such as common beliefs, education, social status and values, who can persuade their peers to adopt the new system and change values and norms within the culture.
o Prior knowledge/ experience/ attitude towards innovation	o Attitudes and prior experience and knowledge may influence the adoption & diffusion of an innovation. The theory of absorptive capacity tells small businesses that the more knowledge they provide their employees, the greater their capacity to absorb more and become a more proactive learning organization/intelligent enterprise.

facilitate a knowledge sharing initiative, a small business may be able to make better use of scarce resources and become more intelligent than their competitors; become better at learning, innovation and creativity. For a small business to increase the speed and effectiveness of the diffusion process for a knowledge management initiative or other processes/technologies, it may be important for them to understand the components of an innovation, communication channels, and/or social systems within the context of a small business environment.

Therefore, incorporating a knowledge management strategy holds some promise as a mechanism for small businesses to improve performance. However, the "build it and they will come" philosophy may be simplistic and an investment in knowledge sharing technologies may be wasteful if the systems are not used effectively. Therefore, small businesses should be aware of the issues associated with adoption and diffusion of knowledge management practices.

Similarly, small businesses should understand that creating a learning organization/intelligent enterprise potentially involves huge cultural changes. Thus, a major challenge is whether a small business owner is interested in fundamentally changing the culture of the organization including the reward and recognition structures. For example, Pan and Scarbrough (1999, 2000) found that the major challenge to implementing a knowledge management initiative was successfully overcome when the CEO initiated cultural changes that actively promoted and rewarded knowledge acquisition, knowledge sharing, and knowledge use. This led to significant performance improvements such as considerably reduced time in process for product development, reduced costs and improved customer satisfaction. However, this involved a complete commitment to cultural change by a new CEO, who made dramatic changes in the culture and the reward/recognition structures and company policies.

EMPIRICAL INVESTIGATION

In an effort to validate or refute the literature, a small study was undertaken to examine factors influencing the diffusion, as well as the continued, effective use of a knowledge management collaborative technology within one small business. Knowledge sharing is acknowledged as a critical component within a knowledge management system. Because this small business, a contract research organization, was considered knowledge intensive, the effective diffusion and implementation of a knowledge sharing technology was considered a significant goal.

In this study, an assumption was made that within an organizational setting, top managers make most adoption decisions. Therefore, the adoption by subordinate users throughout the organization represented a forced adoption. Therefore, the initial adoption decision was not considered. Rather, the primary focus was on the continued and effective use of the technology after the initial adoption; a specific focus on how and why people might be willing and motivated to use or to resist using a particular technology effectively.

The sample consisted of 37 users of a knowledge-sharing collaborative technology. This technology, called BSCW (Basic Support for Cooperative Work, http://bscw.gmd.de/) represented a Web-based system that enables collaboration over the Web, allowing users to share knowledge irrespective of time or location. The convenience sample was drawn from a total user population of approximately 50. There were approximately 250 employees in this small business. E-mail was sent to all 50 users requesting an in-depth interview. Thirty-seven people agreed to be interviewed on their perceptions of use, benefits, and obstacles in knowledge sharing. This sample included five of the six top executives, who represented the heaviest users of the system. These individuals included the president/CEO, three of the four vice presidents, and the chief financial officer. In addition, five of the six business development (marketing) managers, who represented moderate users, were interviewed as well as the director of information systems. Finally, from the remaining pool of approximately 37 occasional-moderate users, 20 were selected by using a quota system to represent the remaining functional areas. Eight managers, four quality-assurance/compliance, and eight data entry people agreed to be interviewed. In addition, actual usage of this collaborative technology was monitored on a daily basis during an eight-month study period.

While this was an exploratory study in one small business, the results both supported and refuted the literature. One general finding was that, in this business, not all of the factors were found to be equally important in the diffusion and effective use of a knowledge sharing system.

The major finding was that perceived relative advantage was the major influence on usage to facilitate knowledge sharing. The second major finding was that leadership influence was also very important in the effective use of a knowledge sharing system. While this was a forced adoption situation, this finding is based on the issue of accountability in using the system. When employees knew that they were being monitored and evaluated in terms of their use, it motivated their effective and continued use of this knowledge sharing system. Therefore, the second finding combines the aspect of leadership influence with a reward/compensation structure that is integrally tied in with a knowledge sharing initiative.

Performance Improvements

Did this create performance improvements and make this small business a better intelligent enterprise? Respondents clearly articulated their enthusiasm for using BSCW to share information and knowledge with statements emphasizing the large efficiency, timesavings, and quality gains derived from having access to needed information regardless of time or physical location. Another benefit cited from relative advantage was the ability to share information with multiple users as well as the issue of accountability introduced by the collaborative system. Accountability provided by a version control system was perceived as increasing quality and timeliness of input. Therefore, it does appear that the successful adoption and diffusion of this knowledge management system did contribute to some extent to some performance gains in the organization. It could also be asserted that this small business did increase its learning capability and became a better and more effective intelligent enterprise because people who used the KM systems were able to better share knowledge, solve problems, and increase efficiency and customer satisfaction.

Adoption of Knowledge Management

Why did people in this small business adopt this KM system? Again, relative advantage emerged as the factor that contributed to the adoption and continued, effective use of this knowledge sharing system. The employees could clearly see that using this system saved them time and improved their performance. They were also able to see that sharing ideas led to better ideas and better solutions to problems.

Many researchers including Pan and Scarbrough (1999), Reisenberger (1999), and Puccinelli (1998) among others stressed the critical need for strong and active executive commitment to and support of a collaborative technology to facilitate knowledge sharing. They suggested that leaders not only champion the collaborative system and knowledge sharing, but also possess the power and authority to invest in the needed technology, create the collaborative culture to enable it, and to create reward/incentive structures to reinforce it. In this particular organization, the forced adoption of a new technology appeared to have a powerful influence on adoption and continued, effective use of the collaborative technology to facilitate knowledge sharing.

Scheraga (1998) suggests that the best way to overcome employee resistance to sharing their knowledge was to reward them for it. Reisenberger (1999) similarly contends that top management needs to develop new reward systems to recognize and reward knowledge sharing activities. Pan and Scarbrough (1999) documented the success of rewarding employees for sharing their valuable knowledge at Buckman Laboratories. Rogers (1995) found that the main function for incentives was to increase the degree of relative advantage for the innovation. In this study, many respondents in the interviews acknowledged the benefit of some sort of incentive or reward system with the belief that people do what they are rewarded for. Interestingly, a large number of respondents indicated that incentives would be useful to initially help people overcome their fear of or resistance to using a new technology or sharing knowledge.

Lessons Learned

By understanding the factors that motivate employees in a small business to adopt and embrace the new systems and culture necessary for knowledge management, it may be possible for small business owners and managers to recreate this. The first factor involved the importance of relative advantage. Perhaps we can speculate that human nature provides the answer here. The "what's in it for me" effect may provide the common sense answer. When people see a clear reason for using the new technology such as reduction in time leading to greater efficiency in their work, they see a compelling reason to actively use this new technology regardless of the size of the company. Therefore, in any organization, it is wise to demonstrate the benefits (relative advantage) it will provide the users.

In addition, consistent with the literature, was the need to gain top leadership commitment and support before introducing new technologies for effective diffusion. Inherent in this recommendation is a reward/compensation structure directly related to the initiative. Users should be held directly accountable for their relevant and valuable contributions to knowledge sharing as well as use of the system. A direct cause and effect relationship with the annual performance evaluation appears to work well.

Another consistency with the literature was that users expect innovations to be compatible with their normal work routines and easy to use. This is especially important in a small business where resources for training and time are especially scarce. Users also expect a knowledge sharing system to be recent and relevant. The element of trust is also crucial. Davenport and Prusak (2000) explain that if employees do not trust the information or knowledge contained in the system, they will not use it. Similarly, if people do not trust that they will be rewarded for sharing their valuable knowledge, they will not be motivated to do so.

Limitations of the Research

One small study cannot provide the generalizations needed to promote acceptance of theories by small business practitioners. However, it was rewarding to see that the results of this one small study did reinforce the findings of many researchers from larger studies including the importance of relative advantage, leadership support, and cultural change. In addition, the context of this study was industry specific, focusing on a contract research business in the scientific arena. Therefore, we cannot assert that these findings would be generalizable to other, dissimilar industries. However, in the context of understanding human nature, it seems reasonable to speculate that these variables may be consistent across different industries.

Some Fruitful Directions for Future Research

Based on the limitations mentioned in the previous section, we recommend continued research on the strongest variables including relative advantage, leadership support, and cultural change in different industries and across different cross sections of SMEs with varying sizes, cultures, and product/service lines. In addition, research is greatly needed on causal relationships between the use of knowledge management practices and their impact on real transformation into learning organizations/intelligent enterprises, and whether significant performance improvements can be measured and correlated. The field of metrics associated with knowledge management, intelligent enterprises and specific performance improvements is still in its infancy and represents a fruitful line of research in itself.

CONCLUSION

With respect to opportunities and challenges for SMEs, knowledge sharing appears to represent a mechanism for survival, growth and prosperity. As knowledge management continues to diffuse throughout the global business world, the competitive pressures may necessitate some form of KM as a prerequisite for survival. Therefore, implementing these diffusion methods should prove beneficial to small business owners and operators.

Small businesses can benefit from understanding the factors associated with diffusion including Rogers' five major elements. Another important consideration for small businesses is the cultural issues surrounding their organizations and resource issues that will prove important to employees. By understanding these issues, small businesses may be able to tailor the adoption and diffusion of technologies or a knowledge sharing system to their unique situation, thus improving their chances for success.

While the small business studied represented only one situation, it is interesting that several consistencies with the literature emerged, lending some possible connections and conclusions between the effective diffusion of knowledge management systems and a causal relationship with improved performance. The implication is that knowledge management can facilitate the creation of a learning organization or an intelligent enterprise. This improves creativity and innovation that further enhances productivity, problem solving and customer satisfaction. By promoting a culture that continually learns and improves, organizations can develop a sustainable competitive advantage that is not easily imitated by competitors.

REFERENCES

Advocacy, O. (2001). *Small business economic indicators for 1999: Executive summary, Small Business Economic Indicators for 1999.* Washington, DC: U.S. Small Business Administration.

Alange, S., Jacobsson, S., & Jarnehammar, A. (1998). Some aspects of an analytical framework for studying the diffusion of organizational innovations. *Technology Analysis and Strategic Management, 10*(1), 3-21.

Anderson, V., & Boocock, G (2002). Small firms and internationalisation: Learning to manage and managing to learn. *Human Resource Management Journal, 12*(3), 5-24.

Beckman, J. (1999). The current state of knowledge management. In J. Liebowitz (Ed.), *Knowledge management handbook* . Boca Raton, FL: CRC Press.

Chaston, I., Badger, B., & Sadler-Smith, E. (2001). Organizational learning: An empirical assessment of process in small UK manufacturing. *Journal of Small Business Management, 39*(2), 139-151.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-153.

Daugherty, P. J., Germain, R., & Droge, C. (1995). Predicting EDI technology adoption in logistics management: The influence of context and structure. *Logistics and Transportation Review, 331*(4), 309-325.

Davenport, T. H., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Guimaraes, T. (2000). The impact of competitive intelligence and IS support in changing small business organizations. *Logistics Information Management, 13*(3), 117-130.

Holland, R. (1998) *Planning against a business failure*. Agricultural Extension Service, University of Tennessee, ADC Info #24.

Jones, N., Herschel, R., & Moesel, D. (2003). Using "knowledge champions" to facilitate knowledge management. *Journal of Knowledge Management, 7*(1), 49-63.

Karahanna, E., Straub, D. W., & Chervany, N. L. (1999). Information technology adoption over time: A cross-sectional comparison of pre-adoption and post-adoption beliefs. *MIS Quarterly, 23*(2), 183-213.

Kolle, C. (2001). SMEs are the 'backbone of the economy.' *Asian Business, 37*(3), 68-69.

Kwon, B. (2001). The post-WTC economy: How long a slump? *Fsb: Fortune Small Business, 11*(9), 18-24.

Mcgee, M. K. (1999). Lessons from a cultural revolution- Proctor & Gable is looking to IT to change its entrenched culture- and vice versa. *Information Week,* 46-50.

McGregor, J., & Gomes, C. (1999). Technology uptake in small and medium-sized enterprises: Some evidence from New Zealand. *Journal of Small Business Management, 37* (3), 94-102.

Pan, S. L., & Scarbrough, H. (1998). A socio-technical view of knowledge-sharing at buckman laboratories. *Journal of Knowledge Management, 2*(1), 55-66.

Pan, S. L., & Scarbrough, H. (1999). Knowledge management in practice: An exploratory case study. *Technology Analysis & Strategic Management, 11*(3), 359-374.

Puccinelli, B. (1998). Overcoming resistance to change. *Inform, 12*(8), 40-41.

Reisenberger, J. R. (1998). Executive insights: Knowledge—The source of sustainable competitive advantage. *Journal of International Marketing, 6*(3), 94-107.

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: The Free Press.

Scheraga, D. (1998). Knowledge management competitive advantages become a key issue. *Chemical Market Reporter, 254*(17), 3-6.

Thong, J. Y. L. (1999). An integrated model of information systems adoption in small businesses. *Journal of Management Information Systems, 15*(4), 187-214.

Tiwana, A. (2000). *The knowledge management toolkit.* Upper Saddle River, NJ: Prentice Hall.

Wigg, K. M. (1999). Introducing knowledge management into the enterprise. In J. Liebowitz (Ed.), *Knowledge management handbook* . Boca Raton, FLA: CRC Press.

Wong, C., Marshall, N., Alderman, N., & Thwaites, A. (1997). Management training in small and medium sized enterprises: Methodological and conceptual issues. *International Journal of Human Resource Management, 8*(1), 44-65.

Wong, W. L. P., & Radcliffe, D. F. (2000). The tacit nature of design knowledge. *Technology Analysis & Strategic Management, 12*(4), 493-512.

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Chapter 6.17
Market of Resources as a Knowledge Management Enabler in VE

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INTRODUCTION

Knowledge is, undoubtedly, an indispensable asset for organizations to compete effectively (Alavi & Leidner, 2001; Murray, 2002).

New organizational models, such as the virtual enterprise (VE) model, characterized as dynamically reconfigurable information-based global networked structures, are emerging. New technological environments and solutions are being developed to support them, and the importance of knowledge and the capability of managing it by creating the organizational conditions that facilitate the generation, sharing, and application of knowledge are more and more critical.

In a global organization, as defended by Kluge, Stein, and Licht (2001), face-to-face relationships are not possible, giving rise to difficulties in accepting knowledge from outside. This applies more deeply in virtual enterprises (or in virtual organizations) in the interactions among the independent partners who tend more and more to fear the leakage of private knowledge. This situation promotes competition and rivalry and, as suggested by Prahalad and Hamel (1990), impedes collaboration and knowledge sharing, precisely two of the main underlying issues of this organizational model. A supporting environment, such as the market of resources proposed by the authors, is the way to assure effective knowledge management between the members of a virtual enterprise and business strategic alignment enabling the performance improvement of the VE.

In an environment to support VE integration, knowledge management is simultaneously a tool and an object. As a tool, knowledge management can be used by the market of resources to reduce transaction costs in VE integration and VE reconfiguration; as an object, knowledge must be protected and knowledge leakage prevented to assure trust and protection of VE participants.

The broker (an integrating element of the market of resources) is, besides other attributions, responsible for advising the VE owner in identifying and communicating the role of knowledge management within the VE business plan and for ensuring the permanent alignment between business strategy and knowledge strategy within the network of independent enterprises that constitute the VE. The broker must ensure that the global knowledge sharing is not threatened by deficient knowledge management procedures and, simultaneously, that any instance of the VE (as a reconfigurable network) at a given time, is able to respond to the market requirements with its maximum performance, that is, is business aligned.

In this article, we introduce the VE disabling factors and the functionalities for VE integration, briefly present the market of resources as an environment to support VE integration, assuring business alignment and knowledge management, identify the main strengths and problems associated with the implementation of knowledge management functions, and, finally, discuss the main opportunities associated to the implementation and exploitation of the market of resources.

BACKGROUND: VIRTUAL ENTERPRISE INTEGRATION

The virtual enterprise model can be viewed as a global networked and information-based organizational structure in dynamic adaptation (reconfiguration) to the market or business requirements. Virtual enterprises (in a broad sense) are defined as enterprises with integration and reconfiguration capability in useful time, integrated from independent enterprises, primitive or complex, with the aim of taking profit from a specific market opportunity (Byrne, 1993; Camarinha-Matos & Afsarmanesh, 1999; Cunha, Putnik & Ávila, 2000; Preiss, Goldman & Nagel, 1996; Putnik, 2000). After the conclusion of that opportunity, the virtual enterprise dissolves itself. During its lifetime, the VE changes its physical structure (reconfigures) to be permanently aligned with that market opportunity.

We designate, by resource, any function, service, or product provided by independent enterprises (resources providers), candidates to integrate a VE. The resource is a recursive construct; resources can be primitive or complex where a complex resource consists on a meaningful combination of primitive resources.

There are several factors determining the performance of the VE model. In the BM_Virtual Enterprise Architecture Reference Model (BM_VEARM) (Putnik, 2000), the author presents "fast adaptability" or "fast reconfigurability" as the most important characteristic for the competitive enterprise, enabling the agile alignment with the market.

In this section, we introduce the VE disabling factors, the tools proposed to overcome the disabling factors, and the functionalities required to efficiently implement this organizational model.

The Virtual Enterprise Disabling Factors

The main critical aspects associated with the recent concept of dynamically reconfigurable global networked structures; that is, the main factors against networking and reconfigurability dynamics are the transaction costs and the leakage of private knowledge.

In an ideal business environment, a firm makes an informed assessment of the relevant costs, benefits, and risks of outsourcing vs. internal procurement. If there exists a profitable opportunity to outsource a service or operation, the client and the suppliers enter into a contract with full knowledge of the nature of the work, signing a complete and explicit written agreement covering all aspects of the outsourced service and payments, eventually including contingency plans. But in most contractual relationships, things do not happen this way; processes are much more complex than idealized.

In concrete, when integrating a VE rather than outsourcing a service or a set of simple products or operations, difficulties arise. Selection, negotiation, contractualization, and enforcement can be too complex and too delicate. There is a vast spectrum of available resources providers, each with different characteristics, leading to difficult selection and integration decisions.

The costs of outsourcing are composed of both the explicit cost of carrying out the transaction as well as hidden costs due to coordination difficulties and contractual risks. The major costs associated with outsourcing include (1) the transaction costs and (2) the leakage of private knowledge.

Transaction Costs

Transaction costs include the time and expense of negotiating, writing, and enforcing contracts. They include the adverse consequences of opportunistic behavior, as well as the costs of trying to prevent it. In the VE model, transaction costs are the firm (re)configuration costs, associated with partners search, selection, negotiation, and integration as well as permanent monitoring and the evaluation of the partnership performance (Cunha & Putnik, 2003a). If externalizing functions can involve high transaction costs, networking relies intensively on extending the enterprise boundaries, partnering functions, and the VE model is extremely dependent not only on networking but on dynamically reconfiguring. This way, the implementation of the VE concept requires tools to overcome the transaction costs barrier, and knowledge management is a tool, assured by the market of resources, supported by an intelligent knowledge base and by the human brokerage function.

Leakage of Private Knowledge

The preservation of firm's knowledge on organizational and management processes is the firm's competitive factor.

A firm's private knowledge is based on information that no one else knows and gives a firm an advantage in the market. Most of the time, this private knowledge is a core competitive advantage that distinguishes a firm from its competitors (Prahalad & Hamel, 1990). It may concern production know-how, product design, or consumer information.

Networking or partitioning tasks between resource providers increases the risk of losing control of such type of information, which only through complete contractual agreements, could be safeguarded and, furthermore, through an environment assuring trust and accomplishment of the duty of seal. The implementation of the VE model enables the preservation of the firm's knowledge.

Overcoming the Disabling Factors

The implementation of networked and dynamically reconfigurable organizations requires the existence of tools and environments that overcome these two disabling factors, improving knowledge management and allowing dynamics as high as required to assure business alignment. The main tools suggested in the BM_VEARM (Putnik, 2000) for managing, controlling, and enabling networking and dynamics are:

- The market of resources is the environment for enabling and management of efficient configuration and assuring virtuality at low transaction costs and reduced risk of knowledge leakage, this last requiring particular attention by the definition of knowledge management procedures.
- The broker or organization configuration manager is the main agent of agility and virtuality, acting either between two operations of the VE (off-line reconfigurability, providing agility only) or online with the operation (online reconfigurability, providing virtuality and a higher level of agility).
- Virtuality that makes possible the transition from one physical structure (instance) to another in a way that the enterprise or process owner is not affected by the system reconfiguration and is not aware of the reconfiguration (the underlying service structure and reconfiguration process are hidden).

Functionalities for Virtual Enterprise Integration

The organizational challenges of (1) partitioning tasks among partners in the distributed networked environment so that they fit and take advantage of the different competencies in an VE, (2) integration of the same, (3) coordination and reconfigurability management in order to keep alignment with the market requirements are of main concern and can determine the success or failure of a VE project.

As discussed in (Cunha & Putnik, 2004, 2005), in order to achieve its maximum competitiveness, that is, to be competitive in delivery time, quality, and cost and to yield satisfactory profit margins, the implementation of the VE model requires a supporting environment assuring two main interrelated aspects (designated virtual enterprise requirements): (1) Reconfigurability dynamics (assuring fast transition between VE instantiations) and (2) Business alignment (maintaining the VE aligned with the market).

An environment designed to assure the two above-mentioned VE requirements should present as main characteristics the ability of (1) flexible and almost instantaneous access to the optimal resources to integrate in the enterprise, negotiation process between them, selection of the optimal combination and its integration; (2) design, negotiation, business management, and manufacturing management functions independently from the physical barrier of space; (3) minimization of the reconfiguration and integration time; and (4) managing knowledge within each instance of the integrated network.

The first characteristic implies the existence of a market of independent candidate resources for integrating a virtual enterprise. This market role is (a) to provide the environment and technology and the corresponding procedure protocols, that is, an open system architecture for the efficient access to resources, efficient negotiation between them, and its efficient integration and (b) to provide a domain for selection of participant resources providers in a VE, large enough to assure good options.

The second characteristic implies the utilization of advanced information and communication technologies to the operation of the market of independent resources, that is, technologies providing technical conditions to efficiently access to the globally distributed resources providers, efficient negotiation between them, and its efficient integration.

The third characteristic is necessary in order to provide flexibility, as high as possible, that is, reconfigurability as fast as possible.

The fourth characteristic is assured by the broker, supported by the market of resources knowledge base and information infrastructure by specific contractual agreements settled by the market of resources between the involved parties in a given VE instance and by a VE management regulation.

Any environment attempting to support the VE model, that is, to assure VE dynamic integration and business strategic alignment should implement a set of functionalities traducing the VE requirements, which, as proposed in Cunha, Putnik and Carvalho (2002), include:

- Responsiveness or almost real-time answer, as one instantaneous physical structure (or one instance) of a virtual enterprise may last (on the limit) only for a few days or even hours. It should be possible to reduce negotiation time and time-to-contract.
- The permanent alignment of the VE with the market (business) requirements, which can justify a dynamic process of VE performance evaluation and the analysis of reconfiguration opportunities.
- The ability to find the right potential partners and further efficient negotiation are essential; this should require a normalized description of products, operations, and services (resources) participating in the environment.
- Monitoring the performance of every integrated resource, increasing trust and the highest possible performance of the VE.
- Risk minimization through contractual agreements.
- Provision of knowledge in VE creation/reconfiguration through appropriate algorithms, artificial intelligence support, intelligent knowledge base, and brokerage systems.

MARKET OF RESOURCES: AN ENVIRONMENT FOR VIRTUAL ENTERPRISE INTEGRATION

Offer and demand are usually matched under several different circumstances from unregulated search to oriented search, from simple intermediation mechanisms to the market mechanism, all of them with the possibility of being either manually performed or automated (Cunha, Putnik & Gunasekaran, 2002). A marketplace of resources providers will enable the matching between firms looking for potential partners for integration and firms offering their resources, facilitating VE integration, and offering to participants a larger number of business opportunities.

Several supporting infrastructures and applications must exist before we can take advantage of the VE organizational model such as electronic markets of resources providers, legal platforms, brokerage services, efficient and reliable global information systems, electronic contractualization and electronic negotiation systems, and software tools (Carvalho, Putnik & Cunha, 2002; Cunha, Putnik & Carvalho, 2002).

The authors have proposed the market of resources concept as an alternative to existing applications, which were developed to support isolated activities within supply chains such as partners search and selection, negotiation, and enterprise collaboration but without the purpose of responding to the VE requirements.

The market of resources is an institutionalized organizational framework and service assuring the accomplishment of the competitiveness requirements for VE reconfigurability dynamics, business alignment, quality assurance, trust and optimization in resources utilization, and quick response to market. It is an alternative to the dispersedly developed Internet-based solutions that can be used to support search and selection of partners to integrate in a given supply chain.

The operational aspect of the market of resources consists on an Internet-based intermediation service, mediating offer and demand of resources to dynamically integrate in a VE, assuring low transaction costs (demonstrated in (Cunha & Putnik, 2003a, b)) and the partners' knowledge preservation. Brokers act within the market of resources as intermediation agents for agility and virtuality (Ávila, Putnik & Cunha, 2002) and, simultaneously, as knowledge management promoters and consultants.

In this virtual environment, offer corresponds to participants (enterprises, resources providers) that make their resources available, as potential partners for VE integration, and demand corresponds to the client (or VE owner), the entity looking for a product, components, or operations (resources) to create/integrate/reconfigure a VE to satisfy the customer.

The service provided by the market of resources is supported by (1) a knowledge base of resources and results of the integration of resources in previous VE, (2) a normalized representation of information, (3) intelligent agent and algorithms, (4) a brokerage service, and (5) a regulation covering management of negotiation and integration processes. It is able to offer (1) knowledge for VE selection of resources, negotiation, and its integration; (2) specific functions of VE operation management; and (3) contracts and formalizing procedures to assure the accomplishment of commitments, responsibility, trust, and deontological aspects, envisaging the integrated VE accomplishes its objectives of answering to a market opportunity (Cunha, Putnik & Gunasekaran, 2002).

A comprehensive explanation of the market of resources structure and operation can be found in Cunha et al. (2005).

MARKET OF RESOURCES: AN ENVIRONMENT FOR KNOWLEDGE MANAGEMENT AND BUSINESS ALIGNMENT

In the context of VE integration, by aligning, we mean the actions to be undertaken to gain synergy between business, that is, the market opportunity (or business opportunity) and the provision of the required product with the required specifications at the required time with the lowest cost and the best possible return (financial or other) (Cunha & Putnik, 2005). In particular, we propose alignment strategies between business and the integration of resources in a VE to answer to a market opportunity, supported by the environment of a market of resources.

The Market of Resources Entities and Relationships

As introduced in Cunha and Putnik (2005), the entities present at the market of resources are:

1. Clients (or VE owner): Those looking for a product, components, or operations to integrate a VE, according to a VE project. Information considered relevant concerns the product to be produced and its process plan, the negotiation parameters, project constraints, and so forth.
2. Virtual Enterprise: The set of integrated resources providers respecting the VE project, able to answer to a market opportunity. The VE created/reconfigured is itself a complex entity, constituted by the client and the resources integrated to provide the operations to manufacture the product or its parts. The resulting VE is expected to produce the specified product, according to the process plan defined by the client, respecting all the project constraints. Information considered relevant concerns the network structure, dependencies between the resources providers, the contract and commitments between them and the client, and all the details in order to manage the process.
3. Resources Providers (enterprises registered in the market of resources to specifically provide resources or add value to products or processes): Resources providers are mapped into resources (products and operations). Information considered relevant concerns the enterprise, its structure, products/operations provided, conditions, and negotiation

details. The same enterprise can be present in the market offering several resources.

4. Products (we are including services in this entity): Resources providers are mapped into components or parts of products. Information considered relevant concerns conditions in which resources providers provide each product or part, negotiation details, and availability.
5. Operations: Associated to each component of a product; elementary operations performed by resources providers while executing an operation on a specific product or part. Resources providers are mapped into operations, and operations are mapped into products. Information considered relevant concerns conditions under which resources providers provide each operation, negotiation details, information to allow further production control, and evaluation.

Knowledge Management and Business Alignment in Virtual Enterprise Integration

Business alignment in VE integration is complex and challenging, as alignment has to incorporate immaterial components in the relationships within the integration of resources. It is not just an internal strategy but a set of integrated and interrelated integration strategies that must be verified so that the integrated VE is able to meet the objective giving rise to the VE itself, that is, to meet the market requirements (Cunha et al., 2005). Business strategic alignment is a matter for knowledge management.

The introduction of the VE concept and of the corresponding supporting environments requires the definition of business alignment strategies. If organizations respond to market requirements (end-users requirements), traducing these requirements into a project of VE and pushing them along the process of selection and integration of resources providers under the format of a VE, the role of the market of resources is to assure the permanent (dynamic) alignment of the resulting VE with the market. The market of resources is the environment enabler for efficiency and effectiveness in the integration process, thus, generating, sharing, and using knowledge to strategically align the virtual enterprise with business.

Strategic alignment between business and VE integration involves a mix of dependencies between market requirements, product requirements, and resource providers requirements.

The market of resources must assure the client the alignment between the market and the resources providers selected and integrated in the VE. Also, the market of resources must try to assure that the client has correctly captured the market requirements, which is a task performed by a broker. This way, the process must align the client with the market (business) and then align the resources (by the selection and integration processes) with the client and business (Cunha & Putnik, 2005).

Integrating a VE corresponds to aligning the five entities of the previous section with business. The market of resources is expected to guide the client in aligning the VE with the market opportunity. The process consists on pushing downstream the market requirements.

The referential for alignment proposed in Cunha and Putnik (2005) considers:

1. Market Alignment (alignment with customer or market requirements): Before the creation of the VE, the client traduces the customer requirements into product specifications and projects the system of resources for the VE. The VE project consists on the generic identification of the characteristics of the resources that will accomplish the execution of the process plan to the required product, that is, the process plan that will allow the production of the product verifying the market requirements.

2. Product/Service and Operations Alignment: Aligning the product with the specifications, that is, with the market requirements. Operations provided by the selected resource providers must conduct to the desired product.
3. Resources Providers Alignment: Aligning resources providers with the market requirements involves the verification of which characteristics resources providers must assure so that the client can trust that the selected set of enterprises is able to be integrated in a VE able to produce the product that meets the requirements previously captured by the client (market requirements).

Resources providers requirements include economical, managerial, and organizational aspects.

These three sets of requirements for alignment are grouped in Table 1. In Cunha and Putnik (2005), the interested reader can find a development of these alignment strategies between business opportunities and the creation/reconfiguration of the VE that is expected to meet that opportunity.

KNOWLEDGE MANAGEMENT FUNCTIONS: STRENGTHS AND PROBLEMS

In this section, we highlight some strengths and problems associated with the implementation of knowledge management procedures and supporting technologies in the market of resources.

Knowledge Management Strengths

Knowledge management in the market of resources enables some functions such as (1) the ability to assure trust (given by the partnership performance monitoring and utilization of historical information in processes of search and selection) and responsiveness; (2) knowledge based guidance in VE design and integration (assured by the introduction of brokers); (3) electronic automated negotiation and contractualization;

Table 1. Checklist of requirements to be considered in alignment (Cunha & Putnik, 2005)

Market Alignment	Product/Service/Operations Alignment	Resources Providers Alignment
– Price, cost, and profit – Quality – Quick response: the desired product, on time, in the required conditions – Transparency and legality – Trust and confidence – Correct capture of market / customer requirements	– Cost – Quality – Integrability – Interoperability between different providers – Standards	– Availability – Ability to meet product/service/ operation requirements – Certification – Dependability – Flexibility – Responsiveness – Competitiveness and proactiveness – Past information of previous VE integrations

(4) performance evaluation of the VE participants; and (5) contract management and enforcement (based on performance evaluation of the VE participants).

Trust and Responsiveness

Trust is a major concern that any environment to support VE integration must assure. In the market of resources, trust is assured by a detailed regulation, enforcement procedures through contracts and safety mechanisms, duty of seal, and so forth. Responsiveness or almost real-time answer is essential. The market enables the reduction of the integration time and increases integration efficiency as demonstrated in Cunha and Putnik (2003a, b).

Knowledge-Based Guidance in VE Design and Integration

Brokerage implementation (human brokerage), search, and selection support algorithms and an efficient organization of the market of resources intelligent knowledge base and business intelligence are on the origin of this knowledge-based guidance. The broker, supported by computer-aided tools, validates all the steps in the process of designing the VE project that is most suitable to achieve the VE underlying objectives, manages VE integration, and monitors VE operation.

Electronic Automated Negotiation

The market of resources service is designed to offer different processes of electronic negotiation (passive and active) and is supported by automated tools of search, selection, and negotiation, which can increase the performance of the process when the solution space size is high.

Performance Evaluation of the VE Participants

The requirement for permanent alignment of the VE with the market (business) asks for a dynamic process of VE performance evaluation and analysis of reconfiguration opportunities. To answer to this requirement, the market of resources offers procedures for performance monitoring and, through the broker allocated to a given VE project and using computer aided coordination mechanisms, is permanently monitoring the partnership and recording historical information to be used in the future. The market makes use of historical information of the behavior of the resources providers in previous integrations, in the search processes, to increase trust and achieve better results. This activity of monitoring the performance of every integrated resource increases trust and contributes to the highest possible performance of the VE.

Contracts Management and Enforcement

The market of resources offers mechanisms for contract generation, management, and enforcement. To reduce the contractualization time, the market of resources (empowered to represent the parties in the contract formalization), is able to perform almost real-time contractualization between the parties to integrate in the VE.

Knowledge Management Problems

Two of the main difficulties identified are related with (1) the difficulty of expressing the resources requirements by the VE owner who must be able to use a resources representation language to traduce the VE project and resources requirements in the knowledge base of the market of resources and (2) the necessity of implementing partnerships with other similar services in order to extend the coverage domain.

Difficulty in Expressing the Resources Characteristics

The efficiency of the service is dependent on the ability of representation and organization of the resources information in the market of resources intelligent knowledge base and the capture and translation of the requirements for resources selection and negotiation parameters. If the first is dependent solely of a unified representation language, the second requires also the ability of the VE client to translate the requirements for the VE project into this language, which is far more complex than describing the individual resources provided by resources providers. These functions are essential to knowledge organization, maintenance, and extraction.

The developments toward unified representation languages, such as the XML-based developments, represent a tremendous contribution that should help to overcome this problem.

Limitations in Coverage: Dependability on Similar Services

A project can touch many different areas, and our market is both vertical and horizontal (matricial) to allow a better coverage of domains of activity. To overcome the lack of coverage, it is necessary to establish partnerships with other similar markets so that the broker does not see its search space limited to the market of resources database, but this situation of partnering with similar services is constrained by the existence of unified representation languages. If this does not happen, translating software will be required to support interoperability between services, or the broker will have to know different representation languages in order to transport requests into other services.

OPPORTUNITIES FOR A MARKET OF RESOURCES AS AN ENVIRONMENT FOR KNOWLEDGE MANAGEMENT AND BUSINESS ALIGNMENT

Cost savings do not seem to be a major key driver for enterprises to use the market of resources. Rather, they should be interested in time and quality benefits, trust, dynamic reconfigurability, and so forth. Opportunities should come from technological developments, which will enable more efficiency in the implementation and from the current state of ICT investment and usage by the enterprises, which traduces the willingness to drive business online. But the main opportunity seems to come from the actual strong competition environment, which is expected to force companies to the adoption of VE models, and this shift may represent an opportunity for services as the one provided by the market of resources.

Emerging VE Organizational Model

As demonstrated in Cunha and Putnik (2003a, b), the market of resources environment is more efficient in coping with the VE model than the Internet-based traditional ways (e.g., WWW search using search engines, e-mail, etc.). With the predictable evolution of the organizational models, services as the one provided by the market of resources will appear as the previewed evolution toward a new generation of business-to-business electronic marketplaces and support services.

Technological Development

The rise of Internet-based business-to-business marketplaces is progressing rapidly. At the same time, we are assisting the fast appearing of networked enterprises, extended enterprises, and VE. However, the developments or solutions still do not respond to the VE model requirements. Several enabling technologies are suffering significant developments from electronic payment to security. Finally, the emerging standards for information representation will be a major requirement for efficiency and integrability in electronic business.

Investment in Information and Communication Technology

Several surveys (for example, Boston Consulting Group, 2002) suggest that there is a very favorable environment for the adoption and increased usage of new value-added services, as enterprises have invested in the enabling technology and are looking for reducing costs and increasing productivity, which means that it could be understood as potentiating the acceptability for the market of resources.

Competitive Pressures

We feel that enterprises of all sectors perceive the threat of competition and see, both in the emergent virtual enterprise organizational models and in the Internet-based applications, a possibility to improve productivity and reduce some type of costs. This is pushing traditional business to adopt business-to-business electronic commerce practices and represents an opportunity for the deployment of new applications, one of these, the market of resources.

At the same time, companies providing e-business services represent a competitive pressure toward the success of the market of resources (while competition is simultaneously a threat).

Technology Accessibility to Small and Medium Sized Enterprises

A key driver of growth of business-to-business electronic commerce will be the increased adoption of e-commerce initiatives by small- and mid-sized companies. Solutions, up until recently, associated with huge investments and dedicated to large companies are now accessible to small and medium enterprises.

CONCLUSION AND FUTURE TRENDS

This article intended to provide a better understanding of the environment supporting virtual enterprise integration from a knowledge management perspective. We have introduced the support to VE integration by the creation of a market of resources and introduced a referential for knowledge management to assure the alignment between business requirements and the integration of resources providers in a VE.

The development of environments to support the VE model in general are of increasing importance, and the market of resources intends to be a contribution toward that direction. However, it is an innovative approach when compared with the other developments that literature provides, which are not as integrated as the market of resources is and covering only aspects of the VE life cycle in a less dynamic approach to the virtual enterprise concept.

All the technologies and techniques necessary to support the several phases of the life cycle of a VE, as well as many valuable applications, already exist and some are in operation, but most of them fail to answer to the VE integration requirements, as they were not developed specifically to support this model. What we have designated as an adequate environment to support the requirements of the emerging VE paradigm is missing.

Simultaneously, besides the strengths identified for the implementation of knowledge management functions in the market of resources, some problems are also identified. The article also identifies some opportunities associated to the implementation and exploitation of the market of resources as an environment to support knowledge management in VE integration.

REFERENCES

Alavi, M., & Leidner, D. E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quartely, 25*(1), 107-136.

Ávila, P., Putnik, G. D., & Cunha, M. M. (2002). Brokerage function in agile/virtual enterprise integration: A literature review. In L. M. Camarinha-Matos (Ed.), *Collaborative business ecosystems and virtual enterprises* (pp. 65-72). Boston: Kluwer Academic.

Boston Consulting Group. (2002, February). *Company communication trends: Growth of new communication technologies demands rethinking of companies' internal communication strategies, a survey report*. Retrieved May 8, 2005, from http://www.bcg.com

Byrne, J. A. (1993, February 8). The virtual corporation: The company of the future will be the ultimate in adaptability. *Business Week*, 98-103.

Camarinha-Matos, L. M., & Afsarmanesh, H. (1999). The virtual enterprise concept. In L. M. Camarinha-Matos & H. Afsarmanesh (Eds.), *Infrastructures for virtual enterprises* (pp. 3-14). Porto, Portugal: Kluwer Academic.

Carvalho, J. D. A., Putnik, G. D., & Cunha, M. M. (2002). Infrastructures for virtual enterprises. In A. Baykasoglu & T. Dereli (Eds.), *Proceedings of the 2nd International Conference on Responsive Manufacturing* (pp. 483-487). Gaziantep, Turkey.

Cunha, M. M., Putnik, G. D., & Ávila, P. (2000). Towards focused markets of resources for agile/virtual enterprise integration. In L. M. Camarinha-Matos, H. Afsarmanesh, & H. Erbe (Eds.), *Advances in networked enterprises: Virtual organisations, balanced automation, and systems integration* (pp. 15-24). Berlin: Kluwer Academic.

Cunha, M. M., Putnik, G. D., & Carvalho, J. D. (2002). Infrastructures to support virtual enterprise integration. In R. Hackney (Ed.), *Proceedings of 12th Annual BIT Conference - Business Information Technology Management: Semantic Futures*. Manchester, UK: The Manchester Metropolitan University (CD-ROM).

Cunha, M. M., Putnik, G. D., & Gunasekaran, A. (2002). Market of resources as an environment for agile/virtual enterprise dynamic integration and for business alignment. In O. Khalil & A. Gunasekaran (Eds.), *Knowledge and information technology management in the 21st century organisations: Human and social perspectives* (pp. 169-190). Hershey, PA: Idea Group Publishing.

Cunha, M. M., Putnik, G. D., Gunasekaran, A., & Ávila, P. (2005). Market of resources as a virtual enterprise integration enabler. In G. D. Putnik & M. M. Cunha (Eds.), *Virtual enterprise integration: Technological and organizational perspectives*. Hershey, PA: Idea Group Publishing.

Cunha, M. M., & Putnik, G. D. (2003a). Market of resources versus e-based traditional virtual enterprise integration - part I: A cost model definition. In A. Gunasekaran & G. D. Putnik (Eds.), *Proceedings of the 1st International Conference on Performance Measures, Benchmarking and Best Practices in New Economy*. Guimarães, Portugal.

Cunha, M. M., & Putnik, G. D. (2003b). Market of resources versus e-based traditional virtual enterprise integration: Part II: A comparative cost analysis. In A. Gunasekaran & G. D. Putnik (Eds.), *Proceedings of the First International Conference on Performance Measures, Benchmarking and Best Practices in New Economy*. Guimarães, Portugal.

Cunha, M. M., & Putnik, G. D. (2004). Trends and solutions in virtual enterprise integration. *Tekhné - Review of Politechnical Studies, 1*(1).

Cunha, M. M., & Putnik, G. D. (2005). Business alignment in agile/virtual enterprise integration. In M. Khosrow-Pour (Ed.), *Advanced topics in information resources management* (Vol. 4). Hershey, PA: Idea Group Publishing.

Kluge, J., Stein, W., & Licht, T. (2001). *Knowledge unpluged: The McKinsey & Company survey on knowledge management.* New York: Palgrave and McKinsey & Company.

Murray, P. (2002, March-April). Knowledge management as a sustained competitive advantage. *Ivey Business Journal,* 71-76.

Prahalad, C. K., & Hamel, G. (1990, May-June). The core competence of the corporation. *Harvard Business Review, 68,* 79-91.

Preiss, K., Goldman, S., & Nagel, R. (1996). *Co-operate to compete: Building agile business relationships.* New York: van Nostrand Reinhold.

Putnik, G. D. (2000). BM_Virtual Enterprise Architecture Reference model. In A. Gunasekaran (Ed.), *Agile manufacturing: 21st century manufacturing strategy* (pp. 73-93). UK: Elsevier Science.

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Chapter 6.18
Know-CoM:
Decentralized Knowledge Management Systems for Cooperating Die- and Mold-Making SMEs

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EXECUTIVE SUMMARY

The die- and mold-making industry can be characterized by small and medium enterprises (SMEs), sophisticated technologies, and highly skilled employees who have to cooperate in order to fulfill orders of customers with which they are engaged in an intensive process of knowledge exchange. The knowledge-intensive production process of die and mold makers consequently requires an integrated organizational and technical solution to support the sharing of documented knowledge as well as collaboration. Standard knowledge management systems (KMS) primarily target the organization-internal processes and documented knowledge of large organizations.

Know-CoM intends to overcome the limitations of these solutions and explicitly targets SMEs as well as knowledge processes that cross organizational boundaries. Know-CoM is a European Commission-funded CRAFT project that provides an advanced concept of decentralized management of access privileges to personal, protected, and public knowledge spaces. An easy-to-use solution supports the capturing of experiences. A joint knowledge structure brokers context across organizational boundaries and eases discovery of knowledge and experts. Finally, a knowledge management certification technique allows for a coordinated reuse of knowledge that is integrated with the daily work practices of die and mold makers.

BACKGROUND

Dies and molds are characterized by hard, low-wear materials, complex geometry, and structures. Their production requires sophisticated technologies, for example, five-axis machining, high-speed cutting, and so forth, and highly experienced and qualified staff (Antoñana, 2000). Dies and molds are used in many industries, for example, by suppliers of components in the automotive industry. Their prices vary by an average of 45,000 from 20,000 to 800,000, whereas the margins are about 6%. The lead time for the production of a die or mold ranges from one to 10 months. For toolmakers, the most important competitive factors are time to market, personnel costs, and quality of the resulting tools. The last ISTMA Annual Report (Antoñana, 2000) highlighted some of the handicaps of the European tool and die industry competitiveness:

- Continuous pressure to reduce time to market
- Strong pressure on prices and high personnel costs
- Growing difficulty to attract and acquire skilled workers

In many SMEs, these handicaps lead to bad working conditions, accidents, and even social problems (Antoñana, 2000).

The market size is 25,000 million euros worldwide (Antoñana, 2000). The European die- and mold-making industry is composed mainly of small and medium-sized enterprises (SMEs) with an average of 23 employees. There is a wide variety of dies and molds (e.g., die casting, plastic, or glass molds) for different purposes and industries. Typically, die- and mold-making companies (DMCs) specialize in certain areas of the industry. Many products require the combination of several dies and molds from different fields and thus customers regularly need to obtain them from more than one producer. Thus, cooperation between DMCs holding complementary competencies is necessary in many cases, particularly to acquire large orders. Producers have to coordinate their activities closely and communicate intensively in order to jointly execute orders. However, the specialization of the DMCs is not only complementary, but also overlapping. Therefore, the relationship between the DMCs can be described as coopetition, because they cooperate and collaborate on the one hand during the joint execution of orders and on the other hand, they compete in markets. Regarding the introduction of knowledge management (KM), the state of coopetition on the one hand requires advanced instruments that create an environment for unobstructed knowledge exchange between the cooperating DMCs and on the other hand, competition poses a significant barrier for the exchange of knowledge across organizational boundaries. In addition to the cooperation and exchange of experiences with other die and mold makers, the DMCs often need to exchange and jointly develop knowledge with their suppliers and customers. Suppliers hold expertise concerning characteristics of materials, tools, and about standard parts needed to manufacture dies or molds. Customers possess knowledge about how the parts that are produced using these dies or molds meet the requirements of the customer's customers. For example, when a plastic part for the automotive industry, such as a car dashboard, is produced, the part has to fulfill requirements regarding surface structure or stability. These requirements must be considered by the die and mold maker during the design phase of the tool with which later the car dashboard will be produced. Additionally, customers of DMCs use different injection-molding and die-casting machines to manufacture parts, which vary in the dimensions power, feed, stroke, clamping surface, force, and so forth. Die- and mold-making companies depend much on experiences with customer machines and materials because the produced tool has to fit in the injection-molding or die-casting machine.

In the next section, we discuss the representative knowledge-intensive core business process of DMCs and study the main issues concerning knowledge exchange, application, retention, and securing.

SETTING THE STAGE

For the detailed analysis of the core process and the technical environment of DMCs, we used questionnaires as well as expert interviews with CEOs, designers, and production planners of seven European die- and mold-making companies. Based on the actual state and requirements identified, we derived a number of knowledge-related challenges. The questionnaires were composed of questions concerning the following areas:

- IT infrastructure and use of IT in the companies
- Production process and its information and knowledge flows
- Handling of knowledge in the company
- Cooperation with partners, customers, and suppliers
- Software requirements and expectations from a KMS

The IT part investigated the technical environment of DMCs as well as the employees' technical expertise. Alongside the hardware available and the software used, we studied the media preferred for internal and external communication.

The questionnaire was used to obtain information about typical development processes of DMCs and to distill the core process. For each process step, it was analyzed which data, information, or knowledge is needed; which sources it comes from; which data, information, or knowledge is created; and where knowledge gaps or potential for improvement exist. Furthermore, experts and persons responsible for process steps were determined.

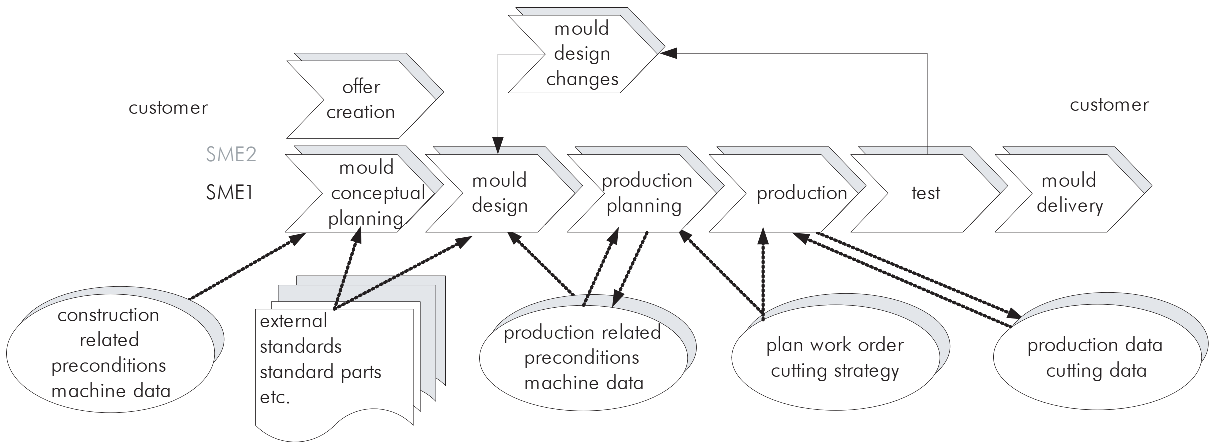
We asked which kinds of knowledge (e.g., knowledge about products, partners, skills) are stored in which way (e.g., electronically, on paper, or in the heads of people), which criteria were used to structure documents, and what were the main topics. Next to the handling of knowledge, the use of KM-related tools was analyzed. Concerning cooperation, it was examined which roles perform cooperative activities as well as which activities the DMCs intend to carry out with Know-CoM in the future. Additionally, we examined confidentiality of the knowledge shared with partners and customers as well as barriers that prevent knowledge sharing across organizational boundaries.

Finally, it was analyzed which KM-specific functions should be integrated in the software (e.g., knowledge maps, automatic classification, personalization).

The Core Process

The typical development process of die- and mold-making companies derived from expert in-

Figure 1. Core process of die- and mold-manufacturing SMEs



terviews and questionnaires (see section "Setting the Stage") is depicted in Figure 1. The symbols below the process illustrate some examples of data needed or created during the particular process phases.

Offer creation is carried out in parallel to mold conceptual planning and is triggered by customer requests. Customers send a drawing of the part and a list with required mold or die materials. The documents have different formats such as sheets of paper (handmade sketch, printings, etc.) or electronic documents (CAD files, etc.). Having received the request, the company calculates an offer and sends it back to the customer. Calculation depends on different information gathered or delivered by the customer, for example, type and characteristics of the materials and the part's complexity. The more detailed the request is, the better the company is able to plan and provide a solution for the request. Independent of the information delivered by the customer, calculating offers is difficult due to the high variety of dies or molds formerly produced. Particularly, estimating the number of cost-intensive redesign cycles is very hard (see process step, mold design changes). The systematic comparison of the die or mold to be produced to already-produced ones with respect to geometry, material, and so forth, can ease the offer creation process, particularly the estimation of the redesign loops significantly and improve the margin. Based on our interviews and questionnaires, we observed that previous offers, CAD drawings, and so forth, are stored unsystematically.

Mold conceptual planning is based on the customer's requirements regarding functionality, behavior, number of parts per mold or die, number of injections per mold or die, and structure of the planned form. Conceptual planning requires information about preconditions related to the construction such as data of the injection mold or die machines, and usability of standard parts. Internal information about availability of production lines and production skills are also needed for suggestions and decisions. As identified by the questionnaires, the required information is rarely delivered completely by the customer and therefore further time-consuming inquiries are the consequence.

When an order is placed, the design starts from an in-depth study of the use of the final product and consists of optional mold-filling simulations, construction and creation of technical documents (e.g., in AutoCAD, CATIA, Solid Edge), specification of CNC (computerized numerical control) programs, as well as the design of inserts, sliders, and cooling system. Examples for the variety of information required during this phase are production-related preconditions, customer machine data, as well as internal machine tool data, and information about standard parts and their specifics.

Based on the product's specifications, the production planner uses information about production-related preconditions such as the company's capacities and capabilities to plan further steps. To implement CNC programs, select cutting strategies or plan work orders, detailed information, and experiences are necessary.

In production, dies and molds are produced using CNC machines or other production facilities. Examples of information required in this process step are standard part information, cutting data and cutting strategies, machine data, as well as production plans. Particularly, the choice of an adequate cutting strategy including selection and sequence of cutting tools is strongly based on experience. To define cutting strategies, the mold material, the tool used (diameter, length, notation, supplier, number of cutting edges, coating), and the cutting parameters (revolutions per minute, cutting speed, feed rate, radial cutting depth, axial cutting depth) have to be taken into account. Knowledge about cutting data and cutting strategies is mostly tacit and therefore not documented. Quality criteria for a cutting strategy are, for example, the wasted material or the lifetime of a cutting tool that is additionally influenced by characteristics of the machine tool used.

The following step test is dominated by extensive testing of dies and molds in compliance with the customer's requirements. Tested parameters are especially surface structure, dimensions of the mold/die, or stability of critical parts. Possibly, improvements concerning design are necessary, if the injection mold or die cast part does not meet the expectations of the customer or the requirements catalog. Insufficient test results can lead to changes of mold design. These changes are expensive, because the process has to restart from the mold design. Every point mentioned as failure in the test phase has to be corrected in the production phase. The number of redesign cycles ranges from 4 to 20 cycles per mold or die and has in Europe an average of seven cycles. Regarding costs, the reduction of the number of redesign cycles promises large improvements in time and costs.

Redesign can be handled by reducing some areas of the die or mold (e.g., milling, grinding, etc.) or adding some material (through welding), if necessary. Adding material to forms reduces the quality extremely and most companies do not give a high lifetime guarantee for such dies or molds. Thus, new design, production, and test cycles can be necessary. When all requirements are fulfilled, then the form is delivered to the customer.

Technical Environment

The degree of process automation and of the use of IT varies much from company to company depending on its size, the region, the type of product, and the customers. However, an average die- and mold-making company has a number of PCs that are distributed in all departments (production, design, management, commercial, after-sales) and are connected by a LAN.

Computer-aided systems such as CAD (computer-aided design), CAE (computer-aided engineering), and CAM (computer-aided manufacturing) are widely used in the business.

Although many companies have licenses for three-dimensional CAD tools, two-dimensional basic tools are still used for designs and drawings of the parts and their assembly. However, a full migration to three-dimensional tools seems inevitable, because of its advantages in terms of design flexibility and visualization. Software for the simulation of injection molding is useful, but requires a high investment in terms of personnel. Therefore, many companies avoid these costs by subcontracting this task to consultants or relying on their experience and test protocols. Additionally, many European DMCs use ERP (enterprise resource planning) systems to store data concerning products, their structure, production routes, orders, suppliers, customers, and so forth.

A substantial part of the data is stored in an unstructured way on individual PCs of the employees. This can range from worksheets or data created and maintained with tailor-made programs that support, for example, the offer creation process, tools for solving technical problems, or project management applications.

Concerning the communication infrastructure, telephone, fax, and face-to-face meetings still dominate information exchange within the company, with partners, as well as with suppliers and customers. E-mail is increasingly gaining acceptance, especially when complex surface parts are the object of orders. However, for simpler 2-D parts, a handmade drawing transmitted via fax is still popular.

In general, die- and mold-making companies are quite familiar with a number of IT tools and systems, but there is a lack of integration of the different systems.

Challenges

The key challenges in the die- and mold-making industry gained from expert interviews and questionnaires during our research (see section, “Setting the Stage”) are as follows:

- Lack of experience management: Experiences are crucial in many process steps of die or mold manufacturing. Missing documentation of experiences, lessons learned, or good practices can lead to mistakes and design failures. Also, relevant experiences from production and production planning are not available for the conceptual design of molds. Information about testing and redesign is also not provided in the conceptual design step.
- Insufficient knowledge about customer production facilities: Missing or insufficient customer machine and environmental data can also cause design changes after delivery of a die or mold which worked fine in the test scenarios at the toolmaker’s site, but does not work on the customer’s machine. Testing thus requires exchanging experiences about these working conditions as well as (planned) changes between representatives of the customer and designers.
- Need for collaboration environment: Subcontracting and splitting of orders require extensive coordination between the DMCs due to minimal tolerances of dies and molds. In some cases, problems arise concerning assembly of the mold or die parts manufactured by various DMCs. Therefore, it is important that an appropriate basis for context-based sharing of knowledge and context-based collaboration between DMCs is established.
- Management of intellectual property: DMCs cooperate on the one hand in certain areas and on the other hand, they compete in markets (coopetition). This fact creates a significant barrier for knowledge sharing across organizational boundaries and requires measures to ensure confidentiality and protect the individual company’s intellectual property.

- Distributed incompatible sources of data: Publicly available information about standard parts or cutting data has to be collected from several sources for each single process step. These retrieval activities are extremely resource consuming and it is not guaranteed that they deliver up-to-date information.

CASE DESCRIPTION

The Know-CoM solution aims to bridge the gap between a technology-oriented and a human-oriented KM approach (Maier, 2004, p. 355). On the one hand, there is a substantial amount of documented knowledge that is spread across the knowledge bases of cooperating SMEs, customers, and suppliers that have to be semantically integrated. On the other hand, important knowledge resides in the heads of highly skilled die and mold makers that act in a number of roles with respect to the production process. Thus, the Know-CoM solution consists of an organizational design of the knowledge processes that have to be supported by a technical solution and a procedure model that guides the implementation of KM in the toolmaking companies.

Standard KMS have a centralized architecture and normally aim at large organizations, but do not focus on the cooperation between multiple small companies in different locations. However, decentralized KMS seem to fit better for SMEs because they help (see Maier, 2004, p. 284)

- to reduce the substantial costs of the design, implementation, and maintenance of centralized knowledge management suites, in terms of hardware, standard software, as well as the often underestimated costs of designing, structuring, and organizing a centralized knowledge server;
- to reduce the barriers of individual knowledge workers to actively participate in and share the benefits of a KMS, because knowledge-sharing procedures are integrated in their daily work processes;
- to include individual messaging objects (e-mails, instant messaging objects) into the knowledge workspace that are rarely supported by centralized KMS; and
- to overcome the limitations of a KMS that (almost) exclusively focuses on organization-internal knowledge whereas many knowledge processes in die- and mold-making companies cross organizational boundaries.

Concerning DMCs and cooperation between them, particularly the low-cost criterion and the consideration of knowledge processes across organizational boundaries are specifics that have to be considered and seem to be better supported by decentralized KMS.

Regarding the company-specific part, we focus on capturing as well as providing experiences in the relevant process steps whereas concerning the cooperation across organizational boundaries the solution focuses on enabling knowledge exchange in a controlled environment on the basis of a shared context. Therefore, a multidimensional knowledge structure should foster a joint understanding between cooperation partners and to provide documented knowledge in the process steps of the core process.

The following section comprises the definition of a joint knowledge structure as basis for cooperation and the definition of knowledge spaces. Additionally, we describe in this section a method to capture experiences and the technique KM certified which aims at the systematic application of previously documented experiences. Afterward, we discuss to what extent the challenges of the die- and mold-making industry could be solved or reduced by the Know-CoM solution. Finally, we outline the reasons of the platform decision and present a procedure model for the rollout.

Definition of Knowledge Structure

A knowledge structure contains knowledge elements and the relations between them as well as metadata, which give further information about their content, and associations. To facilitate knowledge sharing, a joint knowledge structure has to be established in order to create a joint understanding between cooperating partners. Simple hierarchical knowledge structures are not suitable for cooperation, because different enterprises classify their knowledge elements or documents on the basis of different criteria (e.g., processes, topics, etc.) and end up using individual, incompatible taxonomies. Thus, it is difficult to find a structure that meets the needs of all participating companies. Additionally, nontext files (e.g., CAD drawings), which are important in the die- and mold-making industry, are hard to find by navigating the structure. Therefore, we developed a multidimensional knowledge structure on the basis of expert interviews and questionnaires (see section, "Setting the Stage") that classifies knowledge elements and documents using metadata according to the following dimensions (Maier & Sametinger, 2003, p. 4):

- Time: classifies a knowledge element according to time-related characteristics such as time of creation, time of last modification, or time of last access.
- Process: represents the step of the core process and comprises, for example, the subdimensions offer creation, design, production planning, production, or test.
- Topic: provides keywords intended to be relevant for the user. In the case of Know-CoM, the topics represent the most relevant knowledge areas of the die- and mold-making industry (e.g., molds, machines, parts, etc.).
- Person: includes suppliers, manufacturers, customers, and enterprise-internal persons, as well as their different roles within the organization. Regarding messages, the subdimensions, sender or receiver are relevant.
- Format: comprises formats specific to production industry (e.g., CAD file, CNC programs, etc.) next to widely used formats (e.g., .xls, .doc, .html, etc.).
- Type of knowledge: can be classified in contextualized data, experiences (approved, unapproved, private), lessons learned, good or best practices.
- Location: refers to the location described in a knowledge element which a knowledge element or in which a knowledge element was developed, for example, production facilities of customers as well as DMCs.
- Language: is required because Know-CoM is used by companies in several countries.

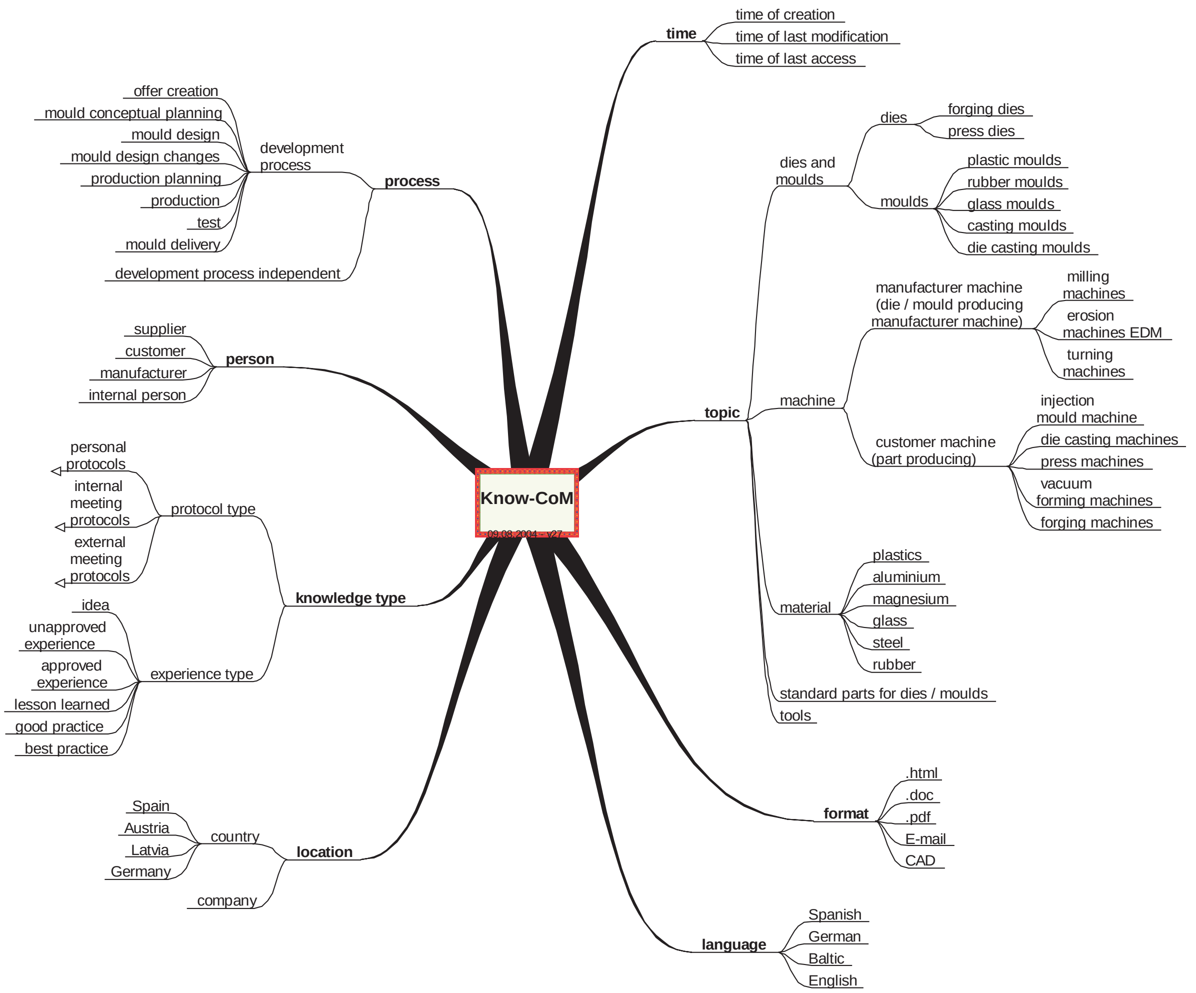
Figure 2 depicts the dimensions described above as a MindMap, which represents a minimal joint knowledge structure for the enterprises participating in Know-CoM.

According to these dimensions, nearly every document can be classified (semi)automatically. With the following example, the classification of a document corresponding to the eight dimensions will be illustrated:

If a tester xy (1) from the Spanish (2) company z (3) gains experiences (4) during the mold-testing phase (5) related to the plastic press mold (6) functionality on August 10 (7) and documents these experiences in the format .doc (8), then the following characteristics of the dimensions result from this documentation:

(1) person: → internal person → tester → tester xy
(2) language: → Spanish
(3) location: → company z in Spain
(4) knowledge type: → experience type → unapproved experience

Figure 2. Joint knowledge structure



(5) process: → development process → test

(6) topic: → dies and molds → mold → plastic mold → plastic press mold

(7) time: → time of creation → August 10, 2004

(8) format: → .doc

The metadata are collected automatically according to the actual working context of the employee or semiautomatically applying, for example, wizards, to guide users through a subset of metadata that cannot be derived automatically. Based on the knowledge structure, specifications of the dimensions are suggested and the user only has to approve or reject these suggestions. This multidimensional structure builds the basis for joint understanding, which is necessary for cooperation with knowledge spaces that are outlined in the following section.

Definition of Knowledge Spaces

Knowledge elements are stored in so-called knowledge spaces. Referring to the fact that SMEs in the die- and mold-making industry on the one hand cooperate in certain areas and on the other hand, compete in markets, we chose to trisect the knowledge spaces on the particular company server in private, protected, and public ones (Maier & Sametinger, 2003, p. 5) in order to reduce barriers for knowledge sharing and to protect the company's intellectual property:

- Private knowledge spaces: Every employee has a private knowledge space, which contains knowledge elements that are only accessible to the employee.
- Protected knowledge spaces: We distinguish two kinds of protected knowledge spaces: (1) team or role-oriented protected and (2) private protected. The first kind of knowledge space is used for sharing knowledge with a limited group of people based on predefined roles. The group can be, for example, an organization-internal or external defined role, group, or project team (e.g., designers, sales persons).
  Additionally, the individual knowledge worker can apply for a protected knowledge space, share knowledge independent of roles or teams, and grant as well as revoke access rights as he/she pleases.
- Public knowledge spaces: Every company server has one public knowledge space, which includes contents that are accessible for every employee in the company as well as for all members associated with Know-CoM.

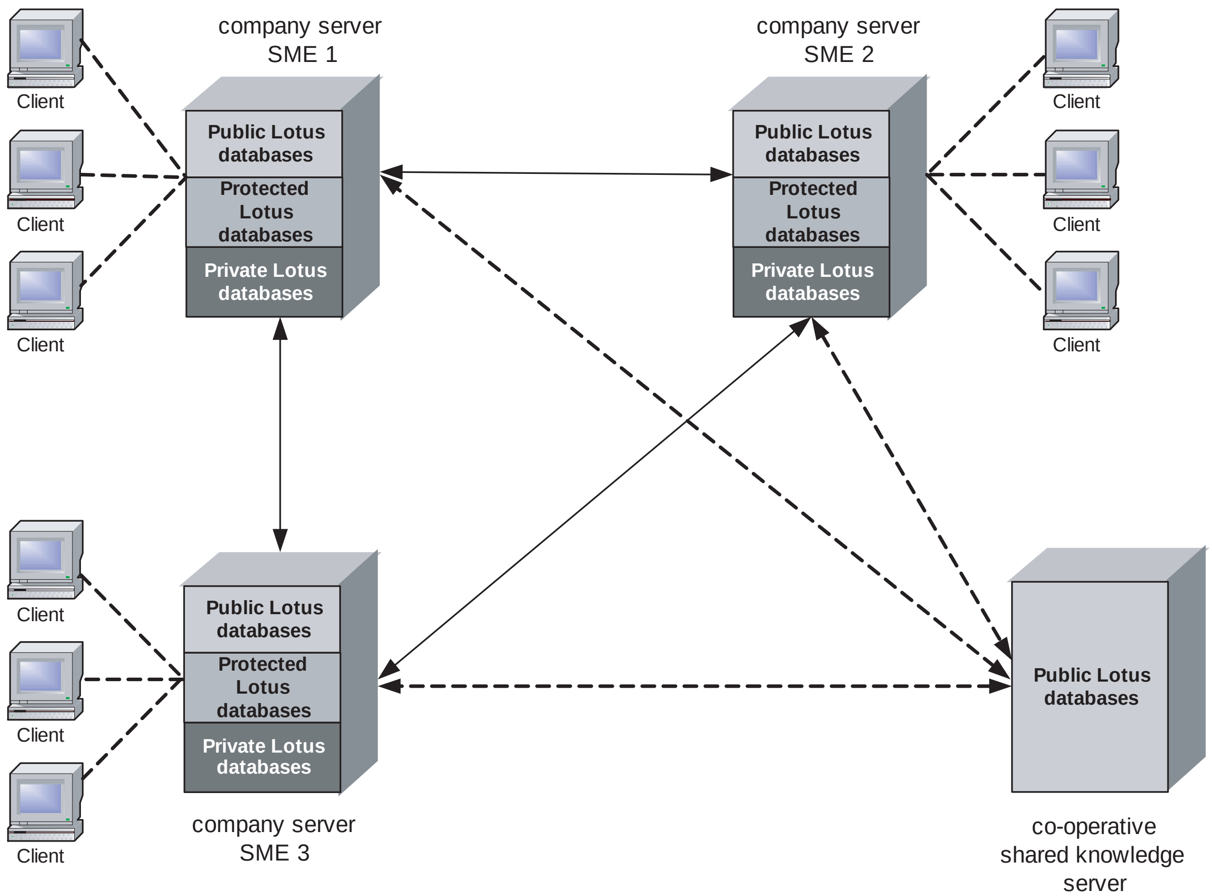
In this environment, significant barriers of knowledge sharing can be reduced, because participants or organizations can decide on their own who is allowed to use their knowledge spaces and have in this way control over their intellectual property. Because of limited user groups, it can be assumed that trust between cooperating employees is higher than without such a limitation and thus sharing of explicit as well as implicit knowledge (e.g., informal exchange of ideas or experiences) is fostered. Access rights which work on the basis of user profiles and the knowledge structure can be adjusted, if a cooperation (e.g., a project spanning enterprises) is dissolved or an employee leaves the cooperation.

Every enterprise participating in Know-CoM has its own company server (Figure 3), which is trisected in different kinds of knowledge spaces. Dashed arrows show connections between the company servers and the cooperative shared-knowledge server, whereas solid arrows illustrate connections between several company servers.

The role of the cooperative shared server is twofold. On the one hand, the server is used to provide publicly available industry-specific information, such as standard part catalogs, cutting data, and so forth, as well as community home spaces for topic-related knowledge exchange of the DMCs. On the other hand, the server should help to localize other companies, find expertise, and bring them together for cooperation. The identification of other companies is supported by company portraits stored on the cooperative server and comprise information about the companies´ areas of competency, machines, capacities, number of employees, location, contact data, and so forth, whereas the cooperation itself occurs in a peer-to-peer mode via protected knowledge spaces of company servers. Concerning roll-out of the Know-CoM solution, this server supports the creation of awareness (see section, "Rollout").

Search inquiries collect relevant documents from the adequate private database of the employee, accessible protected databases and public

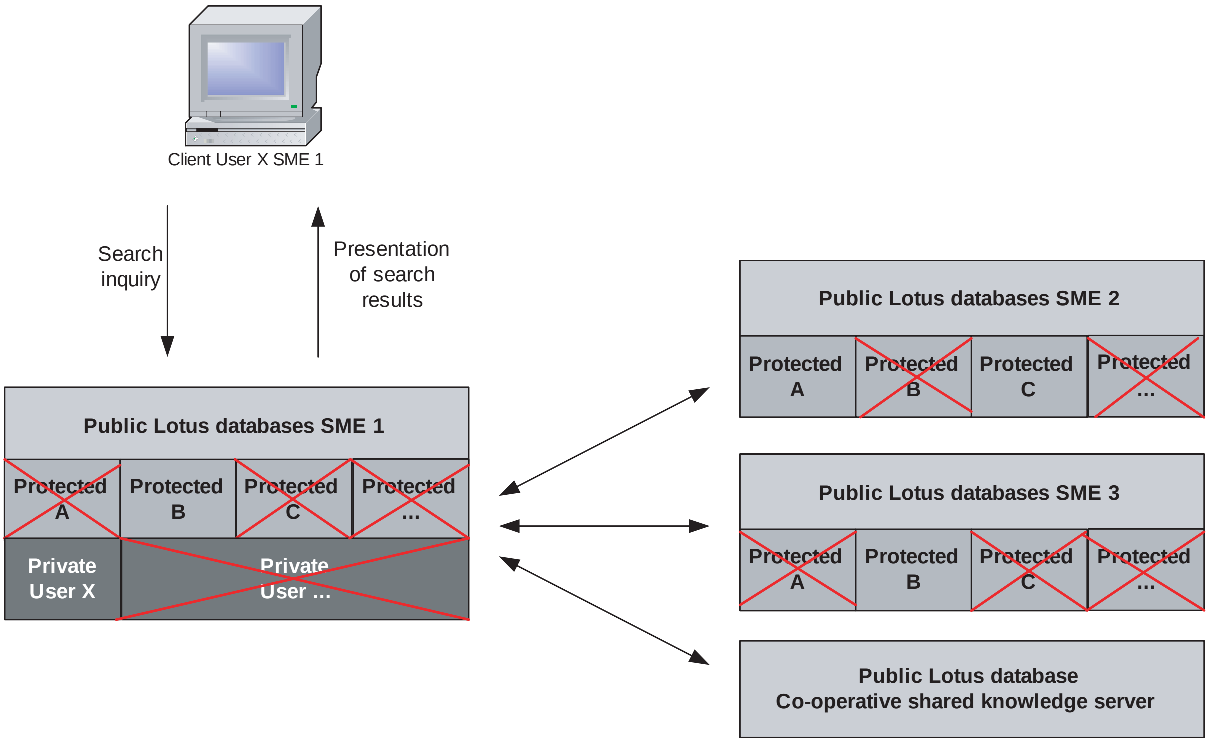
Figure 3. Network of the company servers



databases of the company servers, as well as documents from the cooperative shared-knowledge server according to user profiles and access rights. Figure 4 illustrates processing of search inquiries.

If an employee (here: user X) of a company (here: SME 1) formulates a search inquiry concerning any topic, the company server of the SME the employee works for executes the request and scans his/her private knowledge space and protected knowledge spaces, for which the employee has permission to access. As depicted in Figure 4, the employee can access only the protected knowledge space B in SME 1. Additionally, the company server forwards the request to other connected servers. Also, only protected knowledge spaces accessible for the employee are scanned as well as public knowledge spaces that are not limited to a certain user group. In the example, user X has access to the public knowledge spaces of SME 2, SME 3, and to the cooperative shared-knowledge server as well as to the protected

Figure 4. Processing of search inquiries



knowledge spaces A and C of SME 2 and the protected knowledge space B of SME 3. Private knowledge spaces of other SMEs are generally not accessible. After scanning the knowledge spaces, the company server of SME 1 presents the results of the search inquiry to user X. Depending on the privileges, the user can also insert, update, comment, or delete knowledge elements in the workspaces of participating companies.

After describing the knowledge structure and the network of the Know-CoM solution, including the different kinds of workspaces, the next section focuses on capturing experiences from business processes.

Capturing Experiences

The analysis of DMCs (see section, "Setting the Stage") showed that most experiences are collected in an unstructured way via paper-based or individual electronic notes (e.g., commented test results, etc.) or remain in people's heads. Therefore, the systematic and collective reuse of previously gained experiences is at the actual stage of nearly impossible and the same problems or failures occur over and over again. Thus, the KM solution aims at a technically supported and structured gathering of experiences as well as at providing these experiences in an appropriate format in relevant process steps.

The systematic documentation of experiences enables a company to solve recurring problems more effectively and can lead to sustainable competitive advantages. However, there are some barriers, that prevent documentation of experiences or reuse of already-documented experiences. The required time is a critical factor, because employees have to document in addition to other organizational duties. Therefore, the organization has to provide time tolerances to their employees. However, it must be considered that the effort concerning documentation has to be as low as possible, but simultaneously, sufficient context of the experience has to be provided. The detection of context is important, because reusability of documented experiences depends much on the context. Next to these organizational barriers, personal barriers hinder distribution or application of codified experiences. Typical personal barriers are for example insufficient willingness to share knowledge or to apply knowledge that was created by other employees (not-invented-here syndrome). Regarding the cooperation in a competitive environment, particularly the latter seems to be a serious barrier, which has to be considered by accompanying measures, such as change management, trust management, and incentive systems.

Several approaches exist for capturing experiences such as micro-articles, learning histories, RECALL, after action review, and postproject appraisal (for details, see Schindler & Eppler, 2003; Disterer, 2002; Willke, 2001; Sary & Mackey, 1996). In Know-CoM, experiences should be captured as small articles supported by templates that are structured according to topic, story, insight, and conclusion of the micro-article (according to Willke, 2001). Topic considers the context provided by the knowledge structure. Story describes the experience or learning context. Insight stands for the learning reason (e.g., the cause of the problem). Conclusion comprises the solution (e.g., a procedure) of the problem or a specific situation based on the insight. Experiences that are structured in this way might have a high reusability and traceability due to the provided context. In order to ease codifying experiences, the employees have to answer questions supported by wizards according to the context (story) and document their insights and solutions.

During the whole development process of dies and mold, characteristics of the multidimensional structure are collected. For every order, the collected information is forwarded and extended along the steps of the development process. Metadata are added step-by-step either automatically or semi-automatically by the application of predefined checkboxes that comprise the elements of the joint multidimensional knowledge structure. Intelligent metadata management means that based on the knowledge structure, specifications of the dimensions are suggested to the user for approval. Particularly, the automated suggestion and filling of predefined checkboxes with check marks minimizes the employees' documentation effort. This means that, for example, during work on an incoming order, metadata are added according to part, part's material, customer, customer's machine, and so forth. Metadata already collected are extended in the following steps of the core process (e.g., design, production, and test).

Additionally, employees can document experiences in every process step. After completion of the process step or of one task, wizards ask the employee whether there were specifics or problems he/she solved. The following example should explain the procedure of the capturing of experiences in detail:

A toolmaker uses in the process step production not the cutting tool suggested by the production planner and changes the tool supplier, because he knows that tool wastage is above average due to the material's hardness and machine characteristics. This experience has to be documented during or after the execution of the production step in order to avoid this problem, especially when another less experienced toolmaker uses this cutting tool on a similar mold. Table 1 illustrates a possible

Table 1. Example for capturing experiences

topic:	High tool wastage
insight:	The material was too hard and therefore the tool not suitable.
conclusion:	Use cutting tool xx when you mill material z on machine y

documentation, which contains the elements topic, insight, and conclusion.

Cause and solution of the problem or the specific situation are free-text fields. This kind of documentation helps on the one hand to increase traceability for other employees and on the other hand, implicit knowledge could be externalized when employees write down their interpretations. The context variables (story) can be detected according to the order document forwarded and extended because metadata regarding material, material's hardness, machine, cutting tools, and so forth, are in this example already collected in former process steps such as design and production planning.

Search inquiries are formulated automatically according to the context variables of the actual process step. The results are presented and ranked in dependency on the matching of the documented experiences' context variables with the variables of the actual working context.

Next to capturing experiences, their systematic application is crucial for the success of the KM initiative. This is supported by the technique KM certified.

KM Certified (KMC)

It cannot be taken for granted that employees apply previously documented knowledge. Additionally, success of the application of knowledge in business processes is hard to identify. Know-CoM contains a dynamic checklist (a kind of work flow) according to the core process which shows what KM-related activities they have to do or should perform. The following example illustrates this technique:

When the price for an offer is estimated, the sales person has to search for documented knowledge (e.g., approved documented experiences, documented lessons learned, or good practices) concerning previous similar offers. After viewing the knowledge elements, the sales person encloses or references them. The designer has the task to evaluate CAD drawings by using previous drawings and has to attach the viewed drawing and his/her annotations and eventually the e-mail traffic with cooperating designers. Additionally, he/she should comment on his/her experience-based assumptions related to possible design changes or other problems he/she identified. The die and mold maker has several tasks concerning the offer pricing. He/she also has to attach the knowledge elements viewed and his/her experience-based annotations. In analogy to the work flow activities described above, the tester as well as other employees involved can review all annotations and enclose the documented knowledge viewed according to their tasks. After completing the tasks in the checklist and after reviewing the attached knowledge elements, the audited object, for example, an offer, becomes KM certified.

If a participant identifies a good practice that seems useful or necessary for integration in the work flow, he/she proposes an item to be supplemented to the checklist. An approval process is important in this context to coordinate and check the addition of KM tasks. The possibility of suggesting new tasks renders the KM certification checklist dynamic. Moreover, the checklists are predefined for each process step and designed so that the systematic reuse of experiences and particularly good or best practices are considered. Good practices are proven as valuable for an organization, whereas best practices are worthwhile for the whole community of Know-CoM users. Subsequently, some core tasks of the development process are outlined:

During offer creation, especially experiences and information concerning the number of redesign cycles of similar molds are needed. Therefore, the checklist for offer creation comprises tasks regarding the estimation of the number of redesign cycles of similar molds as well as the application of good or best practices in this area, next to the use of templates for the collection of customer information. During conceptual planning, valuable experiences about standard parts in particular have to be reused. Additionally, employees from the areas of production, design, and test might have to be contacted when this contact turned out as worthwhile in the past. The design is a process step, which has a high potential for improvement for the lowering of costs when proven test experiences are reused systematically. Therefore, typical tasks included in this checklist are, for example, the application of test protocols and documented test experiences to similar molds as well as discussion with the die and mold maker and/or the tester. Such discussions can be supported by the use of application sharing and aim at exchanging knowledge as well as at avoiding mistakes. Particularly, when designers of cooperating enterprises communicate, tools for application sharing (e.g., for CAD) are useful and provide additional context.

The main focuses of the checklists for the production planning and production steps lie in the reuse of good or best practices regarding cutting tools, their sequence, and the sequence of the machines as well as the cutting strategies. Additional tasks aim at fostering communication and knowledge exchange with the toolmaker. The checklist of the tester comprises tasks such as the consequent application of former test protocols or the discussion of test results with the die and mold maker and the designer.

KM certified should help to ensure or foster the application of existing knowledge in the process phases described, to reduce previously made mistakes, and to increase the quality of the dies and molds produced.

Discussion

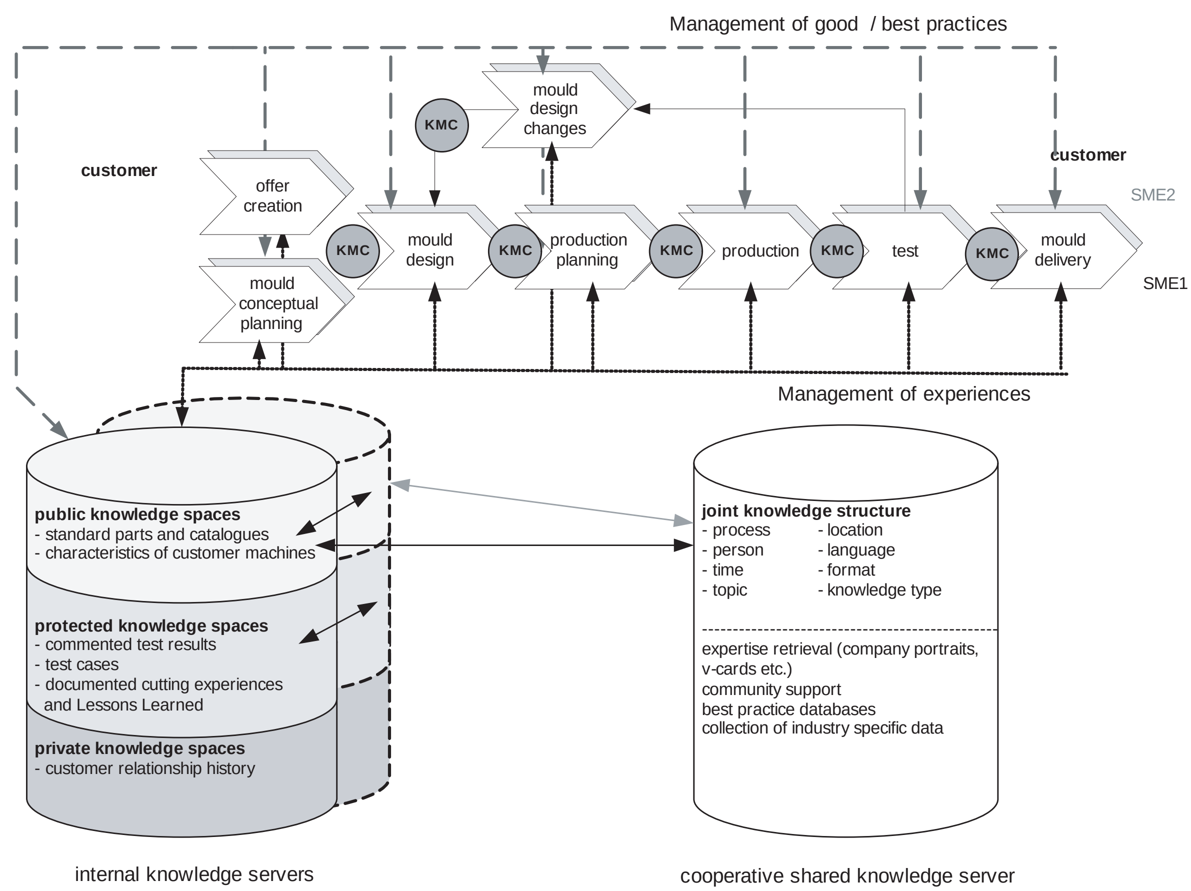
In the following section, we discuss how the elements of the Know-CoM solution could meet the challenges described.

- Lack of experience management: Know-CoM aims at capturing experiences during the execution of process steps supported by templates. In particular, templates and wizards ease the codification and lower documentation effort. The main target is ensuring high reusability by other employees, which is supported by semiautomatically detected context. By the technique KM certified, feedback loops between the steps of the core process are established and previously documented experiences and good/best practices are provided systematically after verifying their value. Thus, quality and efficiency can be enhanced, because especially the missing feedback loops from later to early stages in the development process as well as between cooperating SMEs impact these two factors.
- Insufficient knowledge about customer production facilities: Gathering of customer information is supported by prestructured protocols for customer correspondences with mandatory fields. The information collected in customer communication is documented and forwarded by work flows along the core process. Thus, the information is available in all steps. In order to avoid misunderstand-

ings and to identify problems concerning the mold or die, application sharing and instant collaboration (e.g., Lotus Sametime. See section, "Know-CoM Software Prototype") between the customer and manufacturer can take place.

- Need of collaboration environment: The joint multidimensional knowledge structure provides a shared context and builds the basis for a collaborative environment. Concerning the technical infrastructure, tools for application sharing and instant collaboration provide additional context and support cooperation between DMCs. Moreover, the use of protected workspaces improves flexibility, because access rights can be assigned and revoked depending on the requirements of the companies.
- Management of intellectual property: The management of intellectual property and particularly its security is the basic requirement for the cooperation in a competitive environment. The trisection of the individual company servers in public, protected, and private knowledge spaces provides such a secure environment and flexibly adaptable

Figure 5. Overview of the KM solution for die- and mold-manufacturing SMEs



access rights foster the controlled knowledge exchange.
- Distributed incompatible sources of data: The distributed sources of data such as standard parts, cutting data, machine characteristics, and so forth, are stored on the cooperative shared-knowledge server or on the public knowledge spaces of the DMCs. Thus, search time can be shortened. The shared knowledge structure also provides context for linking previously incompatible sources of data.

Figure 5 visualizes the elements of the Know-CoM solution. Every company participating in Know-CoM has its own company server, which is trisected into public, protected, and private knowledge spaces. Next to the trisected company servers, a cooperative shared-knowledge server supports cooperation between DMCs by providing community home spaces and tools for expertise retrieval. Both the company and the cooperative server work on the basis of the joint multidimensional knowledge structure, which provides a shared context to the participating enterprises and eases knowledge exchange between the companies. The internal core processes of the SMEs are supported in two ways. On the one hand, experiences are captured during the execution of the process steps and on the other hand, the management of good or best practices is supported by the technique KM certified that is symbolized in Figure 5 with the KMC icons. The management of experiences aims at a low documentation effort as well as at high reusability and is therefore supported by an intelligent metadata management. The latter helps employees to classify knowledge elements according to the dimensions of the knowledge structure. Next to capturing of experiences, particularly their approval and the systematic anchoring in the core process are important in order to ensure that valuable experiences, good or best practices are applied in processes and thus improvements concerning costs, time, and quality are realized. The management of good or best practices is realized by the technique KM certified.

After summarizing the elements of the Know-CoM solution, the following section describes the software prototype.

Know-CoM Software Prototype

The Know-CoM software is currently implemented as a Web-based application on a Lotus Notes system (www.lotus.com). Lotus Notes was chosen as the platform for the software prototype, because it provides a set of advanced functions to support database and document management, communication, coordination, collaboration, administration of users, and security mechanisms in a Web-based environment. The CSCW (computer-supported cooperative work) approach provides easy access to communication solutions such as Lotus Sametime (instant messaging and Web conferencing) and Lotus Quickplace (team workplace). Additionally, Lotus Notes comprises integrated discussion boards and supports work flows. Particularly, an integrated and easy-to-use CSCW approach is important in order to foster cooperation between DMCs. Additionally, a VPN (virtual private network) connection is not needed to access a Lotus Notes server, because an encrypted data transfer between clients and servers is supported. This allows secure data or information sharing. Further, advanced applications are full-text retrieval on the local server, mail and calendar integration, the possibility to replicate data of local databases on portable computers, the provided security features, and a policy-based management for different roles. Next to the CSCW integration, particularly the fact that Lotus Notes stores documents on the basis of metadata, influenced the platform decision because this approach fits well with the multidimensional knowledge structure.

As described in the section, "Technical Environment," die- and mold-making companies are quite familiar with a number of IT tools, but their collaboration and communication infrastructure is weak. Actually, much time is lost in communicating details off-line, by sending printed drawings between customer and manufacturer. So the possibility of sharing a CAD application in combination with discussion functionalities and session protocols will bring an enormous time benefit for the participating companies.

Furthermore, a Web-based application needs no local client or sophisticated configuration and can be accessed via Web browsers. As mentioned in the section, “Technical Environment,” die- and mold- making companies normally do not have powerful hardware and software systems in production areas, and also lack advanced knowledge for the administration of sophisticated software. Thus, a Web-based application has been chosen because it is easy to use.

As basis for this software system, the decision was taken to create an application out of the box. This means the delivery of the Know-CoM system with a preconfigured server. A company has to configure the network address and local (company-specific) parameters, such as roles and shared-knowledge spaces, and so forth, to start working with the software. The server does not influence other servers and there is no need for advanced integration efforts.

Lotus Notes provides full support for existing layers of the architecture of a KMS (see Maier, 2004, pp. 257–259). The Notes Web client allows full access to all existing databases and solutions, included in the Know-CoM software. Concerning knowledge services, Lotus Notes provides full-text retrieval for information and knowledge discovery, push-and-pull functionalities in work flows, and a wide range of applications for collaboration like Sametime, Quickplace, team calendars, online communication, and so forth. As complete solution provider, Lotus comes with these last two areas: integration services and infrastructure services. These services are part of the Lotus Notes database philosophy, which is the basis for all applications on upper architectural levels.

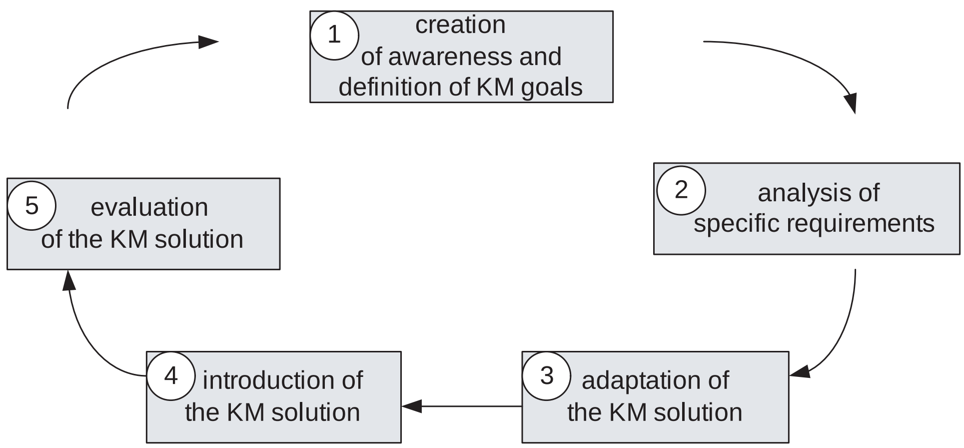
The Know-CoM software prototype builds upon this Lotus Notes solution and implements the services required in order to support the organizational KM instruments laid out in the previous sections.

Rollout

Concerning the process-oriented introduction of knowledge management, the literature provides several approaches. The phases of the process-oriented approaches GPO-WM1 (Heisig, 2002) and PROMOTE (Hinkelmann et al., 2002) build a basis for this KM solution. Additionally, a “road map” for the introduction and customizing of standard software (e.g., SAP) is considered for the amalgamation of the procedure model. Based on these literature studies, we developed the procedure model depicted in Figure 6.

- Creation of awareness and definition of KM goals: The DMCs analyzed are normally not aware of the potential benefits of knowledge management. Therefore, one of the focuses of the introduction of KM is creation of awareness for the KM initiative. The technical initiatives are rather concentrated in basic ICT infrastructures than in sophisticated KM functions. A preconfigured company server is installed that ensures some basic functionality. Thus, in this stage the employees can explore the cooperative shared-knowledge server and the public knowledge spaces of other DMCs participating in the Know-CoM community. Additional support is delivered by FAQ databases that contain questions and answers concerning KM in general and the Know-CoM solution in particular and by an employee who is responsible for the introduction of the solution.

Figure 6. The Know-CoM procedure model



Finally, the communication of the predefined Know-CoM-specific KM goals, such as the improvement of knowledge exchange or the systematic application of documented knowledge and their extension by enterprise-specific KM goals, is important in order to create transparency in the goals and benefits.

- Analysis of the specific requirements: Before the adaptation of the KM solution can occur, an analysis of the company-specific requirements has to take place. The analysis concerns the organizational structure, the development process, the work flows, and the existing knowledge structure. Within the organizational scope, especially the roles and the intra- as well as inter-organizational collaboration structure have to be analyzed in order to consider additional roles or deduce the need for the definition of knowledge spaces. The analysis of the dimension "process" comprises the matching of the core process with the development process of the enterprise concerned in order to consider variations and variants. The analysis of the work flows is necessary for the implementation of KM certified. Additionally, specifics concerning the technical infrastructure of the SME on which Know-CoM should be installed have to be taken into account.
- Adaptation of the KM solution: Based on the analysis of the specific requirements, the Know-CoM solution has to be adapted. During this phase, two different areas of customizing are relevant, on the one hand the technical customizing of the solution and on the other hand, the conceptual customizing of the knowledge structure, the core process, the roles, and the knowledge spaces.
- Introduction of the KM solution: The introduction step comprises the connection of the clients with the company server, the registration of the users, and the setup of private and protected knowledge spaces according to the user profiles on the server.

Information about an employee has to be registered and user profiles created when the

Know-CoM solution is introduced. Person-related information that has to be collected is, for example, skills, topics of interest, and work experience. Additionally, roles, organizational tasks and process steps have to be assigned to the employee for which he/she is responsible or works on. In analogy to the partition of the knowledge spaces in private, protected, and public, this trisection should also be used for the employees´ profiles. Recommendations of interest- or task-related knowledge groups can occur automatically according to the user profile of the employee. Based on the analysis of the organizational design, protected knowledge spaces are introduced for teams, projects, and so forth.

- Evaluation of the KM solution: After the introduction of the solution, there may be needs for improvement that lead to the adaptation of the solution. There are a number of indicators that allow for a systematic evaluation of the use of the solution. In particular, the experiences captured and the dynamics observed in the KM-certified processes as well as the establishment and regular use of knowledge workspaces give hints for subsequent improvements of the KM-supported core processes of the die and mold makers.

Next to the evaluation of the solution aiming at the identification of the needs for improvement, the measurement of the solution's success is also a central issue. Based on the interviews and questionnaires (see section, "Setting the Stage") the most important factors for success measurement in the die- and mold-making industry are lead time from (mold) order to delivery as well as the production time required. A shortened delivery in general or production time in particular also affects production costs of a mold or die. Quality is another key factor in this industry. Referring to the development process, there are a number of indicators that can be used to assess the effects of the Know-CoM solution on time, cost, and quality. These indicators have been documented at the beginning of the project and will be measured again one year after the introduction of the solution. Subsequently, some of these indicators are outlined in Table 2.

Table 2. Indicators for success measurement

criteria	Indicator
time	• average number of design-test-redesign cycles and time required • average lead-time • average time required for the execution of the process steps • average time needed to get complete customer information • search time
cost	• average production costs / mould • average personnel costs / mould • average material wastage • average cutting tool wastage
quality	• average number of internal rejects • average number of external rejects • average lifetime of mould

The average number of design-test-redesign cycles is one of the most important indicators because it affects time, cost, and quality. This means that the more cycles needed, the longer the lead time, the higher the costs, and eventually, the lower the quality. The quality is not necessarily affected negatively by a high number of redesign cycles, but in some cases, a high number of redesign cycles can reduce the stability of the mold and so its lifetime. Also the number of external rejects from the customer is an indicator that affects the quality of the mold and, in particular, the reputation of the toolmaker.

The integration of distributed sources of data can reduce the time required for searching data. Particularly, the systematic reuse of previously documented experiences can shorten lead and production time and can also reduce personnel, production cost, and wastage as well as the number of rejects.

CURRENT CHALLENGES

This case presents an organizational and a technical KM solution that specifically targets die- and mold-making SMEs. Know-CoM particularly considers capturing, sharing, and reuse of experiences both within the knowledge-intensive business process of a die and mold maker and across the organizational boundaries with customers and cooperating DMCs.

In the following section, some preliminary results concerning the application of Know-CoM by the industrial partners are reflected. We concentrate on the management of protocols and experiences, which have been the first focus of the application of Know-CoM. First, those process steps were analyzed where an immediate benefit could be identified as highly feasible. These are the processes not governed by an ERP system, which in this case were the offer creation and the die setting up and testing. The procedure was to detail subprocesses, assign documents to them if necessary (protocols and experiences), and extract the references required to define and manage the mentioned documents. For example, the following subprocesses were identified in offer creation: (1) offer request reception, (2) information request to the customer, (3) obtain main die parameters (pitch and bandwidth), (4) obtain costs, (5) decide on the probable delivery time, and (6) decide on final price.

Protocols used currently include the die characteristics sheet, the offer calculation sheet, and the formal offer document. These protocols are linked mainly to the first four tasks. The need for establishing protocols in the remaining two stages is being discussed at the moment.

Experiences are gathered for any of the mentioned processes. Guidelines or good practices were elaborated for the process of obtaining main die parameters, a key task that was not documented and greatly relied on the experience of certain key personnel in the company. The formalization of this task has allowed a far shorter training period for newcomers and has lowered the dependency that the company as a whole had on certain personnel for running this process with a guarantee for the final result. A number of references were extracted to be used as metadata for the process of searching and filtering the documents mentioned. Examples in the case of the die characteristics sheet are the number of stations, die dimensions, bandwidth, band pitch, number of columns, type of sliding, number of pieces per year, and number of pieces per stroke.

However, there are a number of challenges for the implementation of the solution since there are possibly significant barriers in DMCs that prevent the effective use of the KM solution. In the following, some of these barriers are outlined.

SMEs are characterized by the scarcity of resources. Particularly, limited human resources make it hard for SMEs to assign employees who are dedicated to the KM implementation or perform tasks that are related to the KM initiative (Wong & Aspinwall, 2004, p. 56).

The protection of intellectual capital is an important issue for SMEs since the unintended loss of knowledge to partners can erode competitive advantages of the company. In particular, compared to larger organizations, SMEs that are less diversified and more dependent on the knowledge of key employees fear losing competencies or employees to cooperation partners. These fears create significant barriers concerning interorganizational collaboration and knowledge exchange and it remains unclear if a secure environment for knowledge sharing is sufficient.

Compared to larger organizations the processes and procedures of SMEs are less formalized and standardized, which increase the probability that employees resist the introduction of the KM solution (Wong & Aspinwall, 2004, p. 52) or resist to perform tasks associated with it.

Capturing and applying experiences can also be prevented by individual barriers such as lack of skills to explicate knowledge or low reliability of the knowledge providers as well as by limited absorptive, processing, or learning capacities of the knowledge seekers. Furthermore, on the organizational level, factors like lack of management support or lack of time can prevent the success of the solution as well as interorganizational factors such as groupthink or an exaggerated unified organization culture that particularly affect the external relationships. Individual, organizational, as well as interorganizational barriers can affect the implementation and the use of the solution as well as knowledge sharing across organizational boundaries negatively (Maier, 2004, p. 130).

Finally, building and management of trust will be a crucial factor that influences the use of the protected knowledge spaces significantly. Due to the shared context supported by the knowledge structure, the cooperative shared-knowledge server and the joint KM principles underlying the solution, a community of Know-CoM users might be fostered that ensures trust.

Epilogue

It seems that centralized KMS offered on the market increasingly live up to the expectations of large organizations ready to apply ICT to support a KM initiative. These solutions are too complex, time-, and resource-consuming for SMEs. Peer-to-peer KMS promise to resolve some of the shortcomings of centralized KMS, especially concerning the time-consuming effort to build and maintain a central knowledge repository. However, major challenges still lie ahead until decentralized systems can truly be called KMS and used to support the still-growing share of users involved in knowledge work. Examples for technical challenges that have to be overcome in decentralized KM concern connectivity, security, privacy, fault tolerance, availability, scalability, and interoperability. Moreover, applying the peer-to-peer metaphor to KMS requires a substantial shift in the perspective on organizational knowledge. Executives might fear losing control over the organization's knowledge assets if all documented knowledge is handled by autonomous knowledge workspaces. Consequently, future KMS solutions might attempt to include the "best of both worlds."

Lessons Learned

- In SMEs, particularly the creation of awareness is an important issue concerning the implementation of a KM solution since SMEs are normally not aware of KM and its benefits. Thus, the availability of some basic functionalities and a person responsible for the implementation is favorable.
- Referring to the fact that processes and procedures in SMEs are compared to larger organizations less formalized and standardized a KM solution that is more rigid or directive seems to be appropriate for SMEs.

- SMEs in general and die and mold makers in particular are less diversified and strongly specialized as well as depend often on key employees. These facts combined with the state of coopetition require the providing of a secure environment for cooperation.
- Die- and mold-making SMEs are familiar with certain IT, but concerning the design of KMS, it has to be considered that the solution is easy to use.

REFERENCES

Antoñana, J. (2000). European tool and die making. *Proceedings of ISTMA Europe Colloquium "Tool and Die Making of the Future,"* Aachen, Germany.

Disterer, G. (2002). Management of project knowledge and experiences. *Journal of Knowledge Management, 6*(5), 512-520.

Heisig, P. (2002). GPO-WM: Methode und Werkzeuge zum geschäftsprozessorientierten Wissensmanagement. In A. Abecker et al. (Eds.), *Geschäftsprozessorientiertes Wissensmanagement* (pp. 47-64). Berlin.

Hinkelmann, K., et al. (2002). PROMOTE, Methodologie und Werkzeug für das geschäftsprozessorientierte Wissensmanagement. In A. Abecker et al. (Eds.), *Geschäfts-prozessorientiertes Wissensmanagement* (pp. 65-90). Berlin.

Maier, R. (2004). *Knowledge management systems. Information and communication technologies for knowledge management* (2nd ed.). Berlin.

Maier, R., & Sametinger, J. (2003, July 1-3). Infotop – A shared-context information workspace. *Proceedings of the SEKE 03 – 15th International Conference on Software Engineering and Knowledge Engineering,* San Francisco.

Sary, C., & Mackey, W. (1996). Implementing RECALL: A case-based reasoning system for the access and reuse of lessons learned. *Proceedings of the Sixth Annual International Symposium of the National Council on Systems Engineering,* St. Louis, MO.

Schindler, M., & Eppler, M. (2003). Harvesting project knowledge: A review of project learning methods and success factors. *International Journal of Project Management, 21*, 219-228.

Willke, H. (2001). *Systemisches Wissensmanagement* (2nd ed.). Stuttgart.

Wong, K.E., & Aspinwall, E. (2004). Characterizing knowledge management in the small business environment. *Journal of Knowledge Management, 8*(3), 44-61.

Online References

Lotus Notes, Lotus (IBM). www.lotus.com/

FURTHER READING

Beijerse, R.P. (2000). Knowledge management in small and medium-sized companies: Knowledge management for entrepreneurs. *Journal of Knowledge Management, 4*(2), 162-179.

Borghoff, U.M., & Schlichter, J.H. (2000). *Computer supported cooperative work: Introduction to distributed applications.* Berlin.

Huotari, M.-L., & Iivonen, M. (2004). *Trust in knowledge management and systems in organizations.* Hershey, PA: Idea Group.

Maier, R. (2004). *Knowledge management systems. Information and communication technologies for knowledge management* (2nd ed.). Berlin.

Maier, R., & Hädrich, T. (2004, April 2-3). Centralized versus peer-to-peer knowledge management systems. *Proceedings of the 5th European Conference on Organizational Knowledge, Learning and Capabilities (OKLC),* Innsbruck, Austria.

Staab, S., Studer, R., & Sure, Y. (2003). Knowledge processes and meta processes in ontology-based knowledge management. In C.W. Holsapple (Ed.), *Handbook of knowledge management, vol. 2: Knowledge directions* (pp. 47-69). Berlin.

Susarla, A., Liu, D., & Whinston, A.B. (2003). Peer-to-peer enterprise knowledge management. In C.W. Holsapple (Ed.), *Handbook on knowledge management –vol. 2: Knowledge directions* (pp. 129-139). Berlin.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17,* 27-43.

Wong, K.E., & Aspinwall, E. (2004). Characterizing knowledge management in the small business environment. *Journal of Knowledge Management, 8*(3), 44-61.

ENDNOTE

[1] The German abbreviation GPO-WM stands for process-oriented KM.

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Chapter 6.19
The Contribution of Communities of Practice to Project Management

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INTRODUCTION

More and more organisations are using projects as a means of managing their business; increasingly, 'new initiatives' are the focus of organisational life. Such initiatives could include cultural change programmes, organisation redesigns, or process improvements. Tackling the sociological and psychological aspects of the project is a great enough challenge, but there is often a requirement to develop a technological dimension too. Accelerating technical advancements brings an extra level of complexity to the projects so that, in general, projects have become more complex—not only do they tend to have a wider variety of customers to satisfy, but they also tend to utilise more sophisticated technology and have more far-reaching implications than ever before. It is not too surprising that some projects 'fail'; the increased complexity of projects brings an obvious rise in the associated risks. However, the increased complexity of projects also brings a rise in the opportunities for learning through the management of knowledge therein. These are opportunities that are not being fully exploited at present, as illustrated by the continuation of the 'failure-to-learn' and 'learning-to-fail' themes in the literature (e.g., Lyytinen & Robey, 1999; Cannon & Edmondson, 2004); a more active stance would consciously draw lessons from projects, from 'successes' and 'failures' alike.

Parallel to the growing emphasis on projects in organisational life and their changing nature, there is growing recognition of the interplay between the fields of project management (PM) and knowledge management (KM). Reference has already been made to the opportunities for more effectively managing knowledge within a project setting. This article operates at a finer level of detail and draws attention to the potential synergy between project teams and a much popularised social network derived from the KM arena—that of communities of practice (CoP). In doing so, the disciplines of PM and KM are explicitly bridged and, it is put forward, the prospect of breaking the 'learning-to fail' and 'failing-to learn' loops is raised.

BACKGROUND

New Knowledge and a Commitment to Action

The following brief literature review is a platform from which to launch the main thrust of the article when CoPs are compared and contrasted with project teams. Inevitably the reference material is taken from the second-generation KM arena where human and social aspects are central. Most authors agree on the general characteristics of CoP; this agreement can be tracked chronologically. Of more interest and significance to this article is the changing emphasis on CoPs' intention to act and the distinction that is, at times implicitly, made about the possibility of CoPs generating new knowledge.

Seminal works on CoPs are those of Lave and Wenger (1991) and, later in that decade, Wenger (1998). The concept is now well known throughout the second-generation KM movement and used by various authors. Pór (1998) describes communities as "connecting islands of knowledge into self-organising, knowledge sharing networks." Skyrme (1999, p. 170) goes on to say:

While some communities focus on a particular profession or discipline, the most powerful communities are customer or problem focused. They transcend disciplines and bring in different perspectives. They exchange, develop and apply knowledge.

The indication from Skyrme is that CoPs share knowledge and in turn increase their knowledge base and their sphere of application. However, this is through the development of knowledge rather than through its creation.

When distinguishing between their concept 'enabling context' and CoPs, Von Krogh, Ichijo, and Nonaka (2000, pp. 179-180) assert:

While a community of practice is a place in which members learn knowledge that is embedded there, an enabling context helps create new knowledge. The boundary of a community of practice is firmly set by the task, culture, and history of that community, but an enabling context is determined by the participants and can be changed easily. Membership in a community of practice is fairly stable, and it takes new members time to become full participants. But the many organisational members who interact in an enabling context come and go. Instead of being constrained by history, an enabling context has a here-and-now quality—and it is this quality that can spark real innovations.

There are various angles from which Von Krogh et al.'s (2000) work could be challenged—aspects such as the stability of a group and notions of 'participation' and 'task' will be clarified in the next section. However, Wenger (2000, p. 206) confronts the aspect of whether CoPs generate new knowledge when he states:

What these groups have in common is that engaging with each other around issues of common interest, sharing insights and information, helping each other, or discussing new ideas together are all part of belonging to the group.

He goes on to be more specific when he states that CoP provide "the resources that members use to make sense of new situations and to create new knowledge" (Wenger, 2000, p. 209), and refers to good practice in World Bank and Daimler

Chrysler. So the notions of new knowledge and of action are reinstated, and Von Krogh et al.'s (2000) interpretation of CoP is refuted.

In current times authors, such as Lehaney, Clarke, Coakes, and Jack (2004) retain Wenger's (2000) line, even though, initially, the foci on new knowledge and on action are not obvious. Lehaney et al. (2004, p. 46) say that CoPs are "willing to develop and share tacit and explicit knowledge" and that CoPs have become important means for "sharing information within professions and between like-minded people" (p. 50). However, the balance is redressed when they also say that CoPs may encourage creativity and problem solving through the diversity of their population (p. 49).

This article goes forward with the understanding that KM is concerned with the generation, capture, storage, and sharing of knowledge with an intent to take action in order to increase an organisation's competitive advantage. Therefore, if CoPs are an effective tool for KM, their capacities to create new knowledge (as well as to develop 'old' knowledge) and to apply knowledge, are crucial. The same is true for the argument to embrace CoPs in PM. Otherwise, there could be a tendency to continue to work with the same knowledge with little intention to move into the practical arena, and the 'learning-to-fail' and 'failing-to-learn' cycles of current projects are supported.

COMPARISON OF COMMUNITIES OF PRACTICE WITH PROJECT TEAMS

Sapsed, Besant, Partington, Tranfield, and Young (2002) and Crawford and Cooke-Davies (2000) started to draw together the notions of KM and teams, and KM and PM respectively. I move specifically to project teams and communities of practice, at a different level of focus from these authors. CoPs and project teams probably implicitly co-exist in practice. This section makes their co-existence explicit by identifying their differences and their areas of overlap. In doing so, it is anticipated that the areas of overlap and their associated untapped synergy will be better managed.

A holistic approach is taken and attention is given to features such as purpose, culture, composition, structure, and accountability. Melcrum (2000) was a useful starting point for a comparison, and the table below builds on some of his key themes.

Project teams and communities of practice are not one and the same. One is accepting that project teams are formed for the purpose of completing a project within agreed time, budgetary, and quality constraints, and that CoP develop as a result of a common interest in a field or problem area. However, the table shows that there is some common ground—for instance, their common intent to share and apply knowledge, and their potential interdisciplinary nature and possible cultural overlap.

FUTURE TRENDS

At first sight, CoPs and project teams may appear to be at opposite ends of the spectrum. Nevertheless, CoPs are increasingly being recognised by companies as an effective vehicle for increasing the sharing of learning about projects and, in turn, for improving the success rate of their projects. It is noted, however, that the 'CoP' may be referred to as a 'network' or a 'special interest group', and that this lack of clarity over use of language can cause confusion. With the growing emphasis on projects as a means of managing organisations, it is anticipated that this trend will continue.

There is much work to be done in this area, and I would suggest that future research aim for a deeper discussion about the underpinning ideology of project teams and CoPs. This in turn will enable the features in Table 1 to be expanded

Table 1. Comparison of communities of practice and project teams

	Communities of Practice	**Project Teams**
Purpose		
Overall	To increase capacity for improved action	To successfully complete project
In relation to knowledge	To generate, capture, store, and share knowledge	To share and apply knowledge within project boundaries
Composition		
Membership	Voluntary	Contractual
Profile of membership	Can be multi-disciplinary	Tend to be multi-disciplinary
Life span	'Natural' lifetime	Project lifecycle
Accountability		
Reporting structure	Informal	Formal
Rigidity of structure	Fluid	Relatively fixed
Measures of effectiveness	Intangible	Tangible
Culture		
Based on	Trust	'Esprit de corps'
Leadership style	Empowering	Variable

upon. Of a more practical nature, empirical work needs to be undertaken to discover how to manage the aforementioned similarities more effectively and how to minimise the potential conflict that the differences between project teams and CoPs may bring. Indeed, in "Project Teams and CoPs in the Construction Industry" Remington and Ragsdell explore some specific challenges for CoPs in traditional project environments such as construction.

CONCLUSION

This article has continued a theme that is evident in recent literature—that of building bridges between the disciplines of project management and knowledge management. This has been achieved by advancing discussion of the two groupings known as project teams and CoPs. In doing so, it has drawn attention to their complementary and contradictory aspects, and raised the possibility of tapping the synergy between the complementary aspects.

REFERENCES

Cannon, M.D., & Edmondson, A.C. (2004). Failing to learn and learning to fail (intelligently): How great organisations put failure to work to improve and to innovate. *Journal of Long Range Planning.*

Crawford, L., & Cooke-Davies, T. (2000). Managing projects: Managing knowledge: Sharing a journey towards performance improvement. *Proceedings of the World Project Management Week Conference*, Eventcorp, Brisbane, Australia.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, MA: Cambridge University Press.

Lehaney, B., Clarke, S., Coakes, E., & Jack, G. (2004). *Beyond knowledge management*. Hershey, PA: Idea Group Publishing.

Lyytinen, K., & Robey, D. (1999). Learning failure in information systems development. *Information Systems Journal, 9*(2), 85-101.

Melcrum. (2000). *Teams versus communities of practice*. Retrieved from www.melcrum.com

O'Donnell, D., Porter, G., McGuire, D., Garavan, T.N., Heffernan, M., & Cleary, P. (2003). Creating intellectual capital: A Habermasian community of practice (CoP) introduction. *Journal of European Industrial Training, 27*(2/3/4), 80-87.

Pór, G. (1998). Knowledge ecology and communities of practice: Emergent twin trends of creating true wealth. *Proceedings of the Knowledge Summit '98*, London (cited in Skyrme, 1999).

Sapsed, J., Besant, J., Partington, D., Tranfield, D., & Young, M. (2002). Teamworking and knowledge management: A review of converging themes. *International Journal of Management Reviews, 4*(1), 71- 85 (cited in Lehaney et al., 2004).

Skyrme, D.J. (1999). *Knowledge networking: Creating the collaborative enterprise*. Oxford: Butterworth-Heinemann.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. Oxford University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning & identity*. Cambridge, MA: Cambridge University Press.

Wenger, E. (2000). Communities of practice: The structure of knowledge stewarding. In C. Despres & D. Chauvel (Eds.), *Knowledge horizons: The present and the promise of knowledge management* (pp. 205-224). Oxford: Butterworth-Heinemann.

Wenger, E.C., McDermott, R., & Snyder, W.M. (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.

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Chapter 6.20
Knowledge Management in Supply Chain Networks

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INTRODUCTION

This article reviews current research and practice of knowledge management (KM) and inter-organizational learning in supply chain networks. Knowledge management is the organizational process for acquiring, organizing, and communicating the knowledge of individual employees so that the work of the organization becomes more effective (Alavi & Leidner, 1999). Knowledge management is an increasingly important process in business organizations because “managing human intellect—and converting it into useful products and services—is fast becoming the critical executive skill of the age” (Quinn, Anderson & Finkelstein, 1998). Grover and Davenport (2001) state that KM becomes “an integral business function” when organizations “realize that competitiveness hinges on effective management of intellectual resources.” Grover and Davenport also argue that knowledge management works best when it is carried out by all the employees of the organization and not just KM specialists.

Business organizations frequently partner with other firms to complement their core competencies. To collaborate effectively, partner firms have to communicate with each other information about business processes as well as share ideas of how to design or improve business processes. This phenomenon of knowledge sharing across organizational boundaries is called inter-organizational learning (Argote, 1999). Knowledge management, we posit, is necessary to facilitate inter-organizational learning and direct it in a way that supports the organization’s overall objectives.

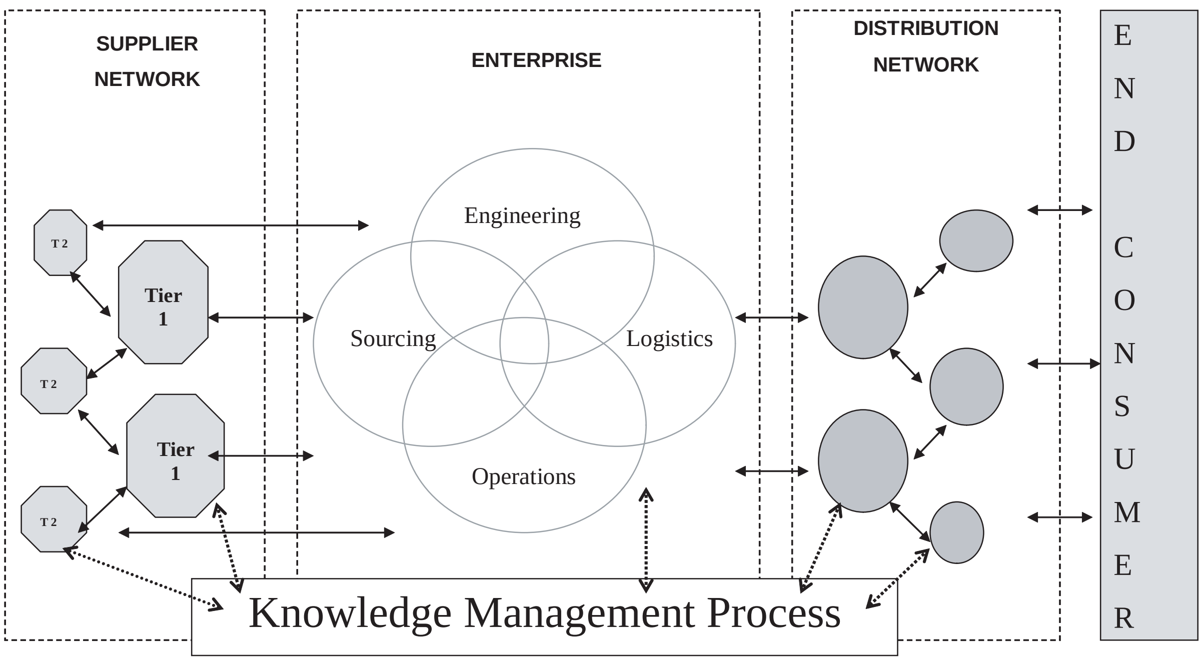
Supply chain systems are an example of business networks. Supply chains involve not only multiple corporate entities but also organizational units within a single organization. We present practices used in business organizations and networks of businesses to manage the information and knowledge sharing processes using the context of supply chain systems.

BACKGROUND

A supply chain consists of all parties involved, directly or indirectly, in fulfilling the end consumer's request. Its primary purpose is to satisfy customer needs while maximizing the overall profitability of the chain. A typical supply chain involves a variety of stages that may include customers; a distribution network of retailers, wholesalers, and distributors; manufacturing enterprises; and tiers of suppliers (Figure 1). Information, knowledge, funds, products. and services flow along both directions of the chain, where more than one player is often involved at each stage. The structure of supply chain systems can be described as a business network where inter-organizational learning and information sharing are critical factors in determining the chain's competitiveness.

The performance of a supply chain depends upon how well its processes are managed for the type of product that is associated with the chain. Fisher (1997) classifies products on the basis of their demand patterns, claiming that a product falls into one of two categories, either primarily functional or primarily innovative. Functional products satisfy basic needs and include the staples that people buy in a wide range of retail outlets such as grocery stores and gas stations. These products have stable, predictable demand, and long life cycles. Due to well-developed competition,

Figure 1. The integrated supply chain



low profit margins occur, requiring the chain to focus almost exclusively on minimizing physical costs. Companies need to coordinate the ordering, production, and delivery of supplies in order to minimize inventory and maximize production efficiency in order to meet predictable demand at the lowest cost.

Innovative products, such as fashion apparel and technology products including plasma TVs, cellphones, and iPods, are differentiated from competition by their designer options and new features and capabilities. The novelty of these products allow higher profit margins, but also result in more demand uncertainty as it is difficult to predict how the market will respond to the newest design features and options. The life cycle for innovative products is short as ensuing competition forces companies to introduce newer innovations in order to maintain the higher profit margins. The short life cycles and the great variety typical of these products further increase demand unpredictability. The demand uncertainty from the market environment increases the risk and costs of shortages and excess supplies throughout the chain. To mitigate this risk, it is crucial that information flows not only within the chain but also from the marketplace to the chain. Fisher (1997) describes managers' primary focus in supply chains for innovative products as market mediation, the need to read early sales numbers or other market signals and have the chain respond quickly. The critical decisions to be made are not about minimizing costs but about where in the chain to position inventory and available production capacity in order to hedge against the uncertain demand and be responsive. Supply chain systems reduce the external environmental uncertainty by introducing formal information and knowledge transfer mechanisms between supply chain partners. In supply chains with innovative products, suppliers are evaluated based on their reliability, speed, flexibility, and product development skills as well as for their cost.

Due to the emphasis on market mediation, supply chains for innovative products require more collaboration about product design and improvement of business processes than supply chains for functional products. While information sharing can improve the performance of functional product supply chains, inter-organizational learning is essential to support the overall objectives of the innovative product supply chain.

KNOWLEDGE MANAGEMENT IN SUPPLY CHAINS

As the goal for functional products is to minimize the physical costs associated with the production and delivery of the product, many supply chains have improved their coordination efforts by sharing information. Efficient Consumer Response (ECR) and Quick Response (QR) initiatives are efforts that certain industries have implemented to reengineer the supply channel to make it more responsive to customer demand. Controlling the flow of information and product between different stages within the chain is a major focus of these initiatives as it helps decrease the costs of inventory and shortages. Chains have used technologies such as electronic data interchange (EDI), the Internet, and satellite systems for transmitting point-of-sale data to provide real-time information. Improved coordination is achieved with this information even when the decision-making responsibilities remain decentralized. A $14 billion savings in the food service industry (Troyer, 1996) and $30 billion savings in the groceries industry (Kurt Salmon Associates, 1993) have been documented as a result of implementing these initiatives. Current MS/OR research (e.g., Lee, So & Tang, 2000) studies the value of different types of information that can be shared given the decentralized decision-making framework. For example, Wal-Mart's Retail Link program provides an online summary of point-of-sale data for Johnson & Johnson and

Lever Brothers as well as direct satellite transmitted point-of-sale data. Cachon and Fisher (1997) describe the cost savings that Campbell Soup's continuous replenishment program generated for the grocery supply chain. In this instance, retailers transmitted daily inventory information via EDI to Campbell Soup, and the manufacturer assumed responsibility for managing retailer inventories, a process commonly referred to as vendor managed inventory. This particular continuous replenishment program reduced inventories in retailer distribution centers by 50%, while increasing service levels from 98.7% to 99.5%.

Some chains have extended their collaborative efforts to include information about processes as well as more centralized decision making. Aviv (2001) and Raghunathan (1999) describe Collaborative Forecasting and Replenishment (CFAR) as a new inter-organizational system that enables retailers and manufacturers to forecast demand and schedule production jointly. CFAR allows the exchange of complex decision support models and manufacturer/retailer strategies so that the two supply chain parties can reduce demand uncertainty and coordinate their decisions. Wal-Mart and Warner-Lambert embarked on the first successful CFAR pilot, involving Listerine products in 1996. Since then several major manufacturers of functional products, such as Procter and Gamble, have undertaken CFAR projects.

Due to the demand uncertainty and short life cycle, supply chains for innovative products need to develop strategies that will create flexibility and responsiveness within the chain. The exchange of knowledge about processes, innovations, and market interest are vital to the members of the chain as it works to design and distribute the newest product to the market quickly. The Knowledge and Learning in Advance Supply Systems (KLASS) pilot project (Rhodes & Carter, 2003) seeks to develop collaborative learning in networks of suppliers in the automotive and aerospace sectors. Focusing on the tiered supplier network, as illustrated on the left side of Figure 1, KLASS utilized an inter-company, computer-mediated learning network that focused on both immediate performance improvements and longer term objectives. It developed learning and knowledge to advance collaborative functioning and improved performance between the tiered companies linked in the supplier network. Similarly, to manage knowledge across the supplier network and enterprise boundaries, as shown in Figure 1, Chrysler developed a successful supplier-suggestion process to reduce costs and build collaborative relationships with its suppliers (Hartley, Greer & Park, 2002). Both of these are examples of inter-organizational systems.

In another example of an inter-organizational network, Mak and Ramaprasad (2003) introduce the idea of knowledge supply networks, which they define as "integrated sets of manufacturing and distribution competence, engineering and technology deployment competence, and marketing and customer service competence that work together to market, design and deliver end products and services to markets." They outline the nature of the business processes associated with designing and delivering innovative products and describe the need to effectively coordinate the knowledge in the market, design, and supply distribution chains. As costs for product development increase and faster time-to-market is expected, more and more original equipment manufacturers (OEM), such as Motorola and Nokia, are refocusing their competence on marketing, research and design, and critical high level design, and outsourcing everything else to contract manufacturers. This changes the chain structure as outlined in Figure 1 and requires the OEM to create a knowledge management network that will allow them to leverage the supplier and contract manufacturer knowledge, yet still preserve their own knowledge and control.

In order to be competitive, supply chains for innovative products must have processes in place to exchange product and market knowledge. Unlike the chains associated with functional products, innovative chains will not incur much competitive advantage as the result of demand and inventory information sharing. Due to high future demand uncertainty and potentially high profit margins, there is often distrust between the stages of the chain. This distrust can result in parties making uncoordinated decisions that are in their best individual interest (local optimization) and not in the best interest of the supply chain.

For instance, in the PC market, manufacturers suspect their distributors of inflating orders to ensure availability of the product. Dell Corporation removed the distributor stage in its supply chain so that it could improve its market mediation and receive end-consumer information directly. In the automotive and aerospace industry, manufacturers provide suppliers with forecasts that are often wrong, resulting in extreme shortages or excess capacity with no return on investment for the suppliers. Suppliers often make locally optimal decisions as a result. When a supplier could not provide an adequate supply of ashtrays and glove compartment doors, GM lost nearly two months of production of the Buick Roadmaster (Suris & Templin, 1993). In 1999, GM canceled two new models, leaving their suppliers with newly developed capacity and no return for their investment (Pryweller, 1999). In 1997, Boeing could not fill their plane orders largely due to a shortage of 500 different parts from 3,000 part suppliers who did not have enough capacity, resulting in a $1.6 billion charge against Boeing's third-quarter earnings (Cole, 1997).

A survey done by Lee and Whang (2000) identifies that firms are also concerned about the confidentiality of shared information when competition exists, and that it is one of the major hurdles that information sharing in a supply chain must overcome. Besides intentional information leaks, Li (2002) defines the leakage effect as the indirect effect of vertical information sharing that occurs when the shared information becomes known to competition as the result of observing the behavior of the party that receives the information. Li illustrates how competing firms can react to the observed behavior and how this reaction can change the strategic interaction, causing additional gains or losses to the parties between which the information was directly exchanged. Powell, Koput, and Smith-Doerr (1996) point out that firms will continue to work with their partners, once the risks are managed at a "tolerable level."

In addition to trust, several other factors impact the ability of a firm to share information and knowledge productively with other parties in a supply chain. These include the technology infrastructure, application software used to manage the supply chain operations, and the culture of knowledge sharing within a firm as well as within the supply chain.

Scott (2000) studied the process of and reasons for information technology (IT) support for inter-organizational learning. Studying the disk drive industry, Scott identified the need for inter-organizational learning to help "cope with the complexity of new products and the capital intensity" in the industry. She noted that the industry had consolidated with several firms working very closely in a "vertically integrated virtual organization." IT helps the organizations streamline the information flow between them, making it easier to provide feedback between partners and facilitate learning across organizational boundaries. The model developed by Scott helps to explain the role of IT in lower and higher levels of inter-organizational learning. In lower level learning, an organization makes changes to its operations based on feedback from a partner. In higher order learning, partners change operating assumptions and procedures based on a new understanding typically resulting from collaborative work. An important finding from her study was that inter-organizational learning strategies "with customers and suppliers in the disk drive industry were facilitated by IT and constrained by lack of trust."

Kent and Mentzer (2003) conducted a study of the impact of inter-organizational information technology (IOIT) in a retail supply chain. They found that when suppliers invest in IOIT, retailers perceive a commitment to the relationship from the suppliers and are willing to reciprocate. The commitment to the relationship leads to the partners working together to improve logistics efficiency. Therefore, the payoff from the investment in IOIT comes from the reduction of costs in the supply chain as a result of improvements in logistics efficiency. Their findings also support Scott's (2000) observation about the role of trust between partners in a supply chain. In addition to the investment in IOIT, they show that firms must also "demonstrate characteristics of trust such as integrity and faithfulness." Only then will partners perceive the commitment to the relationship. As Kent and Metzer state, "relationship trust and investment in IOIT can lead to relationship commitment that can lead to logistics efficiency."

The above examples pertain to inter-organizational systems; however, KM plays an important role even within a single organization. Intra-organizational systems and initiatives are needed to facilitate knowledge sharing across organizational units. Edwards and Kidd (2003) treat knowledge management "as a process rather than as an organizational system" or a piece of technology. In order for this process to work across organizational boundaries, they identify trust, organizational culture, and the "relationship between top down strategy and bottom up organizational learning" as enabling factors. Trust needs to exist between individuals as well as between organizations. There needs to be compatibility between the cultures of organizations for knowledge management processes to work. Aligning the top down strategy with bottom up learning requires the organization to make its strategy for KM clear and create and maintain an atmosphere that supports organization learning. Trust between individuals and organizations can be enhanced by setting up exchange programs and by facilitating voluntary exchange of knowledge.

Another set of factors that Bessant and Kaplinsky (2003) recognize as necessary for learning in supply chain is the "accumulation and development of a core knowledge base," as well as the "long-term development of a capability for learning and continuous improvement across the whole organization." In order for each organization in a supply chain to manage how learning takes place, they need to have formal mechanisms and a clear understanding of the value of learning. Only then can long-term efforts be sustained.

This set of factors is based on the concept of absorptive capacity (Cohen & Levinthal, 1990). Cohen and Levinthal describe this as the capacity of an organization to "recognize the value of new, external information, assimilate it, and apply it to commercial ends." Lane and Lubatkin (1998) suggest that the absorptive capacity of a firm is relative to its partner firms and is dependent on "the similarity of both firms' knowledge bases, organizational structures and compensation policies," and one firm's familiarity with the other firm's "set of organizational problems." Szulanski (1996) shows that a unit's lack of absorptive capacity, a distant relationship with other units and lack of a clear understanding of cause and effect relationships can all become impediments to intra-organizational learning.

In addition to efficiency in logistics is the issue of effectiveness of sourcing in enterprises that have multiple personnel handling the purchasing task. Rozemeijer, Van Weele, and Weggeman (2003) identify three constructs to help corporate purchasing officers create coordinating mechanisms that facilitate purchasing synergies within the corporation. The constructs include purchasing maturity, corporate coherence, and business context. The mechanisms they identified include:

- formal organizational mechanisms such as corporate steering boards or commodity teams;
- informal networking mechanisms such as annual purchasing conferences and job rotation;
- enterprise-wide information and communication systems; and
- advanced management and control systems.

These four mechanisms or systems represent different options for intra-organizational KM. These mechanisms were illustrated for a supply chain with functional products. Rozemeijer et al. (2003) also point out however that purchasing performance depends on increased coordination between multiple purchasing officers and requires constant monitoring to ensure that the purchasing function is aligned with the business context and corporate strategy, which is associated with the type of product and supply chain objectives involved.

CONCLUSION

As the studies cited above show, information technology that supports information sharing is a necessary element for knowledge management processes to work in supply chains. In supply chains for functional products, decentralized decision making can result in good decisions when IT support is effective. However, in innovative supply chains, IT by itself is not sufficient. The other factors are needed as well. Without the other factors, such as trust within and across organizations or an organizational culture that supports learning, the supply chain does not benefit. Even with good IT and information sharing, each company is likely to make decisions that are locally focused, resulting in suboptimal supply chain performance.

Practitioners interested in creating and managing knowledge management efforts in supply chains should consider the following issues carefully:

- The information flow between the tiers in the supply chain and how the systems and organization support information sharing.
- The utilization of information within an organization, especially to support decision making. Decentralized decision making can be beneficial for the supply chain as long as the firms trust each other and want to optimize the performance of the chain. Incentives need to be in place to ensure that each party is motivated to maximize the performance of the chain.
- The organizational culture with respect to learning within each firm and across the tiers in the supply chain. The culture must support learning and facilitate the process of learning.
- Trust between organizations in the supply chain is critical. Unless the firms develop this trust, they will make decisions solely based on their self interest, and that may be detrimental to supply chain performance.
- How the network assimilates the information and how the network changes its actions based on what it has learned is the effect of the knowledge management effort. In the case of functional products, this can be in the form of firms modifying processes to increase efficiency. In the case of innovative products, suppliers may be elevated to status of true partners, taking on more responsibility and risk and sharing in decision making as decisions are made in a more centralized manner.

REFERENCES

Alavi, M., & Leidner, D. E. (1999). Knowledge management systems: Issues, challenges and benefits. *Communications of the AIS, 1,* 1-37.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge*. Norwell, MA: Kluwer.

Aviv, Y. (2001). The effect of collaborative forecasting on supply chain performance. *Management Science, 47*(10), 1326-1343.

Bessant, J., & Kaplinsky, R. (2003). Putting supply chain learning into practice. *International Journal of Operations and Production Management, 23*(2), 167-184.

Cachon, G., & Fisher, M. (1997). Campbell Soup's continuous replenishment program: Evaluation and enhanced inventory decision rules. *Production and Operations Management, 6*(3), 266-276.

Cohen, W. M., & Levinthal, D. A. (1990, March). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Cole, J. (1997, June 26). Boeing, pushing for record production, finds parts shortages, delivery delays. *Wall Street Journal*, p. A4.

Edwards, J. S., & Kidd, J. B. (2003). Knowledge management sans frontiers. *Journal of the Operational Research Society, 54*(2), 130-139.

Fisher, M. (1997). What is the right supply chain for your product? *Harvard Business Review, 75*(2), 105-117.

Grover, V., & Davenport, T. H. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-21.

Hartley, J., Greer, B., & Park, S. (2002). Chrysler leverages its suppliers' improvement suggestions. *Interfaces, 32*(4), 20-27.

Kent, J., & Mentzer, J. (2003). The effect of investment in interorganizational information technology in a retail supply chain. *Journal of Business Logistics, 24*(2), 155-175.

Kurt Salmon Associates Inc. (1993). *Efficient consumer response: Enhancing consumer value in the grocery industry*. Washington, DC: Food Marketing Institute.

Lane, P. J., & Lubatkin, M. (1998, May). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*(5), 461-477.

Lee, H., So, K., & Tang, C. (2000). The value of information sharing in a two-level supply chain. *Management Science, 46*(5), 626-643.

Lee, H., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Technology Management, 20*, 373-387.

Li, L. (2002). Information sharing in a supply chain with horizontal competition. *Management Science, 48*(9), 1196-1212.

Mak, K-T., & Ramaprasad, A. (2003). Knowledge supply network. *Journal of the Operational Research Society, 54*(2), 175-183.

Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996, March). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly, 31*(1), 116-145.

Pryweller, J. (1999, June 21). Delays jolt GM suppliers: Some part makers invest millions. *Automotive News*. Retrieved July 6, 2005, from http://www.autonews.com/article.cms?articleId=20471

Quinn, J. B., Anderson, P., & Finkelstein, S. (1998). Managing professional intellect: Making the most of the best. *Harvard Business Review of Knowledge Management*, 181-205.

Raghunathan, S. (1999). Interorganizational collaborative forecasting and replenishment systems and supply chain implications. *Decision Sciences, 30*(4), 1053-1071.

Rhodes, E., & Carter, R. (2003). Collaborative learning in advanced supply systems: The KLASS Pilot Project. *Journal of Workplace Learning, 15*(6), 271-279.

Rozemeijer, F., Van Weele, A., & Weggeman, M. (2003). Creating corporate advantage through purchasing: Toward a contingency model. *Journal of Supply Chain Management, 39*(1), 4-13.

Scott, J. E. (2000). Facilitating interorganizational learning with information technology. *Journal of Management Information Systems, 17*(2), 81-113.

Suris, O., & Templin, N. (1993, October 5). GM production problems hurt '94 model sales. *Wall Street Journal,* pp. A4.

Szulanski, G. (1996). Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal, 17,* 27-43.

Troyer, C. (1996, May 21-23). EFR: Efficient food service response. *Proceedings of the Conference on Logistics,* Palm Springs, California.

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Chapter 6.21
Corporate Semantic Webs

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INTRODUCTION

An organization is made up of people interacting for common objectives, in a given structure (may be rather formal in the case of a company, an administration, or an institution, or rather informal in the case of an interest community or a practice community), in an internal environment, and with an external environment.

Based on definitions of Grundstein (2004) and O'Leary (1998), we define knowledge management (KM) as the "management of knowledge resources of an organization in order to ease:

- access, sharing, reuse of this knowledge (that can be explicit or tacit, individual or collective), with an objective of capitalization;
- creation of new knowledge, with an objective of innovation."

Among the various approaches for KM, this article focuses on those aimed at knowledge capitalization and sharing. They can rely on the notion of corporate memory (or organizational memory (OM)) that, extending van Heijst's definition (1996), we define as the "explicit and persistent materialization of crucial knowledge and information of an organization in order to ease their access, sharing out and reuse by the members of the organization in their individual and collective tasks" (Dieng-Kuntz et al., 2001).

As such an OM relies on individuals interacting in an organization, with support of software tools, construction and management of a corporate memory require a multidisciplinary approach, taking into account at least three dimensions: (1) individual (memory must be compatible with users' cognitive models and their work environment), (2) organization (memory must be compatible with culture and strategy of the organization), and (3) technology (the chosen software tools must be adapted to the memory objectives and to the environment of future users).

This article will detail a particular approach of OM called the "corporate semantic Webs" approach, proposed by the Acacia team which the author deeply thanks.

BACKGROUND

From Knowledge-Based Systems to Knowledge Management

If the need of KM in enterprises has long been emphasized in management sciences (Grundstein, 2004), this notion started to be studied thoroughly at the beginning of the '90s by artificial intelligence researchers who had previously worked on expert systems and knowledge-based systems (KBSs), and had evolved towards knowledge engineering (KE): Steels (1993) was one of the first researchers in this community to stress the notion of corporate memory in order to promote knowledge growth, knowledge communication, and knowledge preservation in an organization; since 1993, the ISMICK conferences have been dedicated to these topics (Barthès, 1996). In 1996, the KE community emphasized the interest of OMs and its differences with regards to KBS: definitions were proposed (van Heijst, Van der Spek, & Kruizinga, 1996), as well as concrete examples (Dieng et al., 1996). Then several workshops at KAW, ECAI, IJCAI, and AAAI thoroughly studied methods and tools for building and using OMs (Dieng & Matta, 2002).

Ontologies and Knowledge Management

Meanwhile, the KE community was working on ontologies (Gruber, 1993). The Banff Knowledge Acquisition workshops (KAW)1 enabled a better comprehension of foundations of ontologies (Guarino & Giaretta, 1995; Guarino, 1996). Researchers proposed tools for collaborative building of ontologies (Farquhar, Fikes, & Rice, 1996; Domingue, 1998; Tennison & Shadbolt, 1996), as well as concrete, huge ontologies in KM large applications (Swartout et al., 1996; Golebiowska, Dieng, Corby, & Mousseau, 2001). Moreover, some researchers on ontologies emphasized the interest of ontologies for KM (Benjamins, Fensel, & Gómez-Pérez, 1998a; Dieng et al, 2001).

The (KA)2 initiative (Benjamins et al., 1998b) was a significant example of collaborative building of an ontology and of semantic annotations by the knowledge acquisition community.

Knowledge Management Based on Ontologies and Documents

The evolution from KBS to KM was based on the idea that a corporate memory could be naturally materialized in a knowledge repository without any reasoning aims; therefore ontologies seemed to be a quite natural way to make the conceptual vocabulary shared by an organization explicit. But this evolution led to recognition that the most frequent knowledge sources that could be integrated in an OM were documents. The need for a link between documents (considered as informal knowledge sources) and knowledge bases/ontologies (expressing formal knowledge) was emphasized by research that associated to a document a knowledge base aimed at making the underlying semantics of the document explicit and at improving information retrieval by reasoning on this knowledge base (Martin, 1997; Euzenat, 1996). The advent of XML led several KM researchers to rely on XML-based formalisms and on the future semantic Web (Rabarijaona, Dieng, Corby, & Ouaddari, 2000; Martin & Eklund, 2000). Shoe (Luke, Spector, Rager, & Hendler, 1997) and Ontobroker (Fensel, Decker, Erdmann, & Studer, 1998) offered an ontology-guided information retrieval approach; community semantic portals were developed using such tools (Staab et al., 2000).

Knowledge Management and the Semantic Web

The interest of the Web for KM and knowledge distribution over the Internet, either through an intranet or through the open Web, was stressed by O'Leary (1997), by the KAW'98 track on "Knowledge Management and Distribution over the Internet,"2 as well as some special issues of journals (Dieng, 2000) and books (Schwartz, Divitini, & Brasethvik, 2000).

In 1998, Berners-Lee proposed his vision of the semantic Web:

The Web was designed as an information space, with the goal that it should be useful not only for human-human communication, but also that machines would be able to participate and help. One of the major obstacles to this has been the fact that most information on the Web is designed for human consumption, and…that the structure of the data is not evident to a robot browsing the Web. Leaving aside the artificial intelligence problem of training machines to behave like people, the Semantic Web approach instead develops languages for expressing information in a machine processable form.

He gave a roadmap for evolving "from the Web of today to a Web in which machine reasoning will be ubiquitous and devastatingly powerful" (Berners-Lee, 1998).

Several research communities (database, intelligent systems (Schwartz, 2003), knowledge engineering and knowledge representation, information retrieval, language technologies, distributed artificial intelligence and multi-agent systems, machine learning, Computer-Supported Collaborative Work, etc.) recognized in this ambitious objective a fabulous potential application of their research.

Last, the importance of social networks in which interactions and cooperation could be enhanced through the Web explains the privileged role of the semantic Web as a basis for supporting such networks, in particular with participants distributed geographically.

European Projects on Knowledge Management and the Semantic Web

Several collaborative European or national projects studied semantic Web approaches for KM:

- The C-WEB3 (Community Webs) project (Christophidès, 2000) proposed an infrastructure for Web portals in user communities requiring efficient query answering using various information sources. This infrastructure, aimed at semantic portals, can be seen as an architecture for a community semantic Web.
- The On-to-Knowledge4 project (Davies, Fensel, & van Harmelen, 2002) offered languages—such as OIL (Fensel et al., 2000), one precursor of OWL—methods, and tools aimed at applying ontologies to electronically available information for improving KM quality in large, distributed organizations.
- The CoMMA5 (Corporate Memory Management through Agents) project (Gandon, Dieng-Kuntz, Corby, & Giboin, 2002) developed an ontology (O'CoMMA), as well as a multi-agent system for managing a distributed corporate memory materialized in a corporate semantic Web, some agents having machine learning capabilities.
- The British AKT (Advanced Knowledge Technologies) project (Shadboldt & O'Hara, 2004) relies on an integrated approach, combining artificial intelligence, psychology, linguistics, multimedia, and Internet technology, for developing the next generation of knowledge technologies in order to support organizational KM, from acquiring and maintaining knowledge, to publishing and sharing it.
- OntoWeb6 (Ontology-Based Information Exchange for Knowledge Management and Electronic Commerce) network studies

thouroughly techniques and methodologies for building and using ontologies in the framework of the semantic Web.

The convergence of all these research topics led to the idea of the corporate semantic Web, which the next section will explain more precisely.

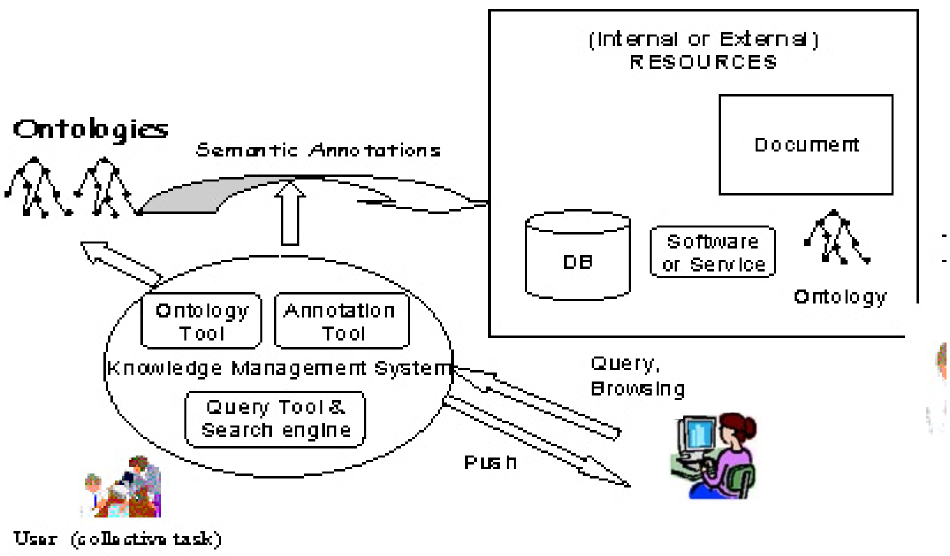
MAIN FOCUS OF THE ARTICLE

The corporate semantic Web approach proposed by the Acacia team relies on the analogy between Web resources and corporate memory resources. Intranets or IntraWebs, based on Web technologies, are a widely used means of information diffusion aimed at improving information and knowledge sharing out in enterprises. As the Web users, members of an organization need to access competent persons, to retrieve relevant information in documents, to discover useful services, and to communicate or publish in order to share specific knowledge.

The semantic Web aims at making semantic contents of Web resources understandable, not only by humans, but also by programs, for a better cooperation among humans and machines, according to Berners-Lee's vision (Berners-Lee, Hendler, & Lassila, 2001). The most popular approach consists of making semantic annotations on Web resources explicit, such annotations being represented in the RDF language recommended by W3C.

Our hypothesis is that the social Web constituted by all actors interacting in an organization could be supported by a KM system materialized in an organization-wide web inspired by the World Wide Web. The importance of semantics of the concepts to be handled leads naturally to a corporate semantic Web, inspired by the semantic Web, but at the scale of the organization.

Figure 1. Architecture of a corporate semantic Web

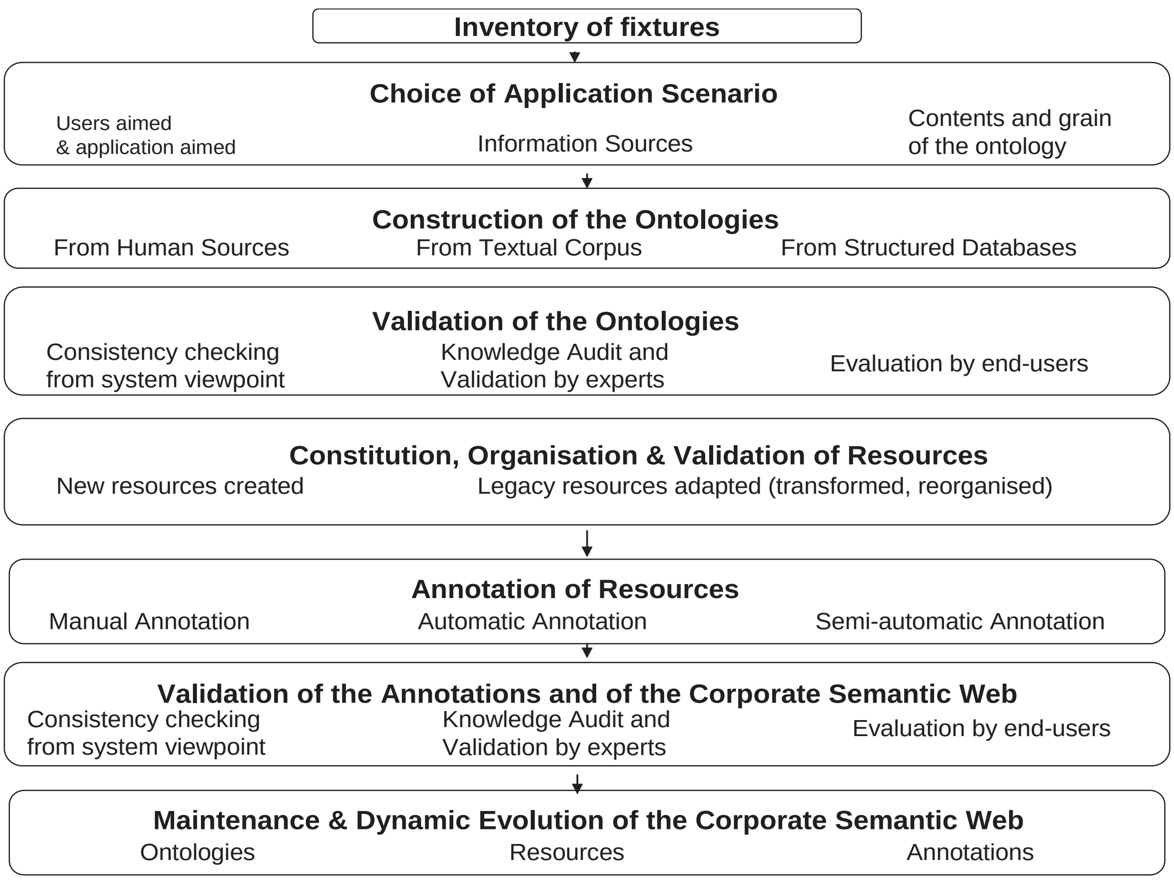


Therefore, we propose to materialize a corporate memory through a corporate semantic Web (or organizational semantic Web) consisting of:

- Resources: These can be documents (in various formats such as XML, HTML, or even classic formats), but these resources can also correspond to people, services, software, or programs.
- Ontologies: Describing the conceptual vocabulary shared by one or several communities in the company.
- Semantic Annotations on Resources: Contents of documents, skills of persons, or characteristics of services/software/programs, based on these ontologies, with diffusion on the intranet or the corporate Web.

However, a corporate semantic Web has some specificities with regards to the Semantic Web. The fact that an organization is bounded allows an easier agreement on a corporate policy, an easier creation of ontologies and annotations, an easier verification of validity and reliability of

Figure 2. Method of construction of a corporate semantic Web



information sources, a description of more precise user profiles, and a smaller scale for corporate documents and for ontologies. But an organization has security and confidentiality constraints, as well as a need to rely on stable tools or standard languages, compatible with the internal work environment.

Figure 1 shows the architecture of a corporate semantic Web, and Figure 2 summarizes our method for building it. Researchers study how to build, represent, use, and evolve each component of the system and the links among such components. After stressing the actors involved, we will analyze the components of a corporate semantic Web (resources, ontologies, annotations).

COMPONENTS OF A CORPORATE SEMANTIC WEB

The Actors

We distinguish several roles among the involved actors:

- The knowledge holders or authors of resources (for example, authors of documents, software, or services constituting the memory resources).
- The end-users: The objective of annotations is to allow end-users to retrieve resources ("pull") or to disseminate these resources towards end-users in a proactive way ("push"), in a more precise and relevant way in both cases.
- The annotators, who can be either knowledge holders or mediators (such as documentation centers). They must annotate resources in order to ease their retrieval by the future memory users. These annotations must thus take into account, on the one hand, the semantics aimed by the authors, and on the other hand, the users' needs for search for information. Objective annotations correspond to an interpretation common to any user, whereas subjective annotations are related to interpretation by a particular reader. As the annotator cannot guess all possible uses of the resources and all the future users' needs, s/he can collect information about profiles of the intended users and about their work contexts.

Resources in a Corporate Semantic Web

One can regard as resource any human, documentary, or software entity that can possibly be considered as a knowledge source thanks to its interpretation by a human accessing this resource. Resources can be documents with various formats (classic formats or formats dedicated to the Web like XML, HTML), but they can also correspond to people (in the case of a memory aimed at easing access to knowledge holders), services, software, programs, databases (DBs), ontologies, knowledge bases (KB), case bases, and so forth. According to the granularity chosen, the elementary resource enabling access to a knowledge element can consist of an entire document or of an element of document, of a whole database or of a DB record, of a whole KB or of a rule, and so forth, provided that this element is identifiable and can be referred.

Resources can be internal or external to the organization: for example, in a technological watch scenario, the semantic annotations of external resources useful for some employees can be considered as part of the corporate semantic Web.

Ontologies in a Corporate Semantic Web

An ontology is the explicit specification of a conceptualization according to Gruber (1993), or more precisely, according to Borst (1997), the formal specification of a shared conceptualization. We can characterize an ontology by:

- its root concepts, indicating the principal semantic axes or points of view considered;
- its concepts: each concept can be characterized by the terms enabling to designate it, its informal definition in natural language, its formal definition in intension in the case of a defined concept, its attributes, and its possible relationships with other concepts (parents, brothers, or concepts to which it is connected by a relation);
- the structure of the ontology: subsumption link enables the structuring of a concept hierarchy (resp. a relation hierarchy), part-of link enables structuring of a partonomy of concepts;
- possible relations between concepts, with the signatures of these relations;
- the instances of concepts when they play an ontological part (such as, for example, some constants in a mathematical or physical field: e.g., π, c, g);
- the axioms on concepts and relations.

The roles of an ontology in an OM are varied (Gandon, Dieng-Kuntz, Corby & Giboin, 2002):

- The ontology can be a component of the memory, a component aimed at being browsed by the end-user: in this case, natural language definitions or explanatory texts understandable for a human user must be associated to concepts and relations of the ontology. Moreover, the ontology contents must be adapted to users' tasks—at grain level, detail level, visibility level, and so forth.
- The ontology can be a reference for indexing/annotating semantically the memory in order to improve resource retrieval or information retrieval in the memory. In this case, the ontology must include concepts significant for annotation (e.g., User, Competence, Organization, Document, Task, Project, Domain), so as to enable annotation of the resources of the memory (e.g., This resource is a document of this type, created by someone having this competence in this department of the organization, related to these domain concepts and useful for this type of user in the framework of this task in the context of this project), and then reuse these annotations and the ontology in order to make inferences for information retrieval.
- Finally, the ontology can be a basis for communication and exchange of information among programs or among software agents. In this case, a formal ontology (with an accurate, non-ambiguous meaning), represented in the formal language of the messages exchanged by these agents, is needed. The content of the ontology must correspond to the needs in messages of the software agents that must be able to handle it formally.

When the OM is materialized in a corporate semantic Web, the situation corresponds to the second case since the ontology must at least be used for semantic annotation of memory resources. However, as we stressed in the previous section, ontologies can also form part of the memory resources, and they can also be annotated semantically.

In the three cases, it is necessary to choose ontology contents (i.e., its domain and its level of granularity), as well as its method of construction and evolution. The following sections will study more thoroughly these two points.

Contents of the Ontology

The applicative objective can help to choose the degree of granularity of the ontology: the contents of an Automobile ontology intended to be used by a design engineer working in the drawing office of a car manufacturer will be different from the Automobile ontology for an accidentologist analyzing road accidents.

Knowledge on the future users or on applications in which the ontology will be integrated can thus be useful to determine whether it is relevant to integrate a given concept, and can help to choose the adequate width and depth of the ontology.

If the ontology plays the role of a reference for annotating the memory elements semantically, it can be compared with an index on the memory. But, instead of the terms of an index or of a thesaurus, a semantic annotation by the ontology allows to associate to an element of the memory concepts, relations, instances, or particular relations between instances. Moreover these annotations can relate to an elementary resource which can, according to the case, consist of an entire document or of an element of document.

In this case, the criterion to build the ontology will be the answer to the question: By which concepts/relations/instances will the annotator need to annotate the resource in order to ease the retrieval of this resource in the most relevant way?

In the OM scenario, the intended user type or even the use context can be helpful for this purpose:

- In a scenario of project memory, concepts allowing description of a project and its organization, its participants, its tasks, problems encountered and possible solutions, lessons learned in the project, and concepts of the project domain will be useful to integrate in the ontology. The SAMOVAR application (Golebiowska, Dieng, Corby & Mousseau, 2001) illustrates such a scenario of project memory. In this scenario—in the context of design of new car—an engineer of a car manufacturer tries to solve a problem encountered on a given part of the vehicle designed, and s/he tries to retrieve in past projects whether the same problem (or a similar one) occurred, which solutions were considered, and which one was adopted for solving it. S/he will then be able either to reuse this solution (perhaps after adapting it) or, if the change of context makes reuse of this solution impossible, to study whether one of the other solutions previously evoked and eliminated would be convenient to be used or adapted.
- In a scenario of skills management (Benjamins et al., 2002), the ontology can include the concepts allowing description of various types of competences (technical, organizational, social, or relational skills) and their links with various functions or tasks within the organization.
- In a scenario of support to a newcomer integration, the ontology can be based on the needs of a newcomer and on all the actors likely to interact with this newcomer; the ontology can, for example, describe the types of documents having to be consulted by a newcomer or to be used by a mentor/tutor, those describing the organization, and those useful for the Human Resources department. The ontology will be able to also include some concepts of the domain (for example, technical concepts useful for the activity of the newcomer or concepts s/he must learn to master). The CoMMA application (Gandon, Dieng-Kuntz, Corby & Giboin, 2002) illustrates such a scenario.
- In a scenario of e-learning, the ontology can rest on the needs of training for acquiring the competences required in the various functions of the company, on the teaching approaches to use, on the profiles of the students, or of the people/companies likely to carry out teaching, on the available e-learning tools, on the possible uses of the Web as exchange medium, on the educational

resources. The MEMORAE application (Abel et al., 2004) illustrates this scenario of e-learning.
- In a scenario of watch (i.e., scientific, strategic, or technological monitoring, business intelligence), concepts allowing description of the actors involved in the watch process of the company, as well as concepts on the relevant domain and all those likely to be watch targets, could be included in the ontology (Cao, Dieng-Kuntz, & Fiès, 2004). For example, in a scenario in the pharmacological sector, the watch department analyzes all documents on published patents of their competitors in order to detect new significant trends of research (confirming their own research strategy or to take into account in this strategy).

The ontology creation depends on the modeling choices and rests on several actors: ontologist, experts serving as knowledge sources, experts taking part in the validation. Some modeling choices will also be influenced by the future application and by the future users of the ontology (either those who will consult it directly, or those who will seek resources annotated through it). Thus the ontology must be viewed as the result of a construction process, via a negotiation between several actors: ontologist, experts, and users.

Construction of the Ontology

The ontology construction methodology can be inspired by manual methods of ontology development from experts (Gómez-Pérez, Fernández-López, & Corcho, 2004; Uschold & Gruninger, 1996) or by methods based on corpus analysis (Aussenac, Biébow, & Szulman, 2000; Bachimont, Isaac, & Troncy, 2002).

The construction of the ontology can be manual, semi-automatic from textual corpora, or semi-automatic from a structured database.

Manual Construction

The method of construction of ontologies proposed in Gandon (2002) and Gandon et al. (2002) for building an ontology in the framework of a corporate semantic Web relies on the following phases:

- collection of data and scenarios, starting from discussions with some knowledge holders and through manual analysis of documents provided by the company, without use of natural language processing tools;
- terminological phase, allowing to determine terms associated with concepts and to solve terminological conflicts (cf., a case where different concepts are designated by the same terms or a case where several terms refer to the same concept);
- structuring of the ontology, through specialization links between concepts or relations;
- validation by experts;
- formalization in an ontology representation language (such as the languages recommended by W3C). According to the expressivity degree needed, one can use RDF(S) (Lassila & Swick, 1999) for basic ontologies, or OWL (Dean & Schreiber, 2004; McGuinness & van Harmelen, 2004) and one of its layers, OWL-Lite, OWL-DL, or Full OWL, for more expressive ontologies.

This method allows development of an ontology by possibly structuring it in several levels:

- a high level including abstract concepts, very reusable but not very usable by end-users in their daily work, and thus needing to be hidden when the end-user browses the ontology;
- an intermediate level comprising concepts useful for the OM scenario and for the do-

main considered, and thus reusable for these scenarios and similar domains;
- a specific level including concepts specific to the company and thus very useful for end-users, but not very reusable apart from this company.

The O'CoMMA ontology (Gandon, 2002), dedicated to two scenarios of corporate memory (support to integration of a new employee at T-Systems Nova, and support to technological monitoring at CSELT and at CSTB) is thus structured in three such levels.

Semi-Automatic Construction from Textual Sources

The methodology of ontology construction from texts proposed by the TIA group7 and described in Aussenac-Gilles et al. (2000) consists of the following stages:

- Set up of the textual corpus, taking into account the aims of the application.
- Linguistic analysis, consisting of choosing and applying to this textual corpus the adequate linguistic tools such as: (a) term extractors allowing to propose candidate terms, (b) relation extractors allowing to propose relations between these terms, (c) synonym managers allowing to detect synonym terms, and so forth.
- Normalization includes two phases:
    - Linguistic normalization: Allows the knowledge engineer to choose among the terms and lexical relations extracted previously, those which will be modeled in the ontology. The knowledge engineer will associate to each term and relation kept, a definition in natural language, if possible close to the text in the corpus. If a term or a relation has several meanings in the domain (i.e., polysemy), the knowledge engineer decides which meanings attested by the corpus will be kept because of their relevance.
    - Conceptual modeling: Semantic concepts and relations are then defined in a normalized form using labels of concepts and relations already defined.
- Formalization consists of ontology construction and validation. Existing ontologies can help to build the ontology top level and to structure it through main sub-domains. Semantic concepts and relations are then formalized and represented in chosen knowledge representation formalism (for example, description logics or conceptual graphs). If needed, additional concepts (i.e., structuring concepts, not necessarily attested by the textual corpus) can be added to structure the ontology. In a corpus-based approach, the terminological concepts (attested in texts) are distinguished from the other concepts (created by the ontologist in order to gather, factorize information, or structure the ontology). A complete validation can be carried out as soon as the ontology reaches a stable state.

This method was, for example, adapted for a vehicle project memory, within the framework of the SAMOVAR project (Golebiowska, Dieng, Corby & Mousseau, 2001), whose objective was to capitalize knowledge on problems encountered during a vehicle design project.

Semi-Automatic Construction from a Structured Database

One can also start from a structured database to translate it into an ontology represented in a standard representation formalism. The translation algorithm will depend on the database internal format, but the generic idea of building an ontology by decoding a database—the principle of coding of which is known—and to represent this ontology in a standard knowledge representation formalism, is interesting for companies having DBs from which they wish to reconstitute an ontology. This semi-automatic construction of ontologies from DBs is illustrated with the example of the Life Line project (Dieng-Kuntz et al., 2004), aimed at developing an organizational semantic Web dedicated to a medical community cooperating in the context of a healthcare network. By using an approach of "reverse engineering" relying on the analysis of its coding principle, Nautilus medical database was decoded to reconstitute a Nautilus ontology represented in RDF(S): the ontology could then be browsed and validated via a semantic search engine, and used for annotating and retrieving documents, and so forth.

Annotations in a Corporate Semantic Web

The construction of annotations relies on the ontology. The choice of grain of resource elements depends on the level to which the user needs to access the OM.

If one compares ontology-based semantic annotation with traditional indexing in information retrieval, their roles are similar, but the hierarchy of concepts, the relations, as well as the presence of axioms, allows several possibilities of reasoning: ontology-guided information retrieval enables retrieval of resources in a more relevant way (Fensel et al., 1998; Dieng et al., 2001; Corby & Faron, 2002; Corby, Dieng-Kuntz, & Faron-Zucker, 2004). An annotation is interpreted as: "This resource speaks about such concept, speaks about such instance of concept, expresses such relation between such concepts or such instances of concepts." One could be more precise and indicate the nature of annotation relation: some annotations can be viewed as argumentations, examples, assertions, and so forth.

For the construction of these annotations, one can use manual annotation editors or semi-automatic annotation tools such as those described in Handschuh and Staab (2003).

The user can then retrieve resources of the corporate semantic Web, which offers semantic browsing or semantic querying capabilities, based on resource annotations related to the ontology. There may also be specific annotations on user profiles and centers of interest if the ontology comprises concepts describing types of profiles or of interest centers. Semantic search engines such as Ontobroker (Fensel, Decker, Erdmann & Studer, 1998), WebKB (Martin & Eklund, 2000), or Corese (Corby, Dieng, & Hébert, 2000; Corby & Faron, 2002; Corby, dieng-Kuntz & Faron-Zucker, 2004) are useful to carry out such a search guided by ontologies. The interest of the ontology is to guide reasoning: this reasoning is based either on concept hierarchy or improvement in answers to users' queries. For example, for a request to retrieve patients suffering from a stomach disease, these reasoning capabilities enable a semantic search engine to retrieve a patient who had a surgery for a stomach cancer.

LANGUAGES AND TOOLS USEFUL FOR CREATING CORPORATE SEMANTIC WEBS

For representing semantic annotations of a corporate semantic Web, one can use RDF (Resource Description Format), a language recommended by the W3C for creating metadata for describing Web resources (Lassila & Swick, 1999). For representing ontologies, according to the expressivity level needed, one can use RDF Schema (RDFS) for simple ontologies or, for more complex ontologies, OWL (Ontology Web Language) (Dean & Schreiber, 2004; McGuinness & van Harmelen, 2004)—the ontology representation language recommended by W3C and intended for publishing and sharing ontologies on the Web.

Several tools can support building, use, and maintenance of a corporate semantic Web:

- Ontology development tools, enabling creation of a new ontology from scratch or modification of an existing ontology: e.g., Protégé (Noy, Fegerson, & Musen, 2000), KAON (Volz, Oberle, Staab, & Motik, 2003), WebODE (Arpirez et al., 2003).
- Annotation tools, enabling manual or semi-automatic semantic annotations on resources (e.g., instances of concepts and of relations)—for example, MnM (Vargas-Vera et al., 2002) or OntoMat-Annotizer (Handschuh, Staab, & Mäedche, 2001).
- Ontology-guided information retrieval tools, allowing retrieval of resources using their ontology-based annotations. Examples include semantic search engines such as Ontobroker (Fensel, Decker, Erdmann & Studer, 1998) or Corese (Corby et al., 2000; Corby & Faron, 2002; Corby et al., 2004), or semantic browsers such as Magpie (Dzbor, Domingue, & Motta, 2003).
- Multi-agent platforms, enabling the handling of distributed corporate semantic Webs—for example, tools described in Gandon (2002), and van Elst, Dignum, and Abecker (2003).

The interested reader can find a detailed description of several of such tools in Gomez-Pérez, Fernández-Lopez & Corcho (2004).

FUTURE TRENDS

Research needs to be performed on the construction, management, and evolution of the different elements of a corporate semantic Web. The most important topics seem to be:

- Maintenance and dynamic evolution of a corporate semantic Web: More specifically, how do we tackle the problems linked to evolution of ontologies, of resources, and of annotations (Klein, 2004; Stojanovic, 2004)?
- Validation of knowledge included in a CSW: Integrity and coherence of the corporate semantic Web (i.e., of the ontology and of the annotations, both after their creation and when they evolve), human validation by experts and evaluation by end-users.
- Automation in the construction of ontologies and of annotations: Progress is needed in ontology and annotation learning, using machine learning techniques, statistical or linguistic techniques.
- Heterogeneity: Integration of heterogeneous sources in a corporate semantic Web, management of multiple ontologies in a single organization/community or in several organizations/communities, management of multiple, contextual annotations according to multiple viewpoints, building and management of interoperable inter-organizations or inter-communities semantic Webs.
- Multimedia resources: Capability to handle multimedia resources and to create semi-automatically semantic annotations on multimedia resources (images, sound, video, etc.).
- Distribution: Large, distributed organizations/communities; intelligent agents, peer-to-peer architectures.
- Semantic Web services: Since Web services can play the role of resources annotated in a corporate semantic Web, current research on ontology-guided description, discovery, and composition of semantic Web services is useful.
- Human factors: Participative design of corporate semantic Webs, taking into account all stakeholders, analysis of social interactions/collaboration through a corporate semantic Web, personalization of interfaces to user, support to such interactions.

- Human-machine interaction: Research on ergonomic, intelligent, adaptive interfaces will be crucial for acceptance and usability of organizational semantic Webs.
- Scalability: Even if it is less crucial than for the open semantic Web, scalability is required for very large organizations or for watch scenarios in order to be able to handle a huge number of resources, huge ontologies, or huge annotation bases.
- Reasoning and inference capabilities: They may help offer a better personalization of interaction with users, according to their profiles.
- Evaluation of a corporate semantic Web: Knowledge valuation criteria need to be studied thoroughly (Giboin, Gandon, Corby, & Dieng, 2002; O'Hara & Shadbolt, 2001).

This research will naturally benefit from general research performed by several research communities on the (open) semantic Web, but it needs to be guided by an actual understanding of the KM needs of an organization or a community.

CONCLUSION

This article has illustrated the "corporate semantic Web" approach that enables us to guide information retrieval from corporate memory by ontologies and annotations. This approach can be applied in various scenarios: memory of a team, of a department, or of a project; strategic, scientific, and technological watch; skills management; collaborative work in a community of practice or in a virtual enterprise.

With joint collaboration of all research communities focusing on the semantic Web, of human factor specialists, of researchers in management sciences, instead of being "yet another technology for KM," corporate semantic Webs can be a natural and popular approach for supporting human social Webs dynamically created in (or between) organizations or communities.

REFERENCES

Abel, M.-H., Barry, C., Benayache, A., Chaput, B., Lenne, D., & Moulin, C. (2004). Ontology-based organizational memory for e-learning. *Education Technology & Society, 7*(3).

Arpírez, J.C., Corcho, O., Fernández-Lopez, M., & Gómez-Pérez, A. (2003). WebODE in a nutshell. *AI Magazine, 24*(3), 37-47.

Aussenac-Gilles, N., Biébow, B., & Szulman, S. (2000, October 2-6). Revisiting ontology design: A methodology based on corpus analysis. In R. Dieng & O. Corby (Eds.), Knowledge engineering and knowledge management: Methods, models and tools. *Proceedings of the 12th International Conference (EKAW'2000)* (pp. 172-188), Juan-les-Pins. Berlin: Springer-Verlag (LNAI 1937).

Bachimont, B., Isaac, A., & Troncy, R. (2002, October 1-4). Semantic commitment for designing ontologies: A proposal. In A. Gómez-Pérez & V.R. Benjamins (Eds.), Knowledge engineering and knowledge management. Ontologies and the semantic Web. *Proceedings of the 13th International Conference (EKAW'2002)* (pp. 114-121), Sigüenza, Spain, Berlin: Springer-Verlag (LNAI 2473).

Barthès, J.-P. (1996). ISMICK and knowledge management. In J.F. Schreinemakers (Ed.), *Advances in knowledge management: Organization competence and methodology* (vol. 1, pp. 9-13).

Benjamins, V.R., Fensel, D., & Gómez-Pérez, A. (1998a, October 29-30). Knowledge management through ontologies. In U. Reimer (Ed.), *Proceedings of the 2nd International Conference on Practical Aspects of Knowledge Management (PAKM'98),* Basel, Switzerland.

Benjamins, V.R., Fensel, D., Gómez-Pérez, A., Decker, S., Erdmann, M., Motta, E., & Musen, M. (1998b, April 18-23). Knowledge Annotation Initiative of the Knowledge Acquisition Community (KA)2. *Proceedings of the 11th Workshop on Knowledge Acquisition, Modeling and Management (KAW'98),* Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW-98Proc.html

Benjamins, V.R., López Cobo, J.M., Contreras, J., Castillas, J., Blasco, J., de Otto, B., Garcia, J., Blásquez, M., & Dodero, J.M. (2002, October 1-4). Skills management in knowledge-intensive organizations. In A. Gómez-Pérez & V.R. Benjamins (Eds.), Knowledge engineering and knowledge management. Ontologies and the semantic Web. *Proceedings of the 13th International Conference (EKAW 2002)* (pp. 80-95), Sigüenza, Spain. Berlin: Springer-Verlag (LNAI 2473).

Berners-Lee, T. (1998, September). *Semantic Web road map*. Retrieved from http://www.w3.org/DesignIssues/Semantic.html

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The semantic Web. *Scientific American,* (May 17).

Borst, W.N. (1997). *Construction of engineering ontologies*. Centre for Telematica and Information Technology, University of Twente, Esched, The Netherlands.

Cao, T.-D., Dieng-Kuntz, R., & Fiès, B. (2004, October 6-9). An ontology-guided annotation system for technology monitoring. *Proceedings of the IADIS International Conference (WWW/Internet 2004),* Madrid, Spain.

Christophides, V. (Ed.). (2000, September). *Community Webs (C-Webs): Technological assessment and system architecture*. Deliverable C-WEB-IST-1999-13479-D5.

Corby, O., Dieng, R., & Hébert, C. (2000, August 13-17). A conceptual graph model for W3C resource description framework. In B. Ganter & G.W. Mineau (Eds.), Conceptual structures: Theory, tools, and applications. *Proceedings of ICCS'2000 (pp. 468-482),* Darmstadt, Germany. Berlin: Springer-Verlag (LNAI 1867).

Corby, O., Dieng-Kuntz, R., & Faron-Zucker, C. (2004, August 22-27). Querying the semantic Web with the CORESE search engine. In R. Lopez de Mantaras & L. Saitta (Eds.), *Proceedings of the 16th European Conference on Artificial Intelligence (ECAI'2004)* (pp. 705-709). Valencia, Spain. IOS Press.

Corby, O., & Faron, C. (2002, May). CORESE: A corporate semantic Web engine. *Proceedings of the International Workshop on Real World RDF and Semantic Web Applications at the 11th International World Wide Web Conference 2002*, Hawaii. Retrieved from http://paul.rutgers.edu/~kashyap/workshop.html

Davies, J., Fensel, D., & van Harmelen, F. (Eds.). (2002). *Towards the semantic Web: Ontology-driven knowledge management*. New York: John Wiley & Sons.

Dean, M., & Schreiber, G. (Eds.). (2004). *OWL Web Ontology Language reference*. W3C Recommendation, February 10, 2004. Retrieved from http://www.w3.org/TR/owl-ref/

Dieng, R. (Ed.). (2000). *Special issue of IEEE Intelligent Systems on Knowledge Management and the Internet*.

Dieng, R., Corby, O., Giboin, A., & Ribière, M. (1999). Methods and tools for corporate knowledge management. *International Journal of Human Computer Studies, 51,* 567-598. Academic Press. Also retrievable from http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW98Proc.html

Dieng, R., Giboin, A., Amergé, C., Corby, O., Després, S., Alpay, L., Labidi, S., & Lapalut, S. (1996, November 9-14). Building of a corporate memory for traffic accident analysis. *Proceedings of the*

10th Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW'96) (pp. 35.1-35.20), Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/KAW96Proc.html. Also in AI Magazine (1998), 19(4), 80-100.

Dieng-Kuntz, R., Corby, O., Gandon, F., Giboin, A., Golebiowska, J., Matta, N., & Ribière, M. (2001). *Méthodes et outils pour la gestion des connaissances: Une approche pluridisciplinaire pour le knowledge management* (2nd ed.). Dunod.

Dieng-Kuntz, R., Minier, D., Corby, F., Ruzicka, M., Corby, O., Alamarguy, L., & Luong, P.-H. (2004, October). Medical ontology and virtual staff for a health network, In E. Motta et al. (Eds.), Engineering knowledge in the age of the semantic Web. *Proceedings of the 4th International Conference (EKAW'2004)* (pp. 187-202), Whittlebury Hall, UK.

Dieng-Kuntz, R., & Matta, N. (Eds.). (2002). *Knowledge management and organizational memories.* Kluwer Academic Publishers.

Domingue, J. (1998, April 18-23). Tadzebao and WebOnto: Discussing, browsing, and editing ontologies on the Web. *Proceedings of the 11th Workshop on Knowledge Acquisition, Modeling and Management (KAW'98)*, Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW98Proc.html

Domingue, J., Motta, E., Buckingham Shum, S., Vargas-Vera, M., Kalfoglou, Y., & Farnes, N. (2001, October 23-24). Supporting ontology driven document enrichment with communities of practice. *Proceedings of the ACM International Conference on Knowledge Capture (KCAP)* (pp. 30-37), Victoria, Australia.

Dzbor, M., Domingue, J., & Motta, E. (2003, October). Magpie: Towards a semantic Web browser. *Proceedings of the 2nd International Semantic Web Conference,* Sanibel Island, FL.

Euzenat, J. (1996, November 9-14). Corporate memory through cooperative creation of knowledge bases and hyper-documents. In B. Gaines & M. Musen (Eds.), *Proceedings of the 10th Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW'96)* (pp. 36.1-36.18), Banff, Canada. Also retrievable from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/KAW96Proc.html

Farquhar, A., Fikes, R., & Rice, J. (1996, November 9-14). The Ontolingua server: A tool for collaborative ontology construction. In B. Gaines & M. Musen (Eds.), *Proceedings of the 10th Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW'96)* (pp. 44.1-44.19), Banff, Canada. Also retrievable from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/KAW96Proc.html

Fensel, D., Decker, S., Erdmann, M., & Studer, R. (1998, April 18-23). Ontobroker or how to enable intelligent access to the WWW. *Proceedings of the 11th Workshop on Knowledge Acquisition, Modeling and Management (KAW'98),* Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW98Proc.html

Fensel, D., Horrocks, I., van Harmelen, F., Decker, S., Erdmann, M., & Klein, M. (2000). OIL in a nutshell. In R. Dieng & O. Corby (Eds.), *Knowledge engineering and knowledge management: Methods, models and tools* (pp. 1-16). Berlin: Springer-Verlag (LNAI 1937).

Gandon, F. (2002). *Distributed artificial intelligence and knowledge management: Ontologies and multi-agent systems for corporate semantic Webs.* PhD Thesis, UNSA.

Gandon, F., Dieng-Kuntz, R., Corby, O., & Giboin, A. (2002, August 25-30). Semantic Web and multi-agents approach to corporate memory management. *Proceedings of the 17th IFIP World Computer Congress IIP Track* (pp. 103-115), Montréal, Canada.

Giboin, A., Gandon, F., Corby, O., & Dieng, R. (2002, September 30). Assessment of ontology-based tools: Systemizing the scenario approach. *Proceedings of the EKAW'2002 Workshop on Evaluation of Ontology-Based Tools (EON'2002)* (pp. 63-73), Sigüenza (Spain).

Golebiowska, J., Dieng, R., Corby, O., & Mousseau, D. (2001, October 23-24). Building and exploiting ontologies for an automobile project memory. *Proceedings of ACM International Conference on Knowledge Capture (K-CAP)* (pp. 52-59), Victoria, Australia.

Gómez-Pérez, A., Fernández-López, M., & Corcho, O. (2004). *Ontological engineering.* Berlin: Springer-Verlag.

Gruber, T.R. (1993). A translation approach to portable ontology specification. *Knowledge Acquisition, 5*(2), 199-220.

Grundstein, M. (2004). De la capitalisation des connaissances au management des connaissances dans l'entreprise. In I. Boughzala & J.L. Ermine (Eds.), *Management des connaissances en entreprise*. Hermès.

Grunstein, M., & Barthès, J.-P. (1996, October). An industrial view of the process of capitalizing knowledge. In J.F. Schreinemakers (Ed.), Knowledge management: Organization, competence and methodology. *Proceedings of the 4th International Symposium on the Management of Industrial and Corporate Knowledge (ISMICK'96)* (pp. 258-264), Rotterdam, The Netherlands. Ergon.

Guarino, N. (1996, November). Understanding, building, and using ontologies. *Proceedings of the 10th Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW'96),* Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/KAW96Proc.html

Guarino, N., & Giaretta, P. (1995). Ontologies and knowledge bases: Towards a terminological clarification. In N. Mars (Ed.), *Towards very large knowledge bases: Knowledge building and knowledge sharing* (pp. 25-32), University of Twente. Enschede, The Netherlands: IOS Press.

Handschuh, S., Staab, S., & Mäedche A. (2001, October 23-24). CREAM—Creating relational metadata with a computer-based, ontology-driven annotation framework. *Proceedings of the ACM International Conference on Knowledge Capture (KCAP)* (pp. 76-83), Victoria, Canada. ACM Press.

Handschuh, S., & Staab, S. (Eds.). (2003). Annotation for the semantic Web. *Frontiers in Artificial Intelligence and Applications, 96*. IOS Press.

Klein, M. (2004). *Change management in distributed ontologies*. PhD Thesis, Vrije Universiteit, The Netherlands.

Lassila, O., & Swick, R.R. (1999). *Resource Description Framework (RDF) model and syntax specification*. W3C Recommendation, February 22, 1999. Retrieved from http://www.w3.org/tr/rec-rdf-syntax/

Luke, S., Spector, L., Rager, D., & Hendler, J.. (1997, February 5-8). Ontology-based Web agents. In W.L. Johnson (Ed.), *Proceedings of the 1st International Conference on Autonomous Agents (Agents'97)* (pp. 59-66), Association for Computing Machinery, New York.

Martin, P. (1997, August 3-8). CGKAT: A knowledge acquisition and retrieval tool using structured documents and ontologies. In D. Lukose, H. Delugach, M. Keeler, L. Searle, & J. Sowa (Eds,), Conceptual structures: Fulfilling Peirce's dream. *Proceedings of the 5th International Conference on Conceptual Structures (ICCS'97)* (pp.581-584), Seattle, Washington. Berlin: Springer-Verlag (LNAI 1257).

Martin, P., & Eklund, P. (2000). Knowledge retrieval and the World Wide Web. *IEEE Intelligent Systems, 15*(3), 18-25.

McGuinness, D.L.,& van Harmelen, F. (Eds). (2004, February 10). *OWL Web Ontology Language overview*. W3C Recommendation, February 10, 2004. Retrieved from http://www.w3.org/TR/owl-features/

Noy, N., Fegerson, B., & Musen, M. (2000, October 2-6). The knowledge model of Protégé-2000. In R. Dieng & O. Corby (Eds.), Knowledge engineering and knowledge management: Methods, models and tools. *Proceedings of the 12th International Conference (EKAW'2000)* (pp. 17-32), Juan-les-Pins. Berlin: Springer-Verlag (LNAI 1937).

O'Hara, K., & Shadbolt, N. (2001, August 5). Issues for an ontology for knowledge valuation. *Proceedings of the IJCAI-01 Workshop on E-Business and the Intelligent Web,* Seattle. Retrievable from http://www.csd.abdn.ac.uk/~apreece/ebiweb/programme.html

O'Leary, D.E. (1997). The Internet, intranets and the AI renaissance. *Computer, 30*(1), 71-78.

O'Leary, D.E. (1998). Enterprise knowledge management. *Computer, 31*(3), 54-61.

Rabarijaona, A., Dieng, R., Corby, O., & Ouaddari, R. (2000). Building and searching an XML-based corporate memory. *IEEE Intelligent Systems and their Applications, Special Issue on Knowledge Management and the Internet* (May/June), 56-63.

Schwartz, D.G., Divitini, M., & Brasethvik, T. (Ed.). (2000). *Internet-based organizational memory and knowledge management.* Hershey, PA: Idea Group Publishing.

Schwartz, D.G. (2003). From open IS semantics to the semantic Web: The road ahead. *IEEE Intelligent Systems, 18*(3), 52-58.

Shadboldt, N., & O'Hara, K. (Eds.). (2004). *Advanced knowledge technologies.* Selected Papers, ISBN 85432 8122.

Staab, S., Angele, J., Decker, S., Erdmann, M., Hotho, A., Maedche A., Schnurr H.-P., Studer R., & Sure Y. (2000). Semantic community Web portals. *Computer Networks, 33*(1-6), 473-491.

Steels, L. (1993). Corporate knowledge management. *Proceedings of the International Symposium on the Management of Industrial and Corporate Knowledge (ISMICK'93)* (pp. 9-30), Compiègne, France.

Stojanovic, L. (2004). *Methods and tools for ontology evolution*. PhD Thesis, University of Karlsruhe, Germany.

Tennison, J., & Shadbolt, N.R. (1998, April 18-23). APECKS: A tool to support living ontologies. *Proceedings of the 11th Workshop on Knowledge Acquisition, Modeling and Management (KAW'98),* Banff, Canada. Retrieved from http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW98Proc.html

Uschold, M., & Gruninger, M. (1996). Ontologies: Principles, methods and applications. *The Knowledge Engineering Review, 11*(2), 93-155.

van Elst, L., Dignum, V., & Abecker, A. (Eds.). (2003, March 24-26). Agent-mediated knowledge management. *Proceedings of the International Symposium of AMKM 2003*, Stanford, CA. Berlin: Springer-Verlag (LNCS 2926).

van Heijst, G, Van der Spek, R., & Kruizinga, E. (1996, November). Organizing corporate memories. In B. Gaines & M. Musen (Eds.), *Proceedings of the 10th Knowledge Acquisition for Knowledge-Based Systems Workshop (KAW'96)* (pp. 42.1-42.17), Banff, Canada. Also retrievable from http://ksi.cpsc.ucalgary.ca/KAW/KAW96/KAW96Proc.html

Vargas-Vera, M., Motta, E., Domingue, J., Lanzoni, M., Stutt, A., & Ciravegna, F. (2002, October 1-4). MnM: Ontology driven semi-automatic and automatic support for semantic markup. In A. Gómez-Pérez & V.R. Benjamins (Eds.), Knowledge engineering and knowledge management. Ontologies and the semantic Web. *Proceedings of the 13th International Conference (EKAW'2002)* (pp. 379-190), Sigüenza, Spain. Berlin: Springer-Verlag (LNAI 2473).

Volz, R., Oberle, D., Staab, S., & Motik, B. (2003, May 20-24). KAON SERVER—A semantic Web management system. *Alternate Track Proceedings of the 12th International World Wide Web Conference (WWW2003),* Budapest, Hungary.

ENDNOTES

1. http://ksi.cpsc.ucalgary.ca/KAW/
2. http://ksi.cpsc.ucalgary.ca/KAW/KAW98/KAW98Proc.html
3. http://cweb.inria.fr
4. http://www.ontoknowledge.org/
5. http://www.ii.atos-group.com/sophia/comma/HomePage.htm
6. http://ontoweb.semanticweb.org/
7. TIA (Terminologie et Intelligence Artificielle) is a French working group on Terminology and Artificial Intelligence

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Chapter 6.22
E-Commerce as Knowledge Management: Managing Consumer Knowledge

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ABSTRACT

This chapter constructs the concept of e-commerce as knowledge management. The socially constructed approach to knowledge management is adopted. Through qualitative research, rooted in the Social Constructionist-Critical Theory paradigm, the chapter examines how consumers use the Internet in commercially related activity. Through semi-structured interviews with consumers three main themes are identified and explored (interaction with commercial organizations, consumer-to-consumer interaction, power and control in business-to-consumer interaction). The chapter concludes that the Internet facilitates the construction and sharing of knowledge amongst consumers, but appears to strengthen barriers and boundaries between consumers and companies. An illustration of how companies could effectively utilize the Internet to communicate with customers is offered in an analysis of a discussion forum.

INTRODUCTION

Customer and company expectations of e-commerce are far from aligned. While companies value the Internet as a marketing channel, customers value the Internet for its connectivity and potential for increased communication.

This dichotomy reflects two extremes of technology adoption. In the first wave of e-commerce, companies rushed to establish a virtual presence and generally adopted a transactional approach.

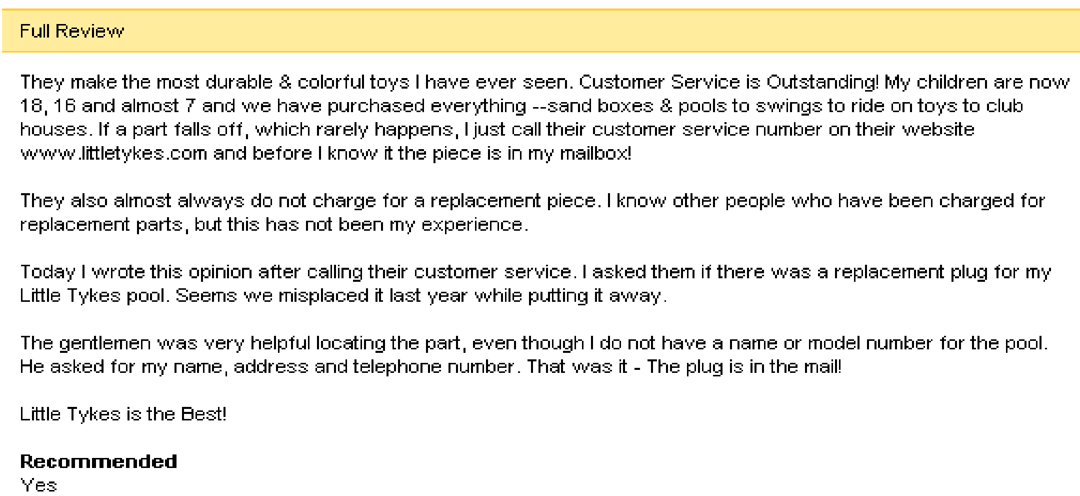
The technology was available to facilitate online "virtual" retail exchanges, so that's what companies did. It was generally believed that these new Internet start-up companies or dot-coms would supplant traditional business models and change the face of business forever. Newspaper headlines declared, "Britain prepares for boom.com. Exciting times are ahead for the stock market as Internet start-up companies get set for flotation" (Keegan, 1999) in a fervor of optimism.

However, within a matter of months, headlines such as "Net bubble@burst.com: Analyst warns that only a few big online firms will survive" (Martinson, 1999) replaced the optimism of the initial wave. The stakeholders weren't ready for e-commerce, they hadn't seen it evolve, or more importantly they hadn't been involved in its construction. The success of this phase of e-commerce demanded too much immediate change. It was a technologically determinist, reactionary phenomena. The customers rejected the technology.

This dichotomy is visible in today's e-commerce world as well. The Internet is changing the way that companies do business, and technology is impacting business practices. For companies, "consumer knowledge" is knowledge about the consumer's lifestyle, preferences and significant life events. They are operating in a knowledge gathering culture. In contrast, for customers, "consumer knowledge" is knowledge that consumers have about different products, companies and services. People's lives are made up of conversations and the Internet facilitates conversation amongst and between a wide circle of individuals. On neutral ground away from the commercial Web, a knowledge sharing culture is evolving. Here, the impact of the Internet is vast. Nobody planned it this way. Discussion forums, review sites, chat rooms and communities have all evolved as people have shaped the way that the Internet is used.

In the technological integrationist or constructivist tradition (Elster, 1983; Kimble & McLoughlin, 1995), and echoing the work of Bijker (1999), ordinary people are constructing the World Wide Web, shaping the way it is used in a recursive, proactive and evolutionary process. Outlining

Figure 1. epinions.com


Full Review

They make the most durable & colorful toys I have ever seen. Customer Service is Outstanding! My children are now 18, 16 and almost 7 and we have purchased everything --sand boxes & pools to swings to ride on toys to club houses. If a part falls off, which rarely happens, I just call their customer service number on their website www.littletykes.com and before I know it the piece is in my mailbox!

They also almost always do not charge for a replacement piece. I know other people who have been charged for replacement parts, but this has not been my experience.

Today I wrote this opinion after calling their customer service. I asked them if there was a replacement plug for my Little Tykes pool. Seems we misplaced it last year while putting it away.

The gentlemen was very helpful locating the part, even though I do not have a name or model number for the pool. He asked for my name, address and telephone number. That was it - The plug is in the mail!

Little Tykes is the Best!

Recommended
Yes

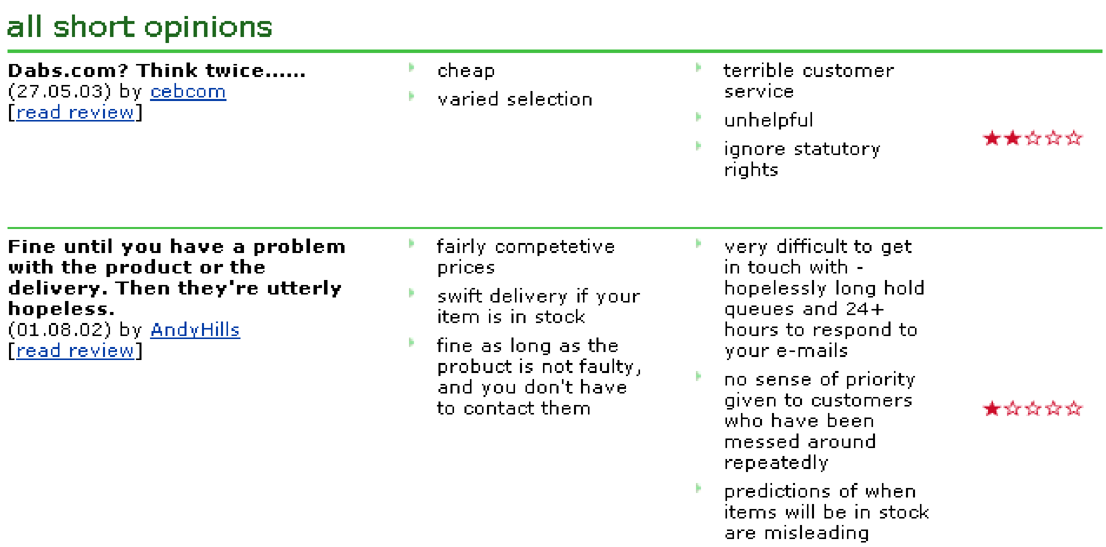
Polanyi's theory of knowledge (Polanyi, 1962), Nonaka and Takeuchi suggest that "scientific objectivity is not the sole source of knowledge. Much of our knowledge is the fruit of our own purposeful endeavors in dealing with the world" (Nonaka & Takeuchi, 1995). "New knowledge" is created by people as they interact with others in society. The potential for this interaction has increased significantly through the Internet. In terms of commercial activity, consumers are using the Internet to gather and share knowledge about products and companies. They are using the Internet as a consumer knowledge exchange forum, claiming neutral territory away from the commercial Web as their own. There has been an increase in the amount of sites such as epinions.com (see Figure 1 for a screenshot), notacceptable.com and bitchaboutit.com and DooYoo reviews (see the screenshot featured in Figure 2) where, significantly consumers have conversations with each other, and share their experiences or stories of interacting with companies and using products.

KNOWLEDGE MANAGEMENT

Drawing on the theory of the "personalization strategy" and on the "socially constructed models" of Knowledge Management identified by McAdam and Mcreedy (1999), this research project constructs the concept of e-commerce as knowledge management. In order to justify the knowledge management approach and model adopted here it is necessary to review and critique the "classic models" more traditionally adopted by academics in the field of knowledge management, and to illustrate why they are not considered appropriate for application to a study of consumers' knowledge creation and exchange via the Internet.

Knowledge creation and conceptualization are context-dependent. They depend upon our ways of viewing the world (Johnson & Duberley, 2000). From a positivist perspective knowledge is "true fact" which can be objectively observed. Whilst from an interpretivist or constructivist perspective knowledge is constructed and negotiated by

Figure 2. DooYoo reviews



people in day to day interactions, and can only be understood and communicated subjectively (Chua, 1986; Burrell & Morgan, 1979). The different approaches to the creation of knowledge are echoed in approaches to knowledge management (Hansen, Nohria, & Tierney, 1999). McAdam and McCreedy's paper, A Critical Review of Knowledge Management Models, (McAdam et al., 1999) identifies and critiques three models of knowledge used in a management context:

- Intellectual capital models
- Knowledge category models
- Socially constructed models

Table 1 illustrates the characteristics and key thinkers of each approach.

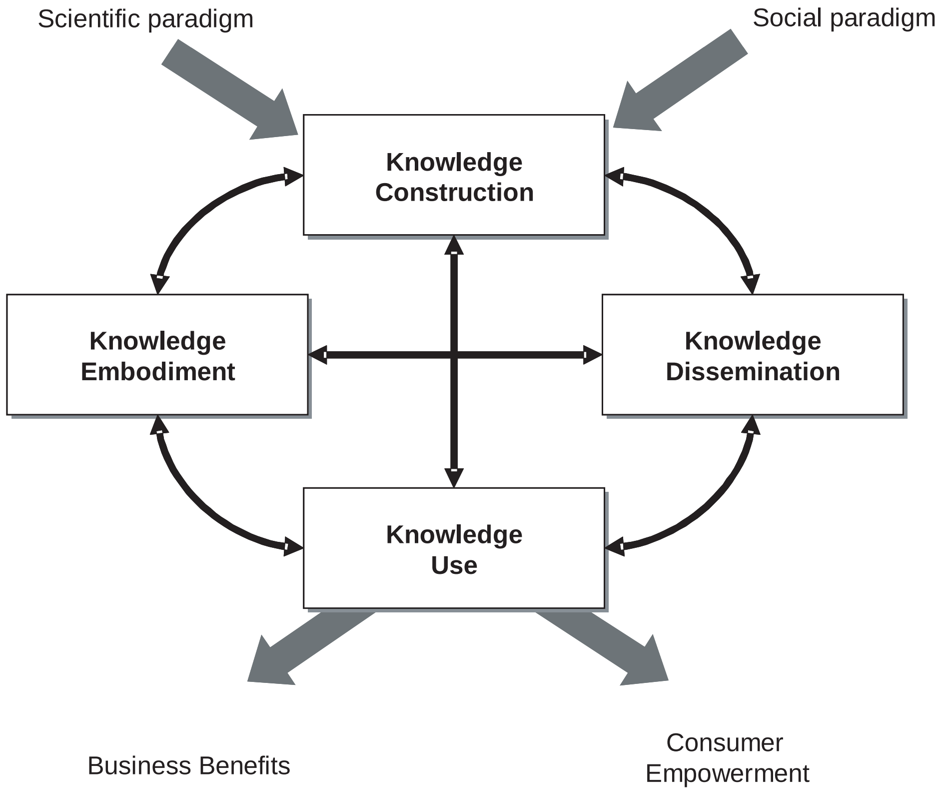
The theory of socially constructed knowledge management does not assume one given definition of knowledge, but adopts a more holistic approach linking knowledge to social and learning processes. This holistic view allows the models to "be used to represent the key dimensions of Knowledge Management in the widest possible sense" (McAdam & Reid, 2000) and, therefore, renders them suitable for a consumer focused exploration of e-commerce as knowledge management.

This study takes the socially constructed approach, arguing that knowledge is socially constructed and subjectively understood. The model that is adopted for this research is a version of Demarest's (1997) adaptation of Clark and Staunton's (1989) model, modified by McAdam and McCreedy (McAdam et al., 1999). This model emphasizes four stages in the knowledge management process, "knowledge construction," knowledge embodiment," "dissemination" and finally "use," but it adds "emancipatory enhancements" through employee use of knowledge and subsequent empowerment. The model is adapted to adopt a consumer focus in order to explore consumer empowerment through knowledge use (Figure 3).

Table 1. Key thinkers and characteristics of knowledge management models

Model	***Characteristics***	***Key Thinkers***
Intellectual Capital	• Objectivist stance. • Knowledge is objectified, measured, valued and controlled. • Focus is on explicit or tangible knowledge. • Neglects social processes.	(Stewart, 1997) (Edvinsson, 1997) (Van Buren, 1999) (Roos & Roos, 1997)
Knowledge Category	• All knowledge can be identified and categorized. • Focus is on dichotomies (e.g. tacit / explicit, personalized / codified). • Cursory consideration of social processes.	(Nonaka et al., 1995) (Hedlund,) (E.G. Carayannis, 1999) (Earl, 2001)
Socially Constructed	• Constructivist stance • Holistic approach to knowledge • Knowledge cannot be controlled • Focus is on communication and knowledge created through social processes	(Clarke & Staunton, 1989) (Demarest, 1997) (McAdam et al., 1999)

Figure 3. Socially constructed model of knowledge management



Adapted from McAdam and McCreedy (1999)

Knowledge Management and E-Commerce

It has been argued that to add maximum value for a company, the e-commerce function should attempt to replicate the way people shop in the "real world" and "create a sense of community and opportunities to communicate" (IPA, 1995). The success of companies such as eBay, which doesn't actually sell anything but simply facilitates consumer-to-consumer exchanges, or Amazon.com, a pioneer of electronic consumer reviews, illustrates the demand for consumer connectivity.

At the same time, consumer research has moved away from the view of a passive, cognitive, information-processing consumer to recognize a more pro-active, discriminatory and social individual. Foxhall et al. state that:

"It is almost certain that …he or she will seek information from friends, neighbours or relatives about the relative merits of different brands. Indeed several studies indicate that informal word-of-mouth communication may be more effective than formal advertising in moulding consumers' decisions." (Foxhall, Goldsmith, & Brown, 1998)

There is substantial literature on word-of-mouth (WOM) marketing (Sheth, 1971; Haywood, 1989; Buttle, 1998; Engel, Kegerris, & Blackwell, 1969). WOM is generally defined as interpersonal communication concerning products, companies or services where the listener regards the communicator as impartial. Established definitions have recently been refined to include not only oral communications, but also electronic communications such as the Internet which is "a growing source of recommending and complaining communications" (Buttle, 1998; Stokes & Lomax, 2002).

Traditionally, a consumer's "information-seeking process" may include an internal search evoking the consumer's memories and previous experiences, and an external search gathering information and knowledge from explicit sources such as consumer guides and reviews. It may also include knowledge of products, services and companies constructed through interactions with family, friends, colleagues, manufacturers, and suppliers. It is into this stage of the consumer experience that electronic channels are most likely to be accommodated. Qualitative research with consumers supports this, suggesting commercial benefits of online communities:

"There appear to be commercial benefits for organizations providing virtual communities on their Web sites. Many … people would like to use a virtual community to communicate with the company itself." (Evans, Wedande, Ralston, & Hul, 2001)

And even a reliance upon a virtual community:

"I go to Amazon instead of a regular bookstore because if I'm interested in a book, I can find out what 100 other people think about it. If I go to a bookstore now, I'm lonely. Where are those 100 people?" (Brewer, 2000)

The reach and impact of word-of-mouth marketing is vastly amplified by the Internet.

Social Constructionists argue that it is through communication and social interaction that knowledge is created. This may be knowledge about products on the market, or the quality of customer services departments of various companies. Through the Internet, the potential for consumer connectivity or interaction is vast. A person can exchange opinions and experiences of a product or company with thousands of other consumers. She can read a customer review of a book, and then read how useful that review was to others before making her decision to purchase. Finally, she can add her own ratings. She can compare the experiences of consumers who purchased different brands of cameras a year ago, reflect on their experiences of using the product and interacting with the company before deciding which brand she should purchase.

Through the Internet, a whole new world of such conversations has opened up. It has even been suggested that online communities of consumers operate a "gift economy," investing great time and effort in contributing their "knowledge." These practices have resounding echoes of the Knowledge Management practices promoted within many organizations, and in particular of the models of socially constructed knowledge management models proposed by Demarest (1997) and McAdam and Mcreedy (McAdam et al., 1999). To explore consumer's use of the Internet as a Knowledge Management system, and to propose ways in which organizations could create maximum value from knowledge created and shared by consumers through the Internet the following research study was carried out.

THE RESEARCH PROJECT

Introduction

This research explores consumers' use of the Internet through the lens of knowledge management with the following research objectives:

- To investigate how consumers use the Internet in commercial activity.
- To explore the idea that consumers currently use the e-commerce facility as a knowledge management function, to seek and share knowledge about products and services.
- To explore the idea that consumers are "empowered" by the Internet.
- To explore what business benefits are achieved through the social construction of knowledge and the empowerment of consumers via the Internet.
- To propose a framework for e-commerce to facilitate interaction, and integrate knowledge exchange with consumers into normal working practices.

Methodology

The approach selected for this research is informed by the debate into philosophical approaches to consumer research. As a generative exploration into the experiential perspective of consumers' uses of the Internet, with the aim of developing a framework for organizations to learn and benefit from the consumer experience, this research is rooted in the interpretive paradigm. The epistemological stance that is adopted is one of Social Constructionist-Critical Theory.

From the approach that this study took, it was important to survey relevant groups with "high experience levels of the phenomena under study" (Pettigrew, 1990), in this case online shopping. Questionnaires were adopted as a preliminary data collection method, and as a means of identifying suitable interview participants with relevant experience. To ensure consideration of stable usage patterns the sample was made up of consumers who are experienced Internet users and have engaged in commercial activity (transaction, product/company research) on the Internet for at least one year.

Twenty-two semi-structured interviews with consumers were carried out, each one lasting between 30 and 60 minutes (for question guide, see Appendix 1). Interviews were recorded with the permission of the participant, and verbatim transcripts were produced from the recordings. In analysis, the researcher made use of transcripts, recordings and field notes. The method of data analysis selected is pattern coding and theme analysis. Such analysis is an iterative process involving data collection and analysis simultaneously. From emergent themes theories are generated and confirmed or refuted by further exploration.

Emergent Themes

The major themes that emerged from the pattern coding and theme analysis of the interview transcripts are:

- Interaction with commercial organizations
- Consumer-to-consumer interaction
- Power and control in business-to-consumer interaction

Before considering each one of these in more detail, and to "set the scene," we describe how the participants thought of the Internet. Participants see the Internet as a source of information (or knowledge), and a means of communication:

"It's a huge body of information…. Like huge libraries ... So it represents a huge body of knowledge really, more so than anything." (Interview 6, male, age 38)

"A source of information really on anything." (Interview 10, female, age 52)

"It's actually made communication a lot easier for me." (Interview 9, male, age 42)

"It's very easy to get in touch with people all over the world, and I find that very empowering, a very positive sort of thing. In terms of a source of information, if you want to know anything, it's all there." (Interview 5, male, age 41)

When asked directly about their use of the Internet in commercially related activities, participants frequently referred to the information available about different products rather than the ability to purchase:

"We used it just to gather information really relating to the product." (Interview 2, male, age 37)

"It tells you instantly all the information about it ... you can go on and compare the different prices that they have for the same thing." (Interview 8, male, age 24)

More significantly, they referred to the range of perspectives available through the Internet:

"Because it's available, it's accessible, I'll get information about the product itself. Whereas before you'd rely on a salesperson to give you that information, I've got there from other sources. So it's different ways of getting information on products that I'm going to purchase." (Interview 12, Female, age 32)

Interaction with Commercial Organizations

Given that participants related that the Internet has opened up communication and information channels, the strong sense of barriers separating customers and companies that emerged was surprising. Narratives using language which constructed dichotomies of oppressor/oppressed, and metaphors of power and control, invasion, and revolution were pervasive. The barriers participants experienced separating them from companies ranged from poorly designed or inefficient Web sites:

"Some Web sites you get a list of topics and it could be in there, it could be in there, so you click on here and that gets you to somewhere else where it might be there or it might be there. It's a labyrinth and you get fed up with it. They're thrown together by people who write PC software." (Interview 5, male, age 41)

"When something hasn't worked and I've found a blockage that I couldn't get around, you know it gives you very negative feelings. Because you've got nobody directly to speak to it can be very frustrating. It's almost like dealing with a faceless bureaucracy kind of thing — you know, there's simply no way around the system and it leaves me feeling useless." (Interview 4, male, age 49)

and lack of channel integration:

"I e-mailed them and I had to ask them by e-mail could they give me a phone number to contact them…. They e-mailed me back with a telephone number and I phoned up, but I couldn't have dome that from their Web site alone so that was a problem." (Interview 12, female, age 32)

To a more negative construct of companies as dishonest, deceitful and controlling: For example in interview 2 (male, age 37), the respondent says:

"…they lie. Companies are selling products that they haven't got in stock."

Interviewer probes:

"What do you mean? Have you had a problem with a company?"

Respondent elaborates with:

"I ordered a little digital camera that's taken seven weeks. The big incentive with the Internet is the immediacy of it and all sorts of convenience and that all goes out of the window if you order something and it takes seven weeks to get there."

Similarly in Interview 1 (male, age 48) the respondent says:

"Of course you hear loads of stuff like ... if you order online you get not so fresh produce. 'Let's get rid of it on our Internet buyers'."

Interviewer probes:

"Do you buy groceries online?"

Respondent elaborates with:

"No I don't. I wouldn't buy fresh produce anyway, I wouldn't trust them."

Another respondent commented negatively on companies' use of his personal details:

"I've filled in enquiry forms and that sort of thing, where they are basically gathering data on me … I just don't like the idea anyway because all they need to do is put in your postcode and your name and there you go! They've got you! And how do they link that up with other databases? You don't know do you?" (Interview 4, male, age 49)

Another barrier to consumer/company interaction was simply failure to reply to e-mails. Significantly, one participant responded that:

"If you talk to someone it's just that you feel like they're doing something about it. It might not actually be any different, it's just a perception. If I get something personal saying so and so has received you order, you know, you can tell when it's not just an automatic reply." (Interview 6, male, age 38)

This suggests that standard automatic replies are not perceived as opening up communication channels, but reinforce the perception of barriers between customer and company. Similarly, electronic marketing communications prompted strong reactions expressed in terms of power and control and, in many cases, ending rather interestingly with imagery of closing down communication channels.

One respondent (interview 6, male, age 38) commented:

"I hate it. It irritates the hell out of me. I hate being bombarded with junk e-mail. I can't stand it. It's the scourge of the Internet. I really think that it needs controlling. There's no control, you know with the Internet it's unstoppable isn't it? It's going to put people off."

Interviewer probes:

"So you wouldn't be likely to respond to a promotional e-mail?"

Respondent replies:

"If someone starts bombarding me with e-mails I'd just refuse to buy anything from them just out of principle."

Another participant responded even more strongly to questions about electronic marketing communications:

"I don't like having to look at advertising. If you log onto the Internet, you're becoming increasingly bombarded with stuff coming into your computer.

You come off the Internet and you realize that there's three or four windows up of advertising stuff and you weren't even aware that they had come into your machine and I don't like that. They do it so that the window is slightly shifted so that you can't get to the cross. Somebody's thought all this through and it's just irritating and they should be shot." (Interview 5, male, age 41)

In the narratives of the participants in this research, the Internet does not facilitate communication with companies, nor does it enable the erosion of organizational boundaries, but appears to strengthen them. For them, the social processes that encourage knowledge construction are not taking place on commercial Web sites. While "scientific" or factual information about products and services may be included on commercial Web sites, knowledge construction through socialization is not facilitated, blocking both outcomes of "Business Benefits" and "Consumer Empowerment" on the model of knowledge management adopted in this study (Figure 3). Consumer discussions, narratives and reviews could provide a company with a rich source of knowledge about their market sector, and their own services and products. In disregarding the contributions made by consumers interacting via the Internet, companies are not hearing a valuable source of knowledge about their products and services.

Consumer-to-Consumer Interaction

Participants were not asked directly about their participation in, or membership of online communities, but the theme strongly emerged. One participant noted that the Internet is "a very good way of making contact with like minded people" (Interview 9). Field notes made by the researcher immediately after each interview frequently highlighted one point at which the participant became animated and enthusiastic. The change in tone was in stark contrast to that used in narratives of researching and buying products or in communicating with companies. One participant became animated when talking about the Web site of a farm where she regularly takes holidays:

"There's a place we go in Scotland who now have a Web site where you can keep up to date with the site. Because I'm into pigs and I collect pigs and this particular place we went was on a farm and they had pigs, so she puts photographs of the pigs on the Web site and you can e-mail and ask how the pigs are. She obviously sends out marketing information too about, you know, we've just bought another cow or whatever and they've built up a real base of people who go. She's even got a forum, I mean she's got the right idea." (Interview 3, female, age 27)

For another, it was a self-help group for a specific medical condition that sparked enthusiasm (Interview 4, male, age 49):

Respondent: "My wife was looking at medication, certain medicines that the doctor had recommended and before taking them, she'd sort of heard that they might be harmful and she's gone on there to collect all kinds of research. She got a lot of information on it, which altered what she actually settled for, got a lot of information about medical conditions and was much more informed about what options she should take and that sort of thing."

Interviewer: "Did what she found change her decision about what to take?"

Respondent: "Yes, inevitably it did, yes, what to take and what action to take as well. It's a sort of non-standard product, but information is out there and it's there in such a way that people can understand it and it's an area of deep personal interest. Looking for this extra information, which five years ago wasn't available really helped."

Interviewer: "What sort of sites were they?"

Respondent: "Yes, they were self help for users — people with medical conditions had set up these self help groups and so on and they have discussion boards and they put on their own experiences of taking certain medicines and that sort of thing."

Interviewer: "So she got some information from other people who had used these products?"

Respondent: "Yes, so there was so-called 'factual information' and then actual users' experiences were on as well."

Interviewer: "Assuming that you were involved in this as well, that she talked to you about it, what value did you place on the other consumers that you'd never met or never had anything to do with?"

Respondent: "Well, they had no reason to put any falsities on there so it was … sometimes they weren't saying anything you didn't already know it was all supporting information and it's very valuable because it's things that you don't normally get."

A third participant spoke very animatedly about eBay:

"Then because I had some questions I actually e-mailed the fella and he was just brilliant because he kept e-mailing me back saying, 'Hello, Susan. Now let me just tell you about this game that I'm sending you,' and it was brilliant, it was like making a new friend. It was really, really good. I was very impressed with eBay. It's like a community. It's like you see names coming up time and time again and you can read what they've done in the past with other people and how good they've been and things like that. They say things about you and you say things about them, it's a two-way thing so it's worth it." (Interview 12, female, age 32)

This contrasts greatly with another participant's comment that corporate marketing messages are "a one-way thing" (Interview 11), preventing social interacting and exchange. These accounts also illustrate how meaningful and valued interchanges are most frequently constructed around an area of interest rather than within a purely commercial interaction. More significantly, even though participants spoke of how they valued reviews by other consumers "because they had no reason to put any falsities on there" (Interview 4), a totally different belief about consumer reviews within a commercial Web site emerged:

"It's whether you would actually trust that as a source. Would they actually put very disparaging comments from consumers on their particular site or would they just be full of glowing reviews for their products?" (Interview 3, female, age 27)

As another participant responded, "you're looking for a negative to prove the positive" (Interview 1, male, age 48), and ultimately:

"If you wanted something a bit less biased perhaps you could go to a forum, there's lots of forums where they discuss anything and everything so if you wanted to know what someone really thought about a subject you'd go on one of those." (Interview 6, male, age 38)

Power Relations in Business-to-Consumer Interaction

Throughout the interviews a discourse of power and control strongly emerged. So, too, did a sense of resigned acceptance on the part of the consumers. Critical to this is the sense of communication breakdown between companies and consumers. One participant narrated his experience of house hunting on the Internet:

"I saw one yesterday, phoned up and it was gone because they haven't updated their Web site. Well, why not? This is really annoying, especially over something like that… I mean, I, being the kind of person I am, I was [makes action to imply speaking on the telephone] WELL, WHY NOT?" (Interview 1, male, age 48)

When asked what the response from the company was, the participant responded, "Oh, they just gave me some line, you know," suggesting a resigned acceptance of a corporate message. Habermas proposed that "where power is present, communication is systematically distorted," and further that "power would act as a barrier to the free and unconstrained realization of the human interest in achieving rational truth or enlightenment" (Clegg, 1989). The model of knowledge management proposed for this explorative research is a model of socially constructed knowledge, which brings about consumer emancipation and business benefits. The process of socially constructing knowledge depends upon effective communication networks.

The participants of this research do not construct a view of the Internet as opening up communication channels with companies where social interaction may facilitate the construction and exchange of knowledge. When asked how commercially oriented use of the Internet could be improved, one participant responded that they would like to see more transparency or transaction tracking devices. It was significant that the language he used to express this constructed an image of the company as a fortress to be invaded. Three times he used the phrase, "You could go right into the company":

"If you could search right into the company without having to phone them up, you could track the progress of where my house purchase is just now, where my will is just now where my injury claim is just now…I think some companies are starting to put these gateways in to go right into the company so you don't have to talk to anybody, but the security implications must be a minefield because you go right into the company." (Interview 1, male, age 48)

This image of invasion also reinforces the idea of organizational boundaries, and barriers between companies and consumers.

Significantly, the participants generally did not feel that the Internet empowered them as consumers. Some participants did say they felt empowered, quoting convenience, choice, or competitive prices available through the Internet. However, the same respondents commented that they tend to return to the same sites, or only use "well known and well trusted" companies' Web sites (Interview 8), implying limitation. Generally however, participants responded that the Internet was "potentially very empowering" for consumers (Interview 6) or simply that they did not feel empowered by it. Several participants commented that they were aware of Web sites where consumers can post their complaints or reviews of companies, but commented that they hadn't done that as, "They just hadn't got round to it" (Interview 3) or because, "There's not much point" (Interview 8), implying a resigned powerlessness.

CONCLUSIONS

Knowledge possessed by consumers can only become a source of organizational knowledge offering business benefits to companies if consumers are given a voice. In order to create value for themselves, companies should explore ways of participating in the consumer-to-consumer conversations that are already taking place around virtually any topic of interest. It is essential that companies that do participate do so without appearing to dominate consumer territory with an obviously commercial motivation. Companies must facilitate interaction, and integrate communication and knowledge exchange with consumers into normal working practices, offering some benefits to the consumers. While consumers are aware that through the Internet they have the potential to share their views of products and services with other consumers, unless their views are responded to by companies, they can have little effect and fail to bring about "Consumer Empowerment."

Consider the following example of a company director engaging in conversation with consumers. This example was brought to the attention of the researcher by one of the interview participants. Following negative comments about

Figure 4. Fish and Fly message board posting

Show all folders | View messages in linear mode

Iain Burgess (Guest) Tue 25-Apr-00 08:37 PM

#1508, "Airflo Fly Lines - The background - The Future"

May I first introduce myself as the Group Managing Director of BVG Airflo. I have read the many comments on this forum relating to Airflo fly lines with interest.

If I may I seek to provide a little background and to address some of the comments posted on this forum.

The Airflo technology was truly ground breaking when its was launched, and to this day offers benefits unmatched by any competitor.

Like any new technology there were the inevitable teething problems. In Airflo's case these problems went on for far too long. Airflo's reputation , particularly for floating lines suffered tremendous damage.

I accept that large numbers of fly fishers purchased fly lines which were sub standard and did not offer the performance promised.

In 1995 I became the MD and the company was completely restructured with the focus placed firmly on long term R&D, thorough product testing and relentless quality control procedures.

The result was that by late 96 Airflo was producing some of the best fly lines in the World, export sales rocketed in markets unaffected by Airflo's prior reputation. In particular Airflo sinking lines have set the standards by which all others follow

You may be surprised to know that there are just four fly line manufacturers of any consequence in the World. Very positive comments on this board (placed by Anti Airflo people) on private label fly lines actually relate to product produced by Airflo. Airflo's historic problems clearly affect peoples opinions.

To prove the point I would be happy to provide a FREE fly line to the first 30 people who respond on this forum with their details and fly line model required. Those connected to the fly fishing trade need not respond.

In exchange for the free fly line all I ask is that the line is tested and a fair review placed back on this forum. If you hate the product then come back on the board and slate it, if as I suspect you agree that the lines are some of the best available then please let everyone else know about it.

Kind Regards

the company's products on a message board, the Managing Director writes:

Airflo's historic problems clearly affect people's opinions. To prove a point, I would be happy to provide a FREE fly line to the first 30 people who respond on this forum with their details and model required. In return, all I ask is that the line is tested and a fair review placed back on this forum. If you hate the product, then come back on the board and state it, if as I suspect you agree that the lines are some of the best available then please let everyone else know about it. (See Figure 4 for screen shot.)

The following responses were posted (Figure 5 for screen shot):

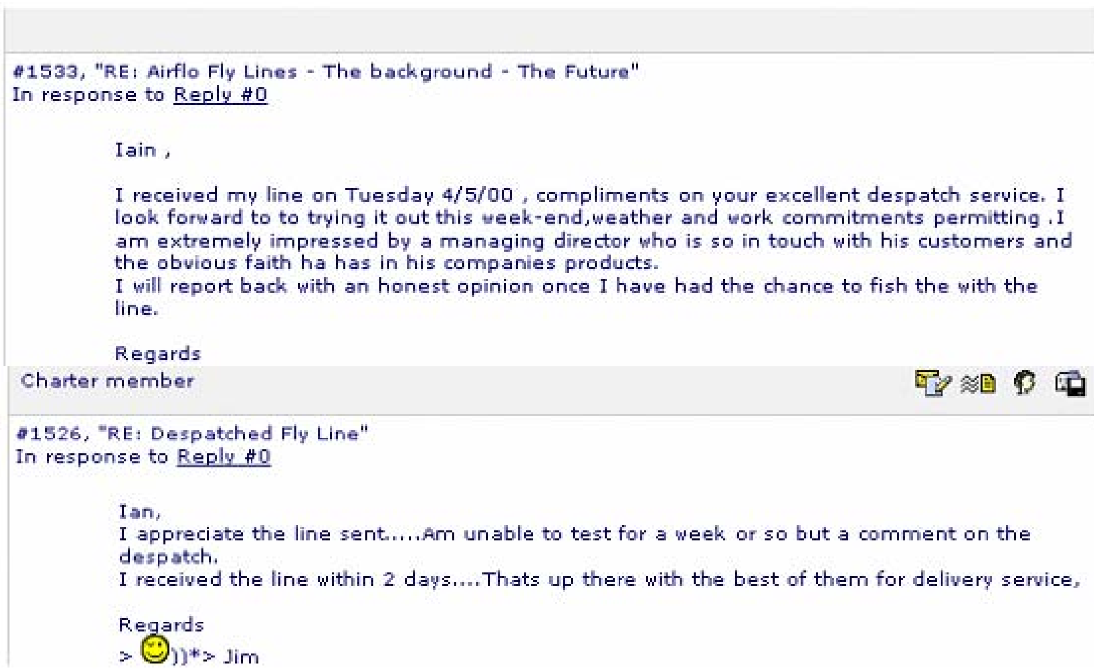
"I appreciate the line sent…. Am unable to test for a week or so but a comment on the dispatch. I received the line within two days…That's up there with the best of them for delivery service." (Posting No. 86)

"I am extremely impressed with a Managing Director who is so in touch with his customers and the obvious faith he has in his products." (Posting No. 95)

"I would have no hesitation in recommending this line to any other angler." (Posting No.100) (Fish and Fly Messageboard, 2000)

By engaging in conversation and exchanging knowledge with his customers, the Director

Figure 5. Fish and Fly message board responses



appears to have improved the reputation of the company and its products. In an earlier posting, he even gains input for a possible new product to develop: "Any chance of an intermediate, with non-stretch core, in double taper format?" (Posting No. 75). This interaction takes place on an independent message board. The customers are offered the power to improve or further damage the company's reputation, and for their views to be archived for future members of the group. In this case, the Managing Director has achieved the business benefits of an improved reputation. This exchange will be archived and available to future customers for some time to come, and provide input from customers for product development.

Consumers are already utilizing the technology to communicate and share knowledge. "The same technology that has opened up a new kind of conversation in the marketplace has done the same within the corporation, or has the potential to do so" (Levine, Locke, Searls, & Weinberger, 2000). Companies must now focus on the communication capabilities of the Internet and use the technology to facilitate conversations across the corporate boundary. They must meet consumers on neutral ground and encourage consumer-to-consumer and consumer-to-business interaction in order to leverage a most valuable resource: the knowledge constructed by and embodied in the customers. In return, they must share corporate knowledge with the consumer. Sinkula proposes that for organizations to learn from their customers:

"Particular attention should be paid to serendipitous, unsolicited, customer information, particularly that which revolves around complaints. Marketing managers must do two things to better listen to customers…" (Sinkula, 2002).

Firstly, he argues they, "must process the information better," and secondly they should "become more open to criticism" (Sinkula, 2002). This research suggests that before they can do this, companies must first learn to have conversations with their customers.

RECOMMENDATIONS

How can Company Representatives Engage with an Online Community?

To be effectively adopted, this new marketing channel demands that you analyze how you communicate with customers, and challenges how you traditionally measure the success of this communication. In general, classically hard outcomes such as complaints resolved or sales achieved are used to measure communication success. Participating in an online community initially offers less tangible benefits. For example, it may enhance the value of the knowledge socialized within the community to the benefit of both customers and companies, or improve the reputation of a brand.

The starting point is to recognize that you will have to adopt a new approach to communicating with customers — an approach that challenges many of your traditional assumptions about customer relationship management. You will need to accept that the power and position that you naturally project into conversations and interactions with customers are counter-productive when interacting in this new channel. You are advised to remodel your ingrained communication patterns. Customers welcome natural speech through an individual human voice rather than a scripted corporate monologue. Discussion forums and online communities facilitate this kind of interaction.

For those most unsure of how to start, the best place is to take the position of the customer. Participate as a customer in forums discussing things you have an affinity to or feel passionate about (a sport, cars, music). Join in, contribute to the discussions and make time to do it regularly. You will quickly get a feel for the tempo and social "Netiquette" within the groups. These will be variable so don't expect to replicate them in discussions about your company, but you will see a range of examples of how to do it and how not to. Critically evaluate the exchanges that take place and reflect upon how effective they could be in relation to the forums your company could participate in.

Consider the contribution made by the Managing Director in Figure 4:

"May I first introduce myself as the group managing director of Company X? I have read the many comments on this forum relating to Company X fly lines with interest."

The Director succinctly establishes his position and invites himself into the discussion. It is extremely pertinent that he doesn't just "barge in" and start to sell his product. Note the heavy use of first person "I" and complete lack of references to the corporate line or "what the company says" throughout the entire posting. This man has power within the organization, but he projects it very subtly, almost with a suggestion of, "You may want to hear my opinion, but you don't have to."

He then moves quickly to establish the background and balance of opinion in the postings. He accepts the problem. He demonstratives a willingness to validate the customers' experience and offers empathy with their issues. He then moves swiftly to the defensive:

"I accept that large numbers of fly fishers purchased fly lines which were sub standard and did not offer the performance promised. In 1995, I became the MD and the company was completely restructured with the focus placed firmly on long term R&D, thorough product testing and relentless quality control procedures."

However, he just manages to avoid a "yes, but" followed by a corporate line which may alienate customers as it demonstrates a lack of empathy and a negation of their experience.

He then switches to a pitch that borders close to a direct attempt to market the company voice in the community. He is walking on the edge of acceptance and rejection based on the customer's evaluation of his credibility to make such statements. It is a signature of this posting how swiftly it moves through these phases. It is fast, but not slick in an obvious manipulative way. He retains a genuine voice of concern and natural tempo throughout. It reads like a stream of consciousness, rather than stock phrases from a brochure.

The second to last paragraph in the post is perhaps one of the most significant. The Director invites others in. From an early pitch that engages the individual, he suddenly switches to the onlookers in the crowd and seeks to pull them closer to the action:

"To prove the point I would be happy to provide a FREE fly line to the first 30 people who respond on this forum with their details and fly line model required."

He is challenging the community on conventional measures of product performance, but also challenging the community to increase their collective knowledge of these products through their interaction. This is real skill with unmistakable echoes of marketplaces of the past. The director moves beyond the attempt to develop a personal conversation with customers to developing an inherent right of focus within the community. He is seeking to host the dialogue, as distinguished from controlling it, and is increasing his importance as a credible central voice within the community.

To judge whether he succeeded, consider the responses and again witness the importance of the first person "I" in the customer evaluations quoted:

"I appreciate the line sent…. Am unable to test for a week or so but a comment on the dispatch. I received the line within two days…That's up there with the best of them for delivery service." (Posting No. 86)

"I am extremely impressed with a Managing Director who is so in touch with his customers and the obvious faith he has in his products." (Posting No. 95)

"I would have no hesitation in recommending this line to any other angler." (Posting No.100) (Fish and Fly Messageboard, 2000)

If this does not convince you, consider the closing words of the Director himself:

"I would like to thank the visitors to this forum for their feedback. I have learnt a great deal from the discussions and thank you all for your input. Most of all, I have confirmed my position that our reputation lies purely with floating lines produced prior to 96."

"I have learned from this forum that trial products are the best way to convince people of the performance of our fly lines. Thanks for your comments, as you can see, they make a difference."

What is most significant is that nothing will make a customer happier in a discussion forum than the words, "Sorry I got that wrong... let me try to put it right."

REFERENCES

Bijker, W. E. (1999). *Of bicycles, brakelites, and bulbs: Toward a theory of sociotechnical change.* London: MIT.

Brewer, C. (2000, October 1). *Deepening brand loyalty.* Computer User.com. Retrieved April 2, 2002, from http://www.computeruser.com/articles/1910,2,3,1,1001,00. html

Burrell, G., & Morgan G. (1979). *Sociological paradigms and organisational analysis: Elements of the sociology of corporate life*. London: Heinemann.

Buttle, F.A. (1998). Word-of-mouth: Understanding and managing referral marketing. In Anonymous, *Proceedings of the Academy of marketing Annual Conference* (pp. 100-106). Sheffield: Sheffield Hallam University.

Carayannis, E.G. (1999). Fostering synergies between information technology and managerial and organizational cognition: The role of knowledge management. *Technovation, 19*(4), 219-231.

Chua, W.F. (1986). Theoretical constructions of and by the real. *Accounting, Organisations and Society, 11*(6), 583-598.

Clarke, P., & Staunton, N. (1989). *Innovation in technology and organisation*. London: Routledge.

Clegg, S. R. (1989). *Frameworks of power*. London: Sage.

Demarest, M. (1997). Understanding knowledge management. *Long Range Planning, 30*(3), 374-384.

Earl, M.J. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-242.

Edvinsson, L. (1997). Developing intellectual capital at Skandia. *Long Range Planning, 30*(3), 366-373.

Elster, J. (1983). *Explaining technical change: A case study in the philosophy of science*. Cambridge: Cambridge University Press.

Engel, J.F., Kegerris, R.J., & Blackwell, R.D. (1969). Word-of mouth communication by the innovator. *Journal of Marketing, 33,* 15-19.

Evans, M., Wedande, G., Ralston, L., & Hul, S.v.t. (2001). Consumer interaction in the virtual era: Some qualitative insights. *Qualitative Market Research: An International Journal, 4*(3), 150-159.

Fish and Fly Messageboard. (2001). *Fish and Fly Messageboard (archived thread) Airflo Fly Lines - The background - The Future*.

Foxhall, G. R., Goldsmith, R. E., & Brown, S. (1998). *Consumer psychology for marketing.* London: Thomson.

Hansen, M.T., Nohria, N., & Tierney, T. (1999, March-April). What's your strategy for managing knowledge? *Harvard Business Review, 77,* 106-129.

Haywood, M.K. (1989). Managing word of mouth communications. *Journal of Services Marketing, 3*(2), 55-67.

Hedlund, G. (1994). A model of knowledge management and the N-form Corporation. *Strategic Management Journal, 15*(Summer), 73-90.

IPA. (1995). *Interactive Publishing Alert. Quoted in it's shopping, but not as we know it - women and home e-shopping in the UK*. Helen J. Richardson. Gemisis Millenium Conference Digest.

Johnson, P., & Duberley, J. (2000). *Understanding management research: An introduction to epistemology.* London: Sage.

Keegan, V. (1999, June 10). Britain prepares for boom.com. *The Guardian, 1.*

Kimble, C., & McLoughlin, K. (1995). Computer based information systems and managers work. *New Technology, Work and Employment, 10*(1), 56-67.

Levine, R., Locke, C., Searls, D., & Weinberger, D. (2000). *The Cluetrain manifesto. The end of business as usual.* London: ft.com.

Martinson, J. (1999, October 11). Net bubble@burst.com: Analyst warns that only a few big online firms will survive. *The Guardian, 1.*

McAdam, R., & McCreedy, S. (1999). A critical review of knowledge management models. *The Learning Organisation, 6*(3), 91-101.

McAdam, R., & Reid, R. (2000). A comparison of public and private sector perceptions and use of knowledge management. *Journal of European Industrial Training, 24*(6), 317-329.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press.

Pettigrew, T.F. (1990). *How to think like a social scientist.* London: Longman.

Polanyi, M. (1962). *Personal knowledge, towards a post critical philosophy*. London: Routledge and Keegan Paul.

Roos, G., & Roos, J. (1997). Measuring your company's intellectual performance. *Journal of Long Range Planning, 30*(3), 413-426.

Sheth, J.N. (1971). Word of mouth in low-risk innovations. *Journal of Advertising Research, 11*(3), 15-18.

Sinkula, J.M. (2002). Market-based success, organizational routines, and unlearning. *Journal of Business and Industrial Marketing, 17*(4), 253-269.

Stewart, T. (1997). *Intellectual capital: the new wealth of organisations.* London: Nicholas Brealey.

Stokes, D., & Lomax, W. (2002). Taking control of word-of-mouth marketing. *Journal of Small Business and Enterprise Development, 9*(4), 349-357.

Van Buren, M. (1999). A Yardstick for knowledge management. *Training and Development Journal, 53*(5), 71-78.

APPENDIX 1

Consumer Interview Schedule

I am researching into how people use the Internet in consumer related activities. I want to hear about your experiences, opinions, thoughts, lessons learned. So far I have looked at reports and research papers and commercial Web sites. Now I need some input from people who actually use the Web sites to gain a richer understanding of how people use the Internet in consumer related activity.

The Interview will address the following issues:

- Your general views on the Internet
- Significant changes (that the Internet has brought about for you)
- Internet in consumer activity
- Communication (business-to-consumer and consumer-to-consumer)
- General conclusions

1. What does the Internet represent to you?
   - Understanding & experiences of the Internet.
   - Opinions about what the Internet is good/bad at.
   - Whether their general expectations are met.
   - How they think it could be improved

2. What has changed for you as a result of the Internet?
   - New things achieved/learned?
   - Cultural shifts
   - Any area of life that has changed significantly?

3. Tell me about your experiences of researching products online.
   - How would you research a product through the Internet?
   - Where would you look?
   - Why?
   - Have you learned anything new?/Had a change of opinion about a product or company?

4. Tell me about your experiences of buying products online (good/bad)

Communication

5. Can you tell me about any experiences of using the Internet to communicate with or consult other consumers?
   - Have you ever shared your opinions of products/services online? Why? Why not?
   - Have you ever shared your experiences of a company online?
   - How much value would you place on the opinions of other online consumers?

6. Can you tell me about any experiences of using the Internet to communicate with companies?
   - Are you more or less inclined to communicate with a company online?
   - How do you feel about companies contacting you through the Internet?

Empowerment

7. How far would you say the Internet "empowers" you as a consumer?

- Do you feel that you have more choices available to you through the Internet? (products/companies/time/space)

General Conclusions

8. How effective do you feel commercial Web sites are?

9. How would you like to see businesses using the Internet for commercial purposes in the future?

This concludes the interview.
Thank you for your time.

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Chapter 6.23
Knowledge Producers and Consumers

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INTRODUCTION

In a knowledge-based economy, organizations find it difficult to compete based upon the individual knowledge of a few organizational members. This provides the rationale for knowledge management wherein organizational knowledge must be shared, combined, and reused in order to enable organizations to compete more effectively. Hence, knowledge sharing is considered an essential process in knowledge management. Unfortunately, sharing is often unnatural for the parties involved in it, that is, knowledge contributors or producers and knowledge seekers or consumers. Hoarding knowledge and not accepting knowledge from others are natural tendencies that are difficult to change (Davenport & Prusak, 1998). Knowledge contributors may be inhibited from sharing their knowledge due to perceptions of loss of power, lack of time or incentives, and other barriers. Knowledge seekers may find it laborious to seek advice from others and desire to discover solutions for themselves. Therefore, it is vital to understand and foster the motivations of knowledge contributors and seekers toward participating in knowledge sharing.

With the attention to knowledge management and the knowledge-based view of the firm, research in knowledge sharing and its motivations has gained interest over the last decade and a half. The initial focus of research was on investigating what motivates knowledge contribution (e.g., Orlikowski 1993; Constant, Kiesler, & Sproull, 1994) as this appeared to be a more intractable problem than motivating knowledge seeking. Subsequently, knowledge seeking behavior also has been researched (e.g., Goodman & Darr, 1998; Jarvenpaa & Staples, 2000; Kankanhalli, Tan, & Wei, 2001), although there is still considerably more attention devoted to studying knowledge contribution behavior.

Concurrently, the role of technology (known as knowledge management system or KMS) in enabling knowledge sharing has received research interest. However, in spite of the advent of new technology enabled forms of knowledge sharing such as knowledge logging (the enterprise flavor of blogging), the challenges of promoting knowledge sharing persist. This is because culture and management issues appear to dominate over technological issues in ensuring knowledge sharing success. For example, Ruppel and Harrington (2001) found that employee acceptance of or resistance to Intranets as a knowledge-sharing environment was more of a management and culture problem rather than a technology hurdle. Calls have been made to address both social and technical issues together (Zack, 1999) in order to be able to reap the benefits of knowledge management that have been experienced by some organizations (Davenport & Prusak, 1998).

BACKGROUND

Knowledge sharing is typically defined in two ways depending on the perspective toward knowledge. Researchers who view knowledge as an object tend to use the term “knowledge transfer” while others who see knowledge as a process use the term “knowledge sharing” (Allee, 1997). The notions of knowledge sharing and knowledge transfer can be combined by defining knowledge sharing as voluntary activities (process) of transferring or disseminating knowledge from one person to another person or group in an organization (Hansen, Nohria, & Tierney, 1999). A number of theoretical perspectives have been used to investigate the motivation of knowledge contributors and seekers.

Public Goods Theory

One of the initial lenses employed in studying motivations in knowledge sharing has been public goods theory (e.g., Thorn & Connolly, 1987; Fulk, Flanagin, Kalman, Monge, & Ryan, 1996). Knowledge shared in an organization through means such as a knowledge repository (referred to as a discretionary database in some previous literature) can be considered as a public good, that is, non-excludable, non-rival, and exhibiting jointness of supply. Knowledge shared is considered non-excludable because other repository users who did not contribute to its production are not prevented from access to the knowledge. The knowledge is non-rival because even if one consumer uses the knowledge, it still remains available to others, who also may apply the knowledge in their own situations. The knowledge contributed exhibits jointness of supply because it costs as much to produce for use by one person as for use by many.

Research along this perspective tends to focus on the motivational dilemma faced by knowledge contributors to such repositories. The dilemma for knowledge contributors is that collective interests bid them to share knowledge whereas self-interest may discourage them from contributing. Collective interest suggests that knowledge contributed will allow it to be combined or reused for greater benefit to the organization (Fulk et al., 1996). However, self-interest seems to dictate that contributing knowledge would reduce the unique knowledge possessed by the individual and thereby make him or her more replaceable in the organization (Kollock, 1999). In a broader sense, the dilemma for the community is that all members of the community stand to gain if everyone contributes. However, individually members are better off free-riding on the contributions of others. Therefore, research along this stream tries to understand how to promote collective action of knowledge contribution when it does not appear individually rational (Wasko & Faraj, 2000).

Expectancy Theory

Another perspective on studying motivation for knowledge contribution and seeking has attempted to apply more rational theories of motivation such as expectancy theory (Vroom, 1964) to understand the phenomenon. These studies (e.g., Kalman, 1999) suggest that individuals contribute knowledge based on their expectancy of certain benefits. Kalman's research found that organizational commitment, organizational instrumentality (the belief that sharing knowledge will produce organizational gain), and connective efficacy (the belief that the repository can be used to reach other people) positively influence individual's motivation to contribute to a repository.

Studies on knowledge seeking also have made use of expectancy theory (e.g., Nebus, 2004). Nebus' study proposed that the relationship between perceived value from knowledge seeking and knowledge seeking behavior is moderated by the perceived expectation of obtaining value. The perceived value from knowledge seeking depends on contributor's expertise and credibility while the perceived expectation of value depends on trust, obligation, and contributor's willingness to help. The perceived cost of seeking depends on monetary and time costs as well as the seeking risk in terms of the distance between the contributor and seeker.

Technology Adoption Theories

Theories of technology adoption have been applied to study motivation to use technologies for knowledge sharing. Particularly, the theory of planned behavior (Ajzen, 1991), which has been applied to technology adoption, has been used for this purpose. The theory proposes that the intention to use a technology depends on the attitude toward the technology, subjective norms, and perceived behavioral controls. Studies of knowledge contribution (e.g., Bock & Kim, 2002) have sought to find the antecedents of attitude, subjective norms, and perceived behavioral controls for knowledge contributors. Bock and Kim (2002) found that anticipated reciprocal relationships affected the attitude toward knowledge contribution while autonomy, innovativeness, and fairness of the organization impacted the subjective norm to contribute knowledge. As expected, attitude and subjective norm were positively related to knowledge contribution intention and to actual knowledge contribution behavior. Anticipated extrinsic rewards were found to play a facilitating role in individual's knowledge contribution.

The theory of planned behavior in conjunction with the task-technology fit model (Goodhue & Thompson, 1995) has been used to explain knowledge seeking behavior (Kankanhalli et al., 2001). Kankanhalli and colleagues' study found that technology-related factors (perceived output quality) and organization-related factors (availability of resources) directly impact seeking behavior, while task factors (task interdependence and task tacitness) play a moderating role on the effect of incentives on knowledge seeking from repositories.

Gaps in Literature

Prior empirical studies tend to focus on the benefits (acting as motivators) rather than the costs (acting as inhibitors) of knowledge contribution. This is in spite of the fact that practitioner literature (e.g., O'Dell & Grayson, 1998) and conceptual academic literature (e.g., Ba, Stallaert, & Whinston, 2001) suggest that costs are important in determining knowledge contribution behavior. Another feature of the prior research is that most studies consider knowledge sharing for all electronic media without focusing on a particular form of KMS. Even when studies are situated in the context of a particular technology, they may not refer specifically to the technology features and the consequences thereof. However, it is likely that differences in antecedent factors of contributing and seeking and the relative importance of antecedent factors can be expected for different forms of KMS. Further, since most empirical studies have been single case studies or surveys within one organization, there is a lack of theoretically grounded, empirically generalizable results regarding the phenomenon of interest.

Considering these gaps, newer research in knowledge sharing attempts to develop socio-technical frameworks for knowledge contribution and knowledge seeking via KMS considering both cost and benefit factors as antecedents. Organizational community factors that provide the context in which sharing takes place also are included in the frameworks. Particular forms of KMS for knowledge sharing are being studied (e.g., Goodman & Darr, 1998; Wasko & Faraj, 2000) and more generalizable research is being undertaken (e.g., Kankanhalli et al., 2001; Bock & Kim, 2002) as knowledge about the phenomena evolves.

FOCUS

This section describes a sample of the newer approaches toward explaining knowledge contribution and knowledge seeking behaviors that can obtain better explanatory power as compared to previous studies. They make use of social exchange theory, which accounts for both costs and benefits of knowledge sharing using collective technologies such as knowledge repositories.

Social Exchange Theory

Social exchange theory explains human behavior in social exchanges (Blau, 1964), which differ from economic exchanges in that obligations are not clearly specified. In such exchanges, people do others a favor with a general expectation of some future return but no clear expectation of exact future return. Therefore, social exchange assumes the existence of relatively longer-term relationships of interest as opposed to one-off exchanges (Molm, 1997). Knowledge sharing through knowledge repositories can be seen as a form of generalized social exchange (Fulk et al., 1996) where more than two people participate and reciprocal dependence is indirect, with the repository serving as intermediary between knowledge contributors and seekers. Knowledge contributors share their knowledge with no exact expectation of future return. Knowledge seekers consume knowledge without certainty of when they will reciprocate in the future. The quantity and value of knowledge contributed or consumed is difficult to specify.

Resources (tangible and intangible) are the currency of social exchange. Resources given away during social exchange or negative outcomes of exchange can be seen as costs. Resources received as a result of social exchange or positive outcomes of exchange can be seen as benefits. Social exchange theory posits that people behave in ways that maximize their benefits and minimize their costs (Molm, 1997). This is in agreement with knowledge management research, which suggests that increasing the benefits and reducing the costs for contributing or seeking knowledge can encourage knowledge sharing using KMS (Goodman & Darr, 1998; Wasko & Faraj, 2000; Markus, 2001).

During social exchange, costs can be incurred in the form of opportunity costs and actual loss of resources (Molm, 1997). Opportunity costs are the rewards foregone from an alternative behavior not chosen. During social exchange, benefits can be extrinsic or intrinsic in nature (Vallerand, 1997). Extrinsic benefits are sought as means to ends. Intrinsic benefits are sought after as ends by themselves. Research has established extrinsic and intrinsic benefits as drivers of human behavior in several domains including knowledge sharing (Osterloh & Frey, 2000). Although cost and benefit factors can impact knowledge contribution and seeking, this impact is likely to be contingent upon contextual factors (Orlikowski, 1993; Goodman & Darr, 1998). Social capital theory accounts for several important contextual factors.

Social Capital Theory

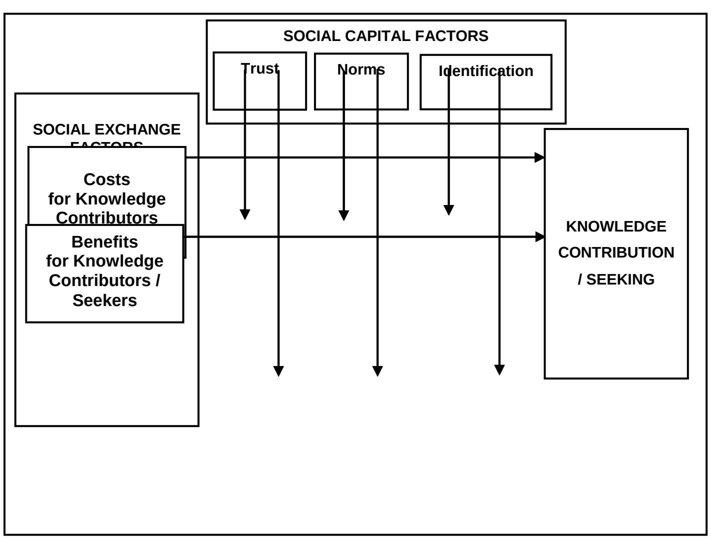
Social capital theory emphasizes the resources (social capital) embedded within networks of human relationships (Nahapiet & Ghoshal, 1998). The theory posits that social capital provides the conditions necessary for knowledge transfer to occur. Three key aspects of social capital that can define the context for knowledge transfer are trust, norms, and identification (Nahapiet & Ghoshal, 1998). Prior research has hinted on the moderating role of aspects of social capital in knowledge sharing (Constant et al., 1994; Jarvenpaa & Staples, 2000).

Trust is the belief that the intended action of others would be appropriate from our point of view. It indicates a willingness of people to be vulnerable to others due to beliefs in their good intent and concern, competence and capability, and reliability (Mishra, 1996). Generalized trust (trust within a community) has been viewed as a key contextual factor affecting cooperation and the effectiveness of knowledge transfer (Adler, 2001).

A norm represents a degree of consensus in the social system (Coleman, 1990). Pro-sharing norms that have been reported to enhance knowledge transfer are norms of teamwork (Starbuck, 1992), collaboration and sharing (Orlikowski, 1993; Goodman & Darr, 1998; Jarvenpaa & Staples, 2000), willingness to value and respond to diversity, openness to conflicting views, and tolerance for failure (Leonard-Barton, 1995). The first two norms can create an atmosphere where people are motivated to share knowledge as an accepted common practice. The last three norms can be crucial to promote knowledge sharing by reducing the risks of sharing.

Identification is a condition where the interests of the individual merge with the interests of the organization, resulting in the creation of an identity based on those interests (Johnson, Johnson,

Figure 1. Framework for knowledge contribution/seeking



& Heimberg, 1999). Three key components of identification have been identified: similarity of values, membership, and loyalty toward the organization (Patchen, 1970). Similarity is the extent to which members of an organization possess joint goals and interests. Membership is the degree to which self-concept of members is linked to the organization. Loyalty refers to the extent to which members support and defend their organization. Identification can enhance communication and knowledge transfer among organizational members (Nahapiet & Ghoshal, 1998).

A framework for explaining knowledge contribution and knowledge seeking incorporating constructs from social exchange theory and social capital theory is shown in Figure 1.

Knowledge Contributor Motivation

In the contributor framework, opportunity costs (e.g., contribution effort) and other costs (e.g., loss of knowledge power) are proposed to negatively impact knowledge contribution. Both extrinsic (e.g., economic rewards) and intrinsic (e.g., enjoyment in helping others, and image) benefits are proposed to positively affect knowledge contribution. Contextual factors (i.e., trust, norms, and identification) may moderate the relationships between cost and benefit factors and knowledge contribution. For example, trust can moderate the relationship between contribution effort and knowledge contribution, and identification may moderate the relationship between economic rewards and knowledge contribution.

Knowledge Seeker Motivation

In the seeker framework, both opportunity costs (e.g., seeker effort) and other cost factors (e.g., future obligation) are proposed to negatively impact knowledge seeking. Extrinsic (e.g., economic reward) and intrinsic (e.g., knowledge growth) benefits are proposed to positively affect knowledge seeking. Contextual factors (i.e., trust, norms, and identification) can moderate the relationships between cost and benefit factors and knowledge seeking. For example, identification may moderate the relationship between future obligation and knowledge seeking while pro-sharing norms can moderate the relationship between knowledge growth and knowledge seeking.

FUTURE TRENDS

Based on practice and previous research, several avenues for future research are suggested. The directions are discussed in terms of studying additional motivational influences and relationships, application of theories across other settings (e.g., different KMS, users, organizations, and other nations or cultures), and extension to allied socio-technical problems.

Additional Influences and Relationships

Additional motivational influences in terms of individual costs (e.g., system learning cost, review cost, and follow-up cost), benefits (e.g., network benefit), organizational context (e.g., size of KMS user community), and task factors (e.g., task interdependence and tacitness) can be included in the frameworks to possibly enhance explanatory power. Interactions and links among cost, benefit, and social capital factors and between factors from different theoretical perspectives can be explored. This will allow us to understand why certain costs or benefits dominate others and why certain factors moderate the effect of others on knowledge contribution or seeking.

Investigation of Different Knowledge Sharing Contexts

Studies examining usage of different types of KMS for knowledge sharing could be conducted based on previous frameworks. The effect of different user demographics on perceived costs and benefits and consequent usage of KMS could be assessed. This will allow specific usage enhancement measures to be catered for different demographic groups. Similar studies could be conducted across different industry sectors. For example, knowledge sharing models could be compared across sectors where different cost, benefit, and contextual influences are expected. Further, the models could be extended to other national and cultural settings. Since knowledge sharing behavior may be culture-dependent and knowledge sharing in global organizations is likely to extend across cultural boundaries, studies of cross-country or cross-cultural nature can better inform the applicability of knowledge sharing theories under different national and cultural conditions.

Allied Socio-Technical Problems

Knowledge contributor and seeker perspectives can be combined to formulate an overall model for knowledge sharing. Other aspects of social capital such as structural and cognitive aspects could be investigated to observe their effect on the motivation, access, and shared understanding for knowledge transfer. Frequency of knowledge transfer transactions as well as contribution and seeking cost per transaction could be studied. These parameters may vary for different forms of KMS and direct knowledge transfer. This may allow for explanation of user decision to choose a particular KMS or form of knowledge transfer. Organizational controls for monitoring knowledge contribution and seeking behavior could be investigated. Finding better ways of monitoring such behavior could help to design appropriate incentive systems for promoting knowledge sharing. Mandates for KMS usage could be explored to understand whether they produce full compliance, and whether the quality of knowledge contributions and reuse would be different for mandated vs. voluntary use. Mechanisms for seekers to evaluate contribution quality could be studied with the purpose of facilitating knowledge seeking.

CONCLUSION

Conceptual frameworks based on social exchange theory and social capital theory can be applied to explain and predict knowledge contribution and knowledge seeking behavior in different contexts. The research has practical implications for organizational management and technology architects. Implications are suggested to promote knowledge sharing by enhancing significant benefits and alleviating significant costs for knowledge contributors and seekers.

Encouraging Knowledge Contribution

Contributor benefits such as enjoyment in helping others and knowledge self-efficacy need to be increased in order to encourage knowledge contribution. Enjoyment in helping others could be increased by connecting knowledge seekers with contributors and allowing them to express their appreciation of how useful the knowledge contributed has been in their work. Perceptions of knowledge self-efficacy could be enhanced by highlighting knowledge contribution success stories and their positive impact on organizational performance. Economic rewards for knowledge contribution could be targeted toward individuals who have greater identification with the organization. High identification individuals may be more readily motivated by incentives to contribute knowledge. Negative effects of contribution effort on knowledge contribution could be alleviated through increasing trust. Higher trust could be promoted by ensuring that credit is given for knowledge contributions, that is, all knowledge contributions are duly acknowledged. Alternatively when trust is low, contribution effort could be reduced by allocating time for their employees to share knowledge and integrating knowledge sharing into work processes.

Encouraging Knowledge Seeking

Seeker benefits such as perceived utility of results and knowledge growth need to be increased to encourage knowledge seeking. Perceived utility of results could be increased by ensuring that knowledge repositories are populated with relevant, accurate, and timely knowledge pertaining to the needs of seekers. This requires that contributors be encouraged to share their knowledge using various recommendations suggested in the preceding section and the quality of knowledge be vetted by implementing appropriate content review processes. Perceptions of knowledge growth can be increased by highlighting the learning benefits of seeking knowledge. If seekers are convinced of personal knowledge growth, they may be motivated to seek knowledge even when knowledge found is not directly relevant to their immediate work. Promoting employees' personal growth and development would also lead to higher employee satisfaction and morale in the long-term. Such measures would be necessary particularly under conditions of low pro-sharing norms. High pro-sharing norms could override the need for such benefits.

Technology Considerations

KMS technology designers could promote usage of their products for knowledge sharing by reducing knowledge contribution effort and increasing utility of results for knowledge seekers. KMS should be designed so that entry of knowledge is as minimally onerous to contributors as possible. Mechanisms to facilitate knowledge entry include intelligent acquisition and improved content taxonomy. An interactive system that prompts for knowledge and organizes the knowledge can reduce contribution effort. A comprehensive domain categorization that captures inter-category relationships can ease contribution effort. Knowledge contribution effort also can be reduced by allowing more natural forms of knowledge acquisition (e.g., audio or video contribution) as opposed to purely text contribution. This may be particularly appropriate for more tacit forms of knowledge.

Utility of results for knowledge seekers can be increased by designing filtering, indexing, and retrieval technologies that ensure appropriate content goes into KMS and can be readily found. Indexing and retrieval technologies need to be designed that can efficiently customize and refine searches and provide relevance feedback. Knowledge seekers need to be provided information about the quality of knowledge retrieved to enable them to make reasonable judgments about reuse. Examples of such information include quality ratings and reviews.

Although large amounts of investments are being made in knowledge management initiatives, a significant number of organizations have difficulties with implementing these initiatives due to the challenges of motivating employees to contribute and reuse knowledge. The above discussion attempts to explain the motivations of knowledge contributors and knowledge seekers and thereby throw light on this problem. Organizational knowledge leveraging would be possible only if both contributors and seekers are motivated.

REFERENCES

Adler, P.S. (2001). Market, hierarchy, and trust: The knowledge economy and the future of capitalism. *Organization Science, 12*(2), 215-234.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50,* 179-211.

Allee, V. (1997). *The knowledge evolution: Expanding organizational intelligence*. Boston: Butterworth-Heinemann.

Ba, S., Stallaert, J., & Whinston, A.B. (2001). Research commentary: Introducing a third dimension in information systems design: The case for incentive alignment. *Information Systems Research, 12*(3), 225-239.

Blau, P.M. (1964). *Exchange and power in social life*. New York: J. Wiley.

Bock, G.W., & Kim, Y.G. (2002). Breaking the myths of rewards: An exploratory study of attitudes about knowledge sharing. *Information Resource Management Journal, 15*(2), 14-21.

Coleman, J. (1990). Foundations of social theory. Cambridge, MA: Harvard University Press.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-421.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Fulk, J., Flanagin, A.J., Kalman, M.E., Monge, P.R., & Ryan, T. (1996). Connective and communal public goods in interactive communication systems. *Communication Theory, 6*(1), 60-87.

Goodhue, D.L., & Thompson, R.L. (1995). Task-technology fit and individual performance. *MIS Quarterly, 19*(2), 213-236.

Goodman, P.S., & Darr, E.D. (1998). Computer-aided systems and communities: Mechanisms for organizational learning in distributed environments. *MIS Quarterly 22*(4), 417-440.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review 77*(2), 106-116.

Jarvenpaa, S.L., & Staples, D.S. (2000). The use of collaborative electronic media for information sharing: An exploratory study of determinants. *Journal of Strategic Information Systems, 9*(2-3), 129-154.

Johnson, W.L., Johnson, A.M., & Heimberg, F. (1999). A primary and second order component analysis of the organizational identification questionnaire. *Educational and Psychological Measurement*, *59*(1), 159-170.

Kalman, M.E. (1999). *The effects of organizational commitment and expected outcomes on the motivation to share discretionary information in a collaborative database: Communication dilemmas and other serious games*. Doctoral dissertation, University of Southern California.

Kankanhalli, A., Tan, B.C.Y., & Wei, K.K. (2001). Seeking knowledge in electronic knowledge repositories: An exploratory study. *Proceedings of the International Conference on Information Systems,* New Orleans (pp. 123-133).

Kollock, P. (1999). The economies of online cooperation: Gifts and public goods in cyberspace. In M. Smith & P. Kollock (Eds.), *Communities in cyberspace* (pp. 220-239). New York: Routledge.

Leonard-Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the source of innovation*. Boston: Harvard Business School Press.

Markus, M.L. (2001). Towards a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-94.

Mishra, A.K. (1996). Organizational responses to crisis: The centrality of trust. In R.M. Kramer & T.R. Tyler (Eds.), *Trust in organizations: Frontiers of theory and research* (pp. 261-287). Thousand Oaks, CA: Sage.

Molm, L.D. (1997). *Coercive power in social exchange*. New York: Cambridge University Press.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nebus, J. (2004). *Learning by networking: Knowledge search and sharing in multinational organizations.* Academy of International Business Annual Meeting.

O'Dell, C., & Grayson, C.J. (1998). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154-174.

Orlikowski, W.J. (1993). Learning from notes: Organizational issues in groupware implementation. *Information Society, 9*(3), 237-251.

Osterloh, M., & Frey, B.S. (2000). Motivation, knowledge transfer, and organizational forms. *Organization Science, 11*(5), 538-550.

Patchen, M. (1970). *Participation, achievement, and involvement on the job.* Englewood Cliffs, NJ: Prentice Hall.

Ruppel, C.P., & Harrington, S.J. (2001). Spreading knowledge through Intranets: An analysis of the organizational culture leading to Intranet adoption and use. *IEEE Transactions on Professional Communications, 44*(1), 37-52.

Starbuck, W.H. (1992). Learning by knowledge-intensive firms. *Journal of Management Studies, 29*(6), 713-740.

Thorn, B.K., & Connolly, T. (1987). Discretionary databases: A theory and some experimental findings. *Communication Research, 14*(5), 512-528.

Vallerand, R.J. (1997). Toward a hierarchical model of intrinsic and extrinsic motivation. *Advances in Experimental Social Psychology, 29,* 271-360.

Vroom, V.H. (1964). *Work and motivation*. New York: Wiley.

Wasko, M.M., & Faraj, S. (2000). It is what one does: Why people participate and help others in electronic communities of practice. *Journal of Strategic Information Systems, 9*(2-3), 155-173.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-5.

Chapter 6.24
Work and Knowledge

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INTRODUCTION

It is widely believed that knowledge work is a relatively new phenomenon and that it constitutes the main form of activity in post-industrial organizations. While the term remains undefined, knowledge work is taken to refer to the knowledge that individuals apply in performing role-related business activities in "knowledge-intensive" organizations. In this scheme of things, the conventional wisdom holds that the subjective knowledge of individual social actors is applied to "objectified" organizational knowledge (i.e., data held in various paper and electronic repositories) as the raw material of the production process. Thus, knowledge is considered to be both an input to, and an output of, business processes: It also is argued to underpin the process by which knowledge inputs are transformed to outputs.

Cooley (1975) was one of the first to employ the term "knowledge worker," however, his conception encompasses both white and blue-collar workers, professionals, and craftspeople alike. This is to be contrasted with Drucker's (1999) perspective on knowledge work, which focuses primarily on the upper echelons of management. This article echoes Cooley's perspective in many respects, however, it seeks to strengthen, extend, and apply it in a contemporary context. The following section provides the rationale and context for this article's thesis by illustrating the socially distributed and collective nature of knowledge. It also helps illustrate certain deficiencies in the conventional understanding of this important topic; these are then addressed in the third section's exploration of the social construction of knowledge. The third section also deconstructs commonly held beliefs on knowledge by examining its relationship to data and information. The fourth section then presents this article's main contribution by presenting a conceptual model and taxonomy of knowledge in organizational contexts. It is hoped that this will help researchers and practitioners better understand the relationship between knowledge and work going forward.

In sum, the article's motivation is to eliminate the misunderstandings that surround the concept of knowledge work and to propose an understanding of the phenomenon that is more in tune with the "reality" of organizational life. The article's marriage of philosophy (Aristotle, 1945; Gadamer, 1975; Heidegger, 1976) and institutional theory (e.g., Berger & Luckmann,1967, from sociology, and Nordhaug, 1994, from economics) acts to "inform" researchers who seek to understand the know-how, -why, and -what of social action in organizational settings. For practitioners, it highlights areas where experiential and skill-based knowledge are of value in organizations and illustrates for them the relative importance of task- and firm-specific knowledge.

BACKGROUND: EVERYBODY KNOWS…BUT ONLY COLLECTIVELY

Aristotle argues that no one individual can know or possess all of the available knowledge, rather, knowledge is dispersed among individuals in society (Aristotle, 1945; Hayek, 1945; Berger & Luckmann, 1967). However, Grant (1996) maintains that knowledge creation is an individual activity, and that the extant emphasis on "organizational knowledge" is misplaced—he argues that organizational knowledge does not exist as a distinct phenomenon (see Stata, 1989; Taylor, 1993; Pfeffer, 1994). Therefore, what Hayek says about society also may be applied to organizations, viz knowledge of and about an organization and its activities will be dispersed among organizational actors and the "communities-of-practice" which they constitute (cf. Tsoukas, 1996). The problem facing social groupings such as organizations, societies, and cultures is therefore "a problem of the utilization of knowledge not given to anyone in its totality" (Hayek, 1945, p. 450). A portion of this dispersed knowledge may, and particularly in more formal institutions will, be codified as information in documents, manuals, books of operating procedures, and so forth, which may be paper-based, electronic, or both (Bruner, 1990; Davenport & Prusak, 1998). Berger and Luckmann (1967) consider this as pretheoretical recipe knowledge and, as such, it forms an operational backdrop for organizations by supplying institutionally appropriate rules of conduct, by placing boundaries on acceptable actions and by defining and enumerating activities to be performed by social actors (see Taylor, 1993; Tsoukas, 1996). Therefore, it acts as both a controlling and predictive mechanism for such conduct.

Thus, institutions are akin to "collective minds" (Weick & Roberts, 1993) whose cultures become a learned product of group experiences, particularly those of the organization's founders (Schein, 1985). Over time, the cognitive dispositions and dispersed knowledge of individual social actors, who actively participate in the dialogic process of institutional reality construction within the aforementioned unarticulated background of wider social and institutional contexts, come to populate this metaphorical "collective mind," which emerges as the unarticulated background of organizational experience. Hence, it is an individual's Heideggerian "fore-knowledge" of the type of actions required of him or her by other actors in the relevant "community-of-practice" and in the wider organization that shapes his or her ongoing actions and utterances (Heidegger, 1976); in turn, these actions once taken and linguistic expressions uttered influence the actions and cognitive dispositions of others (Lincoln & Guba, 1985). Thus, it is the existence of previously acquired knowledge of social convention, in the form of what may be described as a Gadamerian "effective-historical consciousness" (Gadamer, 1975), that guides the self-reinforcing, reciprocal "typification of habitualized" action and dialogue among social actors and which enables individuals to share knowledge relevant to their social grouping or organization (Berger & Luckmann, 1967; cf. Latour, 1993).

This shared corpus of social, communal, or organizational knowledge manifests itself in the form of relatively fixed repertoires of highly reproducible routines, recipes, reciprocal social action, and intersubjective cognitive arrangements (e.g., Nelson & Winter, 1982; Hannan & Freeman, 1984; Spender, 1989; Weick & Roberts, 1993). Alternatively put, an organization's "collective mind" is manifested in the actions and linguistic expressions/narratives of social actors as they commit to and engage in a network of communal and organizational activities (see Bruner, 1990; Law & Callon, 1992). This "collective mind" is, in as much as it represents a collective knowledge of the social groupings concerned, also sedimented in the products of these activities, in the "fused horizons of understanding" of participating actors (Gadamer, 1975), and also in a community's or organization's texts, electronic documents, and databases (Bruner, 1990; Hall, 1994; Boland & Tenkasi, 1995; Kusunoki, Nonaka, & Nagata, 1998). Therefore, it must be emphasized that an organization's "collective mind" is not the property of a single actor, neither is it contained in its entirety in the Gadamerian "horizons" (fused or otherwise) of all actors; rather, it is distributed among all participating actors as a knowledge of and about communal and/or organizational activities (Weick & Roberts, 1993).

The logical conclusion of this argument is that all work in organizations is "knowledge work," as knowledge about organizational activities is dispersed either within "communities-of-practice" or across them. The next section further elaborates on this and explores how knowledge is socially constructed; it also differentiates between practical wisdom or experiential knowledge and technical or skills-based knowledge. This helps put knowledge in context and points toward a more inclusive appreciation of knowledge work.

AN ONTOLOGICAL PERSPECTIVE ON THE SOCIAL CONSTRUCTION OF KNOWLEDGE

Boland (1987) gives an account of five misguided fantasies that surround the concept of information, viz that it is structured data, that an organization is information, and that information is power, is intelligence, or is perfectible. This observation could be extended to the concept of knowledge. For example, conventional wisdom dictates that knowledge is processed information and as such is capable of objective representation. In order to dispel such notions, the ontological basis of knowledge is explored. This fosters an understanding of how people come to know what they know and provides insights into the constitution of knowledge.

It is clear from Gadamer's (1975) hermeneutics that data, information, and knowledge are loosely coupled: Depending on the "worldview," "lived experience," and "tradition" of the recipient, the same data can yield different knowledge and understanding. Consider, for example, Heidegger's (1976) argument that Dasein's "'Being-in-the-world" is characterised by a "pre-understanding" or "fore-knowledge" of the nature of being and its constituent phenomenon. Consider also Heidegger's argument that Dasein, as the mode of being characteristic of all humans, always understands itself in terms of its existence and the possibilities it presents. Any "breakdown" in Dasein's understanding of phenomena results in the search for data that will enable phenomena to be interpreted in a new light and thereby repair the "breakdown" by developing an enhanced understanding. Thus, as Brown and Lightfoot (1998) argue, "knowledge occurs in the wake of the breakdown. It proceeds slowly, perhaps without clear direction" (p. 293).

In Gadamerian terms, the process of acquiring new knowledge-informing data on a phenomenon is governed by the hermeneutic "circle of understanding," which involves the cycling back and forth between the actor's existing "horizon of understanding" and that suggested by the phenomenon of interest. A dialectic of question and answer, of thesis, antithesis, and synthesis, operates to help the actor interpret new data in light of the old. Hence, a new understanding is arrived at when a "fusion of horizons" occurs between the interpreter's horizon of understanding and that of the phenomenon under consideration (Butler, 1998). Thus, knowledge is, first and foremost, an enigmatic and personal phenomenon in that it arises from the practical experience of social actors. In order to delineate the dimensions of such experience, the work of Aristotle is presently explored.

Phronesis and Techne as the Core Constituents of Practical Knowledge

Gadamer (1975) and Dunne (1993) drew on Aristotle's Nicomachean Ethics to extend further our understanding of individual knowledge. Aristotle presents what he considered to be the core components of practical knowledge in social contexts—phronesis as experiential self-knowledge (practical wisdom) and techne as skills-based technical knowledge. The conduct of social affairs involves the application of phronesis in a thoughtful and competent manner, this Aristotle refers to as praxis. The social activity that has as its concern the "making" or "production" of social artefacts is called poiesis and involves the application of techne. A techne is knowledge of how to perform task-based activities in pursuit of some practical end: This end may be tangible or intangible. Thus, techne provides managers, professionals, craftsmen, labourers, and scientists with an understanding of the why and the wherefore, the how and with-what of their concerns. The skills of qualified craftsmen, artists, musicians, surgeons, computer programmers, physicists, accountants, and so on, all fall into this category—as indeed does the oft-ignored skills of ordinary "unskilled" workers. On the other hand, a social actor's "self-knowledge" (phronesis) is a synthesis of his temporal experience of social phenomena and his ability to take or perform practical action in relation to such phenomena—and this clearly applies to every class of worker. All this has important implications for the way in which knowledge is viewed in research and practice, as will be seen in the concluding sections. However, it is clear from Aristotle that phronesis and techne possess a social nature, accordingly, the social context of knowledge construction is now explored.

The Social Construction of Knowledge Work

Researchers point out that social action is the dominant means of knowledge diffusion in organizations (Berger & Luckmann, 1967). However, it must be noted that individual knowledge is inseparable from the social context and practices that help construct it and which shape and influence its acquisition (Berger & Luckmann, 1967; Bruner, 1990; Brown & Duguid, 1991). Following this line of argument, Tsoukas (1996) argues that a social actor's knowledge lies, first and foremost, in the social and occupational practices in which he or she engages and, in effect, knowledge is socially constructed (Berger & Luckmann, 1967). It is clear, however, that while knowledge is embodied in the social actors that comprise the various "communities-of-practice" that constitute organizations, no one actor or group of actors possesses all the knowledge required to effect social action. This gives rise to the notion that knowledge in organizations is dispersed (Hayek, 1945), as actors may not be in a position to observe, at first hand, the knowledge embedded in the actions of others or communicate linguistically with them (Kogut & Zander, 1992). Therefore, social actors resort to texts and other media, such as IT, to augment their limited cognitive capacities (Bruner, 1990); these mechanisms provide conduits or repositories for the spatial and temporal transfer of knowledge-informing data between actors (Boland & Tenkasi, 1995). They are not, as this article argues, knowledge repositories and therefore cannot be managed as such. It is clear, however, that social narrative is the dominant mechanism for understanding acts of meaning in social contexts, hence, this issue is next explored.

The cultural psychologist Jerome Bruner (1990) illustrated the role of narrative in all human understanding (see Brown & Duguid, 1991). Accordingly, Gadamer argues that language is an essential component of communication and understanding. Nevertheless, Heidegger (1976) maintains that:

Communication is never anything like a conveying of Experiences, such as opinions or wishes, from the interior of one subject into the interior of another... In discourse Being-with becomes "explicitly" shared, that is to say, it is already, but it is unshared as something that has not been taken hold off and appropriated. (p. 205)

Thus, strictly speaking, language is not normally used for the exchange of information, as is commonly assumed; instead, it merely calls attention to some aspect of the shared existence of social actors. As Taylor (1993) argues, human knowledge and understanding are based upon the unarticulated background of the "ready-to-hand," that is, the taken-for-granted understandings that constitute the web of human relationships (Heidegger, 1976). This has profound implications for the commonly held conception of knowledge. Accordingly, Winograd and Flores (1986) point out that "knowledge lies in the being that situated us in the world, but not in a reflective representation" (p. 74). Thus, individual knowledge is possible because of the social practices actors engage in. However, it is clear that social practices are not an aggregation of individual experiences; rather, they constitute the set of background distinctions that underpin individual action. In addition, actors are socialized into institutional practices which involves internalizing the set of background distinctions that constitute such practices (see Brown & Duguid, 1991; Taylor, 1993). Knowledge is therefore open-ended and its creation goes far beyond the mere processing of knowledge-informing data.

Working on Data, Not Knowledge

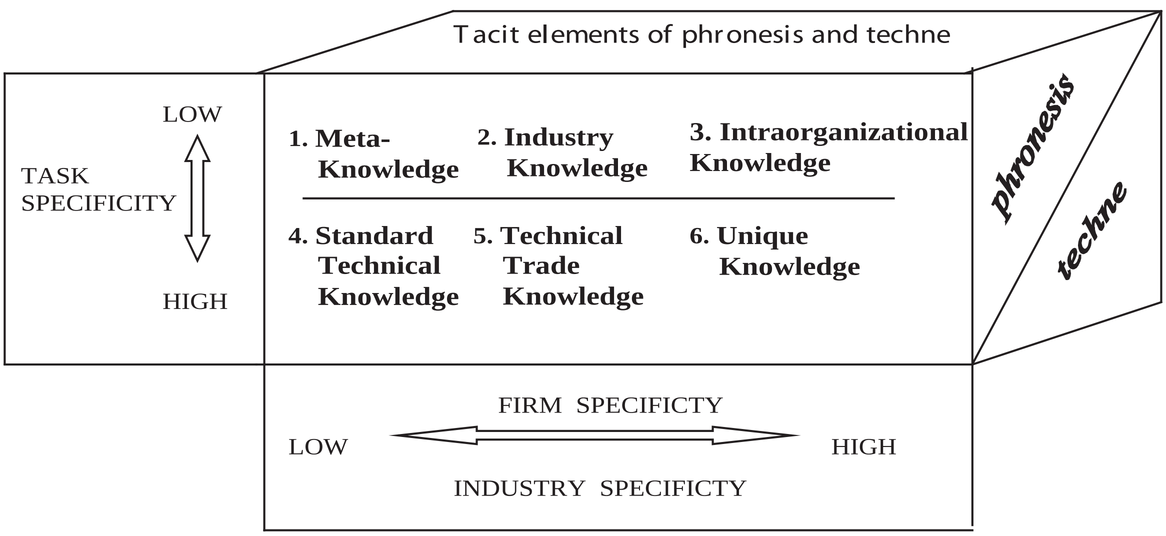
Von Foerester (1984) states "information is the process by which knowledge is acquired" (p. 193). However, texts, documents, computer files, databases, and so forth merely provide data. Why? Individuals become informed through the process of interpretation and the application of individual "fore-knowledge" (Introna, 1997). Therefore, as a text (social action is included here) is read and interpreted, it informs. So, from a hermeneutic perspective, texts and narratives contain data that when interpreted inform the reader. Hence, information is abstract and ambiguous in its depiction, and data is all that can be represented, stored, transferred, and manipulated by information and communication technologies (ICT) (Galliers & Newell, 2001). Ultimately, all that can be said of knowledge then is that it is always in a process of becoming, extending beyond itself (Fransman, 1998). This "becoming" refers to different interpretations or meanings attributed to data derived from the multi-voiced dialectic that takes place within and between social actors who are embedded in cultural contexts that are historical, on the one hand, and that are oriented toward the future, on the other (Bruner, 1990).

FUTURE TRENDS: TOWARD A CONCEPTUAL MODEL AND TAXONOMY OF KNOWLEDGE IN ORGANIZATIONS

It has already been established that the two basic components of social actors' knowledge are phronesis and techne. When coupled with the tacit knowledge that arises from the unarticulated web of social activities and relationships, these types of knowledge combine to provide social actors with a unique stock of knowledge and a "worldview." There is, however, a need for an extended conceptualization that incorporates a pragmatic, taxonomic perspective on knowledge in organizational and institutional contexts. Nordhaug's (1994) taxonomy of organizational competencies is of particular interest here, as it indicates the focus and application of individual phronesis and techne in organizational and institutional "communities-of-practice." Therefore, it is of particular relevance to this article's thesis as it contributes to the formulation of a conceptual model and taxonomy of knowledge within organizational settings (see Figure 1). It is hoped that this will inform the future deliberations of practitioners and researchers in the area.

By way of representing the various dimensions of phronesis and techne in finer granularity, the taxonomy of knowledge presented captures what is regarded as organizational knowledge from an individual perspective. In Figure 1, the term specificity refers to the degree to which an individual's knowledge is general or specific1 to (a) the execution of organizational tasks, (b) the organization itself, and (c) the industry the organization competes in. For example, meta-knowledge, which is general background knowledge and which possesses a significant tacit component,

Figure 1. A conceptual model and taxonomy of knowledge in organizational contexts (adapted from Nordhaug, 1994)



can be used in the performance of a range of organizational activities—social and technical. Examples of meta-knowledge are individual literacy, knowledge of a foreign language, and so on. This type of knowledge also is generally available within the firm and the industry as a whole; nevertheless, the widespread possession of such knowledge by individual actors is important for an organization's general "stock of knowledge."

Industry-based knowledge also is a general type of knowledge, widely available to individuals in their role-related organizational activities, across both firms and industry. It is not specific to either organizations or any individual organizational tasks as such, but it is, however, highly industry specific. Examples of this type of knowledge are knowledge of the industry structure, its current state of development, and of the key individuals, networks, and alliances in an industry.

Intraorganizational knowledge is highly firm and industry specific but is not specific to organizational activities or tasks. In effect, this component of social actors' knowledge is firm-specific meta-knowledge. Examples are knowledge about colleagues, knowledge about elements of the organizational culture, communication channels, informal networks, knowledge of a firm's strategy and goals, and so on.

Standard technical knowledge is task specific, industry and firm non-specific, and involves a wide range of technical, operationally oriented knowledge that is generally available to all actors. Examples are knowledge of financial and management accounting practices, knowledge of computer programming and standard software packages, and knowledge of craft and engineering principles and methods.

Technical trade knowledge is task specific, industry specific, and is generally available among firms in an industry. Examples of such knowledge are knowledge of automobile construction methods, knowledge of the techniques of computer hardware construction, and so on.

Finally, unique knowledge is specific across all dimensions and applies to the possession by social actors of knowledge—self-knowledge and skills-based knowledge—of unique organizational routines, production processes, and IT infrastructures, to mention a few.

This section of the article explored the socially constructed nature of individual/collective knowledge in organizations. In order to provide insights into the type of knowledge relevant to social actors in organizational contexts, a taxonomy of individual knowledge in organizational contexts was then offered. The strands of the arguments made are now woven together in the concluding section.

CONCLUSION

An understanding of phronesis and techne is, we believe, essential to an understanding of knowledge work. If the observation that phronesis and techne constitute the practical components of individual knowledge in social contexts is accepted, then those who apply experiential self-knowledge and/or skills-based technical knowledge in institutional settings can be considered knowledge workers. It is clear that this definition applies to workers in pre-industrial and industrial settings, as well as IT-enabled post-industrial organizations. Certainly, the appearance of ICT in the post-industrial age has led to the development of IT-related knowledge and skills by many workers. One example is professional workers who employ personal productivity tools, such as spreadsheets and DSS, while another is scientists and practitioners who develop skills in the use of sophisticated technologies to develop new understandings of natural or social phenomena. But this in itself does not make these individuals any more or less knowledge workers than their industrial or pre-industrial predecessors. What does, then?

Many clearly feel that the quantity and quality of data that can be stored, accessed, communicated, analyzed, and processed by contemporary workers using ICT renders the work they perform a special status (i.e., knowledge work). Maybe it does. And maybe this is why academics and practitioners now accord to data the status of knowledge. In contrast, the argument presented in the second section of this article illustrates that knowledge, unlike data, cannot exist outside the heads of knowers, and that such knowledge has an explicit social context. In the context of ICT, this article posits that "so-called" knowledge workers work on data, not knowledge. In addition, the all-pervasive Taylorist prejudice against workers has led to a focus by decision-makers on the management of what has been described as "objective knowledge" in and by ICT, rather than attempting to leverage the "subjective knowledge" of workers, which is the real and only source of organizational knowledge. Thus, like the emperor in the fairytale, practitioners have been duped by consultants and some well-meaning academics into believing that there is something special in the "knowledge management paradigm." What can and should be managed are workers and the data they create, collate, and disseminate, but stating the obvious would not make many consultancy dollars or help have papers accepted for publication. How then can researchers begin to understand what is happening in organizations where workers employ ICT in innovative ways? Taken in the context of the theoretical argument articulated in the foregoing sections, the model and knowledge taxonomy presented in the fourth section should act to "inform" researchers who seek to understand the know-how, -why, and -what of knowledge and social action in organizational settings. Accordingly, it highlights areas where experiential and skill-based knowledge are of value in organizations and recognizes the relative importance of task and firm specific knowledge.

REFERENCES

Aristotle (1945). *Nicomachean ethics.* Translated by H. Rackham. Cambridge, MA: Harvard University Press.

Berger, P., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge.* Garden City, NY: Doubleday and Company, Inc.

Boland, R.J. (1987). The in-formation of information systems. In R.J. Boland & R.A. Hirschheim (Eds.), *Critical issues in information systems research* (pp. 362-379), Chichester, UK: John Wiley.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, J.S., & Duguid, P. (1991). Organisational learning and communities-of-practice: Toward a unified view of working, learning and innovation. *Organisation Science, 2,* 40-57.

Brown, S.D., & Lightfoot, G.M. (1998). Insistent emplacement: Heidegger on the technologies of informing. *Information Technology and People, 11*(4), 290-304.

Bruner, J. (1990) *Acts of meaning.* Cambridge, MA: Harvard University Press.

Butler T. (1998). Towards a Hermeneutic method for interpretive research in information systems. *Journal of Information Technology, 13*(4), 285-300.

Butler T., & Murphy, C. (1999, December 13-15). Shaping information and communication technologies infrastructures in the newspaper industry: Cases on the role of IT competencies. In Prabuddha De and J. I. DeGross (Eds.), *The Proceedings of the 20th International Conference on Information Systems* (pp. 364-377), Charlotte, NC.

Cooley, M. (1975). *The knowledge worker in the 1980s*. Doc. EC35, Diebold Research Programme, Amsterdam.

Cooley, M. (1987). *Architect or bee? The human price of technology*. London: The Hogarth Press.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organisations manage what they know*. Boston: Harvard Business School Press.

Drucker P.F. (1999). *Management challenges for the 21st Century*. New York: Harper Business.

Dunne, J. (1993). *Back to the rough ground: 'Phronesis' and 'techne' in modern philosophy and in Aristotle*. Notre Dame, IN: University of Notre Dame Press.

Fransman, M. (1998). Information, knowledge, vision, and theories of the firm. In G. Dosi, D.J. Teece, and J. Chytry (Eds.), *Technology, organisation, and competitiveness: Perspectives on industrial and corporate change* (pp. 147-192). New York: Oxford University Press Inc.

Gadamer, H.G. (1975). *Truth and method*. New York: The Seabury Press.

Galliers, R.D., & Newell, S. (2001, June 27-29). Back to the future: From knowledge management to data management. In *Global Co-Operation in the New Millennium, The 9th European Conference on Information Systems* (pp. 609-615). Bled, Slovenia.

Grant, R.M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17,* Winter Special Issue, 109-122.

Hall R. (1994). A framework for identifying the intangible sources of sustainable competitive advantage. In G. Hamel and A. Heene (Eds.), *Competence based competition* (pp. 149-170). Chichester, UK: Wiley & Sons Ltd.

Hannan, M.T., & Freeman, J. (1984). Structural inertia and organizational change. *American Sociological Review, 49,* 149-164.

Hayek, F.A. (1945). The use of knowledge in society. *American Economic Review, 35,* 519-532.

Heidegger, M. (1976). *Being and time*. New York: Harper and Row.

Introna, L.D. (1997). *Management, information and power: A narrative for the involved manager*. London: MacMillan Press Ltd.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technologies. *Organisation Studies, 3,* 383-397.

Kusunoki, K., Nonaka, I., & Nagata, A. (1998). Organizational capabilities in product development of Japanese firms: A conceptual framework and empirical findings. *Organization Science, 9*(6), 699-718.

Latour, B. (1993). *We have never been modern*. Cambridge, MA: Harvard University Press.

Law, J., & Callon, M. (1992). The life and death of the aircraft: A network analysis of technical change. In W.E. Bijker & J. Law (Eds.), *Shaping technology/building society: Studies in sociotechnical change* (pp. 21-52). Cambridge, MA: MIT Press.

Lincoln, Y.S., & Guba, E.G. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Nelson, R.R., & Winter S.G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: The BeIknap Press of Harvard University Press.

Nordhaug, O. (1994). *Human capital in organisations: Competence, training and learning*. New York: Oxford University Press.

Pfeffer, J. (1995). *New directions for organization theory*. New York: Oxford University Press.

Schein, E.H. (1985). *Organizational culture and leadership: A dynamic view*. San Francisco: Jossey Bass.

Spender J.C., & Grant, R.M. (1996). Knowledge and the firm. *Strategic Management Journal, 17,* Winter Special Issue, 5-9.

Spender, J.C. (1989). *Industry recipes*. Oxford: Blackwell.

Stata, R. (1989). Organizational learning: The key to management innovation. *Sloan Management Review, 30*(3), Spring, 63 74.

Taylor, C. (1993). To follow a rule… In C. Calhoun, E. LiPuma, & M. Postone (Eds.), *Bourdieu: Critical perspectives* (pp. 45-59). Cambridge, UK: Polity Press.

Tsoukas, H. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal, 17,* Winter Special Issue, 11-25.

Von Foerster, H. (1984). Principles of self-organization in socio-managerial context. In H. Ulrich & G.J.B. Probst (Eds.), *Self-organization and management of social systems* (pp. 2-24). Berlin, Germany: Springer.

Weick, K.E., & Roberts, K.H. (1993). Collective mind in organisations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38*, 357-381.

Winograd T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Norwood, NJ: Ablex Publishing Corporation.

ENDNOTE

[1] The classification of knowledge into general and firm specific categories is a fundamental tenet of human capital theory (see Nordhaug, 1994).

Chapter 6.25
Key Performance Indicators and Information Flow:
The Cornerstones of Effective Knowledge Management for Managed Care

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ABSTRACT

It is paradoxical that, although several major technological discoveries such as Magnetic Resonance Imaging and Nuclear Medicine and Digital Radiology, which facilitate improvement in patient care, have been satisfactorily embraced by the medical community, this has not been the case with Healthcare Informatics. Thus, it can be argued that issues such as Data Management, Data Modeling, and Knowledge Management have a long way to go before reaching the maturity level that other technologies have achieved in the medical sector. This chapter proposes to explore trends and best practices regarding knowledge management from the viewpoint of performance management, based upon the use of Key Performance Indicators in healthcare systems. By assessing both balanced scorecards and quality assurance techniques in healthcare, it is possible to foresee an electronic healthcare record centered approach which drives information flow at all levels of the day-to-day

process of delivering effective and managed care, and which finally moves towards information assessment and knowledge discovery.

INTRODUCTION

The advantages of the introduction of Information and Communication Technologies (ICT) in the complex Healthcare sector have already been depicted and analyzed in the Healthcare Informatics bibliography (Eder, 2000; Englebardt & Nelson, 2002; Harmoni, 2002; Norris, Fuller, Goldberg, & Tarczy-Hornoch, 2002; Shortliffe, Perreault, Wiederhold, & Fagan, 2001; Stegwee & Spil, 2001). It is nevertheless paradoxical that, although several major technological discoveries such as Magnetic Resonance Imaging, Nuclear Medicine and Digital Radiology, which facilitate improvement in patient care, have been satisfactorily embraced by the medical community, this has not been the case with Healthcare Informatics. Thus, it can be argued that issues such as Data Management, Data Modeling, and Knowledge Management have a long way to go before reaching the maturity level that other technologies have achieved in the medical sector.

A variety of reasons could be proposed for this issue, though with a short analysis it becomes rather clear that modern ICT present integration problems within the healthcare sector because of the way the latter is organized. Healthcare is a strongly people-centered sector in which ICT has been considered more as an intruder, as a "spy" to the healthcare professionals' way of doing things and as a competitor to this people-centered model. Thus, if ICT intend to prove its advantages towards establishing an information society, or even more a knowledge society, it has to focus on providing service-oriented solutions. In other words, it has to focus on people and this has not been the case in most of the circumstances. It is common knowledge that in order to install any type of information system in healthcare, especially if it involves knowledge management, six main groups of issues have to be dealt with (Iakovidis, 1998, 2000):

1. The organizational and cultural matters related to healthcare. This issue is rather important, regardless of any information system, since organizational models and culture do not endorse the continuity of care or any type of structured data collection. Issues such as mistrust between different specialists, between the different healthcare structures or between doctors and nurses prevent in many cases the effective sharing of information. Health reforms are currently under way in many countries stressing the will to deal with this problem.
2. The technological gap between healthcare professionals and information science experts. Doctors are often reluctant to use information systems that they believe are not designed for them. From another point of view, Healthcare Informatics have been introduced in healthcare institutions mostly on pilot-based projects aiming at addressing specific issues and have proposed solutions addressing a small number of healthcare practitioners, resulting in establishing a complex map of information niches. This approach is the consequence of applying information technology to procedures that where not designed for it, thus creating a panspermia of information models which are neither compatible nor interoperable, even within a single institution's environment. Efforts in creating interoperability standards and protocols such as HL7 are proposing solutions to address this issue, thus enabling data manipulation and knowledge management.
3. The legal requirements on the confidentiality of personal and patient related data and on data privacy. It is clear that if this issue is not addressed at a managerial and procedural

level by imposing suitable policies to meet these requirements, there is little chance that medical data will be kept digitally in a structured manner (thus allowing the transition from digital islands of clinical data towards a structured electronic healthcare record). The implementation of an information system, where the electronic healthcare record is considered to be the core of the system (patient-centered model), is the only way to drive data management towards creating new knowledge. The complexity of the problem can be explained if one just observes the course of implementation of both the Health Information Privacy and Accountability Act (HIPAA) in the US and Directive 95/46/EC in the EU. The issues seem to have been dealt with at the strategic level, but still a lot has to be done in the implementation and setup of those strategies.

4. The industrial and market position of Healthcare Informatics. In general, the healthcare market is seen by the industry as large in size but not highly profitable, mainly due to the lack of standards in implementing and interoperating healthcare informatics products. As a consequence, the industry has focused on creating mostly small-scale products (i.e., Laboratory Information Systems, Radiology Information Systems, Clinical Information Systems) and not on evangelizing the production of information system that are dealing with healthcare as a whole. The lack of end-to-end solutions is dealt with by interconnecting heterogeneous information systems (a rather complex task with constant change management issues) and by introducing solutions from other business sectors (i.e., ERP, SCM, CRM) that have often been rejected by "key users" as non-compliant with their job description. Nevertheless, the new Web technology approaches (Web services, XML, etc.) and the new information technology strategies (i.e., service oriented architecture) could be the drivers towards merging information technology and healthcare services and thus enabling the establishment of knowledge management products.

5. The lack of vision and leadership of healthcare managers and health authorities, and the lack of willingness to re-engineer healthcare processes for the benefits of efficiency and quality of care delivery. Some countries are in the process of introducing or implementing such Business Process Reengineering projects in order to address healthcare delivery in a more information flow conformant way. This is a key point in reaching knowledge management, knowledge re-use and sharing, and finally proposing a solution for the knowledge-based society of tomorrow. This issue should be dealt with by proposing strategies that focus on processes and by establishing key performance indicators, balanced scorecards, or other metrics that are the upper level of a structured information flow-based model.

6. User acceptability and usability of the proposed information systems. This issue is the one most strongly related to the problem of dealing with the people-centered approach of the healthcare sector. This issue deals with information systems' user friendliness, with usability issues such as the time to reach a data entry point, the speed of information retrieval, the quality of information retrieval, the complex security procedures, and so on. In order to implement information systems and knowledge management systems, education and training must be addressed with high priority since user acceptability is strongly related to them. Service oriented models and patient-centered information systems have a higher chance of passing the user acceptability test. A system that is not accepted

by the user is often a system with poor data quality (or no data at all) and knowledge management, business intelligence or data warehousing solutions are consequently inoperable and unsuccessful.

Taking all of the above issues into consideration, this chapter proposes to explore trends and best practices regarding knowledge management from the viewpoint of performance management, based upon the use of Key Performance Indicators (KPI) in healthcare systems. By assessing both balanced scorecards (Kaplan/Norton) and quality assurance techniques in healthcare (Donabedian), it is possible to foresee an electronic healthcare record centered approach which drives information flow at all levels of the day-to-day process of delivering effective and managed care, and which finally moves towards information assessment and knowledge discovery (both with administrative and medical data). KPIs should be regarded as the strategic assessment tool, for both the executives and the clinical decision-makers, that will lead healthcare delivery to excellence and to knowledge discovery and assessment.

BACKGROUND

Knowledge Management as a Transformation Driver in Healthcare

Today, Knowledge Management (KM) is on everyone's mind. Healthcare organizations are no exception and are accepting the challenge to more effectively share knowledge both internally and externally (Strawser, 2000). The growth of KM projects (i.e., decision support systems, data mining tools, business intelligence solutions) signals a growing conviction that managing institutional knowledge is crucial to business success and possibly business survival. When the hype and confusion are stripped away, it is apparent that KM initiatives can profoundly change a healthcare enterprise for the better, and bring numerous advantages to Healthcare Information Management (HIM) professionals. For HIM professionals, KM is worthy of special attention because it informs them not only on how to do things, but also on how they might do them better. In order for this to happen, data should be provided in specific patterns and should be based upon a strategy that will empower a healthcare system by gaining knowledge of its processes, its outcomes, and its structures.

Despite the obvious advantages, many healthcare decision makers view the idea of a KM initiative with scepticism, possibly because of an incomplete or incorrect understanding of the tools needed to achieve it. Many of the tools and strategies associated with implementing KM are not new; what is new is a cohesive approach to KM design and implementation. Certainly there are pitfalls and limitations in using information technology for KM—trying to force fluid knowledge into rigid data structures, for example, or focusing too much on the tools and not enough on the content. But networks and computers, with their ability to connect people and store and retrieve virtually unlimited amounts of information, can dramatically improve departmental efficiencies. Some examples of knowledge management applications are listed below:

- Data Mining tools enable decision makers to search and analyze large sets of data by using specific querying methods and tools (Standard Query Language, Rough Data set, On Line Analytical Processing).
- Document and Content Management systems are widely used to store and archive files of any type (text, images, video, etc.) and correlated them with keywords that have a business meaning to the end user.
- Knowledge Maps are graphical or other representations of how and by whom a specific

set of information is created, distributed and assessed. Knowledge Maps are very important tools in Total Quality Management projects.

- Intelligent Agents use a combination of profiling techniques, search tools, and recognition algorithms to provide up to date specific information to the end user. For example, intelligent agents could be used to forward completed test results to the corresponding physicians of a patient.
- Web Browsers are the most commonly used tools for searching information in an intranet or the Internet. As such, Web browsers are increasingly becoming the most common graphical user interface, even for specific software products such as financial accounting and patient order entry systems.
- Business Intelligence tools and Data Warehouses enable the decision maker to have predefined access to specific information of interest regardless of the physical location of the data. Such systems are ideal for performance management and executive reporting and serve as the technological base for supporting the idea of a digital dashboard of indicators.
- Workflow applications play a very important role in KM since knowledge is created during the process-based operations that take place in a healthcare institution. A computerised patient order entry system is a classic example of a process-based operation in healthcare that requires the constant monitoring of the workflow status.
- E-learning and collaboration tools are part of the knowledge distribution process, which is extremely important in healthcare, since continuous education is a key factor in effective practice of care.

The essence of effective knowledge management does not rely on the use of one or more existing or forthcoming information technology tools. It is mostly about people, about processes and about capturing the results of people following processes, about transforming information into knowledge (explicit or tacit) and reusing it within a healthcare framework.

Performance Management: Monitor and Manage Healthcare

In order to persuade healthcare decision makers to assess the added value of KM tools, the latter should initially be used to propose new performance measurement and performance management techniques at all levels of a healthcare system (Hurst & Jee-Hughes, 2001). In that sense, performance management has long been considered as a tool for controlling spending and for increasing the efficiency of healthcare systems (Oxley & MacFarlan, 1994). There are three broad goals that governments generally pursue in the healthcare area:

- Equity: where citizens should have access to some incompressible minimum level of healthcare and treatment based on the need for care rather that solely on income.
- Micro-economic efficiency: where quality of care and consumer satisfaction should be maximized at minimum cost.
- Macroeconomic cost control: where the healthcare sector should consume an “appropriate” share of GDP.

In addition, healthcare systems are often facing factors that put pressure on the system. As a consequence, an effective performance management framework is the only solution towards controlling factors such as:

- Population aging
- Increased income and higher demand for healthcare services;

- Increased access to healthcare services; and
- Increase of high technology usage which in turn increases the healthcare services usage creating sometime unnecessary demand (from a medical point of view).

Most existing policies for controlling the performance of healthcare systems were based upon financial assessment of past results (macroeconomic control of spending and micro-efficiency improvements) by giving incentives to payers and providers of a healthcare system. By its very nature the financial measurements are not forward looking and are exclusionary to non-financial measures. In addition, the emergence of the Information Society in the late 90s rendered many of the fundamental performance management assumptions obsolete. Information Society has brought a new set of assumptions that institutions have to include into their strategy. Amongst others we could refer to:

- The cross functional aspects of processes based upon specialisation, increased skills and high technology
- The integration of processes in the healthcare sector from the suppliers to the patient and the ability to manage and monitor materials upon requests and needs
- The ability to offer specific services to patients in accordance to their needs while being able to constraint costs of this customised care. In fact this is the essence of managed care: providing satisfactory and high quality of care at a reasonable cost.
- The global scale of healthcare: This sector is no exception to any other global marketplace, thus making healthcare delivery more comparable at a national or regional level and within accepted standards (e.g., clinical procedure guidelines)
- Innovation, which has been a key driver towards quality of care and quality of life for many years in the healthcare sector
- Knowledge workers: the increasing complexity of medicine and technology has created a need for highly skilled personnel at every level of a healthcare institution. Employee empowerment is driven by knowledge as it is created in the daily process of delivering healthcare services.

Nowadays, performance measurement is moving towards the adoption of a set of objectives for a healthcare system. To our knowledge, there is no complete agreement on what is meant by “performance” of health systems and many sets of objectives are generally proposed. The use of Key Performance Indicators (KPI) helps to establish this set of objectives more thoroughly by focusing on the real needs.

Using Balanced Scorecards

In order to address the issue of creating a set of KPIs , the Balanced Scorecard (BSC) framework (Kaplan, 2001; Norton & Kaplan, 1996) initially proposed by Kaplan and Norton for the strategic management of financial organizations in the mid 1990s, is one of the most suited approaches in that direction. This model has now proven its value and since it is a generic framework it is applicable to the healthcare sector. The BSC concept involves creating a set of measurements and objectives for four strategic perspectives:

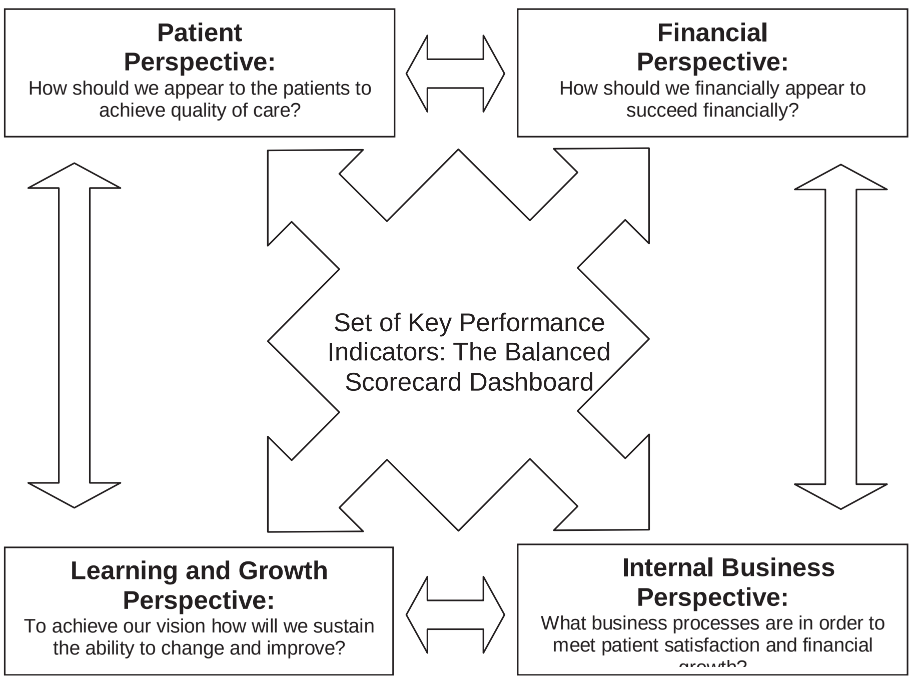
- Financial: financial performance measures typically indicate whether a proposed strategy implementation and execution is contributing to bottom line improvements, based upon an accurate summary of economic consequences of actions already taken.
- Customer (i.e., the Patient): this perspective is a set of objectives that focuses on identifying

the patient's needs, the targeted market (this could be the case of a specialised institution) and on measuring the performance of each specific business unit (i.e., a department) that has some influence on how the patient sees the healthcare organization.

- Internal Business Process. This perspective should gather all objectives related to processes and the way these are monitored and fine-tuned in order to achieve both excellence in financial accomplishments and patient satisfaction. In that sense, the BSC approach is a constant business process reengineering process based upon specific goals to meet and not on improving de facto established processes.
- Learning and Growth (innovation and vision). This is an important perspective of a BSC implementation because it focuses on the objectives and goals to achieve the incorporation of business innovation (e.g., installing a Positron Emission Tomography Device) and the continuous education of medical and administrative staff. In that sense, this perspective identifies measurable tasks in order to build long-term growth and improvement. In the healthcare sector, improvement is also measured by assessing the outcome of treatment and care.

These four perspectives comprise a framework, meaning that they must be assessed and populated in accordance to each business case. In order to achieve this, one has to set for each category a list of objectives that can be feasibly measured. To each objective, a specific target should be set and the initiative to reach that target well described.

Figure 1. A healthcare oriented BSC framework



The BSC approach retains the "traditional" financial perspective, which mostly focuses on reporting about past events. Financial figures, even if prospected in the future by statistical means, are inadequate for guiding and evaluating the journey that healthcare institutions must make to create future value through innovation, knowledge, patient satisfaction, employee empowerment, process refinement, technology assessment and material management. In that sense, the three other cited perspectives are completing the puzzle in order to create a more valid and future-oriented performance management strategy. In recent years, there have been some implementations of BSC frameworks in the healthcare sector mostly on a single institution base (i.e., a hospital, a clinic, an information technology component). Readers are encouraged to read and assess the best practices, cited as references to this chapter (Aidermark, 2001; Castaneda-Mendez, Mangan, & Lavery, 1998; Forgione, 1997; Freeman, 2002; Gordon & Geiger, 1999; Inamdar, Kaplan, & Bower, 2002; Oliveira J, 2001; Pink, Mc Killop, Schraa, Preyra, Montgomery, & Baker, 2001; Tarantino, 2003; Weber, 1999)

The model in Figure 1 enables decision makers to also value how the latter three perspectives have worked and thus it enables the measurement of intangible aspects of a system. The measurements focus on a single strategy that can be easily broken down to the various levels of depth, depending of the organization type. Thus, by using BSC one can create a top-to-bottom design of a system, starting up from the needed strategy (what is the market, who are the customers, what are the critical processes, what is required by the stakeholders) going down to design metrics, processes, structures and finally the needed technical and functional specification to create an information system and a knowledge management framework capable of producing the right data and serve the strategy.

QUALITY ASSURANCE IN HEALTHCARE AND THE ROLE OF INFORMATION TECHNOLOGY

Known Problems and Issues of the Healthcare Sector

It is rather of common knowledge that the healthcare sector is not a sector without problems. Especially in Europe, the great majority of healthcare organizations are state funded. This means that institutions have in some cases very restricted budgets to satisfy their needs thus making performance management a critical issue in their daily routine. Other common problems are increased bed coverage (some institutions are almost at 100 percent), long length of stay, increased waiting lists, poor facilities, and so on. Taking all this into account and adding the life-related processes, one can clearly see that healthcare organizations are difficult to manage even for experienced managers of other sectors. One could list some of the major issues that healthcare stakeholders are confronted with:

- Diversity of cases
- Need of high technology medical devices
- Public Policy Restrictions (e.g., payment by per day quotas that do not cover the inpatient treatment costs)
- High lengths of stay
- Increased waiting times
- Obsolete facilities
- Restricted funds for training
- Restricted funds for maintenance
- Increased number of medical errors (sometimes fatal)
- Erroneous drug prescription and intake (sometime fatal)
- Geographical issues (too many patients, too few nurses and medical staff)
- Large lists of materials to be managed (more than 3000 on average)

- Excessive waste management (10 m3 per day on average)

Quality Assurance and Performance Management

The application of a BSC framework will not by itself solve any of the aforementioned problems and issues. One could even say that BSC projects often fail as a consequence of misunderstanding or of not using a BSC strategy. BSC projects also fail because the variables of the scorecard are incorrectly identified as the primary drivers and because the improvement goals (the targeted objectives) are negotiated across an institution instead of being based upon stakeholders' requirements, fundamental processes and improvement process capabilities. They also fail because there is no deployment system installed to disseminate, maintain and promote the BSC framework, or because some very important KPIs are not used, or metrics are poorly defined.

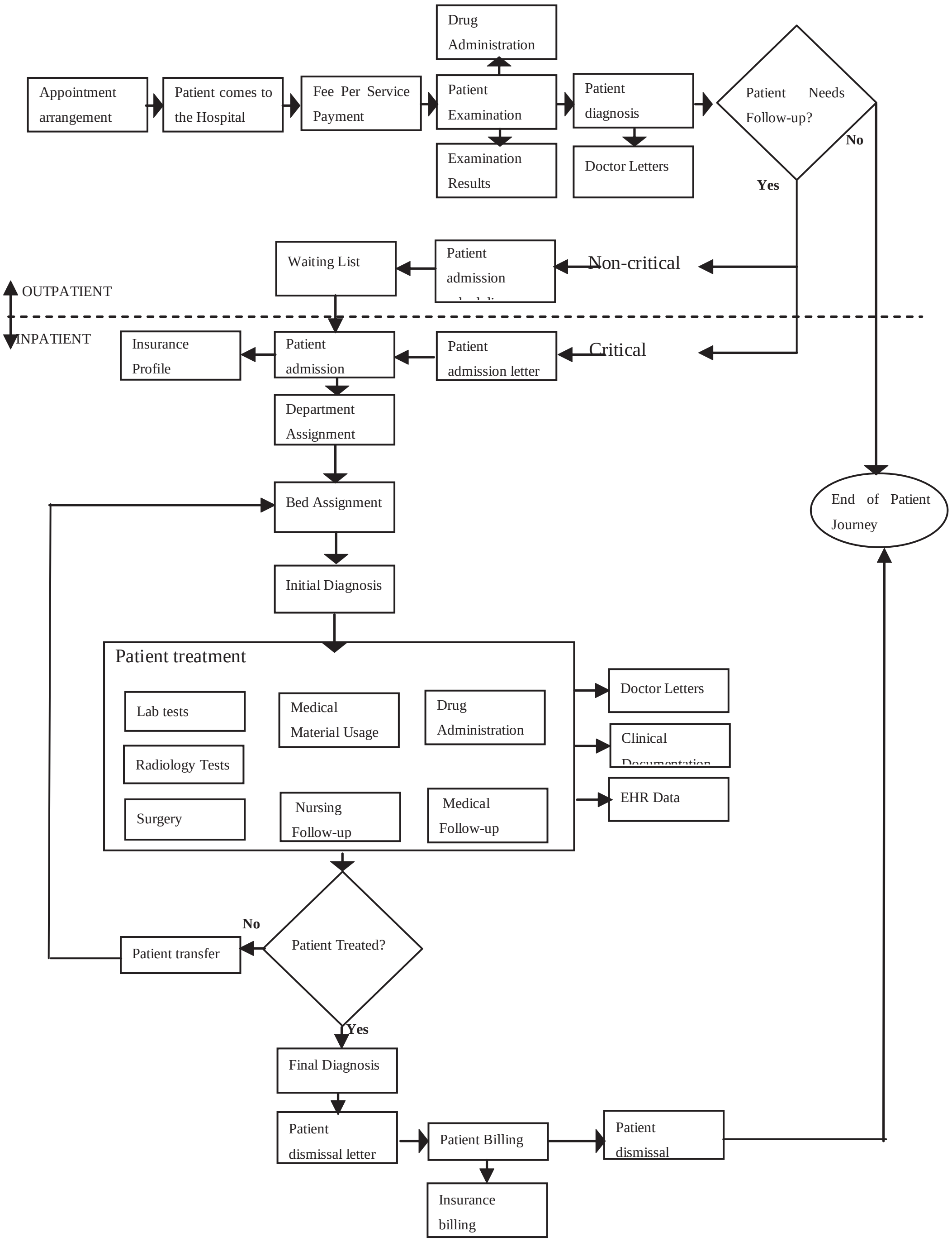
Furthermore in order to create a structure that can be monitored the KPIs should not be more that 10 for each perspective, while non financial metrics should overcome the financial metrics by approximately six to one (Schneiderman, 1999). In order to support any BSC framework, a deployment and maintenance system based upon quality assurance specially designed for Healthcare should be established. Traditionally in healthcare, Quality Assurance (QA) has been meant to apply predominantly to healthcare itself as provided directly to patients by legitimate healthcare practitioners. We also include other services that directly affect the ability of practitioners to perform well, meaning services such as radiology, pharmaceutical, laboratory, and patient admission. The basic quality assurance terms (Donabedian, 2003) are:

- Efficacy: the ability of the science and technology of healthcare to bring about improvements in health when used under the most favorable circumstances.
- Effectiveness: the degree to which attainable improvements in health are in fact attained.
- Efficiency: the ability to lower the cost of care without diminishing attainable improvements in health.
- Optimality: the balancing of improvements in health against the costs of such improvements.
- Acceptability: conformity to wishes, desires, and expectations of patients and their families.
- Legitimacy: Conformity to social preferences as expressed in ethical principles, values, norms, mores, laws, and regulations.
- Equity: Conformity to a principle that determines what is just and fair in the distribution of healthcare and its benefits among the members of the population.

One can clearly see the benefit of applying quality assurance components in the development of a BSC strategy. A BSC framework that meets quality assurance in healthcare is most probable that will meet patient needs, practitioners' feelings, patient-practitioner relationship, amenities of care (e.g., confidentiality, privacy, comfort, cleanliness, convenience), as well as financial and organizational aspects required.

The most popular quality assurance model in healthcare is based, to the best of our knowledge, upon the Donadebian approach (Donabedian, 1980, 1982, 1985, 1993, 2003) where a healthcare organization (i.e., a hospital) is a system formed by the interaction of structures, processes, and outcomes. Structures are used to establish processes in order to create healthcare outcomes that have an effect on structures that need to change or adjust processes to meet the required outcomes. Strongly believing that healthcare outcomes

Figure 2. The patient journey centered model for a hospital institution



are more important than financial outcomes in a healthcare system, we are confronted with a model where intangible assets are more important than tangible assets. This last statement makes a healthcare system very difficult to manage and a straightforward strategy hard to define.

The Need for a Specific Implementation Plan

In order to implement a viable performance management strategy (i.e., a BSC framework) the steps one needs to take include:

- Determining what to monitor
- Determining priorities in monitoring
- Selecting an approach to assessing performance
- Formulating criteria and standards (i.e., Key Performance Indicators)
- Obtaining the necessary information
- Determining how and when to monitor
- Constructing a monitoring system
- Managing changes and improvements

Building a Patient-Centered Healthcare Model

Finally, the proposed KPIs are directly or indirectly driven from healthcare processes. As an example, we propose to analyze a standard patient journey of a citizen in a healthcare institution. Figure 2 shows how the patient journey for a hospital is conceived (the patient journey in a primary care setting may be simpler). This workflow is the heart of the healthcare system and a prerequisite for any patient-centered information system to properly manage the information flow. This workflow is nowadays extended to include new processes such as emergency pre-hospital care and home care monitoring in order to create the hospital without walls of the 21st century.

Based on Figure 2 one can create a table where quality assurance and balanced scorecard features are confronted, analyzed, assessed and finally set. Table 1 is an example (non exhaustive) of the initial process.

From the above, it becomes apparent that the design and proposal of KPIs is not an easy task. KPI selection can vary upon specific measurement needs, upon goal set, and so on. In order to manage and validate the proposed KPIs by each BSC strategy, a set of KPI dashboards for each management entity, department or any other region of interest should be created.

USE CASE: REGIONAL HEALTHCARE AUTHORITIES IN GREECE

In 2001, a reform of the Greek National Healthcare System was introduced in order to enhance the performance and control of healthcare provision in Greece (Greek National Healthcare System Reform Act, 2001; Vagelatos & Sarivougioukas, 2003). One of the main changes was the division of the country in 17 autonomous healthcare regions where the Regional Healthcare Authority (RHA) is responsible for the regional healthcare strategy. This reform introduced the need to establish a three-level decision-making and performance management mechanism as described in Figure 3.

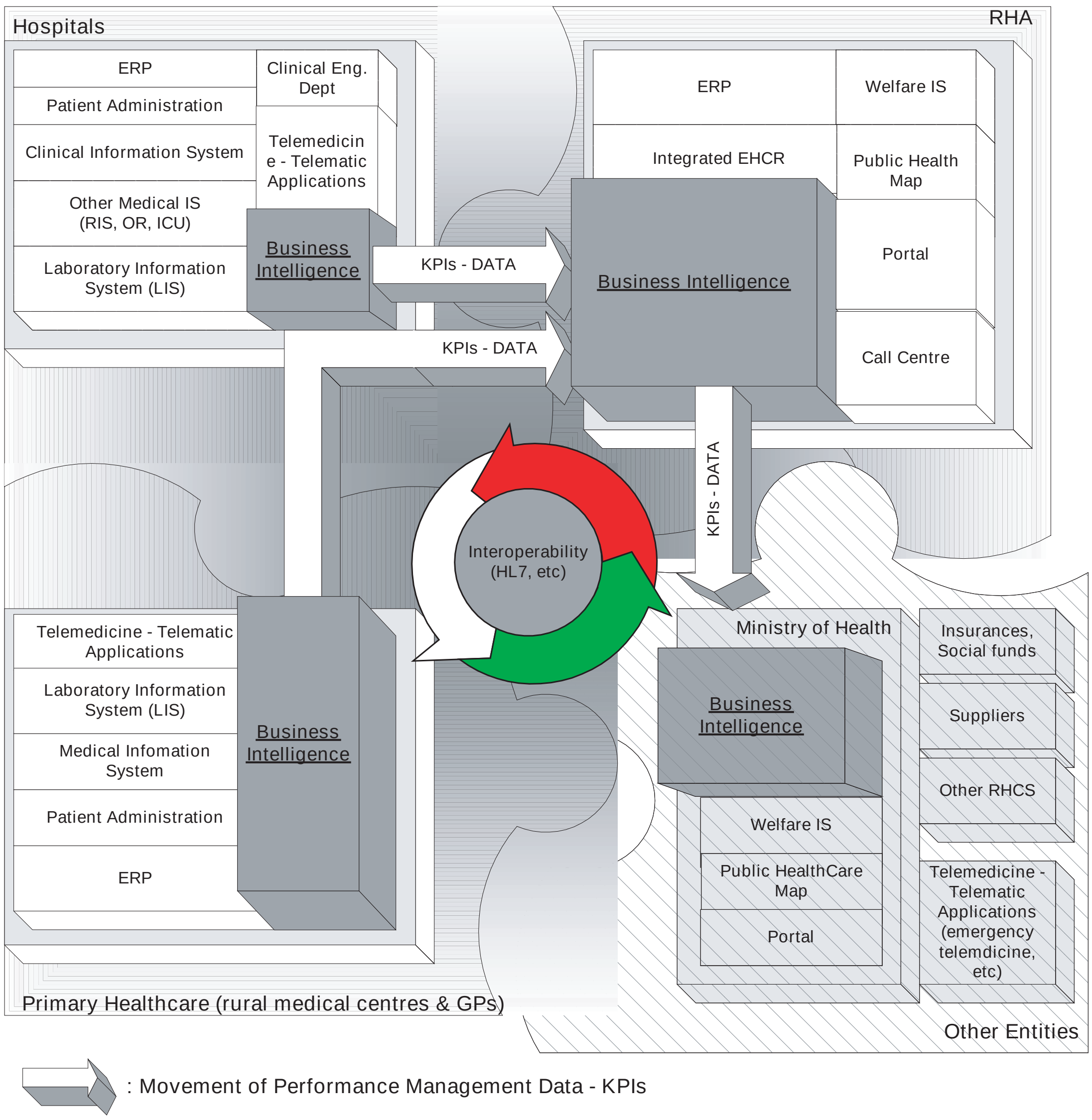
The proposed methodology was used to reach an initial set of KPIs by assessing existing knowledge and future needs (Decision No 1400/97/EC, 1997; McKee & Healy, 2002; Polyzos, 1999). Those KPIs were processed especially to serve the new strategy introduced in Greece.

As described in Figure 3, the regional healthcare system is comprised of a series of information systems covering the whole structures existing at any level, the processes required to meet the administrative and medical needs and finally, the outcomes that must come out from the implementation of such a complex interpolation of informatics infrastructure. The above information

Table 1. Defining KPIs from processes, an example

Workflow process	BSC Perspective	KPI	QA approach	Source of information
Appointment arrangement	Patient	Appointments/day	Process	Hospital Information System (HIS), Scheduling S/W
Patient comes to the Hospital	Process	Number of outpatients	Process	Hospital Information System
Fee Per Service Payment	Financial	Mean cost per examination	Process	Billing, ERP S/W
Drug Administration	Process	Number of prescription/ drug	Outcome	Patient Order Entry S/W, HIS
Patient Examination	Patient	Patient satisfaction	Process	HIS, surveys
Examination Results	Growth	Number of patient with re-examination	Outcome	HIS, Electronic Healthcare Record (EHR)
Doctor Letters	Process	Number examinations/practitioner	Outcome	HIS, Electronic Healthcare Record (EHR)
Patient diagnosis	Growth	Visits/ICD codes	Outcome	HIS, Electronic Healthcare Record (EHR)
Patient Needs Follow-up?	Process	Number of inpatient from outpatient clinic	Process	HIS
Waiting List	Patient	Waiting time in days	Structure	Hospital Information System (HIS), Scheduling S/W
Patient admission scheduling	Patient	Equity of delivered care	Process	Hospital Information System (HIS), Scheduling S/W
Patient admission letter	Process	Number of emergency cases/day	Process	HIS
Patient admission	Process	Number of inpatients	Process	HIS
Insurance Profile	Financial	Net cash flow per insurance company	Process	HIS, ERP
Department Assignment	Financial	Mean operational cost per department	Structure	HIS
Bed Assignment	Process	Bed coverage rate	Structure	HIS
Initial Diagnosis	Process	Admission per case type (ICD 10)	Outcome	HIS, Electronic Healthcare Record (EHR)
Lab tests	Process	Mean value of lab test per doctor, per patient	Outcome	Laboratory Information System (LIS)
Radiology Tests	Process	Mean value of radiology test per doctor, per patient	Outcome	Radiology Information System (RIS)
Surgery	Financial	Mean cost of surgical procedure	Structure	HIS, Electronic Healthcare Record (EHR)
Medical Material Usage	Financial	Mean cost of medical material consumption	Outcome	HIS, ERP
Nursing Follow-up	Growth	Number of Nurses per bed	Process	HIS, Electronic Healthcare Record (EHR)
Medical Follow-up	Growth	Number of practitioners per bed	Process	HIS, Electronic Healthcare Record (EHR)
Clinical Documentation	Process	Number of medical procedures per day	Outcome	HIS, Electronic Healthcare Record (EHR)
EHR Data	Patient	Number of cases with EHR	Outcome	HIS, Electronic Healthcare Record (EHR)
Patient transfer	Process	Number of patient transfers/ patient or /day	Process	HIS
Patient Treated?	Growth	Number of patients treated under a specific critical pathway	Process	HIS, Electronic Healthcare Record (EHR)
Final Diagnosis	Growth	Cases per final diagnosis	Outcome	HIS, Electronic Healthcare Record (EHR)
Patient dismissal letter	Patient	Inpatient Satisfaction	Process	HIS, surveys
Patient Billing	Financial	Mean treatment cost per day	Process	Billing, ERP S/W
Patient dismissal	Process	Mean length of stay /per dept. per ICD code	Process	HIS
Insurance billing	Financial	Return of Capital Employed (ROCE)	Process	Billing, ERP S/W

Figure 3. Regional healthcare information systems framework and interoperability



model was introduced to establish a community of networked healthcare organizations (hospitals, primary care) that are interoperating in order to support and implement the new healthcare strategy: to provide integrated and high quality healthcare services to the citizens based upon equal access to the resources (Information Society SA, 2003). In order to achieve this goal, two main issues were raised:

- How and when will information systems interoperate?

Table 2. KPIs in a regional healthcare setting

No	Financial KPI description	No	Process KPI description
F1	Mean treatment cost per day	P1	Length of stay
F2	Mean cost of medical treatment per patient	P2	Patient admission rate per medical unit
F3	Mean cost of drugs consumption	P3	Percentage of bed coverage
F4	Mean cost of radiology testing	P4	Vaccination rate
F5	Mean cost of laboratory testing	P5	Mean value of performed test per patient, per doctor
F6	Mean cost of material consumption	P6	Number of inpatients
F7	Mean cost of surgical procedure	P7	Number of outpatients
F8	Mean operational cost per dept./clinic	P8	Number of drug prescription
F9	Mean cost of vaccination procedures	P9	Number of laboratory tests
F10	Mean cost per medical examination	P10	Number of surgery procedures
F11	Return of capital employed (ROCE)	P11	Number of radiology tests
F12	Net Cash flow	P12	Number of visit in outpatient clinics
F13	Income per employee	P13	Number of visits in primary care institutions
F14	Payroll rate versus operational costs.	P14	Number of dental care processes
		P15	Number of processed emergency cases
		P16	Number of unprocessed order entries on the same day
		P17	Number of preventive care visits
		P18	Number of home care monitored patients
		P19	Assessment of patient satisfaction

No	Customer (patient) KPI description	No	Learning and Growth KPI description
C1	Mortality rate	L1	Medical device usage growth
C2	Morbidity rate	L2	Healthcare professionals training rate
C3	Number of medical staff per 1000 inhabitants	L3	Employee Satisfaction rate
C4	Number of beds per 1000 inhabitants	L4	Number of doctors per bed
C5	Accessibility of patients to the medical units	L5	Number of nurses per bed
C6	Time in a waiting list	L6	Number of existing healthcare professionals versus expected job positions
C7	Equity of delivered care	L7	Personnel productivity rate
C8	Number of readmission per patient	L8	Number of medical interventions per doctor
C9	Mean length of stay	L9	Number of patient with re-examinations
C10	Patient Satisfaction rate	L10	Visits/ICD codes
		L11	Admissions per case type (ICD 10)
		L12	Dismissals per case type (ICD 10)

- What is the minimum required dataset to achieve the proposed strategy?

The first issue can be answered by using standards and protocols such as HL7 to meet with interoperability issues in healthcare (Spyrou, Berler & Bamidis, 2003). The second issue is partially addressed by the proposed initial set of KPIs presented below. The proposed KPIs are forming a complete set of metrics that enable the performance management of a regional healthcare system. In addition, the performance framework established is technically applied by the use of state-of-the art knowledge management tools such as data warehouses and business intelligence information systems.

The proposed KPIs are categorised into the four perspective stated by Norton & Kaplan, having also taken into account the raised quality assurance issues stated earlier. The performance indicators in a regional healthcare setting are depicted in Table 2 as below.

Each of the above KPIs is the result of analysis based upon the needs of a standard regional healthcare authority. The proposition of a set of KPIs is nevertheless not the complete solution of the problem. Implementing KPIs is a constant process based upon specific metrics that each regional healthcare authority and each department or institution under its control must periodically assess and reengineer. Assessment should be based upon specific goals met and reengineering is often required due to administrative, demographic or other important changes that must occur. Focusing for example in the KPI marked as "mean treatment cost per day" one should notice that the KPI does not mean much without a metric. In Greece, most of inpatient treatments are based upon fixed prices per day and do not follow the pay per service model which is financially more viable.

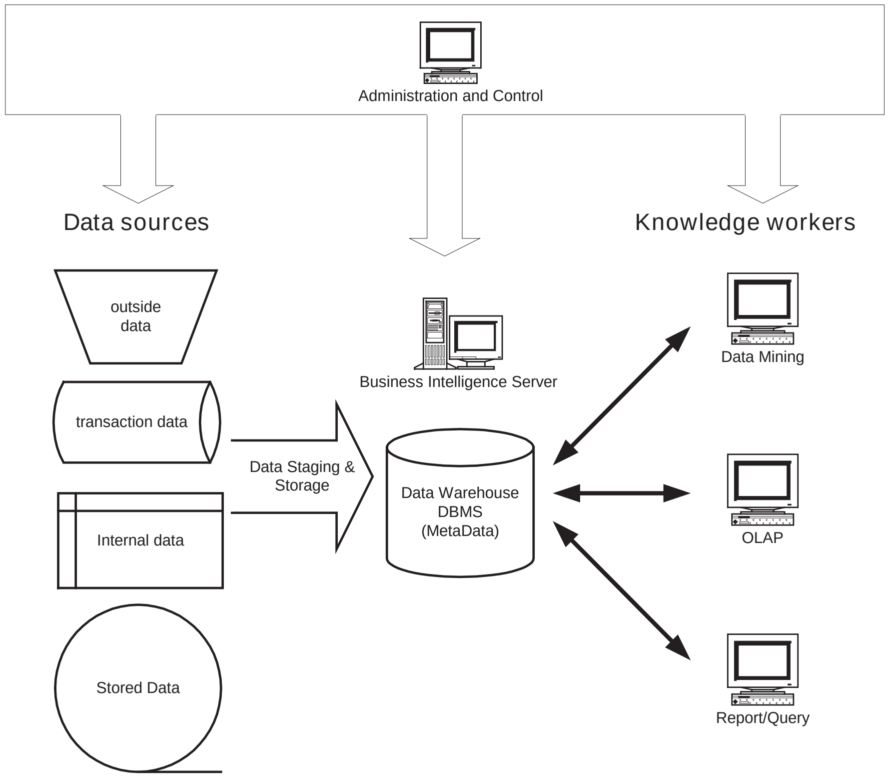
Healthcare financials are part of a national policy aiming at providing high quality healthcare services to all citizens regardless of their income, social status or other characteristic. As a consequence, the use of the fixed price model (per day quotas) in Greece serves that purpose albeit with its advantages and disadvantages. Current treatment cost per day (for an inpatient) has been fixed to about 135 Euros and this value could be used as an initial metric. If this value is exceeded this would mean that the RHA budget will cover the difference or transfer the cost to insurance companies and social welfare. In addition, a regional healthcare authority will then have credible proof that national standards are outdated and require revision in order to support the system. As a result, this KPI has now a specific meaning linked to regional strategy and budgetary needs. Following that example, all financial KPIs are therefore an important perspective of BSC since they are the measurement of the financial viability of the regional healthcare authority. In fact, all KPIs should be associated with adequate metrics in order to be assessed, thus driving the RHA towards the right strategic decisions.

In order to meet and populate the above-mentioned KPIs a regional healthcare authority has to implement a complex information technology system in order to gather up all needed information. Then the information collected through the use of enterprise resource planning software, hospital information systems, clinical information systems, radiology information system, and laboratory information systems has to be processed and interpolated to produce the final metadata set from which the KPIs are driven. In other words, the model is complemented by a business intelligence solution similar to the one depicted in Figure 4.

Figure 4 shows how data are collected from the various data sources, cleansed and homogenised, and finally redistributed to the knowledge workers and decision makers of the regional healthcare authority (Extraction, Transformation and Load—ETL).

The data collection process is extremely important since it is a basic feature of successfully populating the KPIs. In that sense both organizational

Figure 4. Regional healthcare authority business intelligence framework



and technological issues to achieve data quality should be considered. In the proposed setting, the regional healthcare authority has imposed on its healthcare units the use of specific classifications, codifications and taxonomies such as the 10th edition of the International Classification of diseases (ICD10). In addition, the proposed KPIs can be seen as attributes of structure, process or outcome (based upon the Donabedian approach) so that they can be used to draw an inference about quality. As such the KPIs are proposed, designed, tested and assessed by a panel of experts (executive officers of the RHA, practitioners). By implementing this organizational structure the quality level of the proposed KPIs is such that technological issues are greatly reduced.

FUTURE TRENDS

Up to this point, this chapter has mostly dealt with organizational and strategic features of knowledge management in healthcare. In the proposed use case we have shown an ongoing implementation of a Balanced Scorecard Framework in a regional healthcare authority environment. This has been done intentionally wishing to state that the technological part on such an implementation is probably the less important issue. If one regards the future trends in knowledge management, one can see that a multitude of new tools are already proposed for use. This chapter will briefly set the focus on the trends that to our knowledge are the most promising and present more opportunities to healthcare organizations in creating effective performance management facilities.

Service Oriented Architecture and Patient-Centered Architecture (Based on the Electronic Health Record)

The term of patient-centered architecture has been already in the literature for some years. Many techniques have been used in the past such as Corbamed (Object Management Group, 2001) and Distributed Healthcare environment (DHE). The introduction of web technologies such as the Extensible Markup Language (XML), the Simple Object Access Protocol (SOAP), the Web Services Description Language (WDSL), and more precisely the concept of Web Services (Deitel, Deitel, DuWaldt, & Trees, 2003; W3C, 2003) are driving information technologies towards a Service Oriented Architecture (SOA).

A service is a software component that is suitable for cross-application access. A service is never a complete application or transaction. It is always a building block. SOA is the architecture of an application that uses services. Services define reusable business functions; SOA binds services into applications. Logically, services are defined by their interfaces. Technically, services are defined by their implementations (sometimes complex integrated flows, other times a single simple program). SOA is a logical concept, and its design is focused on the definition of service interfaces and interactions between service interfaces. Fundamental to SOA is the loose coupling between its components. At the logical level, this translates to the ability to add a new service for the end-user unobtrusively to the service provider. At the technical level, this translates to the ability of software developers to deploy a new application that calls a service without the need to redeploy or change the service. The use of SOA will allow the creation of process-based components of applications that will manipulate knowledge and information based upon the processes and the required or designed outcomes.

The Semantic Web

The Semantic Web goes beyond the World Wide Web by encoding knowledge using a structured, logically connected representation, and by providing sets of inference rules that can be used to conduct automated reasoning. Whilst the idea of knowledge representation languages is not new, existing languages generally use their own set of ontologies and inference rules to identify and eliminate logical contradictions and inconsistencies. The Resource Description Framework—RDF (W3C, 2003) and XML Topic Maps (TopicMaps.Org, 2001) are the most promising tools towards the implementation of the Semantic Web in practice. Nevertheless, a long way towards maturity has still to be covered since issues such as specific metadata frameworks and data quality are not yet solved. In any case, the Semantic Web should enhance the promotion of clinical practice guidelines and evidence based medicine. They can be seen as taxonomies of medical cases that could be both used for performance monitoring (in respect to commonly agreed levels of delivered care) and decision support for the healthcare practitioners.

Critical Pathways

Critical Pathways (Wall & Proyect, 1998) are mechanisms for transforming a reactive bureaucratic ritual to a dynamic, indispensable, clinical improvement process. A critical pathway when established is a mechanism for:

- Integrating continuous quality improvements with traditional patients' care review
- Managing and impacting of clinical and financial outcomes for a specific treatment procedure
- Proactively addressing economic and regulatory changes
- Improving clinical outcomes through reduction in variation
- Controlling unnecessary cost and resource usage without jeopardising quality of care
- Fostering multi-disciplinary approach to patient care
- Linking quality management to staff education
- Managing limited financial resources
- Making efficient use of scarce organizational resources
- Increasing readiness for anticipated changed in healthcare
- Applying and using clinical practice guidelines and other taxonomies set up by different professional societies

Critical Pathways can be seen as "specialized" performance management tools that would provide a BSC framework with very specific performance indicators for each treatment or clinical process.

CONCLUSIONS

Performance management is a key issue in the continuous process of delivering high quality healthcare services. The use of KPIs has proved that the design of a Balance Scorecard acts as the "cockpit" of a regional (or national) healthcare authority where all metrics are the flight instruments enabling the provision of healthcare based upon equity, financial control, continuous process and structure refinement, and outcome measurements. In that sense, the proposed infrastructure is, technologically speaking, an important knowledge management tool that enables knowledge sharing amongst various healthcare stakeholders and between different healthcare groups. The use of BSC is an enabling framework towards a knowledge management strategy in healthcare since KM is about discovering knowledge from existing information, about creating new knowledge and about implementing processes and taxonomies that enable the reuse and assessment of information as part and bits of knowledge.

Knowledge can be seen as a performance management tool both for administrative purposes and clinical improvements.

During the implementation process of deploying a technological platform for performance management or any other type of knowledge management infrastructure, one must have in mind that:

- The six issues described in the introduction section must being taken into strong consideration from day one.
- It is important to focus on people, processes and outcomes, and to set-up a straightforward strategy to plan, manage, assess, educate, disseminate, and maintain the developed BSC framework.
- Any type of knowledge management project bases its success on continuous improvement and assessment. Metrics and processes are meant to change in order to reflect improvements towards quality of healthcare.
- The knowledge and technology is there, but still very limited best practices have been successfully implemented.
- The implementation of BSC framework is a time consuming process that has to involve all stakeholders' representatives.

REFERENCES

Aidermark, L.G. (2001). The meaning of balanced scorecards in the health care organization. *Financial Accountability & Management, 17*(1), 23-40.

Castaneda-Mendez, K., Mangan, K. & Lavery A.M. (1998, January / February). The role and application of the balanced scorecard in healthcare quality management. *Journal of Healthcare Quality, 20*(1), 10-3.

Decision No 1400/97/EC of the European Parliament and of the Council of 30thJune 1997 adopting a program of Community action on health monitoring within the framework for action in the field of public health, Official Journal L193, 22/07/1997, 0001-0010.

Deitel, H.M., Deitel, P.J., DuWaldt, B. & Trees, L.K. (2003). *Web services: A technical introduction*. Prentice Hall Editions.

Donabedian, A. (1980). *Explorations in quality assessment and monitoring, Volume I: The definition of quality approaches to its measurement*. Ann Arbor, MI: Health Administration Press.

Donabedian, A. (1982). *Explorations in quality assessment and monitoring, Volume II: The criteria and standards of quality*. Ann Arbor, MI: Health Administration Press.

Donabedian, A. (1985). *Explorations in quality assessment and monitoring, Volume III: the methods and findings of quality assessment and monitoring – An illustrated analysis*. Ann Arbor, MI: Health Administration Press.

Donabedian, A. (1993). Continuity and change in the quest for quality. *Clinical Performance and Quality in Healthcare, 1*, 9-16.

Donabedian, A., & Bashshur, R. (2003). *An introduction to quality assurance in health care*. Oxford: University Press.

Eder, L. (2000). *Managing healthcare information systems with Web enabled technologies*. Hershey, PA: Idea Group Publishing.

Englebardt, S., & Nelson, R. (2002). *Healthcare Informatics: An interdisciplinary approach*. Mosby Edition.

Forgione, D.A. (1997). Health care financial and quality measures: International call for a balanced scorecard approach. *Journal of Health Care Finance, 24*(1), 55-58.

Freeman, T. (2002). Using performance indicators to improve health care quality in the public sector, a review of the literature. *Health Services Management Research, 15*(2), 126-137.

Gordon, D., & Geiger, G. (1999). Strategic management of an electronic patient record project using the balanced scorecard. *Journal of Healthcare Information Management, 13*(3), 113-123.

Greek National Healthcare System Reform Act (2001), Greek Government Printing Office, N2889/2001 / FEK-//37/02.03.2001. [In Greek]

Harmoni, A. (2002). *Effective healthcare information system*. Hershey, PA: IRM Press.

Hurst, J., & Jee-Hughes, M. (2001). *Performance measurement and performance management in OECD health systems*. Labour Market and Social Policy, Occasional Papers No. 47, DEELSA/ELSA/WD(2000)8, OECD.

Iakovidis, I. (1998). Towards personal health record: Current situation, obstacles and trends in implementation of electronic healthcare records in Europe. *Internernational Journal of Medical Informatics, 52*(123), 105-117.

Iakovidis, I. (2000). Towards a health telematics infrastructure in the European Union. In *Information technology strategies from US and the European Union: Transferring research to practice for healthcare improvement*. Amsterdam: IOS Press.

Inamdar, N., Kaplan R.S., & Bower, M. (2002). Applying the balanced scorecard in healthcare provider organizations. *Journal of Healthcare Management, 47*(3), 179-195.

Information Society SA (2003, May 15). Healthcare information system for the 2nd Regional Healthcare Authority of Central Macedonia, Request For Proposal co-funded by the 3rd CSF under the EU decision C(2001)551/14-3-2001, Greece.

Kaplan, R.S. (2001). Strategic performance measurement and management in non-profit organizations. Non-Profit Management and Leadership, 11(3), 353-371.

Kaplan, R.S., & Norton, D.P. (1996). *The balanced scorecard: Translating strategy into action*. Harvard Business School Press.

McKee, M., & Healy, J. (2002). Hospital in a changing Europe. European Observatory on Health Care Systems Series, Open University Press.

Norris, T.E., Fuller, S.S., Goldberg, H.I., & Tarczy-Hornoch P. (2002). *Informatics in primary care, strategies in information management for the healthcare provider.* Springer Editions.

Object Management Group (2001). The Common Object Request Broker Architecture (CORBA) specification. OMG Document Number 2001-09-01. Information retrieved on December 15, 2003, from http://www.omg.org/technology/documents/formal/corba_iiop.htm

Oliveira, J. (2001). The balanced scorecard: An integrative approach to performance evaluation. *Healthcare Financial Management Journal, 55*(5), 42-46.

Oxley, H., & MacFarlan, M. (1994). *Healthcare reform controlling spending and increasing efficiency.* Economics Department Working Papers No. 149, OCDE/GD(94)101, OECD.

Pink, G.H., Mc Killop, I., Schraa, E.G., Preyra, C., Montgomery, C. & Baker, G.R. (2001). Creating a balanced scorecard for a hospital system. *Journal of Health Care Finance, 27*(3), 1-20.

Polyzos, N. (1999). *Hospital efficiency based upon the use of DRGs.* TYPET Edition. [In Greek]

Schneiderman, A.M. (1999). Why balanced scorecard fail. *Journal of Strategic Performance Measurement, January*(4), 6-11.

Shortliffe, E.H., Perreault L.E., Wiederhold, G., & Fagan, L.M. (2001). *Medical informatics, computer applications, healthcare and biomedicine* (2nd ed.). Springer Editions.

Spyrou, S., Berler, A., & Bamidis, P. (2003). *Information system interoperability in a regional healthcare system infrastructure: A pilot study using healthcare information standards.* Proceedings of MIE 2003, Saint Malo, France (pp. 364-369). IOS Press.

Stegwee, R., & Spil, T. (2001). *Strategies for healthcare information systems.* Hershey, PA: Idea Group Publishing.

Strawser, C.L. (2000). Building effective knowledge management solutions. *Journal of Healthcare Information Management, 14*(1), 73-80.

Tarantino, D.P. (2003). Using the balanced scorecard as a performance management tool. *Physician Exec*, *29*(5), 69-72.

The TopicMap.Org (2001). Retrieved August 6, 2001, from http://www.topicmaps.org/xtm/1.0/

Vagelatos, A., & Sarivougioukas, J. (2003). *Regional healthcare authorities delivering application services to primary health care units.* MIE 2003, Saint Malo, France.

Wall, D.K., & Proyect, M.M. (1998). *Critical pathways development guide.* Chicago: Precept Press Editions.

Weber, D. (1999). Performance management – The balanced scorecard: A framework for managing complex and rapid changes. *Strategies for Healthcare Excellence*, *12*(11), 1-7.

The World Wide Web Consortium –W3C Web site (2003). Information retrieved March 23, 2003, from http://www.w3.org

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Chapter 6.26
Operational Knowledge Management

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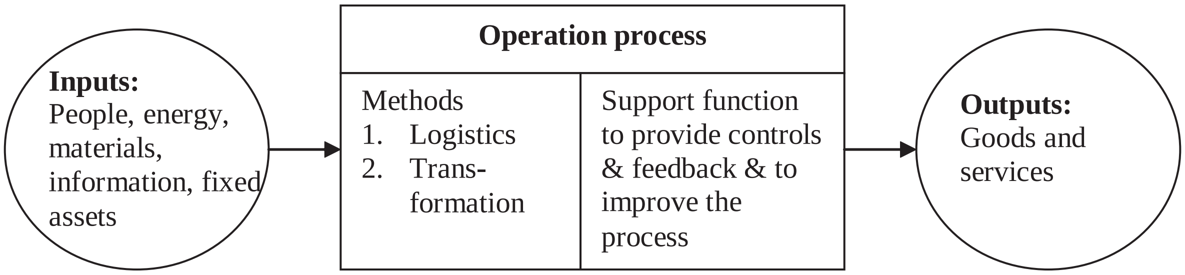
INTRODUCTION

The differences between the paradigms of knowledge management (KM) and operations management are huge. Whereas KM is rooted in the disciplines of human relations, sociology, organization analysis, and strategic management, the operations management paradigm finds its roots in industrial engineering, business economics, and information systems. These differences result in poor acceptance of KM ideas in operations management and vice versa. Several approaches to this problem are possible. For instance, one may state that the operations management paradigm is irrelevant for knowledge management. This is incorrect, because besides of the traditional person-oriented knowledge management processes, modern knowledge intensive firms use reengineered knowledge processes intensively (e.g., Hansen, Nohria, & Tierney, 1999). An alternative approach may be to forget about the KM paradigm and only use the operations management paradigm. This is wrong again, because most industrial enterprises compete on the development and exploitation of their expertise and human capabilities (Hamel & Prahalad, 1994; Quinn, 1992). Consequently, if knowledge management is relevant and if operations management is not irrelevant, then the main question is how to translate knowledge management issues into an operations management framework. I provide a conceptual framework for such a knowledge operations management (KOM) perspective.

BACKGROUND

Operations management studies the handling or transformation of inputs to outputs (the operations function), and the consequent realization of organizational goals via certain means (management of operations) (Hill, 1983). Operations management thus distinguishes objects, which are the inputs and outputs of operations, related support tasks,

Figure 1. The operations function (based on Hill, 1983, p. 25)



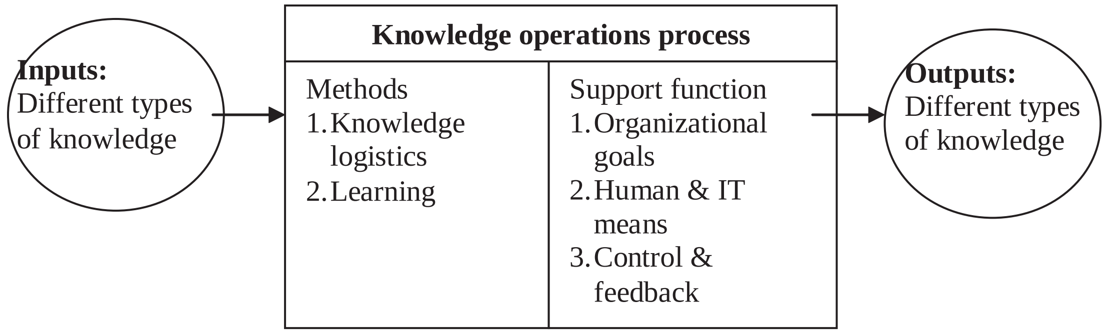
and the setting of goals and application of means. In the operations, I distinguish logistics as the delivery of the input to a client without changing this input (Ballou, 1992) from transformation as the change of the input object to something different (see Figure 1).

Given the wide paradigmatic differences between operations management and KM, not many attempts have been made to apply operations management on KM. One of the scarce attempts is from Armistead (1999), who distinguishes knowledge inputs and outputs and four related operations processes, that is,. two transformation processes (knowledge creation and knowledge embedding) and two knowledge logistics or transfer processes (exchange of knowledgeable people and the exchange of knowledge representations). The KM literature sees knowledge creation and embedding as related organizational learning processes (Nonaka, 1994), therefore, the term learning better covers what we mean by knowledge transformation. Finally, Armistead also defines metrics to control and feedback to improve these processes. This article continues the attempt made by Armistead with a further specification of a knowledge operations management model. Such a model does not only structure the KM field, but at the end of the article I also will explain some of its heuristic value.

MAIN FOCUS: THE KOM MODEL

In the context of KOM, the input-output objects are different types of knowledge. The input objects may be handled in operations without fundamentally changing them. This is what I call knowledge logistics and includes the storing and distributing of knowledge and its related representations. Alternatively, in learning processes, the knowledge inputs are transformed to new or different knowledge objects. The logistic process is an important support for learning, especially when done in organizations where learning is essentially a group process. Authors in the artificial intelligence discipline (e.g., Turban, Aronson, & Bolloju, 2001) have stated that besides people, machines also can learn. Although this is basically correct, the artificial intelligence field mainly regards learning at the behavioral and statistical level and not at the level of understanding and human skills formation, which is the focus of the KM literature. Thus, I exclude machine learning from KOM. In the knowledge operations management framework, the operation methods are supported by human and information technological means for specific goals, and metrics are used to control and deliver feedback on process performance as presented in Figure 2.

Figure 2. The KOM framework



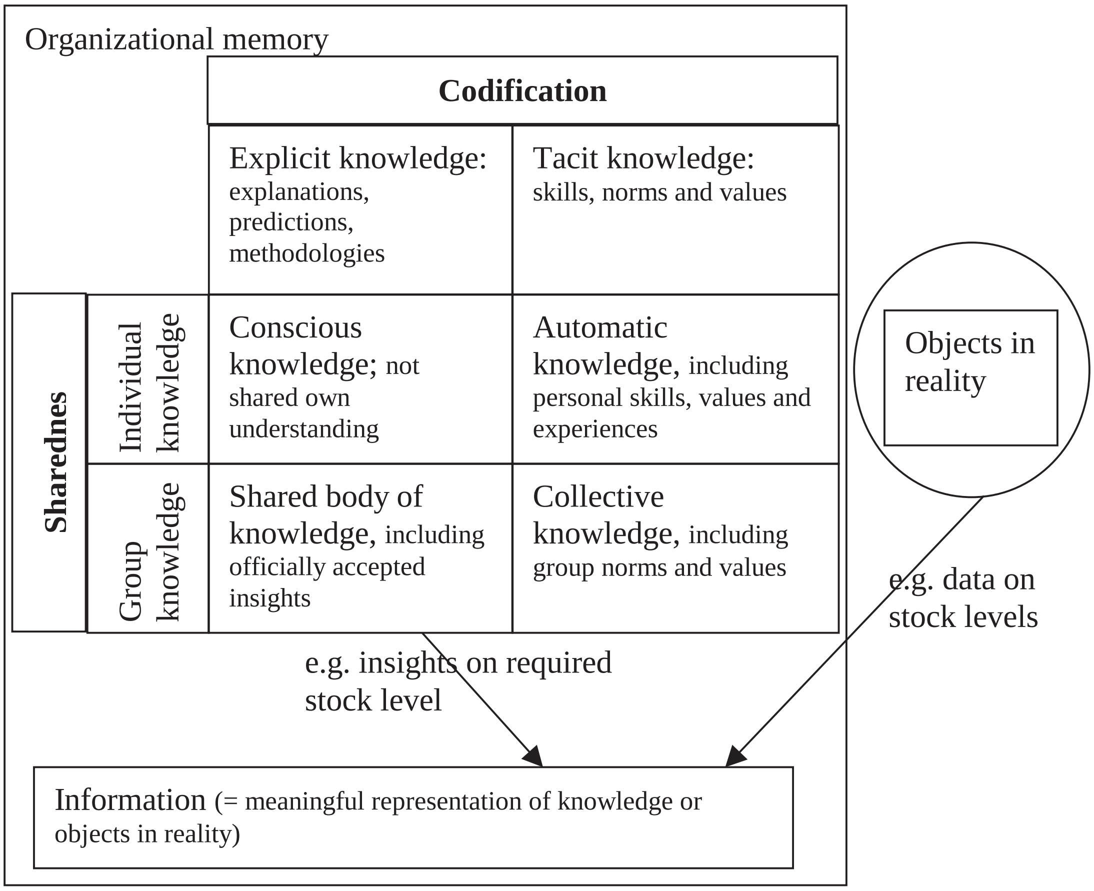
I first treat the input-output knowledge objects, then I discuss the knowledge operation methods. After that, a description of the support function, by a typology of possible organizational goals, means, and metrics for knowledge logistics and learning is given.

Knowledge Objects

Scientists often restrict the term knowledge for explicit understanding, which consists of explanations, predictions, and methodologies (Hempel, 1965). In information management, the term information is mostly reserved for representations of thoughts (e.g., explicit understandings), or the representation of objects and events, which may be stored or communicated (Stamper, 1973). Much of what popularly is called knowledge is neither an explicit understanding, nor a representation, but refers to effective behavior or skills (Spender, 1998). Especially in the arts and professions, people do not express (represent) how they do the job, and they also may not be successful in explaining their success. Thus, effective behavior is "what walks out the organization each day and hopefully returns the next morning" (Senge, 1990), and it is personally owned human capital. Some personal or individual knowledge consists of explicit knowledge that is not shared, while other individual knowledge consists of personal values. Much of a person's effectiveness, though, is based on individual knowledge and the social setting in which the work is done. More precisely, groups have norms and values, based on an underlying (sub)culture, that explain much of a group's effectiveness. For instance, decision-making norms and values that are well shared may speed up decision-making. These norms and values are often tacit knowledge (Leonard-Barton, 1992; Nonaka & Takeuchi, 1995). Their abilities of being shared require longer term and complex organizational change processes (Leonard-Barton, 1992).

The dimensions of sharedness (individual vs. group) and codification (explicitness vs. tacitness) make up four ideal types of knowledge (Spender, 1998; see Figure 3). Besides these types of knowledge, organizations use representations of knowledge to store, reuse, and distribute knowledge (Markus, 2001). Organizations also use representations of objects in reality as part of potential knowledge (Earl, 1994). Knowledge and information, which both form the content

Figure 3. Organizational memory, classes of knowledge, information, and objects in reality



aspects of an organizational memory, are both needed in effective decision-making (Stein & Zwass, 1995).

Knowledge Management Operation Methods

The KM literature often defines the following knowledge operation methods: knowledge generation, distribution and sharing, usage, maintenance, and storage (Alavi & Leidner, 2001; Stein & Zwass, 1995). Generation and maintenance are knowledge transformation processes (i.e., learning). The other knowledge operations are knowledge logistics. The next two subsections describe the activities of these operations in relation to the input-output objects.

Learning

Following Nonaka (1994), learning consists of interactions between tacit and explicit knowledge. The interaction of knowledge as input and output relations is given in Table 1.

Table 1. Learning modes and knowledge objects

Learning mode	**Knowledge object inputs**	**Knowledge object outputs**
Socialization	Individual norms and values	Collective knowledge
Externalization	Automatic and collective knowledge	Shared body of knowledge and related representations
Internalization	Shared body of knowledge	Automatic knowledge and accepted collective and shared body of knowledge
Combination	Conscious knowledge and individual owned information	Shared body of knowledge and information

Socialization transfers individual tacit knowledge to other people, such that these others adopt these tacit insights and collective knowledge is created. Externalization changes tacit knowledge to explicit knowledge, so that the knowledge becomes person-independent. Internalization is the reverse process of externalization and implies that the shared body of knowledge is personally accepted as automatic knowledge and integrated with existing individual norms and values. Finally, combination merges different kinds of individual conscious knowledge to a larger body of shared knowledge. When defining the support function later on, I will explain how goals, means, and metrics can be selected to improve these learning processes.

Knowledge Logistics

As I stated, knowledge logistics is about the sharing, distribution, storage, and retrieval of knowledge and its representations. The sharing and distribution of knowledge can be more or less formal and planned, and the sharing and distribution of information occurs in different reuse contexts. The storage and retrieval of knowledge and information is done by human and person-independent media (see Table 2).

Formality of Knowledge Logistics

Distribution of knowledge objects might vary from very formal and organized to ad hoc. Standard

Table 2. Characteristics of knowledge and information logistics

	Knowledge	**Information (representations)**
Logistic procedures	More or less formal	Different reuse contexts
Storage	Individual, group and cultural media	Ecology and information systems

reporting is most organized, by automatic dissemination of knowledge and information. This may be extremely efficient, though often insufficiently flexible. Less organized is a knowledge communication with a predefined procedure of starts and finish. Even less formalized is the case when a potential user can retrieve specific knowledge objects from a larger resource. For instance, this is the case of libraries, which use an information pull logistic model. Even more informal are research and development activities. However these might be planned, it is mostly unclear what answers they should deliver and the moment of delivery is often unpredictable. These research activities share an organization and the people involved are recognizable, which is not the case in ad hoc search. Ad hoc searching can be done actively (by action of individual's with specific knowledge needs) or passively (by knowledge provision). The message might contain information about knowledge or knowledge itself.

Knowledge Reuse Contexts

According to Markus (2001), knowledge reuse processes can be described in the stages of capturing or documenting knowledge, packaging knowledge for reuse, distributing or disseminating knowledge, and reusing knowledge. A fundamental point here is that after the documenting and packaging of knowledge, only the knowledge representations (and not the knowledge itself) is distributed and reused. Consequently, the receivers and reusers have to interpret the messages. Interpretation errors can easily happen if the distance between the knowledge producer and the knowledge representation user is large (Ackerman & Halverson, 2000). The context of reuse can vary in terms of the cognitive distance of knowledge producers and knowledge (representation) reusers, which supports Markus's (2001) classification of reuse contexts as (1) reuse by shared knowledge producers, (2) reuse by shared work practitioners, (3) reuse by expertise-seeking novices, and (4) reuse by secondary knowledge miners.

Storage and Media

Walsh and Ungson (1991) and Wijnhoven (1998) have listed a number of storage media and related knowledge types. Each medium has different potentials for the handling of different knowledge objects. Table 3 gives a list of the potentially best combinations.

The knowledge logistics can be subject to evaluation with the same criteria as any other

Table 3. Knowledge media and related knowledge objects

Knowledge media	Possible effective media for the following knowledge objects
Individual	Professional skills; personal ethics and beliefs; individual routines
Culture	Schemes; stories; external communications; cultural routines
Transformation	Tasks; experiences; rules, procedures and technology; patents
Structure	Task divisions; hierarchy; social structure; formal structure
Ecology	Layout of work place; building architecture
External	Client and market characteristics; list of knowledgeable people and organizations
Systems	Process control systems; GroupWare, computer aided design systems, knowledge based-systems; administrative systems

logistic process (Wijnhoven, 1998). I will describe these criteria in the next section.

The Support Function for Knowledge Logistics and Learning

This section first presents a typology of goals that the support function may have. Next, I describe some of the human and information technological means for the knowledge logistics and learning processes. Finally, I mention a few metrics for control and feedback of these processes.

Support Function and Organizational Goals

Operations knowledge management may contribute to several organizational goals. These organizational goals may be categorized as follows: (1) organizational integration, (2) adaptation, (3) goal attainment, and (4) pattern maintenance (Quinn & Rohrbaugh, 1984; Stein & Zwass, 1995). The integrative goal aims at multi-local and instantaneous access to shared knowledge and the sharing of knowledge over time and space. The adaptive goal aims at boundary-spanning activities to recognize, capture, organize, and distribute knowledge about the environment to the appropriate organizational actors. Goal attainment aims at assisting organizational actors in planning and control. The emphasis of the pattern maintenance goal is on human resources. "Pattern" pertains to attitudes, values, norms, personal routines, and personal knowledge. Effective organizations "maintain" values, attitudes, and norms that contribute to corporate cohesion and morale. Some of the requirements for the learning and logistic processes are listed in Table 4.

Support for Knowledge Logistic Processes

Knowledge logistics may be parsed into acquisition, retention, maintenance, search, and retrieval of knowledge objects. Knowledge acquisition is the gathering and placing of knowledge into

Table 4. KM objectives and KM process requirements

Organizational goal	**Requirements for KM process**
Integration	Knowledge logistics investments to realize temporal and spatial integration of knowledge resources, for instance by temporally indexed databases.
Adaptation	Investments in knowledge logistics and learning to realize the retention of cross-linked historical information on stakeholders, memory bases of user preferences, links to external sources of information (Stein & Zwass, 1995), and availability of software and people for interpretation of acquired data (Daft & Weick, 1986).
Goal attainment	Investments in learning through the development of templates of the context-plan-result nature, expert planning knowledge, evaluation models, company performance data, past and current performance forecasts (Stein & Zwass, 1995).
Pattern maintenance	At the individual level: knowledge logistic like the creation and dissemination of work history of individuals. At the organizational level: knowledge logistics and learning through the preservation and communication of organizational protocols (Stein & Zwass, 1995).

knowledge stores. This necessitates a knowledge directory giving a storage location for knowledge objects and an index with retrieval keys. The seven storage media mentioned before (individuals, culture, transformation, structure, ecology, external environment, and information systems) all differ on their opportunities and limitations for storing knowledge, as well as in speed, reliability, physical degeneration, and availability. Knowledge maintenance is the management of the integrity of retained knowledge. An inherent problem is the integration of new knowledge with existing knowledge, and applying an effective method of removing obsolete knowledge. Search is the process by which retained information is selected as relevant to particular problems or goals on the part of the user. Retrieval is the reconstruction of the selected information in order to satisfy the user's request. Sometimes the retrievable knowledge permits satisfactory formal definition and the knowledge management system is able to deliver standard reports with interpretations. Often, however, the retrieval demands are unpredictable and the required knowledge is difficult to describe. Consequently, much knowledge may best be kept tacit, which means that only the location of knowledge will be retrieved. Table 5 summarizes several human and IT means to realize the objectives of logistics.

Metric for Knowledge Logistics Control and Feedback

I propose distinguishing at least two classes of knowledge logistic metrics: (1) measures related to the logistic processes and (2) measures related to the customer satisfaction of the outcome of the logistic process. Armistead (1999) and Wijnhoven (1998) mention the following logistic process measures:

- Timeliness: This involves speed and compliance with agreed schedules.
- Reliability: This is the number of deliveries that are according the agreement.
- Completeness: This is the amount of information and knowledge delivered in relation to what is needed; thus, a delivery may be incomplete or over-complete.

Table 5. Knowledge logistic process and means

Knowledge logistics	**IT means**	**Human means**
Acquisition	Business intelligence system, Internet resources	Researchers, library collection service, data collection activities
Storage	Databases, library systems, data warehouses, document management systems	Archiving professionals, database administrators, indexing experts
Maintenance	Content management systems, databases	Content maintenance procedures and quality circles
Search & retrieval	Search engines, retrieval technology	Search and retrieval experts, social networks to find people, information service suppliers
Dissemination	Content publishing software, Internet facilities	Publication procedures, public relations policies, publishing expertise

- Accessibility: This is the ease of getting a knowledgeable person or entering a system that has the knowledge or information.
- Costs and efficiency: Cost is what people have to pay for the service. Efficiency is what costs and other efforts are involved as objects that should be measured to control and feedback the logistics processes.

Measures related to customer satisfaction have been studied intensively in the information systems literature under the heading of information systems end-user satisfaction. Doll and Torkzadeh (1988) have found five main constructs, which have been empirically replicated several times and are relevant for knowledge satisfaction as well:

- Content is the perceived level in which the information (and knowledge) precisely meets the receivers' needs and in which the information and knowledge is regarded as relevant and sufficient.
- Accuracy is the level in which people regard the information and knowledge as reliable and the level in which people feel they can depend on the information and knowledge.
- Format is the level in which people regard that the information and knowledge is well presented, clear, understandable, and, with respect to the information, has a good layout.
- Ease of use is about the user friendliness of the system and the ease of interactions with the knowledge owner.
- Up-to-dateness of the information and knowledge received. Doll and Torkazadeh (1988) use timeliness as the fifth factor, which includes delivery on time, but this is more a logistic feature and not an end-user satisfaction measure. Therefore, I propose up-to-dateness instead of timeliness here.

Support for Learning

The learning processes transform knowledge objects from rather explicit to rather tacit and reverse. These transformations are further analyzed here to define means for the learning support function.

- Socialization: The creation of new tacit knowledge from old tacit knowledge is highly inter-personal. Socialization requires a strong personal commitment of each of the participants and is obstructed from the negative attitude, which is often placed on the communication of uncertain and incomplete knowledge. Possible solutions for these knowledge-sharing obstructions are the creation of reward structures (Lawler & Rhodes, 1976), creation of synergy among knowledge owners (Quinn, 1992; Senge, 1990), and the development of an IT knowledge infrastructure.
- Externalization: The transformation of tacit knowledge to explicit knowledge—requires the coding of experiences, personal and group skills, norms, and values, and thus needs highly motivated experts to give away an important source of personal success. It also requires high communication skills of the system engineer in understanding experts from another discipline. Some methods for knowledge representation are (1) proposition and predicate logic, (2) production rules, (3) scripts, and (4) semantic nets. Besides the quality of the externalization, the importance of maintenance of the knowledge base is high. Particularly in complex knowledge bases, this is hard to realize.
- Combination: The putting together of pieces of explicit knowledge requires configuration or synthesis (Galunic & Rodan, 1998). Configuration puts together the owners

of different objects of explicit knowledge in workgroups, teams, or departments, or just letting each other know each other or refer to each other's knowledge objects (Liebeskind, Oliver, Zucker, & Brewer, 1996). Configuration also can be enabled by information technology, through the creation of Web links between different knowledge objects, the creation of Semantic Webs (Berners-Lee, Hendler, & Lassila, 2001) or ontologies (Borst, Akkermans, & Top, 1997), and the detection of patterns among data in data mining (Singh, 1998). Synthesis is the integration of different knowledge objects to one or more new knowledge objects.

Table 6. Learning processes and possible means

	Means	
	IT	*Human*
Learning processes		
Socialization		
Quickly find people with specific skills.	Skills database	Motivated individuals who submit content, but knowledge delivery pay is likely ineffective.
Development of mutual interests and collaboration among experts.	Communication infrastructure	Requires additional reward structure and reinforcements by management.
Externalization		
Machine processing of knowledge. Reduction of errors in routine processes.	Knowledge-based systems	Knowledge representation. This is difficult in unstable domains and experts sometimes are not willing to participate.
Standardization of work and decision-making.	Electronic manuals	Maintenance of knowledge is especially complex in larger domains.
Combination		
Combination of distributed and formalized knowledge.	Ontologies, Semantic Webs, Internet links	Complex, only applicable on static knowledge. Requires engineers who manage the complexity.
Brings together experts.	Communication infrastructure	May lead to insufficient commitments and poor goal achievement.
Analyzing databases to find explicit understanding.	Data mining and knowledge discovery	Human interpretation needed by adding tacit and explicit knowledge to the data patterns.
Explicit knowledge distribution in an organization.	Word-of-mouth emulator	May lead to poor utilization of insights gained. Need a knowledge coordinator.
Internalization		
Feedback on repertory of action and improves efficiency in routines	Computer aided instruction and decision support	The model needs validation and usability improvements, thus the role of the trainer is not obsolete.

- Internalization: The process by which externalized knowledge is merged with personal existing frames of reference assumes that knowledge is only truly adopted when it leads to changes of existing tacit knowledge (Senge, 1990). This will be manifested in changes of people's repertory of action.

Table 6 summarizes some human and IT means to realize the objectives of the learning processes. Though information technology (IT) is not a necessary component of KM means, in KOM information technology is often indispensable.

Metrics for Learning

Armistead (1999) gives a list of possible measures for learning (what he calls knowledge creation and knowledge embedding). These are presented here with a short explanation:

- Reliability of learning: This implies that we should know if the learning has been done well
- Completeness of learning
- Acceptability of learning: True knowledge needs (organizational) justification before it can be used (Nonaka, 1994)
- Readiness for learning: This is especially a problem when people lack sufficient knowledge to understand the new knowledge, or when people do not recognize the importance of the lessons gained
- Economics of learning: This is about the costs and expected economic benefits.
- Number of new ideas and patents
- Contribution on individual knowledge: It is not always clear how this benefits the organization, because it may raise the power and prestige of individuals and lower the access and control of the organization over this knowledge
- Organizational learning: This is a contribution to collective knowledge and the shared body of knowledge
- Knowledge productivity: This is the speed in which people are able to create new knowledge and the level to which they are able to embed this new knowledge in new products and business processes
- Evidence of best practices

FUTURE TRENDS

The KOM framework distinguishes knowledge objects, operations methods, and the aspect of the support function. Of course, all the distinctions and insights mentioned are more aiming at explaining the KOM framework than pretending that this would be the final word about KOM. I will discuss some of the challenges related to each topic.

In the KM literature, the differences in knowledge objects and their related representations is mentioned many times, but the consequences of these differences is seldom explicitly studied. This omission of the KM literature can be understood from KM research's emphasis on holistic insights instead of a study of a specific type of knowledge. The KOM model indicates the need to more seriously study the consequences of these differences for the development and management of related operations. Such an approach also helps to avoid misfits of knowledge and operation types. For instance, such research could help avoid an overreliance or underutilization of IT means for the management of specific types of knowledge.

I proposed four types of learning, based on Nonaka's work and knowledge input transformations. There is substantial evidence that these four explain most learning processes in and between organizations, though lack of space also prevented me from mentioning Argyris and Schön's (1978) classification of single loop and double loop learning (which emphasize the organizational adoption of innovations), and the different levels of abstraction (Bohn, 1994) that an organization can realize (e.g., changes from elementary observations to complex explanatory models). These different theoretical approaches require the definition of different inputs and outputs, and different operation methods.

I described knowledge logistics in terms of formality, reuse contexts, and storage and media. These are suggestions from the literature, but neither much descriptive nor explanatory research in these fields has been done at the moment.

With respect to the selection of means, goals, and metrics, I have been able to collect several examples, some better and some less based on empirical evidence, but also this can be studied further. The current KM movement seems more rooted in human relations, organization studies, economics, or computer science, which results in less priority for rigorous studies in the mentioned support function. The KOM framework more or less logically indicates the need for such studies. A research topic here could be the study of effective goal specification in KM. Also the tradeoff and balance of human vs. IT means may be a fruitful research topic. The development of KM metrics and their effective use for feedback in the KM context is another topic to study.

Finally, I want to note that the KOM framework is independent of the question if we study KM in an intraorganizational or interorganizational perspective. Though for KOM this probably is true, for the practical implementation of KOM, the context matters a lot. I believe much fruitful research can be done on comparing KOM in intraorganizational contexts (e.g., knowledge management in a department) and an interorganizational context (e.g., KM in interfirm codesign projects and KM by optimally using the Internet; cf. Schwartz, Divitini, & Brasethwik, 2000).

CONCLUSION

This article started from the idea to apply concepts from the operations management field to knowledge management. I gave an elaboration of a knowledge operations management framework (KOM). The framework states that KOM wants to operate on four types of knowledge objects and related representations (of knowledge and of objects in reality). These objects may be transformed by learning and handled without transformation to clients via knowledge logistics. The support function has to manage these knowledge operation methods by selecting specific organizational goals, selecting the best set of human and IT means, and applying metrics for control and feedback. These concepts may be used for the innovation and design of KM, and they (as the Future Trends sections demonstrated) are a fruitful heuristic model for further KM research.

REFERENCES

Ackerman, M., & Halverson, C. (2000). Reexamining organizational memory. *Communications of the ACM, 43*(1), 59-64.

Alavi, M., & Leidner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *Management Information Systems Quarterly, 25*(1), 107-136.

Argyris, C., & Schön, D. (1978). *Organizational learning: A theory of action perspective.* Reading, MA: Addison-Wesley.

Armistead, C. (1999). Knowledge management and process performance. *Journal of Knowledge Management, 3*(2), 143-154.

Ballou, R.H. (1992). *Business logistics management.* Englewood Cliffs, NJ: Prentice-Hall.

Bell, D. (1979). The social framework of the information society. In M. Dertouzos & J. Moses (Eds.), *The computer age: A twenty year view* (pp. 163-211). Cambridge, MA: The MIT Press.

Berners-Lee T., Hendler J., & Lassila O. (2001). The semantic Web. *Scientific American, 284*(5), 34-43.

Bohn, R.E. (1994). Measuring and managing technological knowledge. *Sloan Management Review, 36*(1), 61-73.

Boisot, M.H. (1998). *Knowledge assets: Securing competitive advantage in the information economy.* Oxford, UK: Oxford University Press.

Borst P., Akkermans H., & Top J. (1997). Engineering ontologies. *International Journal Human-Computer Studies, 46*(2-3), 365-406.

Daft, R.L., & Weick, K.E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9*, 284-295.

Damsgaard J., & Scheepers, R. (1999). A stage model of Intranet technology implementation and management. *Proceedings of the European Conference in Information Systems* (pp. 100-116).

Davenport, T.A., & Prusak, L. (1997). *Working knowledge: How organizations manage what they know.* Cambridge, MA: Harvard Business School Press.

Doll, W., & Torkzadeh, G. (1988). The measurement of end-user satisfaction. *Management Information Systems Quarterly, 12*(2), 259-274.

Earl, M. (1994). Knowledge as strategy. Reflections on Skandia International and Shorko Films. In C. Ciborra & T. Jelassi (Eds.), *Strategic information systems: A European perspective* (pp. 53-69). Chichester, UK: John Wiley.

Galunic, D.C., & Rodan, S. (1998). Resource recombinations in the firm: Knowledge structures and the potential for Schumpeterian innovation. *Strategic Management Journal, 19*, 1193-1201.

Hamel, G., & Prahalad, C.K. (1994). *Competing for the future.* Boston: Harvard Business School Press.

Hansen, M., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Hempel, C.G. (1965). *Aspects of scientific explanation and other essays in the philosophy of science.* New York: The Free Press.

Hill, T. (1983). *Production/operations management.* Englewood Cliffs, NJ: Prentice-Hall.

Lawler, E.E., & Rhode, J.G. (1976). *Information and control in organizations.* Beverly Hills, CA: Goodyear.

Leonard-Barton, D. (1992). The factory as a learning lab. *Sloan Management Review, 34*(1), 23-38.

Liebeskind, J.L., Oliver, A.L., Zucker, L., & Brewer, M. (1996). Social networks, learning, and flexibility: Sourcing scientific knowledge in new biotechnology firms. *Organization Science, 7*(4), 428-443.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5*(1), 14-37.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

Polanyi, M. (1967). *The Tacit dimension.* London: Routledge and Kegan Paul.

Quinn, J.B. (1992). *Intelligent enterprise: A knowledge and service based paradigm for industry.* New York: The Free Press.

Quinn, R.E., & Rohrbaugh, J. (1983). A spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. *Management Science, 29*(3), 363-377.

Schwartz, D.G., Divitini, M., & Brasethwik, T. (2000). On knowledge management in the Internet age. In D.G. Schwartz, M. Divitini, & T. Brasethwik (Eds.), *Internet-based knowledge management and organizational memory* (pp. 1-23). Hershey, PA: Idea Group Publishing.

Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday Currency.

Singh, H.S. (1998). *Data warehousing concepts, technologies, implementations, and management.* Englewood Cliffs, NJ: Prentice-Hall.

Spender, J.-C. (1998). Pluralistic epistemology and the knowledge-based theory of the firm. *Organisation, 5*(2), 233-256.

Stamper, R.K. (1973). *Information in business and administrative systems.* New York: John Wiley.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Turban, E., Aronson, J., & Bolloju, N. (2001). *Decision support systems and intelligent systems.* Upper Saddle River, NJ: Prentice-Hall.

Walsh, J.P., & Ungson, G. (1991). Organizational memory. *Academy of Management Review, 16*, 57-91.

Wijnhoven, F. (1998). Knowledge logistics in business contexts: Analyzing and diagnosing knowledge sharing by logistics concepts. *Knowledge and Process Management, 5*(3), 143-157.

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Chapter 6.27
Knowledge Management in a Project Climate

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EXECUTIVE SUMMARY

This case study concerns the company Taylor Woodrow, which is a housing, property, and construction business operating internationally in situations where frontline operations are characterised by project management. Construction projects can sometimes carry substantial risk, and this case examines the role of knowledge management at Taylor Woodrow in minimising the probability of mischance by promoting best practice and lessons learned. The case shows how best practice can be developed through knowledge-sharing facilitated by networks of relationships. Some relationships are external — between the company, its partners, suppliers, and customers. Other relationships are internal — between frontline managers on construction sites and headquarters' staff. The case study indicates how knowledge is collated and distributed for the mutual benefit of all stakeholders.

BACKGROUND

The UK construction industry contributes about 10% of the UK's gross domestic product (GDP) and employed some 1.4 million people in 2001-2002 (DTI, 2002). Construction in the UK is a fragmented trade where there is constant pressure from clients for improvement and innovation in performance. Such is this pressure that the DTI

(Department of Trade and Industry, the Government body responsible in the UK) invested £16.5 million in 2002 on a programme of construction-related innovation and research to develop and disseminate information and knowledge.

Taylor Woodrow: General Company Background

Taylor Woodrow is an international housing and development company employing over 7,000 people worldwide. Its primary business is house building, which accounts for more than 95% of its operating profit. The company is the second largest UK-based house builder, delivering 10,000 new homes in the UK, along with around 3,800 new homes in North America, Spain, and Gibraltar each year. The company's UK house-building operation trades mainly under the Bryant Homes brand. In Canada, homes are marketed as Monarch, and in the United States and Spain, directly under the Taylor Woodrow brand.

In the UK, the company currently trades from a network of 11 regional offices, incorporating a central office based in the West Midlands and the construction headquarters in Watford. In addition to housing and commercial property developments, Taylor Woodrow also undertakes Private Finance Initiative (PFI) projects under the UK Government's Private Finance Initiative, mainly in healthcare. The company also undertakes facilities management and specialist engineering consultancy through Taylor Woodrow Construction. This unique skill base of integrated housing, property, and construction expertise ensures that Taylor Woodrow is particularly well equipped to tackle more complex developments, often on brownfield sites in high-profile city centre locations, and up to 30% of the company's construction activity is now in-house support to deliver large and mixed-use housing and commercial projects for the company.

Taylor Woodrow's core market is the UK with 71% of revenue in 2002 (http://uk.biz.yahoo.com/, 2003). The remainder of revenue comes from North America (25%), and the rest of the world (mainly Spain and Gibraltar) supplies the remaining 4%. In 2003, turnover was up 7% and profit before tax was up 20% on the previous year (Interim Results Statement, June 30, 2003, available on Web site).

According to the company's Web site (http://www.taylorwoodrow.com/), Taylor Woodrow's vision is to be "the leading developer of living and working environments in the UK and other chosen markets."

The company Web site also details full information about the company's

1. stated culture;
2. principles;
3. objectives;
4. responsibility (to shareholders, customers, people, those with whom they do business, and society);
5. business integrity;
6. health, safety, and environment;
7. community (they seek to be responsible corporate citizens);
8. political activities (they do not support political parties or policies in any form);
9. competition (they support free enterprise);
10. communication (open); and
11. corporate governance (detailing the directors, the board, and other committees, how internal control is carried out, investor relations, and corporate social responsibility policy).

SETTING THE STAGE

Knowledge management began in Taylor Woodrow in 2000 and centred on technical knowledge managed by a team based at the Technology Centre in Leighton Buzzard, UK. The remit of the knowledge manager at Taylor Woodrow was to manage knowledge on a groupwide basis. The main reason that knowledge management was introduced related to the board recognising that Taylor Woodrow needed a systematic process to better manage its substantial technical knowledge base. Hence improving the dissemination of best practice and lessons learned, thus reducing technical risks on its projects. So the knowledge management initiative was an approach to sharing technical excellence and best practice, and to demonstrate added value and business differential to their clients. It was able to demonstrate reduced costs and successful learning on projects to both new and existing clients, which helped maintain client relationships and encouraged repeat business. In 2001-2002 its main emphasis was on defect reduction and producing better buildings for clients, thus KM has been integrated into its construction project processes to add value from which both customers and shareholders benefit.

CASE DESCRIPTION

KM, according to Taylor Woodrow's KM manager "is primarily about people and how they behave and how they solve problems." In order to ensure the initiative is well supported, she felt that one needs to persuade the senior management initially as they are the real influencers of construction project outcomes. The KM process incorporates managers to reduce risks early in the construction process and consider the outcomes of actions, which were taken in previous projects. Enthusiasm for the initiative has come from board level and this is essential to gain support from operational (frontline) managers.

A number of forums have been set up in Taylor Woodrow for design managers, project managers, graduates, and commercial managers, which look at improving processes and sharing knowledge. It would seem that the most important motivator in Taylor Woodrow for participation in these forums and to undertake KM was not only kudos but being able to make improvements to the business. The forums were headed up by senior managers, and to be seen to be actively participating and encouraging improvements at the forums was good for professional development for some participants.

So far, the forums have primarily concentrated on sharing best practice and the Taylor Woodrow KM manager hopes that in the future more project managers will feel able to talk about projects where processes went wrong, how they have learned from the experience, and how they can do better next time. To start the process, Taylor Woodrow has begun to publish a Top Tips bulletin, which anonymises the projects and issues. This particular initiative is similar to a Government scheme, which is called Movement for Innovation, where best practice on construction projects will be captured and disseminated across the industry.

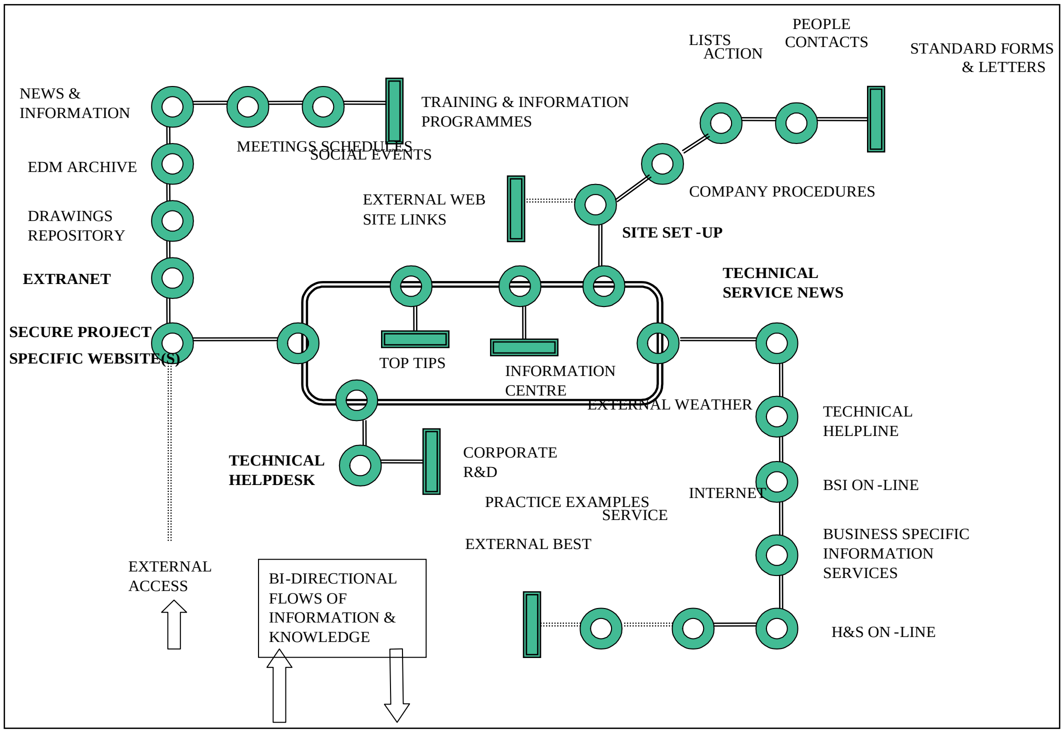
Whilst the KM manager sees herself as a facilitator within the company, Taylor Woodrow has developed and implemented an IT-enabled infostructure called Tayweb for the distribution of organizational knowledge. There are seven main areas that Tayweb supports. These are as follows:

1. One Company – company information;
2. News;
3. People – HR and training;
4. The Way We Work – processes;
5. Knowledge Share;
6. Central Services;
7. Office Zone – information on regional offices.

The Knowledge Share portal of Tayweb can usefully be modelled in terms of a subway metaphor as shown in Figure 1.

This subway operates continuously beneath Taylor Woodrow's business operations supporting the enterprise and its business strategies. In this activity, it is analogous to a computer program constantly running in the background behind other applications. The model, however,

Figure 1. Taylor Woodrow's IT-enabled KM system – Tayweb



only represents the KM system in a single plane, which belies its complexity as it functions in a multidimensional space having a form more like a bowl of spaghetti (Kolind, 1996). The company utilised an eight-step knowledge transfer model (O'Dell, Greyson, & Essaides, 1998) in order to inform the design of its KM system. This involved "focusing on creating, identifying, collecting and organizing best practices and internal knowledge, in order to understand what [organizations] know and where [the knowledge] is. The process must explicitly address sharing and understanding of those practices by motivated recipients. Finally, the process involves helping the recipients adapt and apply those practices to new situations, to create new 'knowledge' and put it into action" (O'Dell et al., 1998).

Tayweb is Taylor Woodrow's intranet, which carries users to any one of seven portals as detailed previously. Technical Service News is an electronic, interactive publication summarising the latest technical innovations, legislation, and best practice and is available in the Knowledge Share portal on Tayweb. This provides access to Taylor Woodrow's in-house technical helpline, to online British standards, construction information, online health and safety standards, and provides links to external Web sites for weather information and industry best-practice examples via the Internet. It is also e-mailed on a monthly basis to technical staff.

The Technical Help Desk (THD) is a facility through which the company's Technology Centre offers its specialist technical expertise. Frequent analyses of inquiries to the THD are used to generate Top Tips (technical guidelines), which demonstrate what lessons have been learnt and what innovations have been introduced, both of which constitute new organizational knowledge. In addition, the queries to the THD will also generate seminars and workshops for training purposes (note here that engineers and surveyors who are members of professional bodies such as the Institute of Building and Civil Engineering, or the Institute of Chartered Surveyors, are required by their professional bodies to do a certain number of continual professional development hours per year in order to maintain their qualification).

An important part of the tendering process for projects includes risk assessment and the KM system is a vital source of both technical and historical data that project managers need to access to discover what has been done in the past, and what are the current best practices. In addition, as the managers on construction project sites have laptops issued and the project managers for homes building operate from a regional office with computer access, they will also have access to these technical guidelines. Site general foreman tend not to have computers and so phone for information, their knowledge requirement is part of their social network — they need to know who to phone for help.

Site Setup is primarily an information portal and is an interactive guidance tool the purpose of which is to assist a project manager in setting up a new construction site. At this one-stop shop, project managers have links to external Web sites for other organizations such as the police service, the fire brigade, and the local authority. In addition to the company's own procedures, the site provides a checklist of actions required for sites being newly established as well as a yellow pages of people contacts. There is also a repository of standard forms and business stationery. The intranet also contains organizational structures, what the company's departments do, project profiles, and so forth.

Although Figure 1 shows only one portal through which a secure Web site can be accessed, there could be several. Taylor Woodrow establishes these extranets on a project-specific basis for blue-chip clients such as airports and supermarkets. These are vortals, collaborative project Web sites bounding virtual communities of practice, which are live for the duration of each contract. These vortals confer all the advantages of electronic document management repositories but with additional benefits deriving from Internet access. Each community member has available a directory of teams, a repository of drawings in two and three dimensions continually updated, a document archive including photographs of work in progress, news and information, schedules of meetings, programmes of induction and training, and even listings of social events.

Finally, Tayweb's Knowledge Share portal features a centralised interactive facility, which is available to Taylor Woodrow's entire workforce providing an extensive range of library information services. Here, there are online services such as British standards, health and safety information, and construction information. It also enables users to access a technical library and to order documents.

The perceived returns by Taylor Woodrow from its investment in KM are primarily in terms of the use of best practice and lessons learnt to improve the quality and reduce the defects of their product. In the construction industry, defects can be very costly both in monetary terms and client relationships. Thus KM in this company supports quality management. Measures are now in place for quantifying the return on investment for Taylor Woodrow's KM system and they are being developed to demonstrate added value in monetary terms. The benefits of qualitative outcomes and some assessments of cost savings are collated in Table 1.

CONCLUSIONS

Over the period we have been studying Taylor Woodrow, the organization has become more aware of the value KM has been able to add to

Table 1. Returns from knowledge management at Taylor Woodrow

	Technical News Service	**Technical Helpdesk**	**Top Tips**	**Site Set-Up News**	**Secure Project Web Sites**	**Infor-mation Centre**
Increased Efficiency Of Information Management	Reduction in time spent by senior managers searching for information			Project managers spend less time implementing site set-up procedures	Faster access to information and quicker response times	Offers Taylor Woodrow fast access to knowledge
Permanent Global Availability	24/7 access	24/7 access	24/7 access	24/7 access	Instant global access anytime	24/7 access
Administrative Cost Reduction	Reductions in paperwork	Reductions in paperwork	Reductions in paperwork	Reductions in paperwork	Reduces routine administration	Reductions in paperwork
Access & Response Time Reductions					Faster access to information and quicker response times	
Dissemination Leadtime Reduction	Proactively keeping managers informed of the latest innovations			More time available to concentrate on value added activities		
On-Site Productivity Improvement	Enabling managers to make better informed decisions			Project managers spend less time implementing site set-up procedures		
Savings - examples		1. Investigation of tar macadam defects saves £60,000; 2. Cavity wall ties save £14,000 in stone façade fixture; 3. Design life technology applied to a flat inverted roof saves client £10,800; 4. Re-designed stainless steel wind posts save £20,000.		More time available to concentrate on value added activities	Relatively inexpensive to establish	Enables Taylor Woodrow to work more efficiently

the organization. Increasingly, project staff and management have seen the benefits of communicating their innovations to others in the organization and lessons learnt are being captured in an increasingly systematic way. Taylor Woodrow is able to demonstrate conclusively to its clients that it is a learning organization. KM has a very high significance for the board, which provides specific funding for its development and dissemination.

DISCUSSION

Construction projects embody risk. The larger the project the higher the potential cost penalties. How can risk of this nature be mitigated? Obviously, insuring against risk is one course, but this generates additional costs, as a third party — an insurance company — requires compensation for assuming the construction company's risk. Another way of insuring against risk by reducing the probability of mischance is to leverage knowledge assets within the business.

How then to capture what individuals know and then to distribute this knowledge so that it can be shared throughout an organization? The willingness of individuals to articulate knowledge gained through involvement in work processes may depend on the organization's prevailing cultural paradigm. Some organizational cultures may be resistant to knowledge sharing — others may facilitate it. Sometimes knowledge transfer can be encouraged by incentivising staff in some way. Taylor Woodrow's approach seems to be driven primarily by the self-esteem generated from peer recognition. The company's culture seems to be receptive to KM and has enabled it to become embedded in the organizational fabric.

The importance of ICTs needs to be recognised, but these technologies are only enablers. They are not the key drivers. The critical driver in this instance may be seen as social capital, which comprises sets of relationships and networks underpinning knowledge sharing. Out of knowledge sharing comes learning, and learning at an organizational level delivers a range of business benefits in addition to ensuring that potentially costly errors are not repeated. Some of the Tayweb links signify the importance of these relationships in partnering and collaborations of various kinds not only through the intranet, but also through the various project-specific extranets.

REFERENCES

Bradburn, A., Coakes, E., & Sugden, G. (2002, May). Searching for linkages between knowledge management, learning organization and organizational culture within large service enterprises in the United Kingdom: What KM practitioners say. In M. Khosrow-Pour (Ed.), *Issues and trends of information technology management in contemporary organizations, IRMA 2002,* Seattle (vol. 2, pp. 928-930). Hershey, PA: Idea Group Publishing.

Department of Trade and Industry (DTI). (2002). *Construction statistics annual 2002 edition*. London: The Stationery Office.

Kolind, L. (1996). The revolution at Oticon: Creating a spaghetti organization. *Research Technology Management, 39*(5), 54.

O'Dell, C., Greyson, C.J., & Essaides, W. (1998). *If only we knew what we know.* New York: Free Press.

Additional Recommended Reading

Kazi, A.S. (2004). *Knowledge management in the construction industry: A socio-technical perspective.* Hershey, PA: Idea Group.

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Chapter 6.28
Assessing Knowledge Management Success

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ABSTRACT

This article proposes a framework for assessing knowledge management system (KMS) success models. The framework uses three criteria: how well the model fits actual KMS success factors, the degree to which the model has a theoretical foundation, and if the model can be used for both types of KMSs. The framework is then applied to four KMS success models found in the literature and is determined to be a useful framework for assessing KMS success models.

INTRODUCTION

Knowledge management systems (KMSs) are systems designed to manage organizational knowledge. Alavi and Leidner (2001) clarify KMSs as IT-based systems developed to support/enhance the processes of knowledge creation, storage/retrieval, transfer, and application. Additionally a KMS supports knowledge management through the creation of network-based organizational memory (OM), and support for virtual project teams and organizations and communities of practice. A final goal of a KMS is to support knowledge/OM creation.

There are several taxonomies of KMSs from Zack's (1999) integrative and interactive KMS to KMS classified according to knowledge lifecycle (Alavi & Leidner, 2001), KM spectrum (Hahn & Subramani, 2000), KM architecture (Borghoff & Pareschi, 1998), and so forth. However, this article classifies KMS by the context captured and the users targeted, resulting in two approaches to building a KMS—the process/task approach and the infrastructure/generic approach. The process/task approach focuses on the use of knowledge/OM by participants in a process, task, or project in order to improve the effectiveness of that process, task, or project. This approach identifies the information and knowledge needs of the process, where they are located, and who needs them. This approach requires the KMS to capture minimal context because users are assumed to understand the milieu of the knowledge that is captured and used.

The infrastructure/generic approach focuses on building a system to capture and distribute knowledge/OM for use throughout the organization. Concern is with capturing context to explain the captured knowledge and the technical details needed to provide good mnemonic functions associated with the identification, retrieval, and use of knowledge/OM. The approach focuses on network capacity, database structure and organization, and knowledge/information classification.

Both approaches may be used to create a complete KMS. The process/task approach supports specific work activities, while the infrastructure/generic approach integrates organizational knowledge into a single system that can be leveraged over the total organization instead of just a process or project. Morrison and Weiser (1996) support the dual approach concept by suggesting that an organization-wide KMS be designed to combine an organization's various task/process-based KMSs into a single environment and integrated system.

Once a KMS is implemented, whichever type it is, its success or effectiveness needs to be determined. Turban and Aronson (2001) list three reasons for measuring the success of a knowledge management system:

- To provide a basis for company valuation
- To stimulate management to focus on what is important
- To justify investments in KM activities

All are good reasons from an organizational perspective. Additionally, from the perspective of KM academics and practitioners, the measurement of KMS effectiveness or success is crucial to understanding how these systems should be built and implemented.

To meet this need, several KMS success/effectiveness models have been proposed. It is the purpose of this article to propose a framework for assessing the usefulness of these models. To do this the article describes an evaluation model based on comparing the KMS success model to KMS success factors, determining the degree to which the model has a theoretical foundation, and determining if the model can be applied to both approaches to building a KMS.

The article will first define the assessment framework. Then four KM/KMS success/effectiveness models will be described, followed by an analysis with respect to how well the models match the assessment framework and a conclusion on the usefulness of the framework. KM/KMS success/effectiveness will not be defined, because we found that each model defines success/effectiveness as part of the model.

METHODOLOGY

The proposed assessment framework consists of three main questions: how well the KMS success model meets KM/KMS success criteria, the degree of the model's theoretical foundation, and if it can be applied to both approaches to building a KMS. Stinchcombe (1968) suggests testing theories by determining how well they reflect observed data and that the more observations that can be compared, the better. The proposed framework does this by comparing the KMS success models to a set of KMS success criteria. The set of KMS success criteria was determined through a literature survey. Several studies were found that reported issues affecting the success of a KMS. The studies used in this article utilize a variety of methods, including surveys, case studies, Delphi studies, and experimentation. A total of 78 projects or organizations were investigated using case studies. Three surveys were administered, and one Delphi study and experiment were performed.

The second criterion is the theoretical foundation of the KMS success model. This criteria is based on being able to generalize the model. It is proposed that a model that is based on accepted theory or other widely supported models will be more generalizable. The theoretical foundation is determined by reviewing the publication the model is presented in. A judgment is made as to the appropriateness of the theoretical foundation.

The third criterion is for the KMS success model to be applicable to both KMS approaches. This criterion is determined by judging the focus of the model to determine if it is specific to either the task/process approach or the generic/infrastructure approach.

KM/KMS SUCCESS FACTORS

A successful KMS should perform the functions of knowledge creation, storage/retrieval, transfer, and application well. However, other factors can influence KMS success. This section creates a KMS success factor framework by reviewing research related to identifying KMS success factors. Additionally, findings from studies looking at knowledge management and organizational memory success are also included. KM is included using a Churchman (1979) view of a KMS which can be defined to include the KM initiative driving the implementation of a KMS (also the counter view is valid, as looking at KM can also include looking at the KMS). OM is included, as Jennex and Olfman (2002) found that KM and OM are essentially the same with the difference being the players. End-users tend to do KM where KM is concerned with the identification and capture of key knowledge. Information systems (IS) personnel tend to be concerned with OM where OM is the storage, search, retrieval, manipulation, and presentation of knowledge. KMS and OMS are the systems built to support KM and OM, and are essentially systems designed to manage organizational knowledge. As stated previously, Alavi and Leidner (2001) clarify KMS as IT-based systems developed to support/enhance the processes of knowledge creation, storage/retrieval, transfer, and application. Additionally a KMS supports knowledge management through the creation of network-based organizational memory, and support for virtual project teams and organizations and communities of practice. A final goal of a KMS is to support knowledge/OM creation. Stein and Zwass (1995) define OMS as the processes and IT components necessary to capture, store, and bring to bear knowledge created in the past on decisions currently being made. Jennex and Olfman (2002), using these definitions of KMS and OMS, along with a Churchman (1979) view of systems, combined the KMS and OMS into a single system.

A success factor framework is constructed by reviewing the literature by author. This is done so that the context resulting in the generation of the success factor can be presented. The identified success factors are then analyzed for similar concepts and combined into composite success factors. The composite success factors are ranked based on the number of authors mentioning the factor. This is problematic, but is done as it implies greater consensus on the existence of the success factor; that is, the more often a success factor is mentioned, the greater the consensus that it is a success factor and the greater the likelihood it is important. Table 1, presented at the end of this discussion, provides the ranked list of composite success factors.

Mandviwalla, Eulgem, Mould, and Rao (1998) summarized the state of the research and described several strategy issues affecting the design of a KMS. These include the focus of the KMS (who are the users), the quantity of knowledge to be captured and in what formats, who filters what is captured, and what reliance and/or limitations are placed on the use of individual memories. Additional technical issues affecting KMS design include knowledge storage/repository considerations, how information and knowledge is organized so that it can be searched and linked to appropriate events and use, and processes for integrating the various repositories, and for reintegrating information and knowledge extracted from specific events. Some management issues include how long the knowledge is useful, access locations as users rarely access the KMS from a single location (leads to network needs and security concerns), and the work activities and processes that utilize the KMS.

Ackerman (1994) studied six organizations that had implemented his Answer Garden system. Answer Garden is a system designed to grow organizational memory in the context of help-desk situations. Only one organization had a successful implementation because expectations of the capabilities of the system exceeded the actual capabilities. Ackerman and Mandel (1996) found that a smaller task-based system was more effective on the sub-organization level because of its narrower expectations. They refer to this narrower system as "memory in the small."

Jennex and Olfman (2000) studied three KM projects to identify design recommendations for building a successful KMS. These recommendations include:

- Develop a good technical infrastructure by using a common network structure, adding KM skills to the technology support skill set, using high-end PCs; integrated databases; and standardizing hardware and software across the organization.
- Incorporate the KMS into everyday processes and IS by automating knowledge capture.
- Have an enterprise-wide knowledge structure.
- Have Senior Management support.
- Allocate maintenance resources for OMS.
- Train users on use and content of the OMS.
- Create and implement a KM strategy/process for identifying/maintaining the knowledge base.
- Expand system models/life cycles to include the KMS, and assess system/process changes for impact on the KMS.
- Design security into the KMS.
- Build motivation and commitment by incorporating KMS usage into personnel evaluation processes, implementing KMS use/satisfaction metrics, and identifying organizational culture concerns that could inhibit KMS usage.

Additionally, Jennex and Olfman (2002) performed a longitudinal study of KM on one of these organizations and found that new members of an organization do not use the computerized KMS due to a lack of context for understanding the knowledge and the KMS. They found that these users needed pointers to knowledge more than codified knowledge.

Jennex, Olfman, and Addo (2003) investigated the need for having an organizational KM strategy to ensure that knowledge benefits gained from projects are captured for use in the organization by surveying Year 2000 (Y2K) project leaders. They found that benefits from Y2K projects were not being captured because the parent organizations did not have a KM strategy/process. Their conclusion was that KM in projects can exist and can assist projects in utilizing knowledge during the project.

Davenport, DeLong, and Beers (1998) studied 31 projects in 24 companies. Eighteen projects were determined to be successful, five were considered failures, and eight were too new to be rated. Eight factors were identified that were common in successful KM projects. These factors are:

- Senior management support
- Clearly communicated KMS purpose/goals
- Linkages to economic performance
- Multiple channels for knowledge transfer
- Motivational incentives for KM users
- A knowledge-friendly culture
- A solid technical and organizational infrastructure
- A standard, flexible knowledge structure

Malhotra and Galletta (2003) identified the critical importance of user commitment and motivation through a survey study of users of a KMS being implemented in a health care organization. They found that using incentives did not guarantee a successful KMS. They created an instrument for measuring user commitment and motivation that is similar to Thompson, Higgins, and Howell's (1991) Perceived Benefit model, but based on self-determination theory that uses the Perceived Locus of Causality.

Ginsberg and Kambil (1999) explored issues in the design and implementation of an effective KMS by building a KMS based on issues identified in the literature and then experimentally implementing the KMS in a field setting. They found knowledge representation, storage, search, retrieval, visualization, and quality control to be key technical issues, and incentives to share and use knowledge to be the key organizational issues.

Alavi and Leidner (1999) surveyed executive participants in an executive development program with respect to what was needed for a successful KMS. They found organizational and cultural issues, associated with user motivation to share and use knowledge, to be the most significant. They also found it important to measure the benefits of the KMS, and to have an integrated and integrative technology architecture that supports database, communication, and search and retrieval functions.

Holsapple and Joshi (2000) investigated factors that influenced the management of knowledge in organizations through the use of a Delphi panel consisting of 31 recognized KM researchers and practitioners. They found leadership and top management commitment/support to be crucial. Resource influences such as having sufficient financial support, skill level of employees, and identified knowledge sources are also important.

Koskinen (2001) investigated tacit knowledge as a promoter of success in technology firms by studying 10 small technology firms. Key to the success of a KMS was the ability to identify, capture, and transfer critical tacit knowledge. A significant finding was that new members take a long time to learn critical tacit knowledge and a good KMS facilitates the transference of this tacit knowledge to new members.

Barna (2003) studied six KM projects with various levels of success (three were successful, two failed, and one was an initial failure turned into a success) and identified two groups of factors important to a successful KMS. The main managerial success factor is creating and promoting a culture of knowledge sharing within the organization by articulating a corporate KM vision, rewarding employees for knowledge sharing, creating communities of practice, and creating a "best practices" repository. Other managerial success factors include obtaining senior management support, creating a learning organization, providing KMS training, and precisely defining KMS project objectives

Design/construction success factors include approaching the problem as an organizational problem and not a technical one; creating a standard knowledge submission process; developing methodologies and processes for the codification, documentation, and storage of knowledge; developing processes for capturing and converting individual tacit knowledge into organizational knowledge, and creating relevant and easily accessible knowledge-sharing databases and knowledge maps.

Cross and Baird (2000) proposed that KM would not improve business performance simply by using technology to capture and share the lessons of experience. It was postulated that for KM to improve business performance, it had to increase organizational learning through the creation of organizational memory. To investigate this, 22 projects were examined. The conclusion was that improving organizational learning improved the likelihood of KM success. Factors that improved organizational learning include:

Table 1. KMS success factor summary

ID	Success Factor	Source
SF1	Integrated Technical Infrastructure including networks, databases/repositories, computers, software, KMS experts	Alavi and Leidner (1999), Barna (2002), Cross and Baird (2000), Davenport, et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Mandviwalla, et al. (1998), Sage and Rouse (1999), Yu, et al. (2004)
SF2	A Knowledge Strategy that identifies users, sources, processes, storage strategy, knowledge and links to knowledge for the KMS.	Barna (2002), Ginsberg and Kambil (1999), Holsapple and Joshi (2000), Jennex, Olfman, and Addo (2003), Koskinen (2001), Mandviwalla, et al. (1998), Sage and Rouse (1999), Yu, et al. (2004)
SF3	A common enterprise wide knowledge structure that is clearly articulated and easily understood	Barna (2002), Cross and Baird (2000), Davenport, et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Mandviwalla, et al. (1998), Sage and Rouse (1999)
SF4	Motivation and Commitment of users including incentives and training	Alavi and Leidner (1999), Barna (2002), Cross and Baird (2000), Davenport, et al. (1998), Ginsberg and Kambil (1999), Jennex and Olfman (2000), Malhotra and Galletta (2003), Yu, et al. (2004)
SF5	An organizational culture that supports learning and the sharing and use of knowledge	Alavi and Leidner (1999), Barna (2002), Davenport, et al. (1998), Jennex and Olfman (2000), Sage and Rouse (1999), Yu, et al. (2004)
SF6	Senior Management support including allocation of resources, leadership, and providing training	Barna (2002), Davenport, et al. (1998), Holsapple and Joshi (2000), Jennex and Olfman (2000), Yu, et al. (2004)
SF7	Measures are established to assess the impacts of the KMS and the use of knowledge as well as verifying that the right knowledge is being captured	Alavi and Leidner (1999), Davenport, et al. (1998), Jennex and Olfman (2000), Sage and Rouse (1999)
SF8	There is a clear goal and purpose for the KMS	Ackerman (1994), Barna (2002), Davenport, et al. (1998), Cross and Baird (2000)
SF9	Learning Organization	Barna (2002), Cross and Baird (2000), Sage and Rouse (1999), Yu, et al. (2004)
SF10	The search, retrieval, and visualization functions of the KMS support easy knowledge use	Alavi and Leidner (1999), Ginsberg and Kambil (1999), Mandviwalla, et al. (1998)
SF11	Work processes are designed that incorporate knowledge capture and use	Barna (2002), Cross and Baird (2000), Jennex and Olfman (2000)
SF12	Security/protection of knowledge	Jennex and Olfman (2000), Sage and Rouse (1999)

- Supporting personal relationships between experts and knowledge users
- Providing incentives to motivate users to learn from experience and to use the KMS
- Providing distributed databases to store knowledge and pointers to knowledge
- Providing work processes for users to convert personal experience into organizational learning
- Providing direction to what knowledge the organization needs to capture and learn from

Sage and Rouse (1999) reflected on the history of innovation and technology, and identified the following issues:

- Modeling processes to identify knowledge needs and sources
- Using a KMS strategy for the identification of knowledge to capture and use, as well as who will use it
- Providing incentives and motivation to use the KMS
- Developing an infrastructure for capturing, searching, retrieving, and displaying knowledge
- Displaying an understood enterprise knowledge structure
- Defining clear goals for the KMS
- Measuring and evaluating the effectiveness of the KMS

Yu, Kim, and Kim (2004) explored the linkage of organizational culture to knowledge management success. They found that KM drivers such as a learning culture, knowledge sharing intention, KMS quality, rewards, and KM team activity significantly affected KM performance. These conclusions were reached through a survey of 66 Korean firms.

These studies provide several success factors. As previously discussed, to analyze the factors they have been reviewed and paraphrased into a set of ranked composite success factors where the ranking is based on the number of sources citing them. Table 1 lists the final set of success factors in their rank order. Additionally, success factors SF1 through SF4 are considered the key success factors, as they were mentioned by at least half of the success factor studies.

KNOWLEDGE MANAGEMENT SUCCESS MODELS

Bots and de Bruijn: Knowledge Value Chain

Bots and de Bruijn (2002) assessed KM and determined that the best way to judge good KM was through a knowledge value chain. In this evaluation process KM is assessed for effectiveness at each step of the knowledge process and is good if each of the indicated activities is performed well, with the ultimate factor being if the KMS enhances competitiveness. Figure 1 illustrates the KM value chain. The model was developed by viewing and contrasting KM through an analytical (technical) perspective and an actor (user) perspective. These perspectives are conflicting, and KM assessment occurs by determining how well the KMS meets each perspective at each step.

Massey, Montoya-Weiss, and Driscoll KM Success Model

Massey, Montoya-Weiss, and O'Driscoll (2002) present a process-based KM success model derived from their Nortel case study. The case study suggested that KM cannot be applied generically and that a process approach to KM will help an organization to understand how it can apply KM to

Figure 1. Bots and de Bruijn (2002) KM value chain

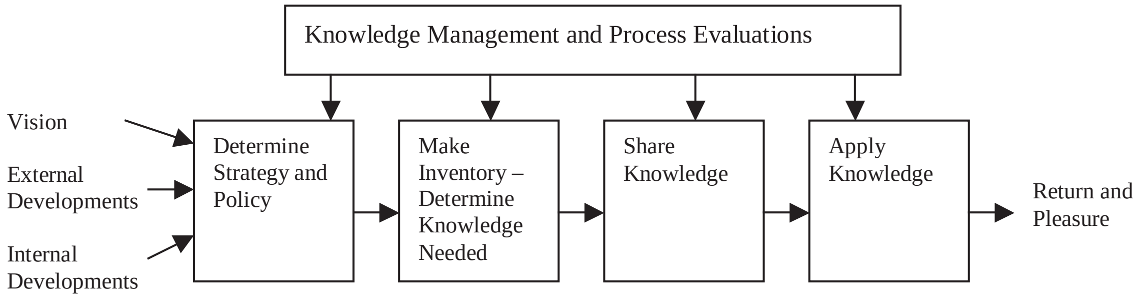
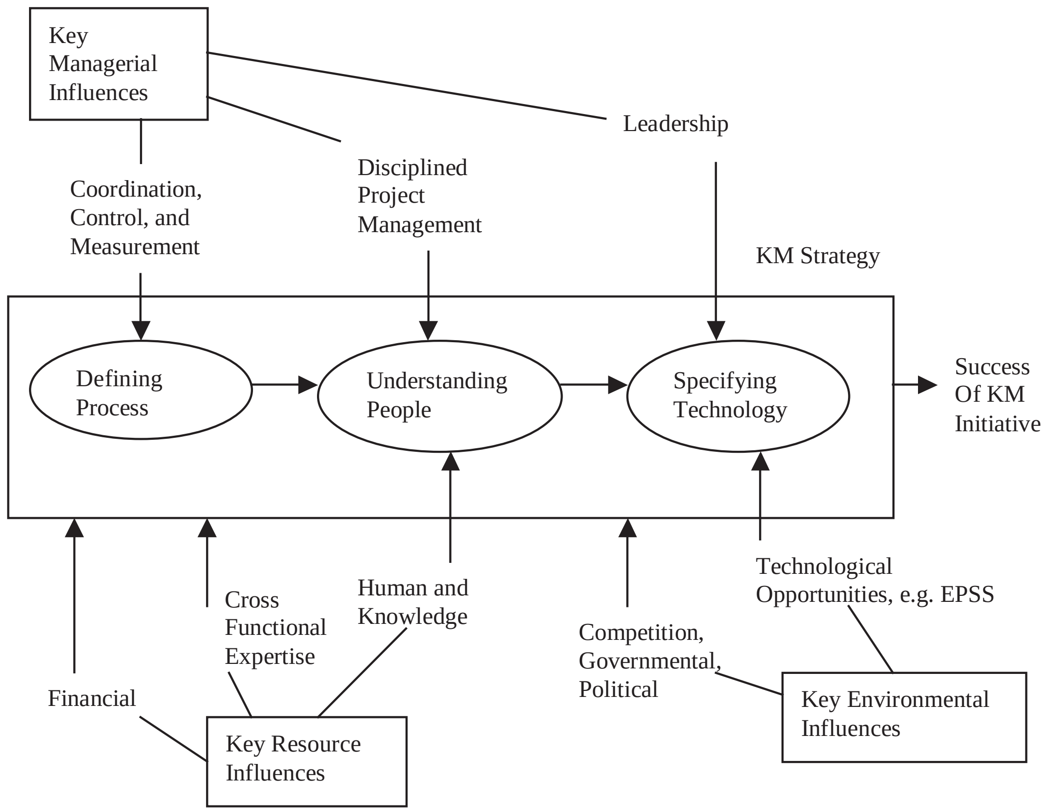


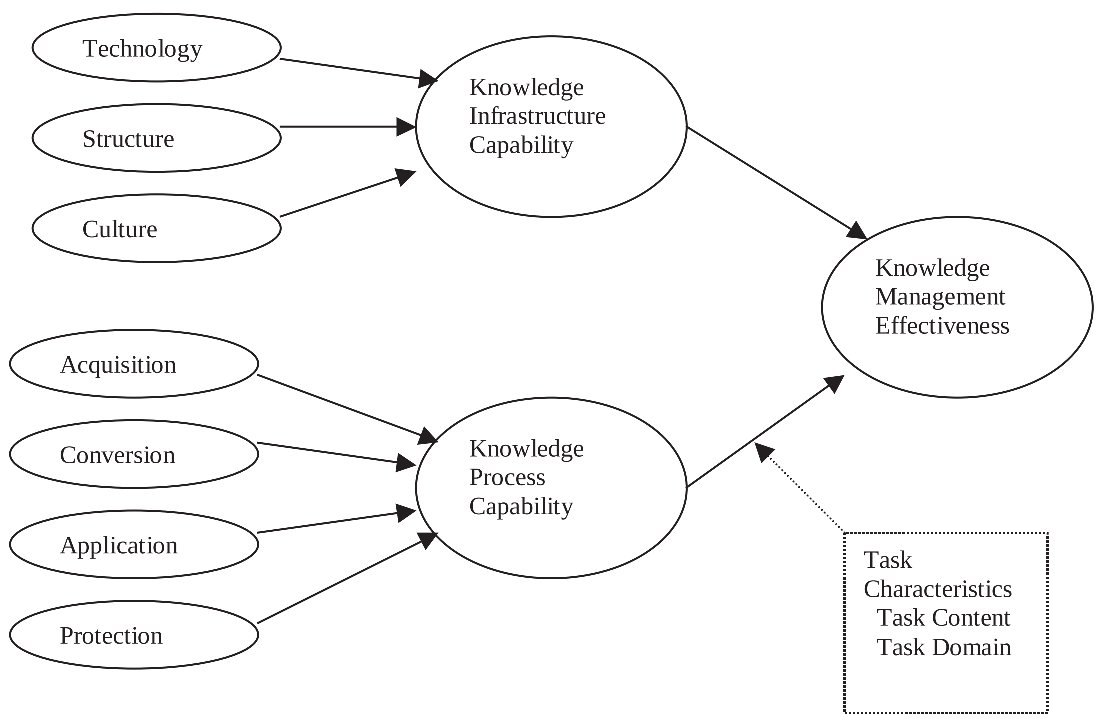
Figure 2. Massey, Montoya-Weiss, and Driscoll (2002) KM success model



improve organizational performance. The model is based on the framework proposed by Holsapple and Joshi (2001), and reflects that KM success is based on understanding a process-oriented KM strategy and its effects on the organization, its knowledge users, and how they use knowledge. It recognizes that KM is an organizational change process and KM success cannot separate itself from the organizational change success with the result the KM success is essentially defined as improving organizational or process performance. The model is presented in Figure 2. Key components of the model are:

- KM Strategy—defines the processes using knowledge and what that knowledge is; the sources, users, and form of the knowledge; and the technology infrastructure for storing the knowledge.
- Key Managerial Influences—defines management support through leadership, allocation, and management of project resources, and oversight of the KMS through coordination and control of resources and the application of metrics for assessing KMS success.
- Key Resource Influences—the financial resources and knowledge sources needed to build the KMS.
- Key Environmental Influences—describe the external forces that drive the organization to exploit its knowledge to maintain its competitive position.

Figure 3. Lindsey (2002) KM effectiveness model



Lindsey KM Effectiveness Model

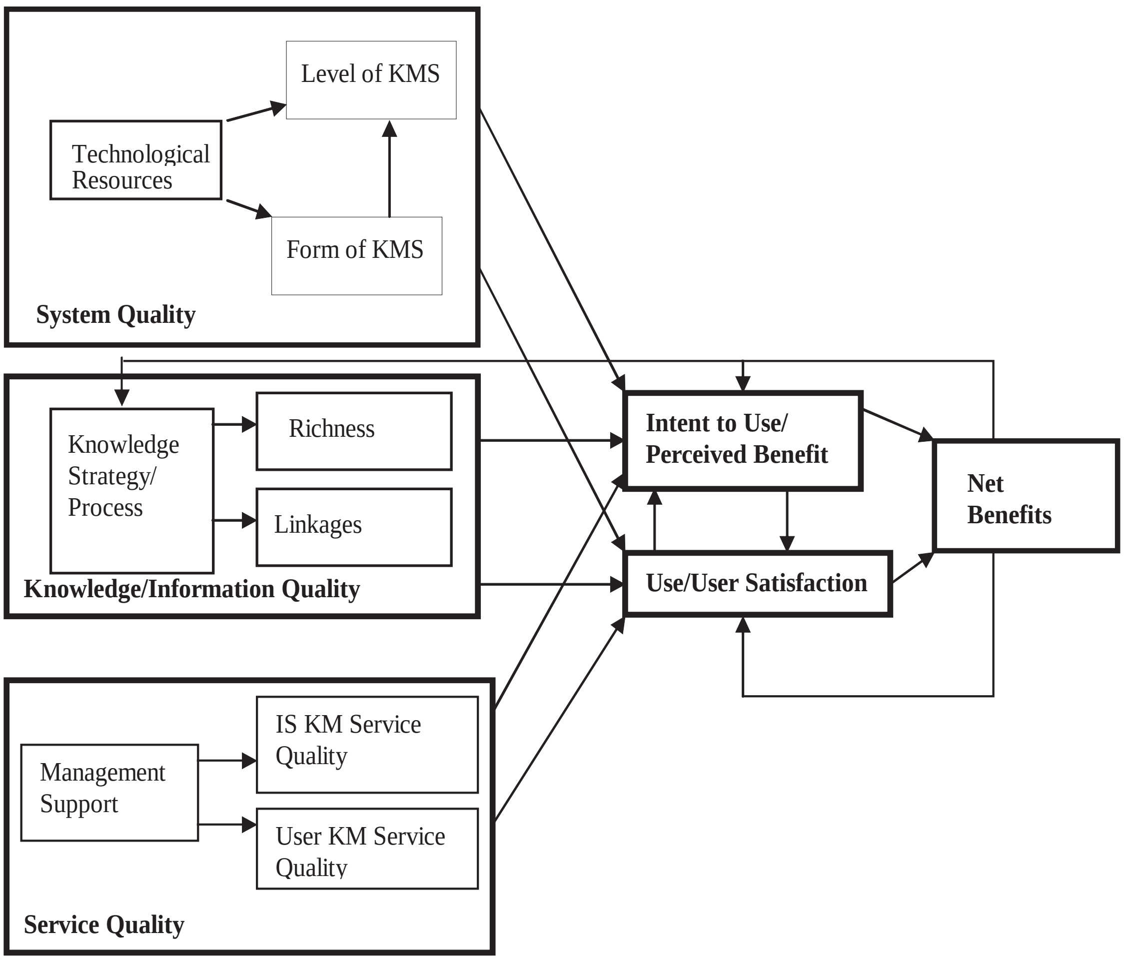
Lindsey (2002) proposes a conceptual KM effectiveness model based on combining Organizational Capability Perspective theory (Gold, 2001) and Contingency Perspective Theory (Becerra-Fernandez & Sabherwal, 2001). The model defines KM effectiveness in terms of two main constructs: knowledge infrastructure capability and knowledge process capability, with the knowledge process capability construct being influenced by a knowledge task. Knowledge infrastructure capability represents social capital, the relationships between knowledge sources and users, and is operationalized by technology (the network itself), structure (the relationship), and culture (the context in which the knowledge is created and used). Knowledge process capability represents the integration of KM processes into the organization, and is operationalized by acquisition (the capturing of knowledge), conversion (making captured knowledge available), application (degree to which knowledge is useful), and protection (security of the knowledge). Tasks are activities performed by organizational units and indicate the type and domain of the knowledge being used. Tasks ensure the right knowledge is being captured and used. KM success is measured as satisfaction with the KMS and is considered a weak definition of success. It is proposed that research be conducted into KMS effectiveness to find ties into organizational effectiveness. Kaplan and Norton's (1992) Balanced Scorecard may be useful in establishing measures for KMS effectiveness. Figure 3 illustrates the Lindsey model.

KMS Success Models Based on the DeLone and McLean IS Success Model

Jennex and Olfman (2004) present a KMS success model that is based on the respecified DeLone and McLean (2003) IS success model. The model in Figure 4 was derived from a longitudinal case study, a quantitative study across an industry, and action research applying the model in the field. The model evaluates success as an improvement in organizational effectiveness based on use and impact of the KMS. Descriptions of the dimensions of the model follow.

- System Quality—defines how well the KMS performs the functions of knowledge creation, storage/retrieval, transfer, and application; how much of the OM is codified and included in the computerized portion of the OM; and how the KMS is supported by the IS staff and infrastructure.
- Knowledge/Information Quality—ensures that the right knowledge/OM with sufficient context is captured and available for the right users at the right time.
- Service Quality—ensures that the organization has adequate service support from management, user organizations, and the IS organization.
- Use/User Satisfaction—indicates actual levels of KMS use, as well as the satisfaction of the KMS users. Actual use is most applicable as a success measure when the use of a system is required. User satisfaction is a construct that measures satisfaction with the KMS by users. It is considered a good complementary measure of KMS use when use of the KMS is required, and effectiveness of use depends on users being satisfied with the KMS.
- Perceived Benefit—measures perceptions of the benefits and impact of the KMS by users, and is based on Thompson, Higgins, and Howell's (1991) Perceived Benefit Model. It is good for predicting continued KMS use when use of the KMS is voluntary, and amount and/or effectiveness of KMS use depends on meeting current and future user needs.

Figure 4. Jennex and Olfman (2004) KMS success model



- Net Impact—An individual's use of a KMS will produce an impact on that person's performance in the workplace. Each individual impact will in turn have an effect on the performance of the whole organization. Organizational impact is typically not the summation of individual impact, so the association between individual and organizational impact is often difficult to draw, which is why this construct combines all impact into a single construct. This model recognizes that the use of knowledge/OM may have good or bad benefits and allows for feedback from these benefits to drive the organization to either use more knowledge/OM or to forget specific knowledge/OM.

Maier (2002) also proposes a KMS success model based on the DeLone and McLean IS success model (1992). This model is similar to the

Jennex Olfman model. Breakdown of the dimensions into constructs is not provided, but specific measures for each dimension are identified. This model is illustrated in Figure 5 and uses the following dimensions:

- System Quality—taken directly from DeLone and McLean (1992) and refers to overall quality of the hardware and software.
- Information, Communication, and Knowledge Quality—refers to the quality of the stored data, information, and knowledge, and to the quality of knowledge flow methods.
- Knowledge-Specific Service—refers to how well subject matter experts and KMS managers support the KMS.
- System Use/User Satisfaction—taken directly from DeLone and McLean (1992) and refers to actual KMS use and the satisfaction users have with that use.
- Individual Impact—taken directly from DeLone and McLean (1992) and refers to the impact KMS use has on the individual's effectiveness.
- Impact on Collectives of People—refers directly to the improved effectiveness within teams, work groups, and/or communities that comes from using the KMS.
- Organizational Impact—taken directly from DeLone and McLean (1992) and refers to improved overall organizational effectiveness as a result of KMS use.

APPLICATION OF THE FRAMEWORK

To illustrate the use of the framework, the KMS success models are first analyzed by comparing them to the identified set of success factors and determining how well the models reflect the set of success factors. Table 2 summarizes this comparison. Assessing responsiveness to the top four success criteria finds that the Value Chain, Maier, and Lindsey models are not as good at reflecting the observed data as the Massey et al. and Jennex/Olfman models. Also, the only difference between the Massey et al. and Jennex/Olfman models is SF5, Culture. Given that this would be the next

Figure 5. Maier (2002) KMS success model application of the framework

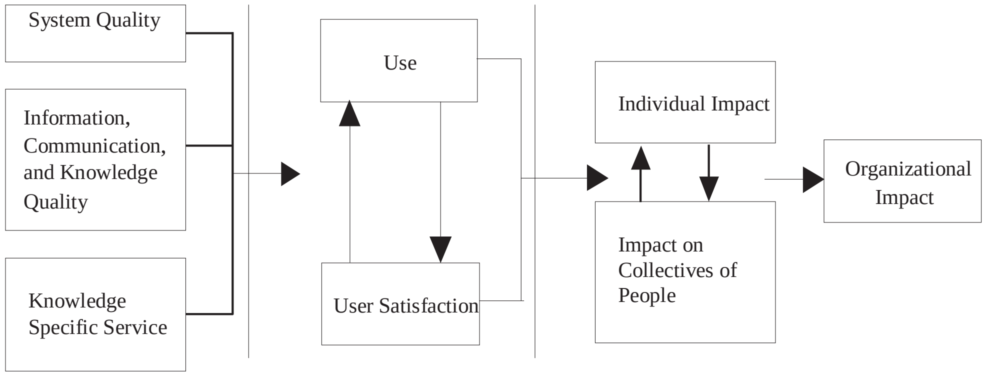


Table 2. KM success models versus KM success factors

Success Factor ID	Value Chain	Massey et al.	Lindsey	Jennex Olfman	Maier
SF1	No clear tie – Share knowledge stage	KM Strategy	Technology construct – networks	Technical Resources and Service Quality Constructs	System Quality and Knowledge Specific Service Quality
SF2	Strategy stage	KM Strategy	Task and Acquisition constructs	KM Strategy / Process Construct	Information, Communication and Knowledge quality
SF3	No clear tie	KM Strategy	Structure and Conversion constructs	Form Construct	Information, Communication and Knowledge quality
SF4	Weak – Apply knowledge stage	Key Management Influences	No clear tie	Perceived Benefit Construct	No clear tie
SF5	No clear tie	No clear tie	Culture construct	Perceived Benefit Construct	No clear tie
SF6	Implied – no clear tie	Key Management Influences	No clear tie	Perceived Benefit Construct	No clear tie
SF7	Return stage	Key Management and Environmental Influences	Task construct	Net Impacts Construct	Impact dimensions, Information, Communication and Knowledge quality
SF8	Strategy stage	KM Strategy	Task construct	KM Strategy/ Process Construct	Information, Communication and Knowledge quality
SF9	No clear tie	No clear tie	No clear tie	No clear tie	No Clear Tie
SF10	Share knowledge and Apply knowledge stages	KM Strategy	Conversion and Task constructs	Level Construct	System Quality
SF11	Apply knowledge stage	KM Strategy	Application construct	Perceived Benefit Construct	No Clear Tie
SF12	No clear tie	No clear tie	Protection Construct	No clear tie	No Clear Tie

most important success factor, it is determined that the Jennex/Olfman model most closely fits the observed data as reflected by the success factors model. It should be noted that further derivation of the Maier model dimensions may improve its fit to the KMS success factors.

Looking at the theoretical foundation for the KMS success models finds that all four have some theoretical foundation. The Value Chain model uses the commonly used Value Chain approach. The Massey et al. model relies on the Holsapple and Joshi (2001) framework. The Lindsey model utilizes organizational capability perspective theory and contingency perspective theory. The Jennex/Olfman and Maier models utilize the widely accepted DeLone and McLean IS success model. Assessing the ability to generalize from the theory, it can be determined that the Value Chain, Jennex/Olfman, and Maier models are utilizing theory that is more widely utilized for assessing effectiveness. However, the Massey et al. and Lindsey models' theoretical foundation may be proven to be more widely applicable after being applied and studied in a variety of organizations and applications.

Assessing the KM success models for applicability to both approaches for building a KMS, it can be determined that the Jennex/Olfman model has no characteristics that would limit its applicability to either KMS approach, while the Massey et al., Value Chain, Maier, and Lindsey models could be interpreted as being specific to an approach. The Value Chain model is typically applied to organizational systems to determine strategic processes, focusing this model on generic/infrastructure uses of a KMS. The Massey et al., Maier, and Lindsey models specifically incorporate task-specific components that may make it difficult to focus the models on assessing organizational effectiveness. However, it can be concluded that all four models could be applied to both KMS approaches if the user is aware of the differences between the approaches and the limitations of the models.

In summary, the proposed framework provides a user a measuring stick for selecting a KMS success model. Users wanting a model based on widely accepted success models and one that fits the observed data (as expressed in the KMS success factors) would rank the models in order of preference as Jennex/Olfman, Massey et al., Value Chain, Lindsey, and Maier. Users wanting a model specifically for assessing a project/task KMS may opt for the Massey et al., Maier, or Lindsey models. Users focusing on generic/infrastructure KMS may opt for the Value Chain model. Users implementing both types of KMS and wanting a single KMS effectiveness model may opt for the Jennex/Olfman model.

CONCLUSION

The proposed framework for assessing KMS success models appears to be useful. It allows users to validate that the KMS success model they are using reflects observed factors that have been found to affect KMS success. The use of the KMS success factors to assess this fit is very powerful and is the major contribution of this article. The KMS success factors were identified from a large number of studies, projects, and KMSs providing a broad view of KMS success.

The use of the other two criteria of the framework is less powerful but still important. It is important to determine that a KMS success model has a theoretical foundation, as otherwise it could simply be a reflection of a single data point's success criteria and may not be applicable to the KMS to be assessed. Additionally, it is also important to ensure that the KMS success model being used applies to the approach of the KMS under consideration. It is inappropriate to apply an organizational effectiveness model to a task/process KMS and vice versa.

REFERENCES

Ackerman, M. (1994). Definitional and contextual issues in organizational and group memories. *Proceedings of the 27th Annual Hawaii International Conference on System Sciences* (pp. 191-200). IEEE Computer Society Press.

Ackerman, M., & Mandel, E. (1996). Memory in the small: An application to provide task-based organizational memory for a scientific community. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences* (pp. 323-332). IEEE Computer Society Press.

Alavi, M., & Leidner, D.E. (1999). Knowledge management systems: Emerging views and practices from the field. *Proceedings of the 32nd Hawaii International Conference on System Sciences.* IEEE Computer Society.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Barna, Z. (2003). *Knowledge management: A critical e-business strategic factor.* Unpublished Masters Thesis, San Diego State University, USA.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Borghoff, U.M., & Pareschi, R. (1998). *Information technology for knowledge management.* Berlin: Springer-Verlag.

Bots, P.W.G., & de Bruijn, H. (2002). Effective knowledge management in professional organizations: Going by the rules. *Proceedings of the 35th Hawaii International Conference on System Sciences.* IEEE Computer Society Press.

Churchman, C.W. (1979). *The systems approach* (revised and updated). New York: Dell Publishing.

Cross, R., & Baird, L. (2000). Technology is not enough: Improving performance by building organizational memory. *Sloan Management Review, 41*(3), 41-54.

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43-57.

DeLone, W.H., & McLean, E.R. (1992). Information systems success: The quest for the dependent variable. *Information Systems Research, 3*, 60-95.

DeLone, W.H., & McLean, E.R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19*(4), 9-30.

Ginsberg, M., & Kambil, A. (1999). Annotate: A Web-based knowledge management support system for document collections. *Proceedings of the 32nd Hawaii International Conference on System Sciences.* IEEE Computer Society Press.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hahn, J., & Subramani, M.R. (2000). A framework of knowledge management systems: Issues and challenges for theory and practice. *Proceedings of the 21st International Conference on Information Systems* (pp. 302-312). Association for Information Systems.

Holsapple, C.W., & Joshi, K.D. (2000). An investigation of factors that influence the management of knowledge in organizations. *Journal of Strategic Information Systems, 9,* 235-261.

Holsapple, C.W., & Joshi, K.D. (2001). Knowledge management: A three-fold framework. *The Information Society, 18*(1), 47-64.

Jennex, M.E., & Olfman, L. (2000). Development recommendations for knowledge management/organizational memory systems. *Proceedings of the Information Systems Development Conference 2000.*

Jennex, M.E., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity, a longitudinal study. *Proceedings of the 35th Hawaii International Conference on System Sciences (HICSS35).* IEEE Computer Society.

Jennex, M.E., & Olfman, L. (2004). Modeling knowledge management success. *Proceedings of the Conference on Information Science and Technology Management (CISTM).*

Jennex, M.E., Olfman, L., & Addo, T.B.A. (2003). The need for an organizational knowledge management strategy. *Proceedings of the 36th Hawaii International Conference on System Sciences (HICSS36).* IEEE Computer Society.

Kaplan, R., & Norton, D. (1992). The balanced scorecard—measures that drive performance. *Harvard Business Review, 70*(1), 71-79.

Koskinen, K.U. (2001). Tacit knowledge as a promoter of success in technology firms. *Proceedings of the 34th Hawaii International Conference on System Sciences.* IEEE Computer Society.

Lindsey, K. (2002). Measuring knowledge management effectiveness: A task-contingent organizational capabilities perspective. *Proceedings of the 8th Americas Conference on Information Systems* (pp. 2085-2090).

Malhotra, Y., & Galletta, D. (2003). Role of commitment and motivation as antecedents of knowledge management systems implementation. *Proceedings of the 36th Hawaii International Conference on System Sciences.* IEEE Computer Society.

Mandviwalla, M., Eulgem, S., Mould, C., & Rao, S.V. (1998). Organizational memory systems design. Unpublished Working Paper for the Task Force on Organizational Memory. In F. Burstein, G. Huber, M. Mandviwalla, J. Morrison, & L. Olfman (Eds.), *Proceedings of the 31st Annual Hawaii International Conference on System Sciences.*

Maier, R. (2002). *Knowledge management systems: Information and communication technologies for knowledge management.* Berlin: Springer-Verlag.

Massey, A.P., Montoya-Weiss, M.M., & O'Driscoll, T.M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *MIS Quarterly, 26*(3), 269-289.

Morrison, J., & Weiser, M. (1996). A research framework for empirical studies in organizational memory. *Proceedings of the 29th Annual Hawaii International Conference on System Sciences.* IEEE Computer Society Press.

Sage, A.P., & Rouse, W.B. (1999). Information systems frontiers in knowledge management. *Information Systems Frontiers, 1*(3), 205-219.

Stinchcombe, A.L. (1968). *Constructing social theories* (republished in 1987). Chicago: The University of Chicago Press.

Thompson, R.L., Higgins, C.A., & Howell, J.M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS Quarterly, 15*(1), 125-143.

Turban, E., & Aronson, J.E. (2001). *Decision support systems and intelligent systems* (6th edition). Englewood Cliffs, NJ: Prentice-Hall.

Yu, S.-H., Kim, Y.-G., & Kim, M.-Y. (2004). Linking organizational knowledge management drivers to knowledge management performance: An exploratory study. *Proceedings of the 37th Hawaii International Conference on System Sciences (HICSS36).* IEEE Computer Society.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

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Chapter 6.29
Linking Small Business Networks with Innovation

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INTRODUCTION AND BACKGROUND

Today, with an economy enabled and driven by connectivity, a fundamental shift in business models is occurring whereby information, knowledge, and relationships underpin competitive advantage. In order to compete in what some refer to as the networked economy, companies across the globe must use technology-mediated channels, create internal and external value, formulate technology convergent strategies, and organize resources around knowledge and relationships (Scott & Storper, 2003).

The rise of information and communication technologies (ICT) and electronic information networks has led firms of all sizes to implement more technology driven solutions for improved productivity and information flow. Malhotra (2000) identified three general information management (IM) developments that have revolutionized company information processes over the last 40 years. The first phase, the automation phase, increased company efficiency of operations. The second phase, the rationalization phase, streamlined those procedures by eliminating bottlenecks made apparent by the automation. The third phase, the business reengineering phase, radically redesigned information and knowledge management processes through technology-intensive implementation of procedures in workflows and work processes (Malhotra, 2000). Now we have reached a fourth phase, the knowledge creation and knowledge transfer phase, that, if possible, is even more closely associated with technology than business process reengineering.

With embedded knowledge flows and innovation linked to communities of practice as well as through linkages using technology, companies of all sizes have the potential to both collaborate and compete by taking advantage of connectivity and new relationships founded on the exchange and sharing of embedded knowledge. This article discusses how knowledge sharing environments such as communities of practice and virtual business communities can be important determinants of commercial viability and business success for small and medium sized enterprises (SMEs), provided that both the (virtual) environment and inter-firm relationships are conducive to information sharing and knowledge flows.

COMMUNITIES OF PRACTICE

Once the domain of special business units and cross-functional teams to perpetuate ideas and embed core competencies, a new form of collective community building has emerged through a spontaneous new knowledge exchange trend known as communities of practice, or CoPs. Burk (2000) simply calls CoPs expansions of one-on-one knowledge sharing. Theorists, Wenger, Snyder, and William (2000) describe them as informal groups of people who regularly share their expertise and experiences; are not formulated or controlled by management; set their own leadership; and follow their own agenda. Lave and Wenger (1991) were among the first to introduce CoPs as context-bound groups of workers who share knowledge around a particular practice.

In many ways, communities of practice are the Western adoption of the holistic Japanese approach outlined by Nonaka and Takeuchi (1995) in acknowledging the importance of tacit company knowledge and transforming it into explicit company assets. However, one of the central benefits of these self-constituting communities is that they sidestep the "ossifying tendencies of large companies and develop rich, fluid non-canonical worldviews to bridge the gap between their organisation's static canonical view and the challenge of changing practice" (Brown & Duguid, 1991, p. 50). This spontaneous think-tank mode of team building through face to face meetings, e-mail, knowledge sharing networks, intranets, and technology-mediated conferencing is an inherently innovative process and is proving to be a crucial aspect of organizational learning and innovation.

Initially, most communities of practice were internal company networking groups to foster shared learning and practices to encourage team-based incentives that directly influenced company profits (McDermott, 2004). Showing great promise in driving organizational learning and innovation, this form of knowledge creation is being adopted in both the public and private sectors, as it is considered the key to survival in the knowledge economy. Communities of practice have also flourished with members from different companies, as exemplified by the chief executive officers (CEOs) of different US companies who make up the Business Roundtable (Wenger et al., 2000).

The application of CoPs to an inter-firm context is in line with the new business models that are favored in the networked economy, in which connectivity, relationships, and knowledge sharing are key assets for competitive advantage (Soekijad, Huis in 't Veld & Enserink, 2004). Within the networked environment, the relationship between connectivity and companies should be seen as reciprocal, whereby ICT and related capabilities – such as virtual community environments like chat rooms and e-mail forums used for product development, product review, and other business information exchange—have a significant impact on how inter-organizational relationships are developed. Examples of new economy inter-firm knowledge sharing may be found in Internet-based companies such as Amazon and e-Toys, which have successfully redefined the value of knowledge assets by fostering information flows between organizations and industries in virtual community environments (Malhotra, 2000). It should be noted that, contrary to the latter example, there are many different forms of sociocultural communities of practice proliferating in the virtual environment with objectives other than competitive advantage, discussion of which falls outside the scope of this article.

While CoPs and other complementary inter-firm relationships have been the subject of considerable empirical research in large enterprises (e.g., McDermott, 2004, p. 624; Pfeffer, 2000, p. 358; Soekijad et al., 2004, p. 623), studies on the role of CoPs with regard to small and medium sized enterprises (SME) are less abundant. Building on the concept that global positioning and competitive advantage for SME may be achieved through clustering or network building and collaborative knowledge creation, the rest of this article explores the potential of a timely synergy between connectivity and collaborative business models for SME in embracing knowledge community practices.

SMALL BUSINESS NETWORKS

As seen above, ICT and related capabilities such as virtual community environments can have a significant impact on how inter-organizational relationships are developed. However, the structure and culture of an existing network of organizations itself also seems to have considerable predictive power for the way in which the telecommunications network is developed, implemented, and used (Nouwens & Bouwman, 1995). Adoption of network structures and networked technologies by SME is generally related to the size and nature of SME and largely depends on their perception of affordability and business growth opportunities for their business (OECD, 2000).

New ways of doing business to achieve success in the techno-economic innovation paradigm bring to the fore ICT adoption and strategic planning issues. Research into the adoption of networked technologies by SME indicates that SME generally approach clustering and networked infrastructures such as the Internet with caution and still hesitate to invest their time and money in a rapidly changing economy (NOIE, 2000), nor do SME necessarily view the Internet as a vehicle to transform their individual business capability from a parochial to a networked or global level, which may be achieved through the set-up of electronic commerce (e-commerce) portals or other Web-enabled cluster structures (Murray & Trefts, 2000). The latter study cites lack of technology skills, lack of a strategic sense of how to move forward, and fear of competitor use of the Internet as significant barriers for uptake of networked technologies by SME. Therefore, creating network infrastructures and knowledge flows between small firms is contingent, not on adoption of ICT technology alone, but on economic and social contexts as well.

European studies on SME positioning in the networked economy point to SME networking and knowledge sharing as contingent on favorable economic conditions, for example, by providing government-sponsored external networks (Cooke & Wills, 1999; Fariselli et al., 1999). An Asian study similarly provides empirical evidence that successful SME collaboration needs to be underpinned by resources that provide SME with the tools to become global players (Konstadakopulos, 2000). The European studies on SME positioning in the new economy also associate social capital with enhanced business, knowledge, and innovation performance (Cooke & Wills, 1999; Fariselli et al., 1999). Social capital can be roughly understood to mean “the goodwill that is engendered by the fabric of social relations” (Adler & Kwon, 2002, p. 17). While social capital and embracing connectivity through public or private initiatives may facilitate the electronic linking of SME to one another for potential business-to-business (B2B) resource and information sharing, and help to reduce isolation of individual SME, there is another critical factor to consider in terms of knowledge exchange between SME, and that factor is trust.

There is a considerable body of literature on inter-firm trust. Trust and social capital are attributes not only of organizations but also of communities, industry networks, or even entire geographic regions, which can help expedite economic development and facilitate large-scale economic activities (Fukuyama, 1995). Trust between network partners is said to reduce fear of opportunistic behavior and improve collective learning and knowledge sharing. The trust may be historical and already exist between different firms, as illustrated above, or it can be built during the relational exchange (Gulati, 1995; Ring & Van de Ven, 1992). Some scholars argue that relationships do not necessarily have to be based on trust as long as systemic mechanisms are in place which allow stakeholders to have confidence that network partners will exhibit cooperative rather than opportunistic behavior and not take competitive advantage of knowledge-based exchanges (Das & Teng, 1997). In the aforementioned Asian example of SME collaboration, information sharing and learning was in fact taking place based on prior existence of trust and in an atmosphere of continued trust building between stakeholders (Konstadakopulos, 2000).

Corporate company members tend to join a community of practice or a community of interest for networking or learning purposes in their field, trusting other company members in the exchange of explicit and implicit company knowledge for the public good aspect and building of company assets. This type of collaborative learning and innovation in large companies is facilitated via the company infrastructure such as e-mail, company intranets, and other technology-mediated tools such as video-conferencing. Given the lack of networked infrastructure between SME and the frequent individualistic nature of small firms, SME are more likely to compete than collaborate in a knowledge exchange milieu. Thus, to approximate community of practice results, if indeed such results are desirable, SME networks are likely to require infrastructure and knowledge exchange conditions that engender trust (Braun, 2002).

FUTURE TRENDS FOR SME

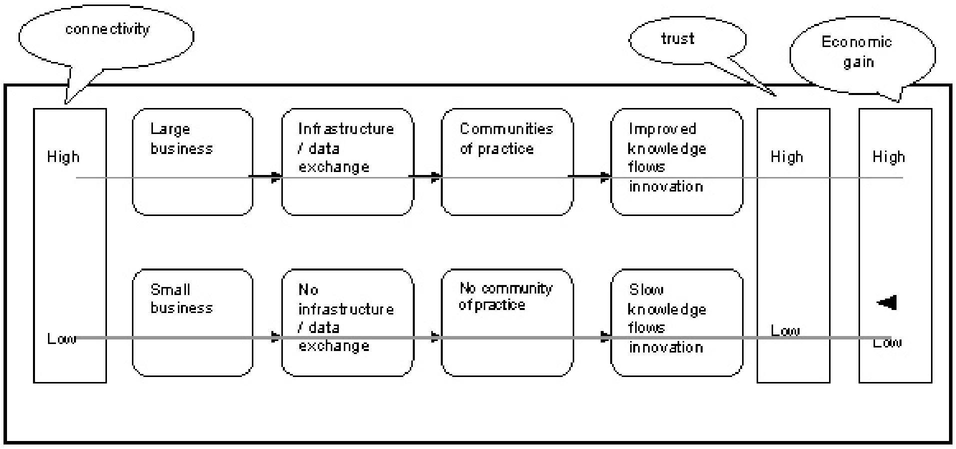
With networking, collaborative information flows, and communal knowledge creation providing potentially beneficial economic outcomes for SME in today's economy, SME may be willing to engage in collaborative knowledge sharing relationships, provided that connectivity (infrastructure), network relationships, and trust conditions are present.

Figure 1 maps knowledge flows against limitations such as size, connectivity, and lack of interaction and suggests that fostering a culture of connectivity, cooperation, and trust building between SME to initiate and encourage community of practice type knowledge diffusion may offer a potential solution to possible loss of competitive advantage for SME in the networked economy.

The top of the knowledge flow model shows how a large company with high connectivity and an integrated infrastructure for information and knowledge exchange via communities of practice can lead to a high level of trust and subsequent innovation and competitive advantage. The bottom part of the knowledge flow model shows how an SME with low access to a networked infrastructure and a low level of knowledge exchange leads to a low level of trust in industry or alliance partnering, which in turn can lead to isolation and loss of competitive advantage for individual SME in the networked economy.

The model displays two extreme positions, for example, a large company with highly integrated connectivity vs. a small company with little or no connectivity. Alternative scenarios in terms of company size, connectivity, and level of interaction would impact on competitive advantage and the level of innovation; for example, a large

Figure 1. Knowledge flow model



company without an integrated infrastructure and a climate of data exchange would likely exhibit lower levels of knowledge flow and innovation. A small company with full connectivity (to the Internet) but without active participation in an online knowledge network would have competitive advantage over a small company with little (e-mail only) or no connectivity, while a high connectivity SME subscribing to a networked knowledge exchange culture would have competitive advantage over a connected yet network-isolated SME. Considering connectivity, local network conditions, the character of local practice, and the uniqueness of social capital within each region is pivotal in developing SME networks for competitive advantage.

In terms of connectivity, large firms with deep pockets have the ability to build their own integrated architecture, while SME access to a networked infrastructure may involve relying on the public purse. Where SME do not have a history of networking and knowledge sharing for the local or regional common good, a knowledge exchange culture will need to be cultivated and coupled to an economic framework that provides clear collaboration benefits and that is linked to tangible results for participating SME (Braun, 2003b).

In addition to offering a networked environment where SME can both collaborate and compete, a culture of trust needs to be fostered through personal interaction and strong relational or social cooperation between firms to learn critical information and know-how from alliance partners (Nonaka & Takeuchi, 1995). Established business networks and regional industry associations can play a key role in stimulating loose collaboration and knowledge exchange between SME.

Stronger ties could potentially be fostered through regional supplier and customer network linkages, as demonstrated by online companies such as Amazon.com. Such linkages can function as conduits for SME communities of practice. With networked technologies now able to provide centralized supplier and customer relations management functionalities, regional SME portals, SME intranets, and other interactive networked environments such as video and desktop conferencing may well provide the required interactive collaborative context to evolve into SME information and learning platforms (Lechner, Stanoevska-Slebeva & Tan, 2000; Stahl, 2000).

Joining the global market as a sole trader, let alone becoming an inter-firm network stakeholder may entail an enormous conceptual leap into the future for many SME owners and managers. Network novices will hence need substantial encouragement and support to make them willing to take the network plunge (Braun, 2003a). Creating awareness of networked opportunities, developing skills in using networked technologies, and providing educational processes around inter-firm relationship building may be beneficial to increase SME understanding of the potential of collaboration. Once individual SME and collective goal orientation is realized, participation in an SME community of practice or industry cooperative is likely to perpetuate trust between SME, which in turn would produce economically beneficial outcomes.

CONCLUSION

This article has discussed how collaborative relationships are becoming one of the most important determinants of commercial viability and business success in the networked economy. With embedded knowledge flows and innovation linked to communities of practice as well as through linkages using technology, SME have the potential to both collaborate and compete by taking advantage of connectivity and new relationships founded on the exchange and sharing of embedded knowledge.

There are obvious differences between large and small firms both in terms of availability of resources for connectivity and in terms of community of practice membership. Given the often independent nature of SME, exact emulation of a large company community of practice may not be feasible or even desirable, but a variety of models can be examined to identify appropriate connectivity-driven inter-firm network structures for SME and approximate desired community of practice results.

Having drawn on the inter-disciplinary fields of economic development, new business models, collaboration, and trust, it is suggested that overcoming potential loss of competitive advantage for SME in the networked economy will require strategic SME community building with connectivity, trust, and relational capital as pivotal building components. Taking communities of practice as the vehicle for knowledge sharing between SME, attention must be paid to local conditions, the concept of practice (Brown & Duguid, 2001), and how practice relates to trust. While this article demonstrates the importance of knowledge sharing in the networked economy, it also shows that the key to economic staying power is vested in people and their culture rather than in technology.

REFERENCES

Adler, P. S., & Kwon, S. W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review, 27*(1), 17-41.

Braun, P. (2002). Digital knowledge networks: Linking communities of practice with innovation. *Journal of Business Strategies, 19*(1), 43-54.

Braun, P. (2003a, June 12-13). SME networks and innovation: Knowledge creation in small firms. *Proceedings of the 11th Annual International High Technology Small Firms Conference (HTSF).*

Braun, P. (2003b). Virtual SME networks: Pathways towards online collaboration. *Journal of New Business Ideas and Trends, 1*(2), 1-10.

Brown, J. S., & Duguid, P. (1991). Organizational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organization Science, 2,* 40-57.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science: A Journal of the Institute of Management Sciences, 12*(2), 198-214.

Burk, M. (2000). Communities of practice. *Public Roads, 63*(6), 18-22.

Cooke, P., & Wills, D. (1999). Small firms, social capital and enhancement of business performance through innovation programmes. *Small Business Economics, 13,* 219-234.

Das, T. K., & Teng, B. (1997). Sustaining strategic alliances: Options and guidelines. *Journal of General Management, 22*(4), 49-64.

Fariselli, P., Oughton, C., Picory, C., & Sugden, R. (1999). Electronic commerce and the future for SMEs in a global market-place: Networking and public policies. *Small Business Economics, 12*(3), 261-275.

Fukuyama, F. (1995). *Trust.* New York: Free Press.

Gulati, R. (1995). Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal, 38*, 85-112.

Konstadakopulos, D. (2000). Learning behaviour and cooperation of small high technology firms in the Asean region. *ASEAN Economic Bulletin, 17*(1), 48-62.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lechner, U., Stanoevska-Slebeva, K., & Tan, Y. H. (2000). Communities & platforms. *Electronic Markets, 10*(4), 231.

Malhotra, Y. (2000). Knowledge management for e-business performance: Advancing information strategy to "Internet time". *Information Strategy, The Executive's Journal*, *16*(4), 5-16.

McDermott, R. (2004). How to avoid a mid-life crisis in your CoPs. *KM Review, 7*(2), 10-13.

Murray, R., & Trefts, D. (2000). *The IT imperative in business transformation*. Retrieved May 6, 2005, from http://www.brint.com/online/

NOIE. (2000). *T@king the plunge 2000: Sink or swim*. Canberra: National Office for the Information Economy, Commonwealth of Australia.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Nouwens, J., & Bouwman, H. (1995). *Living apart together in electronic commerce: The use of information and communication technology to create network organisations.* Retrieved May 6, 2005, from http://www.ascusc.org/jcmc/vol1/issue3/vol1no3.html

OECD. (2000). *A global marketplace for SMEs, progress report by the Industry Committee Working Party on SMEs.* Retrieved May 6, 2005, from http://www.oecd.org/EN

Pfeffer, J., & Sutton, R. (2000). *The knowing-doing gap: How smart companies turn knowledge into action*. Boston: Harvard Business School Press.

Ring, P. S., & Van de Ven, A. (1992). Structuring cooperative relationships between organizations. *Strategic Management Journal, 13*(7), 483-498.

Scott, A. J., & Storper, M. (2003). Regions, globalization, development. *Regional Studies, 37,* 579-593.

Soekijad, M., Huis in 't Veld, M., & Enserink, B. (2004). Learning and knowledge processes in inter-organizational communities. *Knowledge and Process Management, 11*(1), 3-12.

Stahl, G. (2000). Collaborative information environments support knowledge construction by communities. *AI & Society*, *14*, 71-97.

Wenger, E., Snyder, W. M., & William, M. (2000). Communities of practice: The organizational frontier. *Harvard Business Review, 78*(1), 139-146.

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Chapter 6.30
Managing the External Provision of "Knowledge Management" Services for Projects

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ABSTRACT

Knowledge management has largely been considered from the perspective of internal generation. It is posed that external provision will increase due to the diversity of problems and scarce resources, the arising issues being explored through a case study. The aim is to explore this process for construction projects. It will be shown that the successful delivery of knowledge services for the construction industry depends upon the way in which the provider conducts its marketing and the operation of gatekeepers in the project organisation. These issues are explored in relation to the main concepts and theories, applying and evaluating these through the case study approach.

INTRODUCTION

This chapter explores the issues for knowledge management where the knowledge and the application are derived in one organisation and used in another—the external provision of information and knowledge management services. The aim of the chapter is to explore this process for construction projects. It will be shown that there are particular issues to be addressed in the successful delivery of knowledge services for the construction industry, specifically the role of marketing and the operation of gatekeepers where the project is the main means of delivery. These issues will therefore be explored within the project working environment, bringing to bear the main concepts and theories, and applying and evaluating these through a case study approach.

LEARNING OBJECTIVES

This chapter provides the opportunity for:

1. Analysing the issues involved in the external provision of KM.
2. Gaining an understanding of the gatekeeping role of the knowledge manager in the user firm.
3. Securing a knowledge of the marketing requirements of the supplier in external knowledge provision.

BACKGROUND

Nonaka and Takeuchi (1995), following Polanyi (1966), have classified knowledge as being explicit or tacit. It has been argued that specific strategies and processes are needed to make tacit knowledge explicit and to manage that knowledge to the benefit of the organisation (Teece, Pisano, & Sheun, 1997). The process of developing competencies and capacities to achieve these requirements has been divided into four areas of organisational activity (Leonard-Barton, 1995):

- Shared creative problem solving
- Integrating and implementing new methods and adopting new tools
- Formal and informal experimentation
- Learning outside of the organisation

This chapter focuses upon the last of the four areas—the external provision of learning. For external provision from one organisation to another, the knowledge has to be made explicit and managed in such a way that it can be marketed and sold either as a knowledge management service package or a bespoke service to meet specific needs. This is an important and under-researched area in industry and in the whole sphere of knowledge management. The external provision of knowledge management services for problem solving is likely to increase. The strategy for an organisation demands choices, which precludes options, hence the allocation of resources in support (see, for example, Mintzberg et al., 2002; Johnson & Scholes, 2002). KM may not be a strategic area for investment, but even where it is, there are two primary reasons why external KM provision will increase:

1. The specific processes selected by any one organisation to realise knowledge management and organisational learning objectives inherently limit the range of knowledge that can be captured, managed, and successfully applied.
2. There is a high cost to the generation of knowledge and learning, so efficiency of generation is likely to be maximised by those specialising in certain areas of expertise and bodies of knowledge.

Strategies and specific processes provide direction for a firm, which provides the context for knowledge management and organisational learning pursuit both in overall emphasis and the specific areas in which it can be maximised. Other aspects of learning and knowledge management will therefore take second place or be excluded. Hughes and Kao (2001) also demonstrate that there can be advantages to acquiring external information rather than developing it in-house in an integrated way (cf., Shavell, 1994). These include speed and cost of provision, as well as potentially effective solutions mobilised from a different resource base.

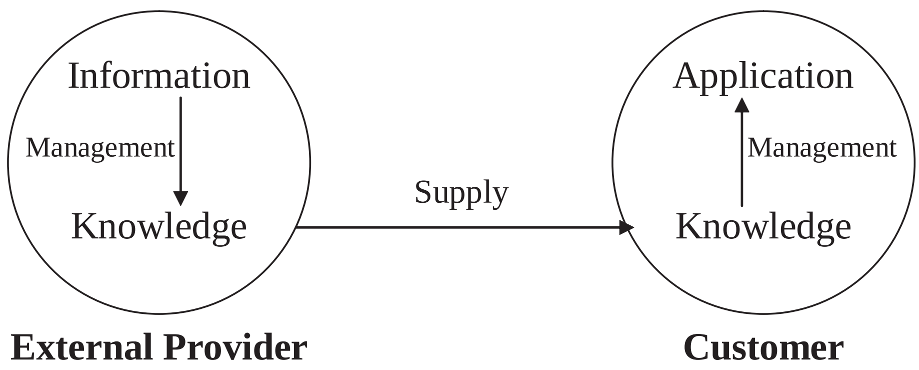
Cost, the second issue, will relate to the above in that budgets and spending will be focused upon the areas of strategic preference. The areas where less effort has been focused will have higher costs as the starting point and will be weaker or at a comparative disadvantage. The internal costs will be high. Thus, when the cost of internal generation becomes high, the cost of purchasing a solution in the market is more favourable. The external production and transaction costs are lower than the internal production costs (Williamson, 1985).

There is the market for information and knowledge. The provision process in the sense of the knowledge generation and application is demonstrated in Figure 1. The market exists where there is asymmetry of information between internal sources (including those that can be obtained 'free') and the external provision of information (Milgrom & Roberts, 1992). Although the quality of information is uncertain in advance (Akerlof, 1970), and therefore the transaction costs may prove to increase in order to search out the quality and assess risk (Williamson, 1985), the external provision may prove the best option. Shavell (1994), however, argues that partial disclosure of valuable information provides an incentive for buyers to acquire remaining information. In these ways the market for knowledge is similar to the market for information. Drucker (1995) was amongst the first to view knowledge as a capital asset or resource to be utilised, and therefore intellectual capital becomes recognised as a scarce commodity. Drucker (1989, 1993) identified the knowledge worker with ways of thinking that transcends industries. Groák (1994) coined the concept demand chain to indicate how technology and innovation for construction projects can be drawn from a range of industries. In this context, the external knowledge can then be injected from outside the construction enterprise, whether in design or contracting, into the other three activities, mostly the first concerning problem solving in a project working environment.

In construction and many other project working environments, teams are multi-organisational (Cherns & Bryant, 1983), giving rise to two additional costs:

1. The creation and realisation of knowledge at the level of the project and capturing; management and diffusion of that knowledge across the organisation and other projects (Smyth, 2004).
2. The transfer of knowledge and learning across organisational boundaries at the project level.

Figure 1. Information and knowledge generation and application from an external provider



External sources of knowledge are therefore a valuable supplement, if complementary and additional to internal sources. Project-specific knowledge is therefore a notion or concept for which external provision is likely to be a practical solution to meeting the practical need—a socio-technical solution for construction. In summary, such sources will be accessed where the value added is greater than the marginal cost to the service or product, or where the organisation secures a competitive advantage relative to the costs.

THE KNOWLEDGE MANAGEMENT MARKET

What is the knowledge service, product, or commodity? Egbu and colleagues (2003a) have drawn attention to the paucity in definition and articulation of the tools for knowledge management (KM). The tools can be divided into:

- KM techniques
- KM technologies

The tools of techniques and technologies both imply a service, which can be dynamic and tailor-made, created and applied internally, or sourced from an external provider. External provision can be sourced as a pre-packaged service or bought off the shelf, hence reconstituted to appear as a product. Such products can be used by a number of clients; the higher the rate of usage, the more the product becomes a commodity, and the value, hence price, diminishes over time. Bespoke services will be relatively, if not totally unique, hence are of potentially high value and price. KM techniques require strategies for development and realisation (Egbu et al., 2003a), yet the external provision of KM services requires a particular form of strategy—marketing principles (Smyth, 2000). The particular problems the KM-marketing interface must address are:

- Identifying the KM needs of consultants and contractors managing projects in order to generate KM service packages and bespoke solutions.
- Marketing the bespoke services and packages to consultant and contractor organisations to create awareness in advance of their perceived need for the KM services.
- Getting past those responsible for information, areas of expertise, and knowledge—gatekeepers—in the organisations to the real end user requiring the project-specific knowledge.

This chapter explores these issues for KM provision in construction through a case study. The case study, Concrete Information Limited (CIL), has its origins in the forerunner to and within the British Cement Association as its former library and information service. The British Cement Association has operated an extensive library and information service for many years. This has been restructured into a knowledge-based service. There are two foci. The first is pre-specification, which is the historic focus for information, which is now being developed around market data. This switch in 'product' area is in its infancy; therefore, this chapter mainly develops the case around the post-specification segment of CIL's business. The pre-specification market segment is composed of a number of areas, The Concrete Centre being a key client. TCC was launched in September 2003 as a new initiative to help specifiers in the choice of structural materials in design. The second and recent focus is on KM service provision post-specification for the cement and concrete sectors. CIL is thus an external organisation responsible for supplying knowledge within a complex field of business-to-business social networks, a large proportion of which are and will increasingly be aimed at problem solving within projects. This case arises from a two-year research project on CIL, during which CIL has been restructured from an information provider based upon a public-sector approach to a commercial KM provider. It is providing information and knowledge to a range of end users, and especially to serve project-specific needs as a key market segment. It is jointly owned by the British Cement Association and the Concrete Society, both trade bodies representing concrete and cement interests.

CONCEPTUAL ISSUES IN THE EXTERNAL PROVISION OF KM

The main objective is to address the three problems cited: identifying the KM needs of consultants and contractors managing projects, marketing the bespoke services and packages, and reaching the real end user. This is achieved by engaging with the literature and by exploring the practical outworking through the case study.

Identifying KM Needs

Using the classification identified in recent research by Egbu et al. (2003b), a profile of services can be generated. Their classification is:

1. Main triggers of knowledge production (and in this case it includes need):
    - Problem solving
    - Innovation
    - Managing change
2. Main sources of knowledge production:
    - Expert individuals
    - Team and supply chain
    - Routines
    - Repositories
    - Communities of practice
    - Knowledge gatekeepers

In the case of CIL, the primary trigger is problem solving in developing the design details and production information or site-based problems on a project. The main source in this context is the repository, CIL, which is external, and therefore knowledge has to be accessed as a free advice service or purchased as a service. CIL therefore operates as part of a community of practice (Egbu et al., 2003a), that is, part of a network of different skill bases, histories, and experience that combine at points to realise shared goals (see Ruggles, 1997; cf., Egbu et al., 2003a). These can be located within a diversified organisation, but in a project context typically include a range of organisations working to realise mutual or compatible goals in completing a project.

The knowledge needs of experts and managers of knowledge, often assigned to the role of technical director and/or knowledge manager in large contracting organisations or consulting groups, will be rather different from a contract's director or a site manager, whose requirements are project-specific knowledge. The technical director or knowledge manager will serve design and production functions, and thus will apply knowledge to reduce uncertainty further down the project process and ensure quality for the finished structure. The KM need is primarily problem-solving innovation according to the classification above. Project-specific knowledge will be entirely focused upon problem solving. These will be issues that have not been recognised upstream or were totally unexpected and require an immediate solution, not only in their own right, but also in the context of completing the project on time and within budget without compromising quality. These needs at the project level are difficult to predict for an external provider, just as they are unforeseen internally. Therefore these needs have to be met from the repository of information available, the external provider creating generic packages of services. The provider derives the packages from experience of past patterns of demand, feedback, and market research. Other services will be bespoke of necessity.

The next issue is to make the market aware of the service and to sell them. This is the marketing function.

Marketing Bespoke Services and KM Packages

Organisational learning and knowledge management are perceived as competencies for the creation of effectively serving clients and improving internal efficiencies. This perspective of KM concerns strategy. At a tactical level, few people in practice talk about knowledge management as a starting point. They talk of performance. Knowledge management follows as a means to enhance performance. Harnessing KM is a means to an end, and is not the driver (Construction Productivity Network 2003). The consequence is that the awareness of the need for KM is secondary within an organisation, performance being primary. Where knowledge is provided from an external source, the perceived need for KM becomes one step removed and thus is tertiary in priority. Within a project environment, especially where the project is spatially removed from the organisational hub, the need for KM becomes a further step removed or quaternary in priority. This is of crucial significance. The final step is where the role of the gatekeeper within the organisation becomes critical and will be returned to below. At this stage, the main aim is to look at the overall picture created by this 'distance' and the role of marketing in bridging this gap.

Marketing is concerned with how to sell services, and the implementation is the sales process. Marketing is about managing the market; that is, creating and retaining a customer (see Kotler, Armstrong, Saunders, & Wong, 1996; Levitt, 1983; and in the construction context, Smyth, 2000). An initial issue for marketing is how to create awareness of the service and then how to promote the content of the service, both in package and bespoke forms. It has been stated that the quality of information is uncertain in advance (Akerlof, 1970); therefore, the transaction costs may increase in order to search out the quality and assess risk (Williamson, 1985). The marketing strategy and the promotion effort are designed to overcome these obstacles that arise from the external provision of information and KM services. The obstacles to overcome are greater in this case:

- Lack of advance need for KM services without increased awareness—project-specific knowledge is mobilised to solve problems as they arise.
- Distance created by external provision—a barrier to being aware of availability.
- Uncertainty of information quality in advance—location in a separate organisation, coupled with private ownership, prevent the uncertainty being automatically overcome.
- Internal distance created by dislocated projects and (in)action of gatekeepers.

These latter two factors arise out of the way in which organisations are constituted and operate (Child & Heavens, 2001).

There are two primary marketing paradigms: the marketing mix or transaction approach and the relationship marketing approach (see, for example, Gummesson, 2001; Smyth, 2000). The marketing mix approach grew up in the post-war era of mass markets of the United States and thus has its origin in the consumer or over-the-counter (OTC) retailing market. The mix is made up of four ingredients, measured out according to the recipe required for the circumstances. The ingredients are called the 4Ps:

1. Product
2. Price
3. Place
4. Promotion

Setting the right price to a product design and specification are clearly key. The delivery channel, which embraces distribution and the retail outlets, are the elements of place. Promotion embraces the full range of branding, advertising, PR, endorsements, and so on. Put simply, if you get the mix right, the marketing campaign will prove successful. This approach works where a number of factors exist:

- The product or service can be specified in advance.
- The market is of sufficient size to justify the packaging and promotion of the services.

This approach is certainly not suited to meeting very specific problems at any stage of the project life, but especially on site. A bespoke service is required. Over the last 20 years, it has been argued that business-to-business marketing is more appropriately conducted on a relationship basis. The Nordic School developed the paradigm of relationship marketing (see, for example, Gummesson, 2001; Smyth, 2000) in recognition that this is how people originally sold their wares, that it had become more problematic as organisations grew, but that systems could be put in place to replicate what had been lost on a business-to-business basis, often articulated through some key personnel.

This paradigm has received much wider recognition, even in consumer markets through reward cards. In this way retailers can profile the spending patterns of groups of customers representing particular market segments. There is a level of certainty of demand patterns that can be derived from aggregated data. In a business-to-business service environment, that feedback comes from listening to and interacting with the customer. The issue with a project problem-solving context once the project is underway on site is that there may be a relationship with the technical director, but not those solving problems on the project itself. The technical director or equivalent essentially becomes the prime relationship, acting as a gatekeeper to others.

The Project End User and Gatekeepers

Gatekeeper is a sociological concept applied to managers of a system in relation to the allocation of scarce resources, and was investigated widely in the public domain (see, for example, Pahl, 1975, for an early influential example). There has been less attention within private enterprises to the allocation. As in the public domain, allocation of resources in private organisations provides a source of power for the gatekeeper. The gatekeeper is an important information source for KM within the customer organisation. In the KM context the gatekeeper is a facilitator of knowledge production, or for its flow from the external environment to the project. However, the gatekeeper can also be an obstacle to effective dissemination of knowledge within an organisation. Child and Heavens (2001) give two reasons:

- Historical embeddedness of processes that goes against the grain of KM creation and dissemination in terms of;
  - Social systems (see also Stinchcombe, 1965; Johnson, 1990)
  - Social behaviour (see also Granovetter, 1985; Leonard-Barton, 1995)
- Leadership and authority systems that do not legitimise or facilitate dissemination—Senge (1993) places leadership in a key position for initiating learning and hence KM.

Child and Heavens recognise that learning and knowledge management are not only a process of generation and processing, but are also outcomes, that is, they impact upon performance, which does not automatically flow from the inputs. The issue about external provision is that it flows at that point of potential disjuncture between the processing and application. In that sense demand is not driven by strategy from above, but is driven by needs at the operational level. Therefore three levels for generating learning and knowledge occur: senior management, operational, and external suppliers (see Figure 2).

From this a model of learning and KM can be constructed that encompasses internal and external sources, which demonstrates the interface both in terms of how firms are organised in hierarchy and the horizontal management functions (see Figure 3).

The boundary of the firm must simultaneously be retained whilst being penetrable. Using a military analogy, the management issue is to know when the drawbridge of the castle should be up or down. In an economic and management environment, where the ability to generate a range of learning and knowledge to be effective and efficient in performance is constrained by management strategy and costs, external sources are becoming and will continue to become of greater significance. Boundaries therefore need to be penetrable—the drawbridge must be down so that key players in the firm are open to external ideas from the stage of receiving information that creates awareness to the stage when a problem surfaces that needs resolving using external information and KM services, hence the possibility of the key player connecting the awareness of the external source with the source to create the solution (cf., Tushman & Katz, 1980).

The key player becomes the gatekeeper of the knowledge source and some of the content, especially service packages. The role of the gatekeeper is:

- Being aware of the external sources and services
- Accessing information and knowledge

Figure 2. Three relationship channels for effective organisational learning (adapted from Child & Heavens, 2001, p. 314)

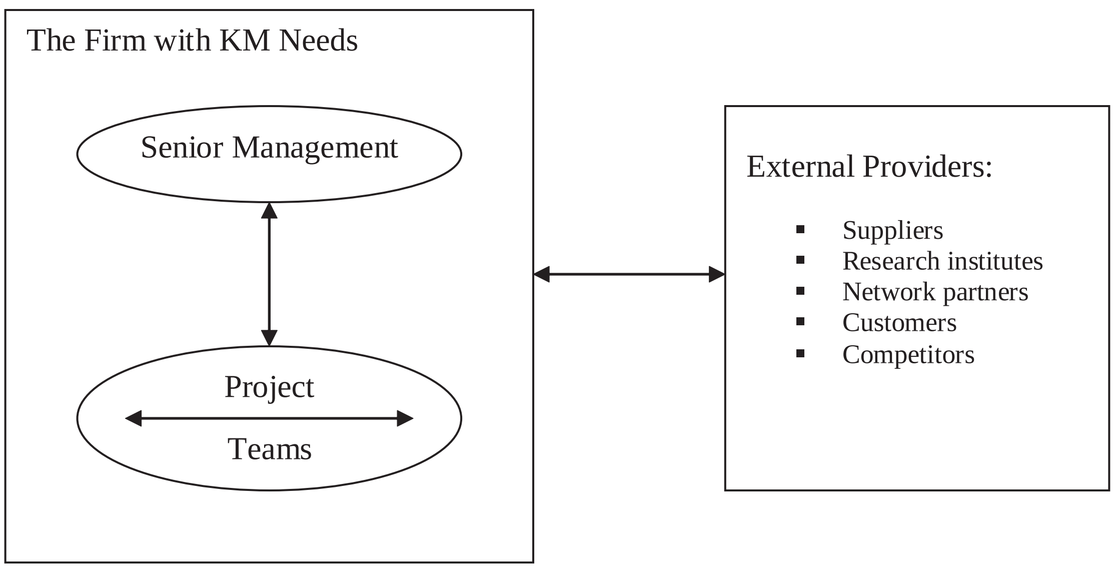
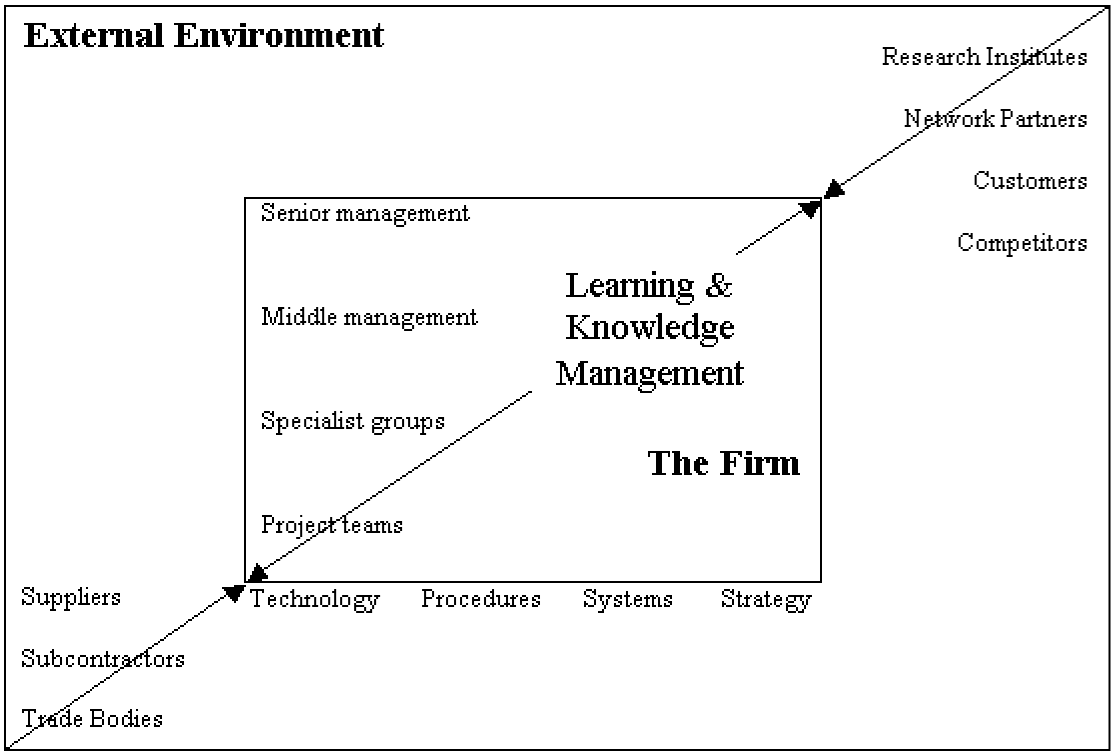


Figure 3. The interface between internal and external learning and KM



- Processing information into knowledge and integrating knowledge to match the culture, systems, and technical needs of the firm
- Disseminating the right knowledge to the right problems at the right time

In practice, there are problems with the effective functioning of those who are responsible for technical information and knowledge management—the gatekeepers:

- Those who primarily have an inward focus will have a tendency to have low levels of awareness of services and therefore will be ineffective at identifying the relevance of external knowledge to fit current and future internal needs.
- Those who primarily have an external focus will have a tendency to be less aware of internal needs and will have more difficulty processing knowledge to fit the internal language, systems, and strategy.
- Knowledge is power and some gatekeepers may use their role to reinforce their position, profile, or political stance in the firm, hence trading off effectiveness in the best interests of the firm in favour of personal power.

THE CASE OF THE CEMENT AND CONCRETE SECTOR IN THE UK

Case Study Method

The methodology is ethnographic, whereby participation and observation occurred within the primary actors (see Dunnette, 1976). The primary actors are CIL, a joint venture between the British Concrete Association (BCA) and the Concrete Society (CS). There has also been an element of action research, as participation has led to influencing the shape of service provision. This started initially with a consultancy contract and then developed through the UK government Teaching Company Scheme, now called Knowledge Transfer Partnerships.

The data is therefore mixed in sources, using observation, formal documentation, and notes derived from participatory activities. The evidence is primarily qualitative and provides greater capacity to address "how" questions in a dynamic and complex context. The method has permitted close contact with the subject over a long timeframe. It assures data validity through both: (1) an iterative process of evaluation over an extended time in conducting the research, and (2) reflection among the actors in examining the findings, thus offering the opportunity to address misunderstandings or misinterpretation in the data analysis. It is inappropriate due to confidentiality to reference all internal documentation. This is provided where possible.

Context

The British Cement Association (BCA) is a key trade organisation for the sector. It provided specialist technical information to the concrete and cement industries through its former library and information services. This service was characterised as being the provider of information, the aim being to provide a service that would help to promote the use of concrete and cement in construction and the design of projects. The approach was a quasi-public sector one. Recipients were typically technical directors and heads of specialist fields, who were responsible for dissemination within their organisations. Some were occasional users, some regular users and subscribed as members, receiving documents, standards, books, and other publications on a preferential basis. Other income was received through some sales and direct support from the BCA.

Restructuring

This service has been restructured, exhibiting some classic features of 'marketisation', to independently serve the knowledge management market. Serving this market requires not only the provision of information for others to process, but also the processing of information into knowledge. The service is now delivered through Concrete Information Limited (CIL).

This change has gone hand in hand with some restructuring of the information services. In essence, the sector launched The Concrete Centre (TCC) in September 2003 to parallel the successful initiatives of the steel sector. TCC is supported by the industry trade organisations and by leading producers. Its remit is to focus upon the specifier market. This was the traditional operating area of CIL. BCA continues direct support to CIL and has also brought in the Concrete Society, having transferred 50% of its shareholding in CIL to this other leading trade association.

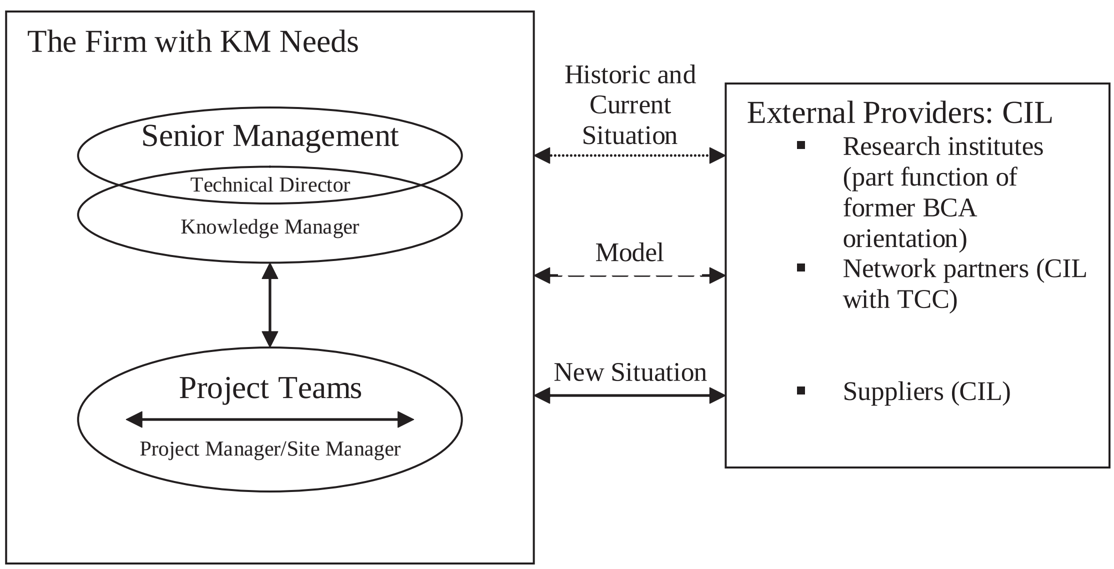
Market Reconfiguration: Awareness, Marketing, and Gatekeepers

Under the new configuration CIL is working towards being a commercial entity in its own right, income derived from open market sales and through membership. One of the key member clients is TCC; therefore a relationship marketing approach is most appropriate, and it is anticipated that the links will strengthen over time. TCC has a pre-specification focus and therefore is one important CIL client in this area. CIL will serve the regional representatives of TCC, and through them build relationships with their customers where concrete is specified and innovation or problem-solving services are required. TCC regional representatives are acting as facilitators rather than gatekeepers. They are more akin to sluice gates, that is, encouraging the rate of information flow, than gatekeepers, who tend to keep back knowledge that is not perceived to be in the best interests to release. The particularities for these circumstances are shown in Figure 4.

Whilst the model may infer that the relationship is three-way due to the automatic dispersal or dissemination up and down the client organisation, it was always dependent upon the internal functioning of the client organisation. That has changed into a new situation. An additional primary market target is the project level, and the technical director, knowledge manager, or people with the responsibility cannot be assumed to be motivated nor committed to making those who may need the service aware of the possibilities, nor be in an informed position to give advice to call upon the services of CIL. In terms of Figure 3, the target has moved from the top right-hand segment—the Research Institutes and Network role of supplying the senior management within the firm—to the bottom-right segment—the Suppliers and Trade Body relating to the project of the firm—where it was always partially located, but is now more concentrated, except for its role in relation to TCC.

While clients, some introduced through TCC, may be tracked and the contact maintained, many other projects may not require the involvement at CIL at the initial stages. So generally, the prime point of contact is no longer solely nor mainly the technical director or the knowledge manager for the entire consultant, contracting, or supplier organisation to those implementing the project.

Figure 4. Relationship channels for CIL



This raises a crucial issue about reaching the end user at the project level. The two main and related marketing issues are:

1. Paradigm choice
2. Creating awareness

Theoretically, a relationship marketing approach would be the ideal choice in this context, as the needs are likely to be very different for each project. However, the project staff confronts a number of issues that have been identified earlier in the chapter which act as filters:

- Uncertainty about the need for information and knowledge in the future (Milgrom & Roberts, 1992)
- Uncertainty of the quality of information and knowledge available (Akerlof, 1970)
- Uncertainty of the availability of information and knowledge
    - Role of gatekeepers
    - Effectiveness of awareness creation from external provider

CIL is facing all these issues and thus the relationship approach is difficult to establish, particularly at the front end of the market changes. Reputation in the new market will help and the project network will create referrals in due course. Until such time, CIL is dependent upon relationship opportunities introduced through TCC and a marketing mix approach. The mix is generated from several sources:

- Market feedback and intuitive feel for service packages based upon experience
- Short-term market research and longer term monitoring of demand patterns

Price is a sensitive issue. The construction industry is reticent to invest by economic predisposition. The previous regime led to a 'free' or minimum charge service. The service is being developed to reflect the high value with a corresponding price tag (Oxon Consulting, 2001). The true cost of production, transactions, and renewing the resource has to be recovered to perpetuate availability. The remix of the services, tailored to needs, will help the transition. Hence the 'product', in this case the service package, is changing. The delivery channel is essentially the same, but both more proactive and more targeted towards the end user segment concerned with projects. Promotion is reliant upon mailouts targeted both across the market and towards niches.

It is recognised that there are limits to this type of marketing mix promotion. The market is not so large that it can withstand too many and sustained direct marketing campaigns of this nature. However, it creates awareness, generates cash flow from a low cost base, and hence is an important baseline for growing more sophisticated and targeted marketing in the longer run. Repositioning in the market and creating awareness amongst a new customer base is a dynamic process, which requires a changing mix (Concrete Information Limited, 2003). The industry network is strong. The former network was based around the roles of technical directors, experts, and whoever performed these information gathering and disseminating roles. This new market is a slightly different network, a network of end users looking for project-specific knowledge to solve problems. Gaining access is the key, as market research indicates that the traditional gatekeepers are proving to be a barrier—rather than facilitators—to reaching the new market. The motives for this are unclear—pure stress and volume of work, wishing to use information as a tool of power within the organisation, or some combination. It is probably that gatekeepers are working in different ways in different organisations—some using their role as political kudos, some as a power position, some simply overloaded to search out and disseminate the information.

Successful access to the market will help to build relationships at the individual level. Multiple needs will help convert some relationships into members. There used to be one key membership package. Conversion is being facilitated by a series of different membership packages designed for different needs and closeness of relationship. It is anticipated that firms will identify the appropriate entry level and subsequently purchase bespoke services. The rationale is that through membership, issues of uncertainty are overcome concerning quality and availability of information.

Some direct enquiries are being made. These unsolicited enquiries have a long history. Most of these have been one-off requests for information or have been treated as such. Those that were not one-off tended to be from existing members or individuals well known in the industry network. What has changed in the market is that there are a number of enquiries that are being made which are more complex. In essence the demand is for knowledge, not information alone. This is positive market data for the changing patterns of demand and the need for external KM services. In addition, direct enquiries are being treated as potentially longer term, with the opportunity to establish or develop relationships. In all these cases where one-off information services are not required, the relationship approach is being used to define and develop bespoke KM services.

PRIMARY RESULTS

The restructured library and information services, formerly of the British Cement Association, have been re-branded Concrete Information Ltd. (CIL) and placed under joint venture ownership between the Concrete Society and the BCA. The restructuring has been aimed at providing the context for new service provision, summarised as:

- From information services to information and knowledge, especially for the project-specific KM market, that is, at the post-specification project end of the construction business
- From a low-cost service to a commercially sound service, priced to reflect the historic high value and value-added bespoke and service packages
- From a predominantly (and frequently re-active) marketing mix approach, towards securing new business to a combined highly proactive marketing mix and relationship marketing approach to new business
- From targeting technical directors or equivalent to also gaining access to end users on a project's post-specification

While there was some initial internal inertia and adjustment within CIL in the face and wake of restructuring, the new approach has been embraced and actively developed, momentum building up over the duration of change. CIL has faced constraints to the implementation of a commercial approach due to:

- The need for additional market data of client needs
- The reactive nature of demand within client organisations
- The inability of client organisations to be able to adequately identify their future needs

The run up to the launch of TCC provided a surrogate framework for CIL in identifying packages that mirror the services offered pre-specification in the post-specification market. CIL now offers levels of membership associated with different service packages (in addition to pay-as-you-go services). Membership levels are important, as services frequently have to be paid out of project budgets, at least initially.

However, the main constraint is external. Gatekeepers within the client organisation are creating a major obstacle to awareness creation of the services. Developing Internet and e-based solutions will provide wider access, hence awareness to the marketplace; however, targeted contact has to be established. The combination of a marketing mix and relationship marketing approach has been developed through a series of short campaigns to gain access and build new networks in the market.

CONCLUSION

The case study has been used to explore some of the issues raised in the literature. The results are of significance. The external provision of KM services to customers requires that KM theory on developing services needs to be engaged with marketing paradigms. This determines the approach to selling in the market. Theoretically, and even intuitively, the relationship approach would appear most suited. Both KM and relationship marketing are competency based and both therefore typically are located at the interface of human capacity and systems. However, this case has shown that this is not always necessary or appropriate. The larger the market, the more potential for a marketing mix approach, but also gaining market access to create awareness is a major issue and the marketing mix approach is efficient. This is likely to be the case in more start-up cases or cases of restructuring provision, as established networks and relations will not exist or will have been 'broken'.

It has also been demonstrated that the role of people within organisations is key. This is the case in terms of relationship building generally, and critical where gatekeepers are evident. They can be a very positive force—the internal marketers of the external service. Gatekeepers can also be a negative force, constraining the ability to create awareness and reach the end user. While CIL presents a case with some unique features, and thus it is not expected that gatekeepers will present an issue for some external providers, it is anticipated from this case evidence that there will be similar circumstances in place in many customer organisations for external providers.

Therefore the management of knowledge in the context of external provision becomes a potential nexus of knowledge-relationship-gatekeeper management. The areas are interlinked conceptually and empirically. The theoretical issues, such as those giving rise to uncertainty and a lack of awareness, asymmetry of the quality of information in advance can be overcome by addressing marketing and gatekeeper management in this context.

The impact also serves to highlight the need for further research to explore the external provision of KM services. The potential for market growth of external services needs further exploration. Further research at the KM-marketing interface is needed in terms of the application of KM tools, that is, techniques and technologies. In addition, these need to be explored within the paradigms of the marketing mix and relationship marketing. Specific research is needed into whether the experiences of the cement and concrete industry and CIL in particular are replicated elsewhere.

In terms of project managers and industry, this chapter is itself part of the awareness-creation process and thus makes an impact in its own right. In terms of the content, project managers are provided with lessons and guidance on accessing KM from external sources on proactive and reactive bases. External providers are provided with lessons and guidance on the creation of KM services through to the delivery of these services to the end user within the client organisation.

PRACTICAL TIPS AND LESSONS LEARNED

This chapter has provided pointers and insight into the following areas:

- Traditional information providers and consultants with strengths in particular areas of learning and knowledge can explore opportunities for externally providing KM services to others.
- Careful consideration should be given to the role of marketing, especially weighing the marketing mix and relationship marketing approaches against costs and opportunities.
- KM user firms must carefully manage the knowledge managers in order that the best interests of the firm are served and that project needs are clearly identified in time.
- Project managers and teams must be equipped in advance with sources of knowledge for problem solving both internally and externally from their firms, being aware that external provision of KM is expected to increase in the coming years.

REFERENCES

Akerlof, G. (1970). The market for lemons: Qualitative uncertainty and the market mechanism. *Quarterly Journal of Economics, 84,* 488-500.

Cherns, A.B., & Bryant, D.T. (1983). Studying the client's role in project management. *Construction Management and Economics, 1,* 177-184.

Child, J., & Heavens, S.J. (2001). The social constitution of organizations and its implications for organizational learning. In M. Dierkes, A.B. Antal, J. Child, & I. Nonaka (Eds.), *Handbook of organizational learning and knowledge*. Oxford: Oxford University Press.

Concrete Information Limited. (2003). *Marketing plan*. Crowthorne.

Construction Productivity Network. (2003). *Knowledge management: Construction industry experience.* Presentation by Bob Robinson, BAE Systems, Members Report E3127, CIRIA, Bracknell.

Drucker, P.F. (1989). *The new realities.* London: Butterworth-Heinemann.

Drucker, P.F. (1993). *Post-capitalist society.* London: Butterworth-Heinemann.

Drucker, P.F. (1995). The information executives truly need. *Harvard Business Review,* (January-February), 54-62.

Dunnette, M.D. (Ed.). (1976). *Handbook of industrial and organisational psychology.* Chicago: Rand & McNally College Publishing.

Egbu, C., Kurul, E., Quintas, P., Hutchinson, V., Anumba, C., & Al-Ghassani, A. (2003a). *Techniques and technologies for knowledge management, work package 3.* Interim Report, Knowledge Management for Sustainable Construction Competitiveness Partners in Innovation Project, Commissioned by the Department of Trade and Industry. Retrieved from www.knowledgemanagement.uk.net.

Egbu, C., Kurul, E., Quintas, P., Hutchinson, V., Anumba, C., & Ruikar, K. (2003b). *Knowledge production, resources and capabilities in the construction industry, work package 1.* Final Report, Knowledge Management for Sustainable Construction Competitiveness Partners in Innovation Project, Commissioned by the Department of Trade and Industry. Retrieved from www.knowledgemanagement.uk.net.

Granovetter, M. (1985). Economic action and social structure: The problem of embeddedness. *American Journal of Sociology, 91,* 481-510.

Groák, S. (1994). Is construction an industry? Notes towards a greater analytical emphasis on external linkages. *Construction Management and Economics, 12,* 287-293.

Gummesson, E. (2001). *Total relationship marketing.* Oxford: Butterworth-Heinemann.

Hughes, J.S., & Kao, J. (2001). Vertical information and proprietary information transfers. *Journal of Economics and Management Strategy, 10*(2), 277-299.

Johnson, G. (1990). Managing strategic change: The role of symbolic action. *British Journal of Management, 1,* 183-200.

Johnson, G., & Scholes, K. (2002). *Exploring corporate strategy* (6th edition). London: Financial Times-Prentice Hall.

Kotler, P., Armstrong, G., Saunders, J., & Wong, V. (1996). *Principles of marketing.* London: Prentice-Hall.

Leonard-Barton, D. (1995). *Wellsprings of knowledge*. Boston: Harvard Business School Press.

Levitt, T. (1983). *The marketing imagination*. New York: The Free Press/MacMillan.

Milgrom, P., & Roberts, J. (1992). *Economics, organization and management.* Englewood Cliffs, NJ: Prentice-Hall.

Mintzberg, H. et al. (2002). *The strategy process* (4th edition). Englewood Cliffs, NJ: Prentice-Hall.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* Oxford: Oxford University Press.

Oxon Consulting. (2001). *BCA CCI business plan approach*. Unpublished Report.

Pahl, R. (1975). *Whose city?* London: Penguin Books.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Ruggles, R. (1997). *Knowledge tools: Using technology to manage knowledge better.* Working Paper, Ernst & Young.

Senge, P. (1993). *The fifth discipline.* London: Random House.

Shavell, S. (1994). Acquisition and disclosure of information prior to sale. *Rand Journal of Economics, 25*(1), 20-36.

Smyth, H.J. (2000). *Marketing and selling construction services.* Oxford: Blackwell Science.

Smyth, H.J. (2004). Competencies for improving construction performance: Theories and practice for developing capacity. *International Journal for Construction Management, 4*(1), 41-56.

Stinchcombe, A.L. (1965). Social structure and organizations. In J.G. March (Ed.), *Handbook of organizations.* Chicago: Rand McNally.

Teece, D., Pisano, G., & Sheun, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.

Tushman, M.L., & Katz, R. (1980). External communication and project performance: An investigation into the role of gatekeepers. *Management Science, 26,* 1071-1085.

Williamson, O.E. (1985). *The economic institutions of capitalism*. New York: The Free Press.

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Chapter 6.31
From Strategic Management to Strategic Experimentation:
The Convergence of IT, Knowledge Management, and Strategy

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ABSTRACT

The new competitive landscape of the 21st century is forcing organizations to move away from traditional conceptualizations of strategy formulation towards an approach of strategic experimentation. The central objective of this chapter is to articulate the requirements that will be placed on IT as organizations move toward strategic experimentation. We base our central argument in contingency theory, which has postulated that to maximize organizational effectiveness, the IT infrastructure must be congruent with organizational structure and processes. Strategic experimentation requires different IT and knowledge management tools to support it than the ones currently prevalent. Information technology, knowledge management, and strategy formulation will have to coevolve for strategic experimentation to fulfill its promise. Each will have to change while maintaining its fit with the other two elements. This gives a renewed mandate for a strategic role of IT in organizations, a role that is central to organizational success.

Over the last decade, developments in information technology (IT) and strategic management have become increasingly intertwined in two major ways. First, advances in information technology and associated business processes (CAD, CAM, CIM, MIS, to name a few) have enabled an ever-increasing pace of product and process innovation, leading to a "hypercompetitive environment" (D'Aveni, 1994). Second, this new competitive landscape is forcing organizations to move away from traditional conceptualizations of strategy formulation towards an approach labeled "strategic experimentation." Still in its infancy and hence only partially practiced in many organizations, the emergent approach relies on knowledge management and enabling information technologies. It has, in turn, renewed the mandate for a strategic role of IT in organizations. Thus, as we enter the 21st century, the merging of the roles of strategy formulation and IT is fast becoming a major requirement for the competitiveness and success of the modern corporation.

The central objective of this chapter is to articulate the requirements that will be placed on IT as organizations move toward strategic experimentation. We base our central argument in contingency theory, which has postulated that for organizational effectiveness, the IT infrastructure should be congruent with organizational structure and processes. During the 1980s, the IT infrastructure changed to keep pace with the evolution of strategy formulation; indeed, the present "state of the art" IT infrastructure has emerged to support the dominant mode of strategy formulation—"strategic management"—practiced in large corporations. However, the hypercompetitive environments of the late 1990s have made it necessary for organizations to move towards a strategic experimentation mode, which requires different knowledge management tools to support it than the ones currently prevalent. We will argue that some fundamental changes in IT infrastructure are needed to support these knowledge management tools.

The plan of this chapter is as follows. First, we define key terms and introduce contingency theory as the root theory of our argument. Second, we articulate the concept of strategy and discuss its use of knowledge and information. Third, we focus on the role of IT and knowledge management in traditional strategic management approaches. In the fourth section we go on to argue that technological and environmental shifts increasingly require a new approach to strategic planning. This "strategic experimentation" approach is highlighted in the fifth section, setting the stage for our discussion of strategic experimentation's knowledge management and information technology requirements. We conclude with some thoughts on the developments in IT that are needed to enable this evolution towards strategic experimentation.

THEORETICAL BACKGROUND

Clarification of Terms

Information technology. When discussing technology, people often use the terms information systems and information technology interchangeably. While in some contexts the differences are relatively insignificant, we choose to differentiate between the two. For the purposes of this chapter, information technology is defined as the physical equipment (hardware), software, and telecommunications technology, including data, image and voice networks, employed to support business processes (Whitten & Bentley, 1998). The overarching plan for IT deployment within an organization is called the IT architecture. Technology infrastructure refers to the architecture, including the physical facilities, the services, and the management that support all computing resources in an organization (Turban, McLean, & Wetherbe, 1996).

Knowledge management. The meaning of the term "knowledge" has been the subject of much debate in the literature, especially in relation to data and information. We adopt the view that data are objective, explicit pieces or units, information is data with meaning attached, and knowledge is information with an implied element of action. Davenport and Prusak (1998) offer the following definition:

Knowledge is the fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. (p. 5)

Knowledge management is "a set of business practices and technologies used to assist an organization to obtain maximum advantage from one of its most important assets—knowledge," (Duffy, 2000, p. 62). In other words, it is the process of actively capturing, sharing, and making use of what is known within the organization. IT often facilitates knowledge management initiatives by integrating repositories (e.g., databases) and indexing applications (e.g., search engines), and user interfaces. Davenport and Prusak (1998) note that knowledge management involves, in addition, traditional management functions: building trust among individuals, allocating resources to knowledge management initiatives, and monitoring progress of the initiatives.

Knowledge management leverages the prevailing IT infrastructure; in turn, the IT infrastructure is typically designed to meet organizational requirements. The dominant prescriptions have flowed from contingency theory, which is the foundation for our argument.

Contingency Theory

Dating back to the mid-1980s, the information systems community has relied upon prescriptions from contingency theory for the design of IT infrastructures. Originally developed in organization theory (see Narayanan & Nath, 1993, for a historical review), contingency theory, when applied to information systems, asserts that organizations are interpretation systems: They continuously scan their environment for information (Daft & Weick, 1984), interpret the information, and take action based on their interpretation, learning over time from their experiences. The right type and amount of information will reduce uncertainty and ambiguity as decision makers analyze their environments. Thus the thrust of IS design should be to match the type of information to the level of uncertainty present in a given situation (Daft & Lengel, 1984).

Organizations generally have an abundance of data and information; their challenge is to make intelligent use of the data to solve business problems by reducing uncertainty and dealing with equivocality (lack of clarity or problem definition; Daft & Lengel, 1986). In other words, in situations of high uncertainty, the very richest information is necessary. For example, if a problem is complex, a face-to-face meeting is suggested as most effective. Therefore, according to the theory, better fit between the IT infrastructure and organizational structure and processes leads to superior organizational performance. Research studies have recently tested this hypothesis, with findings partially supporting the premise (e.g., Keller, 1994). The general rule of thumb is for the organization to use the simplest technology available that will satisfactorily meet the decision makers' needs (Warner, 2001).

We will argue that IT, following contingency theory, has successfully evolved to support the strategy creation process as presently practiced. But, since strategy creation processes are themselves undergoing fundamental transformation, IT will also have to evolve further.

THE CONCEPT OF STRATEGY AND THE ROLE OF KNOWLEDGE

The concept of "strategy" explicated in strategic management is one of marketplace strategy, i.e., winning in the marketplace against competitors, entrenched or incipient. To quote Fahey and Randall (2001), for example, "to enjoy continued strategy success, a firm must commit itself to outwitting its rivals" (p. 30). A large body of literature on strategic management has persuasively argued that effective strategy creation and execution are central to a firm's performance (e.g., Covin, Slevin, & Schultz, 1994; Wisner & Fawcett, 1991). Strategy creation involves both formulating goals—defined in terms of external stakeholders rather than operational milestones—and crafting the strategic means by which to accomplish these goals (Hofer & Schendel, 1978). The means typically include business scope, competitive posture, strategic intent, and the organizational mechanisms for implementation.

Strategy creation processes are distinct from operational decision processes in several ways. First, strategic decisions involve irreversible commitment of substantial resources (Grant, 1996). Second, they have consequences that are removed in time and not clearly discernible. Third, and perhaps most important to our purpose, they represent "messy" problems (Mason & Mitroff, 1973). That is, the decision context is characterized by incomplete and ambiguous stimuli, contradictory and sometimes vaguely felt data, and partially controllable contexts. The decision makers in strategic situations have to interpret and make sense of this messy data and chart the firm's course into the future.

Without a doubt, strategy makers use several sources of explicit or codifiable knowledge while they craft and implement a strategy. To facilitate strategy creation, firms typically employ several complementary approaches: competitive intelligence systems (e.g., Codogno, 1999; Hilmetz & Bridge, 1999; Martinsons, 1994), market research that focuses on customer surveys and behavior (e.g., Denny, 1998; Sterling & Lambert, 1989), and financial modeling and related knowledge bases of the impact of decisions on financial and human resources (e.g., McAleer & Wightman, 1993; Farin, 1991; Asch, 1991; Mockler & Dologite, 1988).

In addition to explicit data or information in the "objective" sense, the decision makers involved in strategy creation rely heavily on the subconscious tacit knowledge (Nonaka, 1991) they have accumulated over the years. This includes judgment, intuition, well-reasoned conjecture, and individual cognitive maps (Dutton, Fahey & Narayanan, 1983). Tacit knowledge is highly subjective, uncodified, and shaped by the individuals' past experiences. It may include predictions of competitive behavior based on the intimate knowledge of the actors in competitor organizations, of how consumers and distribution channels may respond based on vaguely articulated past experience, or even an intuitive assessment of how the internal organization may execute a strategy.

In practice, the process of strategy creation has often taken the form of strategic planning. Comprehensive strategic planning (Gluck, Kaufman, & Walleck, 1978) has historically been practiced in large corporations: A celebrated example is the use of scenarios by Royal-Dutch Shell ("The Worldwide Search for Oil," 1975). It typically consisted of several sequential stages of decision making involving diagnosis, alternative development, evaluation and choice, and implementation. In each step, the strategic planners emphasized deliberate juxtaposition of "objective data" and careful analysis, with top management judgment, thus highlighting the role of tacit knowledge.

The conjunction of explicit and tacit knowledge, indeed the emphasis on tacit knowledge, has fueled an evolution of our conception and practice of strategic planning over the years. Writing in the '70s, Gluck et al. (1978) identified four phases of evolution: budgeting, long-range planning, strategic planning, and strategic management. Each phase of evolution incorporated the lessons from the earlier phases but also took into account the emerging realities faced by corporations. Gluck (1985) noted that during the 1980s the "strategic management" phase represented the cutting edge of practice in the world. We will first examine the role of IT and knowledge management in the (now) traditional "strategic management" phase for comparison purposes.

THE ROLE OF KNOWLEDGE MANAGEMENT AND IT IN TRADITIONAL STRATEGIC PLANNING

Traditionally, the focus of IT infrastructure was to capture the knowledge of experts in a centralized repository (Davenport & Prusak, 1998; Grover & Davenport, 2001). The users of technology approached the repository with a specific purpose, i.e., to obtain knowledge—or more often, simple data—in a narrowly defined domain (Broadbent, Weill, & St. Clair, 1999). Most of the knowledge contained in databases was characteristically explicit and historical (e.g., competitor pricing, market share), and the infrastructure served to facilitate functional decision making or to automate routine tasks (as in reengineering).

Consequently, IT originally played a significant, yet ultimately limited role in the strategy creation process because of its initial emphasis on codified knowledge and explicit databases. Management information systems (MIS) arguably generated information that was only moderately applicable to strategy creation, as noted in early writings on the linkage between MIS and strategic planning (e.g., Lientz & Chen, 1981; Shank, Boynton, & Zmud, 1985; Holmes, 1985). As indicated in our earlier discussions of the information demands of strategic decision making, the complex and ambiguous problem-solving contexts confronted by strategic planning require rich media interaction and tacit information exchange beyond the scope of traditional MIS (Daft & Lengel, 1986).

The active management of knowledge was similarly underdeveloped. Despite the fact that strategic decision makers emphasized the role of tacit knowledge (albeit using other terms such as "judgment"), the actual importance of knowledge was not explicitly recognized. Formalized knowledge management (Davenport & Prusak, 1998) with its associated terminology and tools is a recent development and, as such, did not traditionally inform the strategic planning process.

Recent Advances

However, IT and knowledge management have not remained stagnant. The shifts that have taken place in IT infrastructures over the last decade have brought them closer to the creators of strategy; indeed, IT and knowledge management are enablers in the contemporary strategic management practice. Table 1 compares traditional with "state-of-the-art" IT infrastructures to illustrate this point. The basic focus of IT infrastructure is moving from the functional work unit to a process orientation. Whereas computer systems were once the focal point, the new infrastructure is network-centric, with an emphasis on business knowledge (Nidumolu, Subramani, & Aldrich, 2001; Broadbent, Weill, & St. Clair, 1999). For example, traditional search engines utilized rule-based reasoning to identify elements matching specific search criteria; the "state-of-the-art" knowledge management systems employ case-based search techniques to identify all relevant knowledge components meeting the user's request (Grover & Davenport, 2001). It now takes into account contexts that include cross functional experts and knowledgeable on a wide variety of potentially relevant issues. Additionally, there is greater emphasis on the integration of infrastructure with structure, culture (Gold, Malhotra, & Segars, 2001), and organizational roles (Davenport

Table 1. A comparison of traditional and state-of-the-art infrastructures

	Traditional Infrastructure	State of the Art Infrastructure
A. Components of IT Infrastructure		
Focus	Functional unit.	Processes.
Approach	Computer-centric and technology oriented.	Network-centric and process-oriented.
Purpose	Facilitate batch processing; process simplification; codification and uncertainty reduction.	Facilitate transactions across unit boundaries; promote process innovation; personalization and communication; encourage exploration.
Structural Characteristics	Static and Formal Structure, with separate, functionally independent legacy systems.	Dynamic and flexible structure; distributed systems, including firm-wide integration.
Physical Equipment	Desktop computers; local area networks (LAN) and wide area networks (WAN).	Mobile and wireless computer capabilities: E.g., laptops and cellular phones.
B. Types of Knowledge Management Supported		
Type of Knowledge	Emphasizes systems knowledge; explicit; narrow domain.	Emphasizes business knowledge; broad domain.
Implementation of Knowledge Management	Projects.	Integration of knowledge with business.
Knowledge Infrastructure	Fragmented knowledge repositories. Deliberate structure development.	Fluid exchange of knowledge and communities of practice (collaboration). Emergent structure.
Search Mechanism	Rule-based search engines.	Case-based search criteria.

& Prusak, 1998). In many ways, the newer IT infrastructures have enabled marshalling of explicit knowledge throughout the organization to speed up strategy creation and implementation.

Strategic management was a response to the environment of the 1980s. Since then, Gluck's work has not been updated and few have highlighted the emerging landscape of strategic planning. In the following, we will discuss the environmental developments that have altered the context for strategy creation processes.

THE CHANGING ORGANIZATIONAL ENVIRONMENT

The 1990s witnessed a revolution in information and telecommunications technologies, bringing in their wake radical changes in organizational environments. For example, Fahey and Randall (2001) identify several concrete marketplace changes: product proliferation, technology convergence, breakdown of industry boundaries, and global competition, among others. Michael Hammer (in Pink, 2001) notes the transition of technologies that lie at the core of information systems: from mainframe computing to personal computers, the Internet, various intranets, and eventually, to extended networks across linked businesses. As we noted in our introduction, the competitive landscape created by rapid technological change has recently been described as "hypercompetition" (D'Aveni, 1994).

The changes in organizational environments—both intensified competition and the possibilities opened up by technological developments—have created three major imperatives for organizations: time compression, globalization, and technology integration (Narayanan, 2001). In addition, the increased environmental dynamism also contributes to an increase in the degree of uncertainty confronted by strategic managers, calling into question traditional planning practices.

Thus, the environmental changes and the potential for business process transformation triggered by technology are altering the traditional strategic planning processes outlined by Gluck (1985). During the 21st century, a new type of strategy creation process is evolving which we term "strategic experimentation." With this evolution, the relationship between strategy creation, knowledge management, and IT is undergoing a profound shift. In the remainder of the chapter we elaborate on this transition to strategic experimentation, describe the emerging roles of knowledge management and IT, and outline a set of theoretical and practical implications.

FROM STRATEGIC MANAGEMENT TO STRATEGIC EXPERIMENTATION

Throughout all four phases of strategic planning documented by Gluck et al. (1978, 1980), including their final phase of "strategic management," three implicit assumptions have remained largely unchanged:

1. There is one guiding strategic vision, derived from the analysis of the current and future internal and external environment.
2. This vision is translated into one strategic initiative (or very few initiatives) that involve large parts of the organization.
3. The strategic initiative is implemented with the aim of maximum impact, i.e., using significant resources to ensure its success.

In its most extreme form, this relatively sequential approach to strategy creation and execution leads to the identification of the one winning strategy that has the highest probability of success; thus, it is logical to commit the maximum available resources to its implementation in order to further increase this probability. The goal is to obtain a sustainable competitive advantage vis-à-vis the firm's rivals. Uncertainty is reduced ex ante using analytical forecasting techniques as well as market research. This approach to planning seems to have been effective during the 1980s when the environment was moderately dynamic, and as a consequence firms faced limited uncertainty.

In contrast, firms today often face high velocity environments (Bourgeois & Eisenhardt, 1988; Eisenhardt, 1989). In high tech industries, for example, market participants frequently confront great uncertainty over technological possibilities, consumer preferences, and viable business models. This high level of ambiguity often results in a situation where (a) traditional methods of ex ante uncertainty reduction (e.g., market research) fail, and (b) the costs and risk of the traditional "big bet" strategic management approach begin to outweigh its advantages in terms of focus, decisiveness, and concentrated resource commitment. It is in this situation that the emerging strategic experimentation approach holds significant promise.

Strategic experimentation (Brown & Eisenhardt, 1998; McGrath, 1998; McGrath & MacMillan, 2000) draws on real-options reasoning (e.g., McGrath, 1997), discussions of exploration vs. exploitation (March, 1991), as well as trial-and-error learning (e.g., Van de Ven & Polley, 1992). Companies engaging in strategic experimentation continually start, select, pursue, and drop strategic initiatives before launching aggressively those initiatives whose value is finally revealed (McGrath & MacMillan, 2000, p. 340). Strategic initiatives thus serve as low-cost probes (Brown & Eisenhardt, 1998) that enable discovery learning about product technology and market preferences. They also serve as a stepping stone option for future competitive activity in that particular product-market domain. The role of the strategic manager is to administer a portfolio of strategic initiatives which represent an appropriate mix of high and low uncertainty projects and to maximize the learning from these real options (McGrath & MacMillan, 2000).

Table 2 highlights a number of key differences between the traditional strategic management and the strategic experimentation approach. While strategic experimentation is to some extent the logical extension of the strategic management philosophy, it represents a fundamentally different view of the practice of strategic planning and the path to competitive advantage. Movement is emphasized over position in this approaches. Thus, competitive advantage is viewed as temporary at best, and hence, innovation and learning are considered crucial to success. The spirit of strategic experimentation is perhaps hinted at by Jack Welch, the (now retired) legendary chairman and CEO of General Electric, who in a 1999 interview told the The Wall Street Journal that every acquisition GE makes has

[…] a perfect plan, but we know that 20 or 30% will blow up in our face. A small company can

Table 2. Comparison of approaches: Strategic management and strategic experimentation

	Strategic Management	Strategic Experimentation
Premise/Goal	Seek sustainable competitive advantage	Seek disruption and temporary competitive advantage
Focus	Single core strategic initiative	Portfolio of initiatives
Resource commitment for each initiative	High	Mostly low, higher for more mature initiatives
Role of Uncertainty	Uncertainty is reduced ex-ante, e.g. through market research or futurism	Uncertainty is reduced ex-post by direct experience through small-scale experiments with real options character. These then reduce uncertainty for new or revised strategic initiatives.
Role of Knowledge	Fact based, explicit knowledge is used to identify opportunities and to reduce uncertainty over the outcome of strategic initiatives. Decision makers' tacit assumptions also play a role.	Experiential knowledge is discovered stepwise through series of experiments.
Role of IT	Supply and analyze explicit knowledge	Support acquisition of experiential, tacit knowledge, sensemaking support.
Environmental Context	Slow-paced, low uncertainty	Fast-paced, high uncertainty
Planning Timeframe	Usually long	Usually short

only afford to make one or two bets or they go out of business. But we can afford to make lots more mistakes, and in fact, we have to throw more things at the walls. The big companies that get into trouble are those that try to manage their size instead of experiment with it [italics added]. (Foster, 2001, p. A18)

Strategic experimentation is especially appropriate for high velocity environments such as emerging product markets with high uncertainty surrounding both technology and customer preferences (e.g., the early personal digital assistant (PDA), Internet appliance, and satellite-based telephony markets). Here, low-cost probes can be very effective in gaining knowledge and reducing uncertainty while minimizing exposure to the results of faulty assumptions. To illustrate, when Apple introduced its Newton handheld computer (see Case Vignette 1), it followed a traditional paradigm of immediately launching a highly complex product, with heavy marketing support, in order to gain a sustainable first-mover advantage. Although the market did not yet exist, sales expectations were built on market research. In contrast, the strategic experimentation approach would have implied a small-scale launch of one (or potentially even multiple) simple version(s) with limited resource commitments in order to learn from the market reaction. Subsequently, that learning experience would be used as input for future products.

THE ROLE OF IT AND KNOWLEDGE MANAGEMENT IN THE ERA OF STRATEGIC EXPERIMENTATION

Since “strategic experimentation” represents the cutting edge of ideas in strategic management, we should expect significant advances in tool development and utilization in the next few years. These advancements will enable firms to move the idea towards normal organizational practice. Knowledge management is critical in strategic experimentation, at the core of which lie innovation, experimentation, and learning. Therefore, it is not surprising that many of the tools currently being developed have emerged from the knowledge management field. IT can accelerate the development of strategic experimentation by designing infrastructures that accommodate the new knowledge management demands imposed by this new mode of planning.

We develop the above argument in three steps: (a) identifying the requirements for implementing strategic experimentation, (b) summarizing the knowledge management tasks to fulfill these requirements, and (c) discussing the imperatives the knowledge management tasks generate for the IT infrastructure. Our arguments are summarized in Table 3.

Functional Requirements of Strategic Experimentation

Strategic experimentation necessitates four major functions to be performed by an organization: (a) rapid decision making, (b) integration of learning from experiments, (c) diffusion of learning across organizations, and (d) managing a portfolio of strategic experiments.

1. Rapid decision making. Recall that the need for strategic experimentation was triggered by the emergence of hypercompetitive environments, where rapid decision making is a major requirement for success (Eisenhardt, 1989; Nadkarni & Narayanan, 2001). At the strategic level, decision making relies on tacit knowledge that incorporates the judgment and experience of top-level executives. Thus, the ability to quickly marshal tacit knowledge in all phases of decision making is a central requirement in strategic experimentation. At a minimum, this involves embedding urgency and speed in

Table 3. Knowledge management and IT requirements in the era of strategic experimentation

Strategic Experimentation Challenge	Knowledge Management Tool	Benefits and Outcomes	Examples of IT Tools / Applications in Current Use	Future Development Needed
Rapid decision making	Visualization tools	Reduces decision time by allowing rapid visualization and prototyping as a basis for feasibility and go / no-go decisions.	Rapid prototyping, Computer-Aided Design, CASE tools	Real time display
	Group decision facilitation tools	Reduces decision time by allowing users to share knowledge asynchronously or in real time using rich media independent of geographic location.	Group Support Systems (GSS), MS NetMeeting, Lotus Notes	Advanced multimedia and communication capabilities
	Knowledge representation	Intervention to identify individual mental models and to promote development of shared assumptions and goals.	Decision Explorer	Repository of mental models to promote knowledge sharing
Rapid integration of learning from experiments	Decision histories	Learning requires the understanding of the original situation as well as the assumptions, goals, and reasoning behind the decision to initiate the strategic experiment.	Relational Databases, Decision Support Systems (DSS)	Qualitative databases
	Group brainstorming and decision support	Capture and integration of knowledge from a wide variety of members involved with the experiment	GSS using rich media, Decision Explorer	Multimedia enhanced communication facilitation
	Shared communication platforms	Enable efficient exchange of information and collaboration on individual documents and applications.	Electronic Mail, NetMeeting, Workflow Management Systems, GSS, Lotus Notes	Open platforms – integrating multiple communications systems
Diffusion of learning from experiments throughout the firm	Knowledge Maps or Networks	Represent who knows what; allow rapid access to experts and expertise.	Databases	Dynamic expertise coordination
	Repositories of case histories (learning histories) to identify relevant precedent that sheds light on a particular problem	Compiles chronology of events and decisions; enables access to case histories; facilitates distribution of knowledge	Case based expert systems, Intranets, DSS	Case-based and focused search engines
Management of a portfolio of experiments	Tools for monitoring experiment status	Provides continuous feedback about both qualitative and quantitative performance of strategic experiments	DSS, Content Analysis Applications	Neural networks

three activities: development of pathways or scenarios to the future, identification of failures, and investment of resources in potential blockbuster strategies if, and when, they become apparent.

2. Integration of learning from experiments. Organizational learning, another core concept in strategic experimentation, requires that appropriate learning be distilled from each experiment. This orientation combines decision making and learning: Initiatives judged to be failures are not merely weeded out, nor are successes viewed simply as alternatives to be financially backed. Rather, failures become occasions for discovering root causes, and successes are opportunities to identify best practices.
3. Diffusion of learning. In addition, organizational learning has to be diffused throughout the organization. Since formal organizational channels may stifle transmission of tacit knowledge, diffusion may require interactions among "communities of practice" (Grover & Davenport, 2001; Davenport & Prusak, 1998). An organizational architecture, incorporating relevant tools and IT infrastructure, has to be designed to support these interactions.
4. Managing a portfolio of strategic experiments. Unlike in previous eras, strategic experimentation requires maintenance and management of a portfolio of initiatives. This has three major implications. First, the knowledge base for decisions must be broader and richer, simply due to the increase in the number of initiatives. Second, the knowledge base becomes much more complex, since the initiatives themselves differ in terms of the mix of tacit and explicit knowledge. In essence, newer initiatives are likely to be more dependent on tacit knowledge, whereas mature ones can be augmented by explicit knowledge. Finally, and flowing from the above, the sheer number of people involved in the process will be larger, given that specialized pockets of tacit knowledge would have developed around specific strategic initiatives.

Taken together, these four functions have brought about the need for tools that can accelerate acquisition, assembly, and processing of tacit knowledge, which is likely dispersed throughout the organization.

Knowledge Management Tools

As detailed above, during the strategic experimentation phase, the key purpose of knowledge management is not one of uncertainty reduction and process simplification, but one of rapid decision making, integration of learning from strategic experiments, diffusion of learning, and managing a portfolio of experiments (cf., Broadbent, Weill, & St. Clair, 1999). Table 3 also displays the key knowledge management tools that have evolved to support strategic experimentation. As shown in the table, the tools facilitate:

1. Rapid decision making with the help of tools designed to promote collaborative work in groups. Current tools support visualization and prototyping, group decision facilitation, and knowledge representation. Each method attempts to reduce the time needed for a group to progress from problem identification to solution implementation. These tools help to coordinate the use of data, systems, tools, and techniques to interpret relevant information in order to take action (Little, Mohan, & Hatoun, 1982).
2. Rapid integration of learning from experiments using learning histories (Roth & Kleiner, 1998), group brainstorming, and shared communication platforms.
3. Transmission of learning through knowledge maps identifying the experts in specific areas and repositories of case histories. These

systems are evolving to include dynamic updating of repositories and focused search tools to reduce information overload.
4. Managing portfolios of experiments, currently through DSS and other rich data applications including cognitive mapping, which can be used to capture both knowledge and feedback.

In Case Vignette 2, we have summarized a Cap Gemini Ernst & Young methodology, that (while much more general and not explicitly designed for this purpose) illustrates how some of the knowledge management tools are able to support a specific strategic experiment. During the era of strategic experimentation, organizations will have to learn to do similar strategic experiments on an ongoing basis. Thus, knowledge management tools will be called on to perform four interrelated functions: to customize knowledge for specific decisions on a recurring basis, to connect communities of practice, to assist the simultaneous processing of explicit and tacit knowledge, and to embed speed in decision making.

Since some tools designed to accomplish customization — that have already found their way into practice — originated with IT professionals, they are built upon existing IT infrastructures. For example, the state-of-the-art knowledge management systems that employ case-based search techniques to identify all relevant knowledge components meeting the user's request (Grover & Davenport, 2001) were developed by IT professionals. However, many of the tools detailed in Table 3 have emanated outside the IT field. For example, knowledge representation tools that capture tacit and explicit knowledge have emerged from decision sciences (Eden & Ackermann, 2000) and managerial cognition (e.g., causal mapping, see Narayanan & Fahey, 1990; Nelson, Nadkarni, Narayanan & Ghods, 2000; Kemmerer, Buche & Narayanan, 2001). Similarly, the tacit knowledge transfer among communities of practice is enhanced by telecommunications technologies (e.g., videoconferencing). The potential advancement of tools that have not originated with IT can be enhanced by further evolution of IT infrastructures in organizations, a point to which we now turn.

Needed Developments in the IT Infrastructure

As Davenport and Prusak (1998) state, "knowledge projects are more likely to succeed when they can take advantage of a broader infrastructure of both technology and organization" (p. 155). This is as true in strategic experimentation as it is in typical knowledge management projects. Cap Gemini Ernst & Young's ASE is a case in point: It uses a combination of IT and process tools to facilitate the rapid integration of explicit and tacit knowledge and supports knowledge exchanges through rich media visualization tools as well as knowledge repositories that supply the needed explicit knowledge. In the end, such integrated organizational, IT, and knowledge management tools are needed to implement fast sense making in organizations (Boland, Tenkasi, & Te'eni, 1994).

Knowledge characteristics of strategic experimentation and the application of knowledge tools detailed above impose additional requirements on the IT infrastructure over and beyond those in the strategic management phase. Consider how each of the following functions can be enhanced by IT infrastructure development:

1. Future advances can significantly reduce the time expended in solution development through real time displays and expand opportunities for geographically dispersed collaboration. Also, advanced multimedia and communication capabilities would increase the benefits of GSS and DSS tools.
2. Learning from experiments can be enriched by qualitative database construction, multimedia enhancements to communication applications, and open platforms to permit

the sharing of knowledge over various communication channels, including wireless media.

3. Today, diffusion is hampered by information overload that has intensified competition for the user's attention (Hansen & Haas, 2001). To solve the problem, search tools should include separate parameters for content, rationale, and purpose of the query in order to isolate salient responses. Additionally, knowledge repositories must be maintained to ensure the contents are accurate and of high quality. Also, maintenance that is currently provided by intermediaries (Markus, 2001) might be performed faster by automated systems.
4. Expert systems or neural networks may be developed to manage and track portfolios, promoting reuse of the knowledge captured.

From our discussion, the significant implication for IT infrastructure is the need for technology integration (Narayanan, 2001), i.e., integration with other technologies and disciplines. We can identify two fundamental thrusts of technology integration:

1. IT infrastructure should exploit the potential for integration with other hard technologies such as telecommunications to enhance the organizational capacity for speed and carrying capacity for tacit knowledge.
2. IT should seek to interface with decision sciences to embed AI-based processing tools and with cognitive theorists to capture the tacit knowledge pervasive in organizations.

CONCLUSIONS AND IMPLICATIONS

We have argued that the technological changes of the 1990s have ushered in the need for strategic experimentation as the metaphor for planning practice. Strategic experimentation involves (a) maintaining a portfolio of strategic thrusts, (b) rapid decision making so that successful experiments are backed and failures are weeded out quickly, (c) learning from both successes and failures, and (d) diffusion of both explicit and tacit knowledge throughout the relevant segments of an organization. This phase requires fundamental shifts in our view of knowledge management, including its significance, use, and tools. Finally, we have argued that the shift to strategic experimentation requires fundamental shifts in the development of IT infrastructure. Instead of developing in relative isolation to other disciplines, IT should focus on technology integration by working in close collaboration with telecommunication technologies, artificial intelligence community, and managerial cognition scholars.

Information technology, knowledge management, and strategy formulation will have to coevolve for strategic experimentation to fulfill its promise. Each will have to change while maintaining its fit with the other two elements. In our opinion this gives a renewed mandate for a strategic role of IT in organizations, a role that is central to organizational success.

Case Vignette 1

Traditional Strategic Management in an Uncertain Environment: The Apple Newton

Apple launched its Newton PDA in August 1993, a first major entry into an emerging market full of technological and marketing uncertainties. Apple had made large-scale investments into the development and marketing of the Newton, launching it with great fanfare. However, the product was a flop and was ultimately discontinued in 1998. Several reasons can help explain this failure: At the time of launch, the demand for handheld computers was still very small and would not take off until years later. Similarly, technological challenges (e.g., handwriting recognition) were as yet largely unresolved, despite claims to the contrary. Finally, what consumers wanted from a PDA was far from clear, and a dominant design exemplifying typical product category attributes had not yet evolved. In the end it was the much less advanced, smaller, simpler Palm that would define the PDA mass market. Given the uncertain environment in 1993, a strategic experimentation approach would have probably been more appropriate than a traditional strategic management approach. Early sales numbers—encouraging by other standards—were seen as a failure due to Apple's high resource commitments, encouraging a threat rigidity response of persistence and incremental improvements. In contrast, a less costly and high profile launch would have allowed Apple to declare initial sales a conditional success. It could then have exploited its first-mover advantage by leveraging the insights it had gained about consumer needs and technological challenges to launch another, completely redesigned product into an environment with less uncertainty and risk. As it turned out, it was another company—Palm Inc.—that learned from Apple's mistakes and, in essence, appropriated the rents of Apple's failed experiment. (Sources: Bower & Christensen, 1995; Gore, 1998; Hamel, 2001)

Case Vignette 2

Using IT to Support Strategic Experimentation: CGEY's Accelerated Solutions Environment

Cap Gemini Ernst & Young's Accelerated Solution Environment (ASE) is an integrated combination of group process, physical environment, and technology that supports rapid problem solving and strategy making for complex issues. The ASE combines behavioral process components with IT-based support tools and infrastructures. In 2-3 day ASE events, IT is used in the form of intranet support, online research options, document libraries, documentation of key sessions and session outcomes, graphic support, rapid prototyping, and simulation and modeling tools. The ASE is an example of a new tool that uses IT in a way capable of supporting strategic experimentation. First, it uses IT to improve the speed of decision making, which is key to strategic experimentation that confronts rapidly changing environments and multiple decision points due to its incremental real-options logic. Second, the ASE focuses on creativity, facilitating the exchange of tacit knowledge while also providing necessary explicit knowledge. Thus, IT moves from simply providing the inputs for decision processes to facilitating the individual and collective sense making processes of decision makers. Real-time documentation functions, in addition to supporting the current decision process, also provide a documentary basis to later understand the history and rationale behind decision outcomes achieved. This knowledge is necessary for individuals and firms to be able to extract the maximum possible learning from the strategic experiments conducted. As an integrated process and information tool that can accommodate multiple stakeholders, ASE supports the rapid creative formulation of strategic experiments as well as the integration of the tacit experiential learning from these experiments. It also aids in the translation of such knowledge into new experiments and initiatives.

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REFERENCES

Asch, D. (1991). Financial planning as a strategic tool. *Accountancy, 107,* 106-109.

Boland, R. J., Jr., Tenkasi, R. V., & Te'eni, D. (1994). Designing information technology to support distributed cognition. *Organizational Science, 5,* 456-475.

Bourgeois, L. J., III, & Eisenhardt, K. M. (1988). Strategic decision processes in high velocity environments: Four cases in the microcomputer industry. *Management Science, 34,* 816-835.

Bower, J. L., & Christensen, C. M. (1995). Disruptive technologies: Catching the wave. *Harvard Business Review, 73,* 43-53.

Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23,* 159-182.

Brown, S. L. & Eisenhardt, K. M. (1998). *Competing on the edge: Strategy as structured chaos.* Boston: Harvard Business School Press.

Codogno, E. (1999). Getting CI from internal sources. *Competitive Intelligence Magazine, 2,* 21-23.

Covin, J. G., Slevin, D. P., & Schultz, R. L. (1994). Implementing strategic missions: Effective strategic, structural and tactical choices. *Journal of Management Studies, 31*, 481-505.

D'Aveni, R. A. (1994). *Hypercompetition: Managing the dynamics of strategic maneuvering.* New York: The Free Press.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. M. Staw & L. L. Cummings (Eds.), *Research in organizational behavior* (Vol. 6, pp. 191-233). Greenwich, CT: JAI Press.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32,* 554-571.

Daft, R. L., & Weick, K. E. (1984). Toward a model of organizations as interpretation systems. *Academy of Management Review, 9,* 284-295.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Denny, N. (1998). Listening to your customer is vital. *Marketing, 11*(12), 18.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal, 34,* 62-66.

Dutton, J. E., Fahey, L., & Narayanan, V. K. (1983). Toward understanding strategic issue diagnosis. *Strategic Management Journal, 4*, 307-323.

Eden, C., & Ackermann, F. (2000). Mapping distinctive competencies: A systemic approach. *Journal of the Operational Research Society, 51,* 12-20.

Eisenhardt, K. M. (1989). Making fast strategic decisions in high-velocity environments. *Academy of Management Journal, 32,* 543-576.

Fahey, L., & Randall, R. M. (2001). *The portable MBA in strategy* (2nd ed.). New York: John Wiley & Sons.

Farin, T. A. (1991). Computer modeling: How to play "What If?" *Credit Union Executive, 31,* 26-28.

Foster, R. (2001, September 10). The Welch legacy: Creative destruction. *The Wall Street Journal, A18.*

Gluck, F. W. (1985). A fresh look at strategic management. *Journal of Business Strategy, 6*(2), 4-19.

Gluck, F. W., Kaufman, S. P., & Walleck, S. (1978, October). *The evolution of strategic management*. McKinsey Staff Paper.

Gluck, F. W., Kaufman, S. P., & Walleck, S. (1980). Strategic management for competitive advantage. *Harvard Business Review, 58*(4), 154-161.

Gold, A. H., Malhotra, A., & Segars. A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*, 185-214.

Gore, A. (1998). Feet of clay: The Newton's death should be a lesson for Apple. *Macworld, 15*(5), 19.

Grant, R. M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17,* 109-122.

Grover, V. and Davenport, T. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18,* 5-21.

Hamel, G. (2001). Inside the revolution: Smart mover, dumb mover. *Fortune, 144*(4), 191-195.

Hansen, M. T., & Haas, M. R. (2001). Competing for attention is knowledge markets: Electronic document dissemination in a management consulting company. *Administrative Science Quarterly, 46*, 1-28.

Hilmetz, S. D., & Bridge, R. S. (1999). Gauging the returns on investments in competitive intelligence: A three-step analysis for executive decision makers. *Competitive Intelligence Review, 10158*, 4-11.

Hofer, C. W., & Schendel, D. (1978). *Strategy formulation: Analytical concepts.* St. Paul, MN: West.

Holmes, F. W. (1985). The information infrastructure and how to win with it. *Information Management Review, 1*(2), 9-19.

Keller, R. T. (1994). Technology-information processing fit and the performance of R&D project groups: A test of contingency theory. *Academy of Management Journal, 37,* 167-179.

Kemmerer, B., Buche M. W., & Narayanan, V. K. (2001, August). *Deriving revealed causal maps from non-traditional source documents: Challenges and methodological extensions.* Paper presented at the Academy of Management Annual Meeting, Washington, DC.

Lientz, B. P., & Chen, M. (1981). Assessing the impact of new technology in information systems. *Long Range Planning, 14*(6), 44-50.

Little, J. D., Mohan, L., & Hatoun, A. (1982). Yanking knowledge from the numbers: How marketing decision support systems can work for you. *Industrial Marketing, 67,* 46-56.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*, 71-87.

Markus, M. L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18,* 57-93.

Martinsons, M. G. (1994). A strategic vision for managing business intelligence. *Information Strategy: The Executive's Journal, 10*(3), 17-30.

Mason, R .O., & Mitroff, I. I. (1973). A program for research on management information systems. *Management Science, 19,* 475-487.

McAleer, E., & Wightman, S. (1993). The use of micro computers in corporate planning: A research note. *IBAR, 14,* 127-135.

McGrath, R. G. (1997). A real options logic for initiating technology positioning investments. *Academy of Management Review, 22,* 974-996.

McGrath, R. G. (1998). Discovering strategy: Competitive advantage from idiosyncratic experimentation. In G. Hamel, C. K. Prahalad, H. Thomas, & D. O'Neal (Eds.), *Strategic flexibility: Managing in a turbulent environment* (pp. 351-370). Chichester, UK: John Wiley & Sons.

McGrath, R. G., & MacMillan, I. (2000). *The entrepreneurial mindset*. Boston: Harvard Business School Press.

Mockler, R. J., & Dologite, D. G. (1988). Developing knowledge-based systems for strategic corporate planning. *Long Range Planning, 21*, 97-102.

Nadkarni, S., & Narayanan, V. K. (2001, August). *A comparative analysis of the influence of cognitive frames on organizational performance in high and low velocity industries*. Paper presented at the Academy of Management Annual Meeting, Washington, DC.

Narayanan, V. K. (2001). *Managing technology and innovation for competitive advantage*. Englewood Cliffs, NJ: Prentice Hall College Division.

Narayanan, V. K., & Fahey, L. (1990). Evolution of revealed causal maps during decline: A case study of admiral. In A. S. Huff (Ed.), *Mapping strategic thought* (pp. 107-131). London: John Wiley & Sons.

Narayanan, V. K., & Nath, R. (1993). *Organization theory: A strategic approach*. Burr Ridge, IL: Irwin.

Nelson, K. M., Nadkarni, S., Narayanan, V. K., & Ghods, M. (2000). Understanding software operations support expertise: A causal mapping approach. *MIS Quarterly, 24*, 475-507.

Nidumolu, S. R., Subramani, M., & Aldrich, A. (2001). Situated learning and the situated knowledge web: Exploring the ground beneath knowledge management. *Journal of Management Information Systems, 18*, 115-150.

Nonaka, I. (1991). The knowledge-creating company. *Harvard Business Review, 79*, 96-104.

Pink, D. H. (2001, September). Who has the next big idea? *Fast Company*, 108-116.

Roth, G. and Kleiner, A. (1998). Developing organizational memory through learning histories. *Organizational Dynamics, 27*, 43-60.

Shank, M. E., Boynton, A. C., & Zmud, R. W. (1985). Critical success factor analysis as a methodology for MIS planning. *MIS Quarterly, 9*, 121-129.

Sterling, J. U., & Lambert, D. M. (1989). Customer service research: Past, present, and future. *International Journal of Physical Distribution & Materials Management, 19*(2), 2-23.

Turban, E., McLean, E., & Wetherbe, J. (1996). *Information technology for management*. New York: John Wiley & Sons.

Van de Ven, A. H., & Polley, D. (1992). Learning while innovating. *Organization Science, 3*, 92-116.

Warner, F. (2001, September). He drills for knowledge. *Fast Company*, 186-191.

Whitten J. L., & Bentley, L. D. (1998). *Systems analysis and design methods* (4th ed.). Boston: Irwin/McGraw-Hill.

Wisner, J. D., & Fawcett, S. E. (1991). Linking firm strategy to operating decisions through performance measurement. *Production & Inventory Management Journal*, *32*, 5-11.

The worldwide search for oil. (1975). *Business Week, 2366*, 38-44.

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Chapter 6.32
What Difference Does it Make: Measuring Returns of Knowledge Management

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ABSTRACT

This chapter provides an overview of performance measurement in the area of knowledge management. Salient features of main measures have been described and their role in determining the return on knowledge management work highlighted. While Balanced Scorecard and Intangible Assets Monitor provide comprehensive coverage, several other measures are also in use. A recent study and review of applications of main KM performance measures in selected organizations showed several areas of commonality in the objectives of performance measurement and revealed differences in approaches to the application and presentation of various performance measures. Developing a measurement system for knowledge management is considered the key to the competitive success of the organization.

INTRODUCTION

It is becoming increasingly important that organizations are able to show the value of knowledge management applications by measuring the return on investment of knowledge management activities. A variety of approaches have been used for performance measurement. Most of these measures, however, seem to provide only a partial coverage towards the measurement of the impact of knowledge management work. The processes of knowledge management that underlie and contribute to the creation of knowledge assets and the success of the knowledge management projects have not been covered in depth and effectively by these measures.

This chapter highlights the importance of using appropriate measures to determine the value of knowledge management in an organization.

Based on an extensive literature review, the chapter provides an overview of the main measures currently in use for measuring knowledge assets. The chapter also reports the results of a study carried out to review the use of KM performance measures in selected organizations. Commonalities of applications of performance measures are pointed out and the need for development of more relevant measures is stressed.

An extensive review of web sites and portals in the knowledge management area was carried out. Information was sought from selected organizations through interviews and e-mail communications for verification and validation purposes. The discussion is expected to be helpful in understanding and promoting the use of performance measurement in the context of knowledge management. With the growing importance of performance measurement, the examples of performance measurement systems used by organizations that are active in knowledge management will be useful in offering some practical insights into the use of performance measures to measure the impact of knowledge management, as well as serve to highlight the way these measures can be used to enhance the organization's overall performance.

Context

Measuring the impact of knowledge management (KM) processes is important in determining the benefits that can be reaped by appropriate KM efforts. O'Dell and Grayson (1998) identified measurement as one of the key enablers in their model for transfer of best practices. They defined the measurement as the process of creating and using indicators/measures to determine how each enabler impacts the best practice transfer process within the organization. Traditionally, organizations have used financial indicators for measurement. These indicators, however, are not adept at capturing the measurement of the intangible impact of knowledge management practices and processes on the organization. Some organizations have tried to measure learning and knowledge through the application of a combination of indicators such as customer satisfaction, financial performance, and job satisfaction, among various other measures. But most of these measures are not precise enough to assess the use of knowledge management and may only give a superficial view of the impact of KM. These measures also tend to commodify knowledge and capture it as a static and tangible asset.

Recently, there have been attempts to use the Balance Scorecard (Kaplan, Norton, 2001) and the Intangible Assets Monitor (Sveiby, 1996) to measure the intellectual capital. Barchan (1997) has cautioned that, even though measurement is essential in knowledge management, it is better not to just simply jump on the bandwagon without giving proper thought to what appropriate measures will be used. He stresses that it is pertinent to create an internal understanding of what the intangible assets are and what they mean to the overall performance of an organization (Barchan, 1998, 1999, 2000).

The identification of the performance measurement models in knowledge management and the characteristics of performance measures and their criteria will allow for the use of these indicators for comparative purposes. This will allow organizations to compare and benchmark their knowledge management work with other organizations. As an emerging area of importance in knowledge management, there is a dearth of information available on this aspect.

Wenger, McDermott, and Snyder (2000) discuss the benefits of KM measurement for communities of practice. They stress that measurement efforts are well worth the investment. Measures of value are instrumental for communities of practice to gain visibility and influence, and to evaluate and guide their own development. Measures legitimize the function of communities of practice in the organization, reinforce member participation, and provide a basis for prioritizing activities. Measures help communities translate the value of what they do for teams and business units into the lingua franca of the organization. These authors feel that measures support management processes that help to further integrate and institutionalize the role of communities in the organization. Communities need measures to know how they are doing and to guide ongoing efforts to become more vibrant and effective. It is, therefore, very important for knowledge professionals to be aware of the measures in use and to be comfortable in applying these measures to determine the value and impact of knowledge management in their organizations.

Major KM Measures in Use

Dhansukhlal and Chaudhry (2002) have summarized the features of major measures used in the area of knowledge management. Main measures in use include the Balanced Scorecard (BSC) and the Intangible Assets Monitor (IAM), and Skandia's Intellectual Capital Taxonomy (ICT) & AFS Business Navigator (ABN). These measures provide a comprehensive, developed and tested approach to performance measurement in knowledge management. A summary of salient features of these measures is given in the following section.

Balanced Scorecard (BS)

The Balanced Scorecard (BS), first developed by Kaplan and Norton in the early 1990s in the United States, represented a "method of measuring the performance of a firm beyond the typical financial measures." The Balanced Scorecard was designed primarily to take a more "balanced view" of internal performance measurement (Giaever, 1999). The Balanced Scorecard emphasized that financial and non-financial aspects are part of the information system for employees at all levels of the organization (MeansBusiness, 2000).

The Balanced Scorecard was a strategic management approach where a vision could be translated into a clear set of objectives or critical success factors and this allowed for the linking of corporate goals with direct performance measures within a framework specific to a firm. Each of the critical success factors formed the basis for key performance indicators, which then helped to measure each objective's performance, representing a broad range of outcome measures and performance drivers. This multi-faceted measurement and management tool has been used for communications, alignment, improvement and control. This tool has also been identified as one of the methods of measuring the impact of knowledge management.

It was best summarized by the BMA Group (2000) as a "management system that focuses on the efforts of people, throughout the organization, toward achieving strategic objectives" and could be used to motivate staff "to make the organization's vision happen." Essentially, the Balanced Scorecard is a concept helping to translate strategy into action (QPR Online, 2000). Olve, Roy and Wetter (1999) have pointed out the main measures, objectives, targets and initiatives need to be defined, as shown in Table 1.

For all these perspectives to operate in a meaningful way, a chain of cause and effect between the various objectives and measures through all of the four perspectives was worked out. For instance, an operational zed example given by the BMA Group (2000) was as follows: "Training and improving skills of operating staff (a learning and growth objective) could lead to a reduction in cycle times (an internal process perspective objective) that may lead to improved customer satisfaction and loyalty through shorter delivery times, and hence greater sales revenue (an objective of the customer perspective) leading to an increase in return on capital employed (an outcome measure in the financial perspective)."

Table 1. Measures in the balanced scorecard

Perspectives	Focus Areas	Measures Used
Financial Perspective	How do our owners see us?	Operating incomes, return on capital employed, economic value-added
Customer Perspective	How do our customers see us?	Customer satisfaction, customer retention, new customer acquisition, customer profitability, loyalty of customers, market share
Internal Processes	How effective and efficient are our business processes?	Quality, response time, cost, new product introductions, innovation processes
Learning and Growth Perspective	How well do we generate and adopt new knowledge?	Employee-based measures like employee satisfaction, retention, training and skills

The Balanced Scorecard approach can be used as one of the ways to measure performance of internal business processes. It would serve to assess the impact of knowledge management within the organization through the use of financial and non-financial indicators. The Gartner Group has estimated that 40 percent of Fortune 1000 companies would use some form of the Balanced Scorecard by the year 2000 (Shand, 1999).

Intangible Assets Monitor (IAM)

Sveiby was one of the first to develop a method for measuring intangible assets, in the 1980s, in an attempt to demonstrate how the intangible assets accounted for the difference between a company's market value and book value (Giaever, 1999).

This was sometimes referred to as "The Invisible Balance Sheet," which was a practical exercise for facilitating an understanding of the value of intangible assets. Sveiby's ideas formed the basis of a discussion centred on the "dollar value" of the organization's intangible assets and helped to shape and develop the Intangible Assets Monitor, a tool used by organizations to track and value their intangible assets. Swedish companies like Celemi and Angpanneforeningen AF were the first few companies to consider the value of intangible assets and measure the impact of their knowledge management initiatives through the use of the Intangible Assets Monitor. This method also contributed to the development of Skandia's Business Navigator. The Intangible Assets Monitor is comprised of three main focus areas, as shown in Table 2.

The various indicators for each of these parts of the Intangible Assets Monitor demonstrated change and have been categorized by the following areas of growth/renewal, efficiency and stability. Sveiby (1996) have highlighted various indicators of Intangible Assets Monitor.

Since 1995, the Intangible Assets Monitor has been used by Celemi to report their intangible assets as part of their annual report. Celemi realised early that their financial statements did not represent the true value of their firm (Barchan, 1998). Celemi worked with Sveiby to create a learning process that would simulate the real-life challenges

Table 2. Focus areas of the intangible assets monitor

Focus Areas	**Definitions**	**Examples**
External Structures (Customer capital)	Relationships between customers and suppliers.	Brand names, trademarks and reputation or image.
Internal Structures (Organizational capital)	Created by the employees and were therefore owned by the organization and adhered to.	Patents, concepts, models, computer and administrative systems, the informal organization, the internal networks and culture.
Individual Competence (Human capital)	One's ability to act in various situations.	Skills (including social skills), education, experience and values.

of managing a knowledge-driven company and help people understand the nature of this unique business environment, as well as the value of their own intangible assets (Barchan, 1998). The main philosophy behind Celemi's business strategy was that they "generated profits not by selling a product, but by selling their capabilities, experience and expertise" (Barchan, 2000). Celemi used the three aspects of the Intangible Assets Monitor in their measurement: the customers represented the external structure, their people represented their competence and the organization represented the internal corporate structure. Using the Intangible Assets Monitor, Celemi monitored and used the valuation of both their financial aspects and intangible assets to help their organization to grow as explained by Margaret Barchan, Celemi's President and CEO (Barchan, 1997).

There are several similarities in the Balanced Scorecard and Intangible Assets Monitor, though the models have been developed independent of each other. Giaever (1999) pointed out that the main proposal for both approaches was that non-financial measures must complement the financial indicators.

Skandia's Intellectual Capital Taxonomy & AFS Business Navigator

This worldwide-known approach was one of the first attempts to measure and present the intellectual capital in an organization attributable to the use of knowledge management processes. Developed in 1993 by Leif Edvinsson of Stockholm-based Skandia Insurance, the first corporate Director of Intellectual Capital, this represented the world's approach to reporting the company's intangible assets through an integrated intellectual capital model. As a spin-off of the Konrad Group of the Swedish Knowledge Companies, this method relied primarily on non-financial indicators to monitor and publicly present their intangible assets.

Originating from the Swedish Konrad School, this approach combined Sveiby's conceptual framework with the presentation format of the Balanced Scorecard to produce the accounting term of "Intellectual Capital," instead of the use of the term "intangible assets" used by the former approach. A fifth focus for human resources had also been added to the original four found in

Kaplan and Norton's Balanced Scorecard model (Olve, Roy, Wetter, 1999). This integrated intellectual capital model permitted the definition and classification of intangibles not shown in the balance sheet and tried to detect hidden costs, incomes and values to increase the transparency of intangibles. This model was built on the difference between market capitalization and assets, which gave rise to the business's intellectual capital (Huang et al., 1999).

Since 1994, Skandia has used non-financial ratios and published them in their annual reports. This was published as a supplement to their annual report in 1994, known as "Visualizing Intellectual Capital in Skandia" (Olve, Roy, Wetter, 1999). With much support from management and the effort to give a high profile, such supplements to subsequent annual and biannual reports have also followed every six months (Olve, Roy, Wetter, 1999). Table 3 defines key indicators of the Intellectual Capital Index.

Other Measures

The Business Excellence Model was not specifically designed for the measurement of knowledge management. However, it has many elements that are useful and relevant to today's knowledge-based organizations and has been used by some organizations to gauge their business excellence and efforts in knowledge management. The overall view of the framework followed by the specific enablers and results produces innovation and learning (The Business Excellence Model, 1994).

Intellectual Capital Index (ICI), introduced by Goran and Johan Roos of the London-based Intellectual Capital Services Limited (Skyrme, 1999) is similar to Balance Scorecard. Shand (1999) states that ICI forces managers to define what activities are important. It covers all the intangible resources that contribute to the creation of value for the organization including knowledge, competence and skills, working methods,

Table 3. Key indicators of the capital index

Type of Capital	**Definitions**	**Key Indicators**
Organizational (Structural) Capital	Physical assets that impacted the organization's capability to effectively create and produce knowledge.	Number of accounts per employee and administrative costs per employee.
Customer (Relational) Capital	Increased customer retention and satisfaction and the ability of employees to be ready to anticipate and meet customer demands	Number of accounts, number of brokers and number of lost customers.
Human Capital	Knowledge, skill and capability of individual employees to provide solutions to customer problems	Personnel turnover, proportion of managers, proportion of female managers and training / education costs per employee.
Development/Renewal Focus	Ensuring human performance was reaching its full potential through investment in individual as well as organizational learning	Satisfied employee index, marketing expense / customer and share of training hours.

processes and systems. ICI also emphasizes a culture that support the people, the image in the marketplace and relationships with customers, alliance partners and suppliers.

The Montague Institute provided a synopsis of the various methods of measuring intellectual capital in terms of 12 techniques that could be used to value intangible assets. These include: relative value, balance scorecard, competency models, subsystem performance, benchmarking, business worth, business process auditing, knowledge bank, brand equity valuation, calculated intangible value, micro lending, and colorized reporting (Measuring Intellectual Assets, 1998). These techniques represent various ways in which intangible assets could be measured to show the impact of knowledge management. It is interesting to note that most of the measures are non-financial. This appears to be recognizing that knowledge management is an intangible object and requires special measures to measures its impact on business processes.

The American Productivity and Quality Center (APQC) collaborated with several companies to find real-world examples of measures and suggested a five-stage process for measurement highlighting the importance of best practices (Hartz et al., 2001). These steps include stages of: Enter and Advocate, Explore and Experiment, Discover and Conduct Pilots, Expand and Support, and Institutionalize Knowledge Management. These guidelines highlight different steps that could be used to measure the impact of knowledge management during different stages of the life cycle.

Dhansuklal and Chaudhry (2002) highlighted that though there were many models for measuring the impact of knowledge management, as well as the intellectual capital and intangible assets within the organization, application of these measures for measuring the value of knowledge management work was a real challenge. They conducted a study of the application of major KM measures in selected organizations (Chaudhry, Dhansukhlal, 2002). A summary of their findings is produced in the next section of this chapter.

Application of Measures by Selected Organizations

Chaudhry and Jasna (2002) studied the use of major measures in FUJI XEROX, MICROSOFT CORPORATION, INFOSYS TECHNOLOGIES, and ARTHUR ANDERSEN. A checklist containing major areas related to performance measurement was used to guide the data collection.

FUJI XEROX developed "Eureka" to respond to the problem faced by technicians not being able to solve problems. Microsoft developed a blueprint for the "Digital Nervous System." ARTHUR ANDERSEN focused knowledge management in the area of business consulting. INFOSYS TECHNOLOGIES' knowledge management was introduced as a "Learn once, Use anywhere" paradigm. The knowledge management initiatives of these organizations seem to have been guided by a clear-cut vision and appropriate value propositions. It appears from the statements on their web sites, that knowledge management in these organizations was not viewed as an additional function, but rather as an enabler to facilitate their internal business operations. Their knowledge management work seems to be at a level suitable for review of performance measurement in this area.

In FUJI XEROX, the purpose of measurement was to track the progress of the Eureka system. More than 150,000 problems were solved using Eureka. In MICROSOFT, real knowledge management solutions began by objectively looking at the firm's strategic strengths, weaknesses and goals for clues where knowledge management would have high impact and should provide specific, measurable benefits in the critical areas of the organization. In INFOSYS, the main purpose was to provide a value to the off-balance-sheet assets of the company and to show the financial and non-financial parameters that determined long-term success. In ARTHUR ANDERSEN, the purpose was to justify the outcome of investments in knowledge management and the resources in terms of the involvement of teams in knowledge management.

The selected organizations used a different set of performance measures, but there was an element of commonality in the indicators used to measure the impact of knowledge management. FUJI XEROX focused on the areas of deployment, knowledge content, and productivity; MICROSOFT emphasized Products & Services Design & Development, Business Planning, and Employment Management; INFOSYS selected external and internal environment as their main focus; and ARTHUR ANDERSEN focused on Strategy, Process and Culture. Measures used by the organizations included in this study are given in Table 4.

As shown in Table 4, each of the organizations had adopted and developed a different performance measurement mechanism to suit the needs and focus areas of their knowledge management initiatives. In the case of FUJI XEROX, MICROSOFT and ARTHUR ANDERSEN, customized performance measurement systems were developed pertaining to the different focus areas. In FUJI XEROX, detailed measures were observed for each topic area. For MICROSOFT, the measures were divided among the key areas of the organization. Measures were defined in quantifiable form for the key areas of the knowledge management framework in ARTHUR AN-

Table 4. Performance measures used by selected organizations

FUJI XEROX	**MICROSOFT**	**INFOSYS**	**ARTHUR ADNDERSEN**
Deployment # Of users connected % Of users updating weekly	Product & Services Design & Development Product success rate Cycle time Low design rework	Customers (External Structure) Growth/renewal (revenue and new customers)	Strategy Time saved in proposals and engagements
Knowledge content and quality # Of solutions submitted Number days taken to validate solutions	Customer & Issue Management Customer satisfaction Needs captured in products Breadth of service coverage	Organization (Internal Structure) Growth/renewal (IT and R&D investments) Efficiency (proportion of staff and sale) Stability.(average age of support staff)	Process Number of contributions Contributors Organizing office People accessing documents Useful of documents
Productivity # Of customer problems solved % Reduction in service hours % Reduction in parts dollars Total $ saved in cost of service and support	Business Planning Discovering trends Crisis response times Competitive awareness Acting on complete information	People (Competence) Growth/renewal (education index) Efficiency (value added per employee) Stability (average age of all employees	Culture People reaction about knowledge management

Table 5. Presentation of performance measurement results

FUJI XEROX	MICROSOFT	INFOSYS	ARTHUR ANDERSEN
Names of author and validator available in databases	Results presented and used through the Knowledge Management Platform	Intangible Assets Score sheet is used to evaluate the market worthiness of a company	Measurement of knowledge sharing behavior of staff is included as a section in the staff appraisal

Table 6. Follow-up actions for knowledge management initiatives

FUJI XEROX	MICROSOFT	INFOSYS	ARTHUR ANDERSEN
Worldwide Customer Service Global Program Hall of Fame for Authors (cash and trophy) and Hall of Fame for Validators (cash rewards for outing and trophy)	Use of technology as a foundation for managing knowledge assets and bringing people together in a dispersed organization	Embarked on a number of initiatives aimed at taking the prevailing knowledge sharing culture to even greater heights	Use of formula to translate knowledge management initiatives into dollars and cents to reinforce KM culture by making people see the benefits

DERSON. INFOSYS adopted already available performance measurement models.

In order to demonstrate the results of the performance measurement systems in place, various formats and techniques were used. A summary of presentation formats is given in Table 5.

Each of the selected organizations defined follow-up actions that defined the use of performance measurement results and ensured that measurement played a crucial role in the knowledge management processes. The follow-up actions are given in Table 6.

The follow-up mechanisms seem to ensure that the measurement systems continue on regular basis. These also help in further enhancing and promoting the knowledge sharing culture. Regular knowledge management surveys helped these organizations to assess the levels at different times and also translated the results into monetary value to justify knowledge management investments.

Commonalities in Applications

Despite having different performance measurement systems, there were several common elements between the systems. The main emphasis in all the systems was on the customer and this emphasized the customer orientation of the models. In FUJI XEROX, the topic area of productivity related to the number of customer problems that were solved. In MICROSOFT, one of the perspectives was on customer and issue management, where customer satisfaction, needs and breadth of service coverage were measured. In INFOSYS, the external structure related to their customers and aspects relating to customers were also reflected in growth/renewal, efficiency and stability. In ARTHUR ANDERSEN, the measures were also tied to the customer in that retrieving the right knowledge at the right time would enable them to meet their client needs.

Another common emphasis in all the performance measurement systems was that the contribution of people was recognized as an important factor that needed to be measured. This was evident in all models used by these organizations. In FUJI XEROX, the three topic areas of deployment, knowledge content and quality and productivity related to the technicians involved. In INFOSYS, people were one of the key areas of the monitoring system in terms of their competence. Under this measure, the education index of employees, value added per software engineer and employee and the average age of employees were measured to derive a valuation of the intangible assets of the organization. In Arthur Andersen, individual knowledge-sharing behavior and the usage of the corporate intranet were measured.

KM performance measurement systems in the organization under review did take into consideration intangible factors in their measurements and attempted to quantify, where practical. For instance, FUJI XEROX tried to quantify the intangible factor of knowledge content and quality by measures like number of solutions submitted by country and number of days to validate the solutions. Similarly, INFOSYS used percentage of revenue from image-enhancing, customer sales from the five largest customers over the total revenue, and value-added per software engineer in measuring the intangible aspects of growth/renewal, efficiency ad stability in the internal and external structure and competence of people. ARTHUR ANDERSEN tried to translate all the key areas of the knowledge management framework into measurable indicators, e.g., time saved in new product development/regulatory processes, time to implement a best practice and number of mistakes made twice.

The performance measure used by the organizations selected for this study varied. Some used established systems like the Balance Scorecard and Intangible Asses Monitor, while others developed their own systems of measurement. The emphasis was no longer solely on financial measures, but on the inclusion of intervening, non-financial measures. The focus, however, still seems to be on measuring the intellectual capital and assets, rather than the actual processes of knowledge management. It is understandable that measuring the KM processes is a complex task and is not easily quantifiable, but nonetheless important and essential to make the measurement more useful.

SUMMARY AND CONCLUSIONS

There are various ways in which the impact of knowledge management can be measures using different criteria and dimensions. Major measures used for assessing the KM performance by the organizations (e.g., Balance Score Card, Intangible Assets Monitor, and Intellectual Capital Index) focused on the general aspects related to knowledge management work, e.g., infrastructure, technology, culture, and people. While useful in highlighting the value of KM in general, these measures only provided a partial assessment of the impact of knowledge management in organizations. To provide a comprehensive coverage of the measurement of knowledge management processes, emphasis needs to be placed on examining the processes and developing measures that are more specific to measure the steps involved in these processes.

The measurement system adopted by FUJI XEROX for their Eureka system could be considered a step in the right direction. It does emphasize capturing and measuring tips and sharing and using knowledge in terms of quantified statistics. Similarly, ARTHUR ANDERSEN demonstrated commendable efforts in converting intangible knowledge management concepts into measurable criteria. However, these performance measures should go beyond valuation of intellectual assets and the concept of intellectual capital and focus on the value of the knowledge management processes. These should help measure how different steps in these processes make a difference in the success of knowledge management efforts. Some lessons may be drawn from existing performance measurement systems like the Balance Scorecard and the Intangible Asset Monitor in terms of the perspectives and measures they highlighted. For instance, the four perspectives adopted by the BSC provide a holistic way of measuring different systems within the organization and identifying the major stakeholders. Likewise, IAM may be useful to use the valuations of intangible assets at different periods of time to see if there has been an improvement, and if this could be attributed to the use and implementation of knowledge management within that organization.

In drawing up a blueprint for a measurement system, it is vital to define the purpose of measurement relating to the needs and structure of the knowledge management initiative of the organization. More mature knowledge management initiatives will use a knowledge management framework or paradigm to provide guidelines for the initiative. In contrast, organizations new to knowledge management may have neither yet developed nor be using a well-defined knowledge management framework for their initiatives. Either quantifiable or more intangible measures can be used, depending on the needs of the organization and the purpose of the measurement system. Martin (1999) rightly pointed out that there is no one set of measures applicable to all firms, or even within a company. What is being measured currently may change, owing to changes in the external environment or in the company's direction. Companies should not give up on measurement. Developing a measurement system for knowledge management may well be the key to the competitive success of the organization, allowing it to manage more effectively and efficiently what it can measure.

REFERENCES

APQC. (2001). *Performance measurement benefits*. Retrieved March 15, 2001, from http://www.apqc.org/pm/pmbenefits.cfm

Barchan, M. (1997). *Growing a knowledge company: Answers to frequently asked questions about measuring & managing intangible assets*. Retrieved from http://www.celemi.com/articles/texts/growingknowledge.asp

Barchan, M. (1998). *Capturing knowledge for business growth*. Retrieved from http://www.celemi.com/articles/texts/capturingknow9811.asp

Barchan, M. (1999). *Measuring success in a changing environment*. Retrieved from http://www.celemi.com/articles/texts/measuring success9906.asp

Barchan, M. (2000). *Uncovering hidden assets*. Retrieved from http://www.celemi.company/ia.asp

The BMA Group Pte Ltd. (2000). *Balanced scorecard*. Retrieved March 22, 2001, from http://www.bma.com.au/balscore.html

Business Excellence Limited. (1994). *The business excellence model*. Retrieved March 23, 2001, from http://www.businessexcellence. co.uk/business-excellence-model-framework.htm

Chaudhry, A. S., & Dhansukhlal, J. (2002, May 19-22). Measuring the impact of knowledge management. *IRMA 2002 International Conference*, Seattle, Washington.

Dhansukhlal, J., & Chaudhry, A. S. (2002). Performance measures for knowledge management. *Journal of Information & Knowledge Management*, *1*(1), 27-39.

Giaever, H.M. (1999). *Knowledge based economy in DNV*. Retrieved March 23, 2001, from http://research.dnv.no/KnowEco/intellectual_capital_metrics.htm

Hartz, C., Sammis, S., Hofer-Alfeis, J., Lopez, K., Raybourn, C., & Wilson, J. N. (2001). *Measurement for knowledge management*. Retrieved March 27, 2001, from http://www.apqc.org/free/articles/dispArticle.cfm?ProductID=1307

Huang, K.-T., Lee, Y. W., & Wang, R. Y. (1999). *Quality information and knowledge*. NJ: Prentice Hall.

Kaplan, R., & Norton, D. (2001). *The strategy-focused organization: How balanced scorecard companies thrive in the new business environment*. Boston: Harvard Business School Press.

Martin, W. (1999). Approaches to the measurement of the impact of knowledge management programmes. *Journal of Information Science, 26*, 21-27.

MeansBusiness. (2000). *Effective performance measures*. Retrieved March 19, 2001, from http://www.meansbusiness.com/Finance-and-Profitabilty-Books/Effective-Performance-Measurement

Measuring Intellectual Assets. (1998). Retrieved February 21, 2001, from http://www.montague.com/le/le1096.html

O'Dell, C., & Grayson, J. (1998). *If only we knew what we know: The transfer of internal knowledge and best practice*. New York: The Free Press.

Olve, N.-G., Roy, J., & Wetter, M. (1999). *Performance drivers: A practical guide to using the balanced scorecard*. Chicester: John Wiley & Sons.

QPROnline. (2000). *What is balanced scorecard?* Retrieved June 1, 2001, from http://www.qpronline.com/balancedscorecard/bsc_introduction.html

Shand, D. (1999). *Return on knowledge*. Retrieved March 15, 2001, from http://www.destinationcrm.com/km/dcrm_km_article.asp?id=601&ed=4&2F1%2F99

Skyrme, D. (1999). *Knowledge management - Performance*. Retrieved March 23, 2001, from http://www.skyrme.com/ppt/access/sld005.htm

Sveiby, K.-E. (1996). *The intangible assets monitor*. Retrieved from http://www.sveiby.com.au/IntangAss/CompanyMonitor.html

Sveiby, K.-E. (1997). *The balanced scorecard (BSC) and the intangible assets monitor*. Retrieved March 15, 2001, from http://www.sveiby.com.au/BSCandIAM.html

Wenger, E., McDermott, R., & Snyder, W. (2000). *Cultivating communities of practice: A guide to managing knowledge*. Boston: Harvard Business School Press.

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Chapter 6.33
Where Knowledge Management Resides within Project Management

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EXECUTIVE SUMMARY

This chapter explores how an engineering consulting company creates, manages, and reuses knowledge within its projects. It argues that the informal transfer and reuse of knowledge plays a more crucial role than formal knowledge in providing the greatest benefit to the organization. The culture of the organization encourages a reliance on networks (both formal and informal) for the exchange of tacit knowledge, rather than utilizing explicit knowledge. This case study highlights the importance of understanding the drivers of knowledge transfer and reuse in projects. This will provide researchers with an insight into how knowledge management integrates with project management.

INTRODUCTION

To sustain their competitive edge, businesses are continually searching for ways to differentiate themselves from their competitors. One method of achieving this is for an organization to develop a knowledge management strategy. A knowledge management strategy articulates how the organization creates, values, preserves, and transfers knowledge critical to its operations. The development of an effective knowledge management strategy is important for project management organizations. Crucial factors in achieving these objectives are to manage and more effectively apply and reuse knowledge gained throughout the project life cycle. If useful information is identified, assimilated, and retained within the organization, it represents intellectual capital that can be reused on other projects, reducing the time staff spend recreating what has already been learned. The reuse of knowledge can assist an organization in not reinventing the wheel and ensuring that past mistakes are not repeated. Effective project management is a key enabler for business success. However, where corporate knowledge is ineffectively managed during the project life cycle, valuable intellectual capital is lost, causing rework and lost opportunities.

As a global engineering project management consulting firm Engineering Consulting XYZ consults on projects to organizations worldwide, these projects can potentially reuse knowledge from earlier projects.

The purpose of this case study is to explore how project team members at Engineering Consulting XYZ acquire and reuse knowledge. The chapter analyzes and describes how project staff capture, transfer, and reuse knowledge. The findings are positioned within the Project Management Body of Knowledge's (PMBOK) methodology, the de facto global standard for project management methodology (Project Management Institute, 2000). The case study determines the relative importance and use of tacit, implicit, and explicit knowledge in managing projects.

At the beginning of the research, there was an expectation that the majority of knowledge was obtained via formal means and would provide the most benefit to the organization. However the empirical data suggests that the informal transfer and reuse of knowledge played a more crucial role and provided greater benefit to Engineering Consulting XYZ. The culture of Engineering Consulting XYZ encourages collective learning and sharing.

The chapter initially provides a background to how knowledge management integrates with project management, grounded in relevant literature. The next section looks at how Engineering Consulting XYZ acquires and reuses knowledge on projects, followed by current challenges facing the organization.

BACKGROUND

Project management companies continually compete for business against competitors. The challenge for these companies is to ensure that they deliver their projects faster and more effectively than their competitors. To achieve this, organizations can utilize knowledge gained from earlier projects, or project phases — that is, not reinvent the wheel. Knowledge gained from earlier projects or project phases can be obtained via explicit or tacit means.

Importance of Learning

To succeed competitively and to achieve their business strategies and goals, organizations need to gain knowledge of both the internal and external worlds. An effective knowledge management strategy will help an organization achieve these ends. Stata (1989) suggested that to maintain a competitive advantage, organizations need to learn and obtain knowledge faster than their competitors. Learning allows an organization to respond to changes in the business environment (Baldwin, Danielson, & Wiggenhorn, 1997). A knowledge management strategy is developed by the organization for improving the way it develops, stores, and uses its corporate knowledge. Both tacit and explicit knowledge are important in the creation and reuse of knowledge. Organizational memory forms the basis of intellectual capital that is held in an organization. Intellectual capital is the knowledge and capability to develop that knowledge in an organization (Nahapiet & Ghoshal, 1998).

If an organization is to continually change, it needs to evolve and learn continuously. Kim (1993) defines learning as the acquiring of skills (know how) and "the ability to articulate a conceptual understanding of an experience" (p. 38). Learning is a process of continual improvement and innovation (Baldwin, Danielson, & Wiggenhorn, 1997). Senge (2002) describes a "learning organization" as one "where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together" (p. 3).

For a learning organization to continually learn and develop, organizational learning needs to occur. Organizational learning is the capacity or process within an organization to maintain or improve performance based on experience (Nevis, DiBella, & Gould, 1995).

For an organization to learn, knowledge must be created, shared, and reused (Arygris & Schon, 1978). The learning process has identifiable stages: knowledge acquisition, knowledge sharing, and knowledge utilization (Nevis, DiBella, & Gould, 1995).

Arygris and Schon (1978) define organizational knowledge as knowledge about the organization that can be held in individual's heads, files, physical objects, and embedded in cultures and procedures. McElroy (2003) extends this with his concept of organizational knowledge production—at an organizational level, knowledge is created by individuals and groups building on existing knowledge and creating new knowledge.

Schneider (2002) argues that the new or emerging model of an organization is where organizations are characterized by fuzzy organizational boundaries, flattened hierarchies, and work relationships sometimes brought about by contracts (alliances and contingent workers). Knowledge is predominantly created and used across social networks. It could be argued that knowledge creation and sharing at the organizational level relies on a combination of explicit knowledge and social networks.

Project management organizations are a natural arena for knowledge management as project management staff continually interact with and build on both explicit and tacit knowledge as they move between different projects and phases of a project.

In a project management organization, learning is important as it helps project managers deliver not just one but a succession of successful projects, and to develop the right sorts of capabilities, that is, the project management process, the product development process, and the knowledge management process (Kotnour, 1999). Learning within and between projects is required for this. Organizational learning in the project management environment involves both intra- and interproject learning. Intraproject learning occurs within a project at all phases of the project. Interproject learning is applying knowledge gained from previous projects so that it is reused and new knowledge is created (Kotnour & Hjelm, 2002). Knowledge needs to be developed within a project, where it is used and tested, before it can be transferred to other projects. Projects can have a variety of intra- and interorganizational relationships, especially long-term projects. The challenge within these types of projects is to look at the process for the capture and reuse of knowledge in future projects (or phases of the same project) and to ascertain how intra- and interproject learning occur (McLoughlin, Alderman, Ivory, Thwaites, & Vaughan, 2000).

Learning within a project provides an ongoing store of data, information, and knowledge (Kotnour, 2000). Knowledge can also be transferred between projects (Kotnour, 2000). At a project level, knowledge is created by individuals and groups building on existing knowledge and creating new knowledge (adapting McElroy's [2003] definition of knowledge production at an organizational level).

Definition of a Project

Project Management Institute (2000) in PMBOK defines a project as "a temporary endeavour undertaken to create a unique product or service. Temporary means that every project has a definite beginning and a definite end. Unique means that the product or services is different in some distinguishing way from all other products or services" (p. 4).

For a project management organization to be competitive, project managers need to retain and build knowledge and improve project performance (Cooper, Lyneis, & Bryant, 2000).

Explicit, Implicit, and Tacit Knowledge

Explicit, implicit, and tacit knowledge help to ensure project success. Tacit knowledge is stored in a person's head and cannot be readily expressed in words, while explicit knowledge is knowledge that is expressed tangibly and can potentially be stored in databases or documents (Bollinger & Smith, 2001). Implicit knowledge is knowledge in a person's head that could be coded and stored in databases or documents (Nickols 2000). Tacit and implicit knowledge held within the corporate structure and contexts (e.g., as described by Nelson & Winter, 1982) and from individuals and explicit knowledge together provide a complete picture of the project. Tacit knowledge exists in the corporate structure (in the form of contexts and routines [Nelson & Winter, 1982; Von Krogh & Roos, 1995]) and implicitly and tacitly in members of the organization. Individuals also produce and consume explicit knowledge existing within the organization or from its environment. Sharing of knowledge among multiple individuals with different backgrounds is a critical step in project knowledge creation and reuse. Tacit knowledge based on previous experiences in a similar context is important to project success, as is the transfer of explicit knowledge (Koskinen, 2000). Knowledge can be captured and transferred tacitly within the organization via social networks, while implicit knowledge can potentially be captured and coded.

Knowledge Transfer and Reuse

Knowledge that is gained in a project needs to be transferred to an organization's memory for reuse on other projects; the challenge is to capture and index this knowledge for retrieval while it is available, as project teams are temporary (Damm & Schindler, 2002).

Dixon (2000) identifies five different types of knowledge transfer or reuse: serial transfer, near transfer, far transfer, strategic transfer, and expert transfer.

Project completion is an important phase of the project life cycle in capturing knowledge and preparing it for transfer to other projects. Postimplementation reviews/lessons learned can either occur via the project team members or an independent reviewer. Lessons learned provide a full description of the project with examples that can be used on other projects. In some instances, lessons learned only focus on the success of the project (Disterer, 2002). There is a need to focus on both the positive and negative lessons to ensure that successes are identified and publicized and mistakes not repeated. At NASA, to ensure that lessons learned get to the right people, they are "pushed" out to people who have similar profiles and can benefit from the lessons (Liebowitz, 2002). The challenge is to ensure that knowledge is captured without taking project team members away from their day-to-day tasks. For lessons learned to be effective (both positive and negative), they need to be indexed or searchable for easy retrieval of knowledge for future projects or project phases.

The reason for knowledge reuse failures can be that knowledge capturing processes are too informal, are not incorporated into the organization's processes, or are not supported by the structure of the organization (Komi-Sirvio, Mantyniemi, & Sepannen, 2002).

The Organization Used in the Case Study

Engineering Consulting is a multidisciplinary global engineering consulting company operating across five different business units: buildings and property, heavy industry, resources environmental, and infrastructure. They are a global, internationally recognized leader in the marketplace. Engineering Consulting XYZ is employee owned and has grown organically and via strategic mergers with organizations with similar cultures and values. Its mission is "to focus on valued client relationships to achieve remarkable success for them. The firm has a commitment to service, quality, and high standards of safety and business ethics."

Management of Engineering Consulting XYZ follows a global management structure. The management structure reflects the regional, business, and functional unit structure. Engineering Consulting XYZ employs a wide range of professionals, including architects, engineers, project managers, scientists, economists, and planners servicing a wide range of clients and market sectors.

A key strategy for Engineering Consulting XYZ for the next three to four years is to invest time in the future of the business. This strategy looks at a number of measures where time invested today will secure the long-term future for the company. Knowledge management is highlighted as a key area in which time should be invested on an ongoing basis. To assist in achieving these strategies, there is most likely a reliance on knowledge — explicit, tacit, and implicit.

Engineering Consulting XYZ has recognized the importance of knowledge management within its organization by appointing a knowledge manager and creating an environment that fosters knowledge sharing. The knowledge management strategy is people-centric or personalized rather than systems driven.

In support of its strategy, Engineering Consulting XYZ is pursuing the following:

- Communities of Practice: to try and recreate the informal networks in a slightly more formal way across regions.
- A Human Yellow Pages: to help identify and contact the right person when faced with a problem.
- Lessons Learned: to capture lessons learned through the Communities of Practice (focused by discipline) and through interviews for larger more generic project management-type projects.
- A Knowledge Management System: with access to all documents/drawings at a global level.

SETTING THE STAGE

As a global company, Engineering Consulting XYZ utilizes resources globally for certain projects. There are approximately 15,000 projects on Engineering Consulting XYZ's books at any one time ranging in size from $2,000 to $50 million per annum. Engineering Consulting XYZ has achieved yearly revenue in excess of $380 million.

The culture at Engineering Consulting XYZ is open and encourages everyone to achieve their full potential. The culture was developed by the founders of the company and has evolved with extensive staff consultation. Staff members are encouraged to network and share information within this culture.

- "Our culture is based around personal values of competitiveness and challenge, drive and motivation, high professional standards, controlled risk taking, steady wealth creation, and being good citizens through a demonstration of social and environmental responsibility in what we do.

- Our management style is one of openness, support for colleagues, focussing on success through sharing of strategic business information and no game playing.
- Our management approach is adaptive to change and built on exceptional service delivery and adding value.
- Our people philosophy is based on participative employee development to achieve each individual's potential.
- Our ownership structure is one of broad based sharing of equity, targeting continuity of the practice and equitable ownership transfer.
- Our commitment is to innovation in product quality that adds value to our Clients' businesses." (Engineering Consulting XYZ's Web site)

Engineering Consulting XYZ's key goal is to "achieve remarkable success" for its clients. It works with the client to understand the business and then utilizes the best people for the job in terms of skills and knowledge (both technical and local).

While Engineering Consulting XYZ is a global company, a high proportion of the client base is regional and requires project team members with local skills and a knowledge of regional issues; however, there has been a recognition that some of the most appropriate skills (people and technology) need to be obtained globally. The Human Yellow Pages reflects the need to be able to easily identify the appropriate people.

Engineering Consulting XYZ has recognized that people are the key resource of the consulting company and are critical for it to achieve a sustainable future. A part of this focus is to attract and retain talented staff. There are programs in place to ensure that managers are provided with the right people-management skills and staff are able to develop to reach their full potential.

The project management methodology followed by Engineering Consulting XYZ is based on the Project Management Institute's (2000) Project Management Body of Knowledge (PMBOK) covering the following:

- Initiation
- Planning
- Execution
- Controlling
- Closing

The project management methodology at Engineering Consulting XYZ is an evolutionary process broken into three stages: proposal stage (initiation), project stage (planning and execution), and finalization stage (closing). The controlling phase underpins the process with regular key review points. In addition, progress is monitored on a monthly basis. As part of the development and retention, staff project managers and team members are put through a project management course as well as other appropriate development courses.

As a consulting and project management company, Engineering Consulting XYZ has realized the importance of knowledge management; it tries not to reinvent the wheel on new projects. As part of its knowledge management strategy, a knowledge management system was purchased and implemented, and communities of practice were set up. Both of these were in the very early stages during the reviewed projects.

CASE DESCRIPTION

Engineering Consulting XYZ participated in an alliance project, with a major public client, where all alliance partners were encouraged to focus on agreed-upon project objectives. The role of Engineering Consulting XYZ was to provide the detailed design component of the project, with the deliverables being the design, documentation, and specifications. This case study looks only at Engineering Consulting XYZ's component, and does not take into account other alliance activities. The two phases of the project were treated as two separate projects by Engineering Consulting XYZ with separate deliverables, and as such, have been analyzed as separate projects. At its peak, the project consisted of 30 project team members, with a core of between 15 and 20 members (including the project director and project manager). Of the core project team, eight (including the project manager) worked on both projects.

For the first project, Engineering Consulting XYZ, along with other alliance partners, won an excellence award in their category of industry as

- new knowledge that furthered the knowledge base of the profession was developed;
- new process knowledge was developed; and
- existing knowledge was enhanced and transferred via documented reports.

This case study analyzes and describes how knowledge was captured, managed, and reused in these two projects. In addition, the role that social networks play in the project(s) will be analyzed.

Execution of Company Strategy

Projects are used to execute Engineering Consulting XYZ's strategies. Engineering Consulting XYZ's present vision is to continue to be a sustained consulting group and to be the premier consultant for valued clients. The strategies to achieve the vision focus on identifying and looking after key clients.

Processes

Engineering Consulting XYZ has a robust project management methodology with strong links to the methodology employed by the Project Management Institute's (2000) PMBOK. Each project in Engineering Consulting XYZ undergoes initiation, planning, execution, and closing phases. Business processes and project management systems also support the project.

One of Engineering Consulting XYZ's five business units assigns a project manager to the project. The project is structured according to the work breakdown structure. The project has a project director who provides a mentoring role and is responsible for client relationships, progress monitoring, and performance (quality time costs resources), and overall quality assurance, including risk. In addition, there are review points linked to the project management methodology and quality assurance procedures; these reviews assist in managing the project risks.

Knowledge Management Processes in Engineering Consulting XYZ

Engineering Consulting XYZ supports knowledge management processes throughout the organization. In recognition of this, it has appointed a knowledge manager to develop its knowledge management activities, including the introduction of communities of practice, capturing of lessons learned, and implementation of a knowledge management system.

Knowledge Reuse

Knowledge reuse occurred between projects. New technical knowledge that was created in the first project was reused in the second project. Specific knowledge from the first project facilitated improved designs in the second project.

In Engineering Consulting XYZ, knowledge is reused at all stages of the project life cycle. Project team members continually reuse knowledge and expect to reuse it; one project team member stated that:

In most instances, I expect a level of success. I expect to be able to reuse the information. In fact, if we can't, it will more than likely result in an unpleasant commercial outcome. It's really usually necessary to reuse that information. Every now and then, though, you'll stumble across a piece of information which is so beautifully presented, so valuable that it will deliver a result very quickly, indeed.

At the plan stage, both explicit and tacit knowledge are used. Explicit knowledge is in the form of tenders, proposals, project plans, general project documentation, project methodology, and technical documentation from earlier projects. Documents are stored by project number in hard copy and on the network server. At the tacit level, project team members reused knowledge from earlier projects, either their own knowledge base or via informal networks. Explicit knowledge is usually originated from earlier projects that the project team member has worked on, implying that they do not search electronically or physically for a document but rather use their tacit knowledge to obtain the documentation. Documentation is used as a starting point or for convenience while there is a reliance on networks to obtain more detailed and complex knowledge. As one project team member said:

We use the proposal for convenience because all the words and text are there, so it's readily used and saves you having to reinvent the wheel. But the hard questions like financials and methodology you will usually talk through with the person from the project.

Lessons learned from earlier projects are used at the plan stage to try and ensure that mistakes are not repeated or successes are applied. Most of the lessons learned that are applied are informal lessons. As one person interviewed stated:

Particularly when you are setting it up, you try and incorporate the lessons learned. So if something didn't work last time, you might set the team up a little differently and have different steps in your methodology to try and capture lessons learned previously. There's a lot more in your head than you are able to document.

During project implementation, there is a reliance on both explicit and tacit knowledge; however, there is a greater reliance on personal knowledge. If explicit knowledge is reused, it is obtained by asking an expert for the documentation rather than an electronic search being carried out. A key reason that knowledge is reused is to deliver a solution where any potential pitfalls are known in advance allowing them to be overcome. As one project team member interviewed stated:

You start by discussing how to go about solving a technical problem and how they go about it to ensure that mistakes are not repeated.

Knowledge Creation and Transfer

Knowledge is continually created and transferred within and between projects. In one area of Engineering Consulting XYZ, to overcome the issue of knowledge transfer a mentoring scheme has been implemented to allow the knowledge to be transferred to a number of people within and to become part of organizational memory.

A project director is appointed to each project to mentor the project manager, and review the project. The project director mentors the project manager by meeting with the project manager and discussing the project. Roadblocks, issues, potential risks, and risk mitigation strategies are discussed in these meetings. Knowledge is transferred from the project director to the project manager as he generally has more experience, but knowledge is also transferred to the project director in terms of understanding the status of the project and what impact it may have on the other projects and programs of work. As the project director meets with the alliance partners and the client at a strategic level, the impact that this project may have on the entire body of work is also understood.

Lessons learned, both formal and informal, are an important method of knowledge creation. Formal lessons learned occur at the end of a project or a phase of a project where formal workshops are used to identify issues/lessons and identify how they can be resolved (tacit to explicit knowledge creation and transfer). The lessons are documented and made available on the network server for future use. In addition there is a review process (between the project director and project manager or a reviewer and project manager/project team member), linked to the project methodology, where knowledge gained from one phase is incorporated into the next phase of the process. At the informal level, lessons learned occur throughout the project where project team members meet to resolve issues (tacit to tacit knowledge creation and transfer). At this level, in some circumstances the lessons may be documented in the form of meeting minutes (tacit to explicit knowledge creation and transfer).

Knowledge transfer occurs from the project to the strategic and business unit level allowing it to become part of organizational memory.

Knowledge is transferred from the project director to the project manager. The project director is a member of a formal network — a global group of regional business leaders. This group meets face-to-face three times a year and participate in telephone conferences every two weeks. Knowledge is rolled up from project level and is discussed at a strategic level. As part of this transfer, knowledge is becoming part of organizational memory.

External knowledge is transferred at a strategic level via external meeting that the project director has with alliance partners and customer reviews (monthly).

The project manager participates in a formal section meeting on a regular basis. Participants discuss proposals, projects, and potential business opportunities. This is a forum for knowledge creation, reuse, and transfer where issues can be discussed and resolved. Within this type of culture, knowledge becomes part of organizational memory as it is transferred to other employees.

Networks

The culture at Engineering Consulting XYZ encourages the use of networks. There is a reliance on obtaining tacit knowledge via personal knowledge or networks (both formal and informal). Informal networks are tapped into within and outside working hours. One project team member stated the following:

[You] build up relationships with people over a period of time. You work with them and find out who the specialists are in areas of the company. You talk to a specialist, call that person, and ask questions on how they have approached something and a relationship is established. As you build personal relationships you know who to call.

The project manager and senior project team members initially relied on personal knowledge and then their informal networks. Formal networks (e.g., as established in the corporate e-mail system) were only tapped into if the relevant knowledge could not be obtained from the other sources. In most cases, as well as utilizing tacit knowledge, people sought out explicit knowledge, that is, people interviewed said it was quicker to ask the person who knew where the relevant documentation was rather than searching for it on the server or in folders.

It's a lot more efficient if you know who produced the file last time and you can just go and ask them where it is. It saves having to search.

Informal Use of Knowledge

Knowledge is informally reused or re-created from one project to another (particularly at the plan, implementation, and closure phases) as the culture and system are not in place to formalize it (while a knowledge management system has been implemented, it was not implemented when these project phases were being conducted). Several project team members have worked with Engineering Consulting XYZ for a number of years, and given the length of time that they have been with Engineering Consulting XYZ, they have created informal networks (often with people whom they have worked with on previous projects). Interviewees commented that they just know who to go to. At the more senior levels of the organization formal networks (across the distributed enterprise) also played a crucial role. In addition there was one exception where one team member relied predominantly on informal knowledge transfer but also documented everything so that if he was not in the organization any longer, another person could access the information. The only issue is that as everything (including all e-mails) is stored in hard copy, it may be difficult to find the most appropriate knowledge.

Knowledge Management System

Engineering Consulting XYZ implemented a knowledge management system during the first project; however, it was at an immature stage and the project team relied on a network server to store project documentation in an electronic format. The documents (both project-related and technical documentation) are sorted by project number. In addition to being stored on a network server, they are also stored within files throughout the office making it difficult for people to find explicit knowledge unless they knew what they were looking for. Two areas had their own systems in which to store relevant project documentation; however these systems did not interact with other systems making it difficult for people in other areas to know how to access the knowledge without first asking someone.

The challenge for the sponsors and champions of the knowledge management system was to encourage people to see the benefits of using the systems.

I think the underlying theory and philosophy is pretty sound. The challenge is in the implementation and the culture to get the thing working so the people can see the full benefits of it.

In addition, the culture of the organization needed to change to encourage people to use the system.

It needs to be promoted in the right way from a cultural change perspective. I think it's about getting people to get used to the idea of collective learning and sharing it. It's going to take more time but we need to show people that the benefits outweigh the cost.

Table 1 summarizes the major knowledge processes within Engineering Consulting XYZ, and the methods and artifacts associated with it. The knowledge processes are also related to major stages from the PMBOK project management methodology (Project Management Institute, 2000).

As highlighted in Table 1, within these projects tacit knowledge and social networks play the most

Table 1. Knowledge creation and reuse in projects

Area of Analysis	Method/s	Artefacts	Phase of PMBOK
Knowledge Creation	Tacit knowledge/ Explicit knowledge	Personal knowledge/Networks Tender/technical/project documentation	Plan Implementation
Knowledge Capture	Formal Workshops Informal Meetings Web Portal/email	Lessons learned -(Tacit/Explicit) Meeting minutes Files	Closing
Knowledge Transfer	Tacit knowledge via Mentoring/ Networks Explicit Knowledge	Networks (Formal/Informal) Documentation	Plan Implementation Closing
Knowledge Reuse	Project Review	Review process minutes/notes	Plan Implementation
How do people share/ reuse knowledge	Informal and Formal networks Mentoring	Informal and Formal networks Mentoring	Plan Implementation Closing
Knowledge Management Systems	Web Portal/email Server	Server Database	Plan Implementation Closing

crucial role both in terms of knowledge creation and reuse. However, explicit knowledge may have been used more widely if a system allowing contextual searches was used (a knowledge management system is in the process of being implemented within the company). The culture of Engineering Consulting XYZ encourages the use of knowledge transfer and reuse tacitly at an informal level. For a knowledge management system to be used extensively, a culture (and processes) that fosters the use of formal knowledge would need to be implemented. One of the people interviewed stated that

There is a need to change culture to rely on systems and get people used to the idea of collective learning and sharing it.

CURRENT CHALLENGES FACING THE ORGANIZATION

Knowledge management is a key enabler for Engineering Consulting XYZ to maintain and improve its competitive advantage, reduce project costs, and remove the cost of duplicated learning. However, at the end of this project, the organization faced a number of challenges to ensure that knowledge management enabled it to achieve rather than impede its objectives.

The consulting market has become more competitive, and over the last five years, Engineering Consulting XYZ has adopted a strategy of growth to meet the challenge. This industry sector has also faced the emergence of the generation X with associated higher staff turnover indicative of less long-term organizational loyalty. This means that the informal networks have potentially become diluted and not as efficient.

One of the key challenges that Engineering Consulting XYZ faces is the reliance on informal networks and informal knowledge. As part of its knowledge management strategy, Engineering Company XYZ had purchased and tried to implement a knowledge management system and introduce the concept of communities of practice. Given that there is a reliance on informal networks and informal knowledge and the culture of the organization supports this environment, a key challenge is to encourage employees to belong to communities of practice that are formal and not necessarily linked to their networks or personal relationships. Processes and technology need to be put in place to support these communities of practice. In addition, given that documentation was either kept in hard copy or on a network server, project team members need to be encouraged to use the knowledge management system. In order to be accessible to others, the documents need to be stored in the knowledge management system as well as on a local area network. In addition, the information stored in the system needs to be maintained so that it is relevant and up to date. A culture that encourages the use of the knowledge management system to complement the reliance on tacit knowledge needs to be developed.

Project knowledge needs to be captured, stored, and indexed to allow for easy retrieval and contextual searches. Capturing the context of project knowledge is crucial for Engineering Consulting XYZ; without it, past knowledge may not be relevant and hard to reuse on future projects. Training in utilizing the system needs to occur.

The knowledge management system has been implemented across geographic regions, business units, and functional units. Training has occurred to ensure that staff know how to use the system. The key is to ensure that the culture of the organization accepts the use of a knowledge management system (both utilization and maintenance) and that the explicit knowledge complements the use of tacit knowledge and networks.

EPILOGUE AND LESSONS LEARNED

Epilogue

This chapter looks at how knowledge is created, transferred, and reused in project management. The culture of the organization plays a crucial role within knowledge management. Where there is a reliance on informal networks and informal knowledge and the culture of the organization supports this environment, a key challenge may be to encourage employees to belong to communities of practice that are formal and not necessarily linked to their networks or personal relationships. Processes and technology would need to be put in place to support these communities of practice. Given that culture plays such a key role in knowledge management, if a mature knowledge management system was implemented and the culture changed to reflect this change, tracking will need to occur to ascertain the long-term effects on the organization.

Lessons Learned

1. In this case study, there was an expectation that the majority of knowledge was obtained via formal means and would provide fruitful ground for a knowledge management system implementation. However, the informal transfer and reuse of knowledge played a more crucial role and provided proven benefit to Engineering Consulting XYZ. Thus the implementation of a knowledge management system resulted in a need for major cultural change.
2. The culture of an organization plays a major part in knowledge reuse. If the attributes

of a learning organization are part of the culture, then knowledge reuse can occur. An organization can have all the processes, formality, and structure it wants, but without the right attitude or culture knowledge, reuse may not occur.

3. A total reliance on knowledge management systems does not necessarily suit the needs of Engineering Consulting XYZ; the better use of the system would be desirable. However, as this organization has a culture that encourages collective learning and sharing, a knowledge management system needs to complement the reliance on tacit knowledge and networks.

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REFERENCES

Argyris, C., & Schon, D.A. (1978). *Organizational learning: A theory of action perspective*. Addison Wesley.

Baldwin, T., Danielson, C., & Wiggenhorn, W. (1997). The evolution of learning strategies in organizations: From employee development to business redefinition. *The Academy of Management Executive, 11*(4).

Bollinger, A.S., & Smith, R.D. (2001). Managing organizational knowledge as a strategic asset. *Journal of Knowledge Management, 5*(1), 8-18.

Cooper, K.G., & Lyneis, J.N. (2002). Learning to learn from past to future. *International Journal of Project Management, 20*(3), 213-219.

Damm, D., & Schindler, M. (2002). Security issues of a knowledge medium for distributed project work. *International Journal of Project Management, 20*(1), 37-47.

Disterer, G. (2002). Management of project knowledge and experiences. *Journal of Knowledge Management, 6*(5), 512-520.

Dixon, N.M. (2000). *Common knowledge: How companies thrive by sharing what they know*. Harvard Business School Press.

Kim, D.H. (1993). The link between individual and organizational learning. *MIT Sloan Management Review, 35*(1).

Komi-Sirvio, S., Mantyniemi, A., & Sepannen, V. (2002). Towards a practical solution for capturing knowledge for software projects. *IEEE Software, 19*(3), 60-62.

Koskinen, K.U. (2000). Tacit knowledge as a promoter of project success. *European Journal of Purchasing and Supply Management, 6*(1), 41-47.

Kotnour, T. (1999). A learning framework for project management. *Project Management Journal, 30*(2), 32-38.

Kotnour, T. (2000). Organizational learning practices in the project management environment. *International Journal of Quality and Reliability Management, 17*(4/5), 393-406.

Kotnour, T., & Hjelm, M. (2002). Leadership mechanisms for enabling learning within project teams. *Proceedings of the 3rd European Conference on Organizational Knowledge, Learning and Capabilities*.

Liebowitz, J. (2002). A look at NASA Goddard space flight center's knowledge management initiatives. *IEEE Software, 19*(3), 40-42.

McElroy, M. (2003). *The new knowledge management*. Butterworth-Heinemann.

McLoughlin, I.P., Alderman, N., Ivory, C.J., Thwaites, A., & Vaughan, R. (2000). Knowledge management in long term engineering projects. *Proceedings of the Knowledge Management: Controversies and Causes Conference*. Retrieved May 19, 2003, from http://bprc.warwick.ac.uk/km065.pdf

Nahapiet, J., & Ghosal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *The Academy of Management Review, 23*(2), 242-266.

Nelson, R.R., & Winter, S.G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Belknap Press of Harvard University Press.

Nevis, E.C., DiBella, A.J., & Gould, J.M. (1995). Understanding organizations as learning systems. *MIT Sloan Management Review, 36*(2).

Nickols, F. (2000). The knowledge in knowledge management. In J.W. Cortada & J.A. Woods (Eds.), *The knowledge management yearbook 2001-2002*. Butterworth-Heinemann.

Project Management Institute. (2000). *A guide to the project management body of knowledge*. Project Management Institute.

Schneider, M.A. (2002). A stakeholder model of organizational leadership. *Organization Science, 12*(2), 209-220.

Senge, P.M. (2002). *The fifth discipline the art and practice of the learning organization*. Random House.

Stata, R. (1989). Organizational learning—the key to management innovation. *MIT Sloan Management Review, 30*(3).

Von Krogh, G., & Roos, J. (1995). *Organizational epistemology*. Macmillan.

FURTHER READING

Cross, R., Nohria, N., & Parker, A. (2002). Six myths about informal networks and how to overcome them. *Sloan Management Review, 43*(3), 67-75.

Fiol, C.M., & Lyles, M.A. (1985). Organizational learning. *Academy of Management Review, 10*(4), 803-813.

Koskinen, K.U. (2004). Knowledge management to improve project communication and implementation. *Project Management Journal, 35*(2), 13.

Owen, J., Burstein, F., & Mitchell, S. (2005). Knowledge reuse and transfer in a project management environment. *Special issue of Journal of Information Technology Cases and Applications, 6*(4).

Schindler, M., & Eppler, M.J. (2003). Harvesting project knowledge: A review of project learning methods and success factors. *International Journal of Project Management, 21*(3), 219-228.

Schon, D. (1995). *Reflective practitioner: How professionals think in action*. Aldershot, UK: Arena.

Turner, J.R. (1999). *Handbook of project-based management: Improving the processes for achieving strategic objectives*. London: McGraw-Hill.

Walsh, J.P., & Ungson, J.R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

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Chapter 6.34
Outcomes of Knowledge Management Initiatives

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ABSTRACT

Establishing criteria for knowledge management (KM) is important because criteria help to establish a basis for assessing the value and evaluating its results. Literature review has revealed that widely accepted criteria and performance measures have not been developed for KM. Delphi Technique and survey-based research, using a questionnaire targeting KM professionals as respondents, were aimed at establishing criteria for assessing KM success for different types of organizations. The results show what organizations consider important outcomes of a KM initiative. Contributions from this research effort should support government, non-profit, and for-profit organizations in making decisions about KM initiatives and measuring KM efforts. Future research efforts can focus on developing these KM outcomes into detailed measures.

INTRODUCTION

The continuous progression of civilization is a testimony to its ability to develop, learn, and share knowledge. Recent advances in information and communication technologies have made it easy to develop, store, and transfer knowledge. Globalization, increasing international competition, and a free market philosophy are driving forces for these advances in technology, and many organizations have realized that the creation, transfer, and management of knowledge are critical for success today.

The increasing gap between the book value and the market value of some business entities indicates the increasing importance of knowledge-based intangible assets (Marr, 2003) and knowledge management (KM). However, the dimension of KM has not received adequate attention (Holsapple & Joshi, 1999). Also, the

KM concept is still understood as information management and is associated with technological solutions, such as intranets and databases (Marr, 2003). It should be understood that the primary focus of KM is to utilize information technology and tools, business processes, best practices, and culture to develop and share knowledge within an organization, and to connect those who possess knowledge to those who need the knowledge.

Several organizations are attempting to use KM to improve organizational performance, but commonly accepted KM principles are yet to be developed. KM's lack of focus (Fairchild, 2002) and absence of commonly accepted KM principles (Stankosky & Baldanza, 2001) are some of the gaps in this discipline. Among the commonly accepted KM principles or references that are missing are the criteria for measuring success associated with KM. In this article, a research effort is presented to address this knowledge gap from the practitioners' point of view and leading to identifying expected outcomes of a KM initiative in organizations.

BACKGROUND

Improving organizational performance by using a KM initiative is an investment decision; we must therefore have an understanding of its outcomes. While discussing approaches to building KM systems (KMS), Jennex and Olfman (2004) contend that the measurement of a KMS is crucial to understanding how these systems should be developed and implemented. They cite several reasons for measuring success of a KMS, including three from Turban and Aronson (2001): to provide a basis for valuation, to stimulate management's focus on what is important, and to justify investments.

However, inherent intangible characteristics of knowledge assets make them difficult to measure (Ahn & Chang, 2002). Unlike materials or equipment, the core competencies and distinctive abilities of employees are not listed on balance sheets (Austin & Larkey, 2002). As a result, factors that contribute substantially to a firm's success elude traditional means of quantification, thereby presenting significant challenges to KM performance measurement.

Bassi and Van Buren (1999) suggest that the lack of understanding of how to measure and evaluate impacts of intellectual capital is a major obstacle to turning investments towards promoting intellectual capital into a source of competitive advantage. Similarly, Ernst & Young's Center for Business Innovation survey identified measuring the value and performance of knowledge assets as the second most important challenge faced by companies, behind the challenge of changing people's behavior (Van Buren, 1999).

Instead of trying to measure knowledge directly, which may not be possible, a different approach is to measure its contribution to business performance, which is still considered a major research agenda (Ahn & Chang, 2002). Major consulting organizations agree that measuring KM effectiveness and contributions is a key concern for consulting organizations (Wikramasinghe, 2002).

Some studies have suggested non-traditional KM measurements. A survey of 100 FTSE (the index used by the London Stock Exchange and Financial Times) companies attempted to establish levels of engagement with KM, the organizational implications, and evidence of impact on performance (Longbottom & Chourides, 2001). The survey results suggest that performance measures are not well developed and these measures should be linked to balance scorecard frameworks. According to Fairchild (2002), KM activities are considered integral to other management activities and processes; measuring KM is about how and when KM is integrated into organizational activities, which can be measured. Thus, it is important to identify these activities and determine KM contributions to these activities. The study suggests that organizations should require less precision and exact figures, and more interest in trends using a balance scorecard approach, such as customer and employee satisfaction, and intellectual capital.

The above research findings lead to the conclusion that KM results are difficult to measure, and commonly accepted outcomes of a KM initiative are not yet established. This research effort is aimed at addressing this knowledge gap. This article uses a literature review to identify a number of KM outcomes at the organizational level that are then translated into KM criteria. Based on this literature review, a list of KM criteria and important research questions were established for the Delphi study. To support the Delphi findings, a survey consisting of the same list of criteria and questions was distributed. Based on these research findings, expected KM initiative outcomes from the practitioners' point of view were established. Finally, limitations of the study and future research opportunities are discussed.

LITERATURE REVIEW

Research related to KM success can be classified into two focus areas: KM success factors and KM outcomes. KM success factors can be viewed as facilitating factors for a KM initiative. Though the main focus of this article is on outcomes of KM initiatives, a brief discussion on success factors is relevant for this study to understand the distinction between the two.

There have been efforts to identify organizational factors for successful KM initiatives. While discussing KMS frameworks, Jennex and Olfman (2004) recommend that developing a successful KMS would involve designing a technical infrastructure, incorporating KM into processes, developing a secured KMS and knowledge structure for the enterprise, gaining senior management support, and building motivational factors into the system. Other research indicates that establishing leadership, investing in people, and developing supporting organizational conditions are critical to achieving success in a KM program (Chourides, Longbottom, & Murphy, 2003). Similar success factors were suggested based on a study of several projects (Davenport, DeLong, & Beers, 1998). While these are facilitating factors for a KM initiative, outcomes or results of a KM initiative are different.

A recent conference in London, "Measuring Knowledge Value 2002," addressed the knowledge measurement issue from both macro and micro perspectives (Perkmann, 2002). The macro perspective focused on quantifying intangible assets to capture the value of human capital, competencies, customer relationships, employee collaborations, and so forth, which are not purely financial measures and emphasize the importance of intangible assets. The micro perspective addressed the issue of quantifying the impact of individual knowledge projects. While analyzing the 2002 London conference proceedings, Perkmann (2002) supported the idea of case studies and anecdotal evidence by illustrating that ROI can capture only a part of the project's impact (efficiency and productivity concerns), and projects always have unintended consequences or effects (competency development and learning), negative or positive, that cannot be easily captured in quantitative or financial terms. However, anecdotal evidence and case studies are context-specific artifacts that may not reflect overall reality and may not be commonly accepted. In addition, they do not meet some of the desired characteristics of measures, such as reliability, applicability, and transferability.

In their case study of professional service firms creating competitive advantage through KM, Ofek and Sarvary (2001) identified reducing costs, enhancing product or service quality, or creating value to customers as business strategies for designing and implementing KM to create competitive advantage.

KPMG International, UK (1999) produced a report based on a survey of 423 organizations from Europe and the U.S. In the survey, KPMG identified several expected KM benefits, as shown in Table 1.

A 1997 survey of 431 business organizations in the U.S. and Europe identified four KM application areas (Ruggles, 1998): creation of intranets, data warehousing and knowledge repositories, implementing decision-support tools, and implementing groupware to support collaboration. These application areas focus on knowledge transfer, knowledge retention, better decision making, and support collaboration.

Successful KM programs achieve competitive advantage, customer focus, employee relations and development, innovation, and lower costs (Skyrme, 1997). Though KM promotes development and application of knowledge to attain an enterprise's ultimate goal of profitability, the implicit purpose of KM is to empower knowledgeable individuals with intellectual tasks to promote learning (Wiig, 1999).

Based on the discussions above and several other references, 26 factors were identified for inclusion in the list of outcomes (Anantatmula, 2004). All of them have direct references, not necessarily as outcomes, but under different terms such as "benefits," "impact," "focus," "performance factors," "metrics," "results," "strategies," and "value." Table 2 presents a summary of literature review consisting of KM outcomes and important sources.

The Table 2 list of outcomes is used in the Delphi as a reference list for its participants and in the survey questionnaire to establish priority.

RESEARCH QUESTIONS

The main research objective is to establish the criteria for measuring KM success. Since a criterion can be considered as a standard on which a judgment may be based, establishing criteria and using them to evaluate KM initiatives will lead to knowing expected outcomes of KM initiatives. Thus, the main research question is: What should be the criteria for measuring KM success?

Though KM principles are similar irrespective of the type of organization, criteria and consequent KM outcomes could be different for different types of organizations for two reasons. First, an organization's reason to invest in a KM initiative could be business specific and thus could be dif-

Table 1. KM benefits (KPMG, 1999)

• Better decision making	• Reduced costs
• Better customer handling	• New or better ways of working
• Improved employee skills	• Increased market share
• Faster response to key business issues	• Create additional business opportunities.
• Improved productivity	• Improved new product development
• Increased profits	• Staff attraction/retention
• Sharing best practices	• Increase share price

Table 2. Summary of KM outcomes

KM Outcome	Source
Better decision making	KPMG (1999), Ruggles (1998)
Better customer handling	KPMG (1999), Skyrme (1997), Kelly (2003), Van Buren (1999), Longbottom et. al (2001)
Faster response to key business issues	KPMG (1999), Van Buren (1999), BP Amoco (2001), Longbottom et. al (2001)
Improved employee skills	KPMG (1999), Skyrme (1997), Perkman (2002), Van Buren (1999)
Improved productivity	KPMG (1999), Perkman (2002), Kelly (2003), Van Buren (1999), BP Amoco (2001)
Increased profits	KPMG (1999), Van Buren (1999), Wiig (2000)
Sharing best practices	KPMG (1999), Perkman (2002), Van Buren (1999), BP Amoco (2001), Longbottom et. al (2001), Riggles (1998), Allee (1997)
Reduced costs	KPMG (1999), Skyrme (1997), Wiig (1993), Ofek & Sarvary (2001), BP Amoco (2001), Longbottom et. al (2001)
New or better ways of working	KPMG (1999), Perkman (2002), BP Amoco (2001), Longbottom et. al (2001), Riggles (1998), Allee (1997
Increased market share	KPMG (1999), Wiig (2000), Kelly (2003), BP Amoco (2001),
Creation of new business opportunities	KPMG (1999), Wiig (2000), Longbottom et. al (2001)
Improved new product development	KPMG (1999), Wiig (2000), BP Amoco (2001), Longbottom et. al (2001)
Better staff attraction/retention	KPMG (1999), Skyrme (1997), Kelly (2003), BP Amoco (2001)
Increased share price	KPMG (1999), BP Amoco (2001)
Enhanced product or service quality	Skyrme (1997), Wiig (2000), Kelly (2003), Ofek & Sarvary (2001), Van Buren (1999), Longbottom et. al (2001),
Creation of more value to customers	Skyrme (1997), Wiig (2000), Kelly (2003), Ofek & Sarvary (2001), Van Buren (1999), Longbottom et. al (2001),
Enhanced intellectual capital	Allee (1997)
Improved communication	BP Amoco (2001), Longbottom et. al (2001), Allee (1997)
Increased innovation	Skyrme (1997), Perkman (2002), Allee (1997)
Improved learning/adaptation capability	Skyrme (1997), Perkman (2002), Kelly (2003), Van Buren(1999), BP Amoco (2001), Ruggles (1998)
Return on investment of KM efforts	Van Buren(1999), BP Amoco (2001)
Increased market size	Wiig (2000), Kelly (2003), BP Amoco (2001)
Entry to different market type	BP Amoco (2001), Ruggles (1998)
Increased empowerment of employees	Skyrme (1997), Wiig (2000), BP Amoco (2001)
Enhanced collaboration	BP Amoco (2001) Jennex et. al.(2002), Perkman (2002), Riggles (1998)
Improved business processes	Jennex et al (2002)

ferent. Second, this initiative is driven by what the organization's goals and objectives are, and each type of an organization may have different objectives and goals.

Many studies support that KM initiatives should be aligned with organizational goals and objectives. A poll of executives from 80 large companies in the U.S., such as BP Amoco, Chemical Bank, Hewlett-Packard, and Kodak, indicated that 80% believed managing knowledge of their organization should be an essential or important part of business strategy (Takeuchi, 1998). Strategic goals and business requirements drive process requirements, which in turn determine knowledge requirements (Massey & Montaya-Weiss, 2002). Massey and Montaya-Weiss (2002) contend that KM initiatives will be effective when they are aligned with the performance goals and requirements of a business, its processes, and its people. Citing that KM is about creating synergy in organizations, Davenport and Probst (2001, as reported by Chourides et al., 2003) contend that such action translates into aligning individual goals with organizational goals. In other words, aligning KM practices with organization goals is a desired way of implementing a KM initiative. Thus, an extension of the main research question is: Are the criteria for measuring KM success different for different types of organizations? The second research question focuses on establishing the criteria or outcomes for different types of organizations.

RESEARCH METHODOLOGY

Literature review findings and research questions discussed in previous sections suggest that those who are well versed with KM theory and practice can better address these issues. For this reason, this research effort uses the Delphi Technique, with occasional use of in-depth interviewing and personal discussions. The Delphi Technique uses a group of experts to deliberate a research issue or a problem anonymously, that is, without having a direct interaction among the group members and without knowing whom the other members of the group are. The Delphi Technique does not involve face-to-face group discussion (Anderson, 1990), and it does not have the disadvantages of conventional groups because it provides anonymity and controlled feedback. However, the Delphi Technique has certain disadvantages. It is time consuming (Anderson, 1990), and swiftness of the decision-making process is controlled by participating individuals to some extent. As results are limited by the number of experts and the number of organizations they represent (Anantatmula, 2004), the Delphi Technique research effort is supplemented by a survey questionnaire, which also helped to set up priority among the established criteria. The survey was aimed only at KM professionals for the same reasons the Delphi was chosen for this research effort.

THE DELPHI TECHNIQUE

The Delphi Technique was developed by RAND Corporation in the 1960s for forecasting purposes, and was later enhanced by the U.S. government for group decision making (Cline, 2000). It is a technique that has also been used to develop lists of objectives or indicators of successful programs (Abramson, Title, & Cohen, 1979). In the KM discipline, the Delphi Technique was used for identifying attribute dimensions to characterize knowledge (Holsapple & Joshi, 2001).

The Delphi Technique was used to gather responses to important research questions by choosing KM professionals and researchers. The Delphi Technique involved the following steps:

- Test research questions
- Select members of the expert group
- Have each member respond to questions
- Summarize responses and distribute the summary
- Seek second responses
- Summarize and distribute responses again
- Continue the process until an agreement emerges

The Delphi Technique addressed the following questions to the select group of KM experts:

1. If an organization wishes to measure success of its KM program, what should be the criteria for measuring KM success?
2. Are the criteria for measuring KM success different for government, non-profit, and for-profit organizations? If different, what should be the criteria for different types of organizations?

The chosen participants of the Delphi Technique were academicians and senior-level KM professionals in organizations such as the George Washington University, Gartner Research Group, Xerox Corporation, U.S. Federal Government, and independent consultants.

THE SURVEY

The initial survey instrument was generated from Table 2, then modified based on pilot test feedback (the pilot test checked the survey's reliability and validity). The final survey was designed with the following features:

- There are 19 questions divided in three parts, making the questionnaire short and less time consuming.
- A brief note about the purpose of the questionnaire is provided in the cover letter.
- Definitions are provided for important terms used in the questionnaire.
- An information sheet is included to obtain consent and ensure confidentiality of the responses.
- Instructions and questions are simple and easy to understand.
- Respondents are given an option to receive research findings.

The survey consisted of 17 closed-ended and two open-ended questions. The primary research question has three parts:

- Establish the criteria that are used to measure KM success
- Establish the importance of each criterion
- Establish the effectiveness of each criterion

The importance of the criterion gives the evidence of significance or consequence, whereas effectiveness denotes the capability of being used to a purpose. A criterion that is important may or may not be effective. If a criterion is chosen as both important and effective, it is considered useful.

The questionnaire was aimed at a target population of KM professionals and practitioners. Those surveyed were from government, non-profit, and for-profit organizations. The survey instrument was used to solicit responses from a number of KM professionals around the world. A total of 152 valid responses were received. Statistical analysis of the results presents the most useful criteria for measuring efforts associated with KM efforts.

FINDINGS

Final Delphi Technique responses are summarized below.

1. If an organization wishes to measure success of its KM program, what should be the criteria for measuring KM success?

All the participants agreed on knowledge sharing and learning, and organization performance as the criteria for KM. Table 3 lists the criteria identified in response to the question.

All Table 3 criteria can be found in Table 2, either with identical phrases or with similar meaning. However, this list could not be shortened, as no further agreement could be reached among the Delphi participants.

Table 3. KM criteria identified by the Delphi respondents

• improve efficiency and effectiveness • improve innovation • make faster, better decisions • improve processes • better business practices • improve capacity (learning and adaptation) • improve collaboration • bottom line (return on investment, increase profits)	• increase intellectual capital • improve knowledge sharing and learning • improve schedule • reduce cost • improve performance • improve customer satisfaction • improve employee satisfaction

2. Are the criteria for measuring KM success different for government, non-profit, and for-profit organizations? If different, what should be the criteria for different types of organizations?

Table 4 lists KM criteria for all three types of organizations. KM criteria for non-profit organizations could include criteria from those of both government and for-profit organizations and are influenced by government. One participant noted that the mission and objectives of each department or agency are different, and hence measures are different for each agency or department. Another participant felt that except for the bottom line argument, the criteria would be the same for all.

Similar to the literature review findings, the Delphi Technique results revealed a list of 15

Table 4. KM criteria for different types of organizations identified by the Delphi

Government	**Non-profit**	**For-Profit**
• cost (budget limitations and fair value) • schedule (milestone requirements) • performance (constituent satisfaction) • customer service • fulfilling government mandate • public service • mission accomplishment • mission results	• public service • mission results • mission accomplishment	• business cost (profit and loss) • schedule (cost reduction and meet customer needs) • performance (quality and customer satisfaction) • business results • customer satisfaction • financial results • innovation • customer loyalty • quality

criteria (Table 3), making it necessary to use a survey to determine the most useful criteria.

SURVEY RESULTS

All survey respondents have some KM experience, with 79% of respondents having more than three years of experience and 42% with six or more years of experience. When asked to rate themselves on KM expertise, only 3.3% of respondents rated themselves as novice, and more than two-thirds considered themselves to be either experts or close to being experts. The majority of those surveyed hold positions such as chairman/CEO, president/CEO, founder/CEO, chief knowledge of-

Table 5. Descriptive statistics of KM criteria (N = 152)

Criteria	Importance		Effectiveness	
	Mean	SD	Mean	SD
Better decision making	4.303	0.828	3.746	0.962
Better customer handling	4.135	0.936	3.727	0.971
Faster response to key business issues	4.023	0.919	3.563	1.005
Improved employee skills	4.094	0.926	3.829	0.985
Improved productivity	4.109	0.981	3.739	0.974
Increased profits	3.458	1.297	3.103	1.267
Sharing best practices	4.068	0.906	3.802	0.988
Reduced costs	3.708	1.069	3.388	1.100
New or better ways of working	3.992	0.897	3.692	1.083
Increased market share	3.067	1.241	2.790	1.081
Creation of new business opportunities.	3.815	1.137	3.416	1.194
Improved new product development	3.769	1.151	3.542	1.142
Better staff attraction/retention	3.604	1.048	3.316	1.118
Increased share price	2.593	1.412	2.493	1.298
Enhanced product or service quality	4.110	0.959	3.743	1.022
Creation of more value to customers	4.065	1.058	3.582	1.102
Enhanced intellectual capital	3.992	1.073	3.761	1.008
Improved communication	4.244	0.842	3.992	0.929
Increased innovation	3.875	1.050	3.627	1.148
Improved business process	3.974	1.021	3.819	0.998
Improved learning/adaptation capability	3.975	0.987	3.761	1.017
Return on investment of KM efforts	3.644	1.299	3.268	1.229
Increased market size	2.933	1.321	2.843	1.254
Entry to different market type	3.128	1.387	3.088	1.389
Increased empowerment of employees	3.844	1.132	3.653	1.108
Enhanced collaboration within organization	4.346	0.794	3.976	0.911

ficer, managing director, director (KM), director, KM architect, KM consultant, senior knowledge strategist, principal, and principal strategy officer. Through descriptive statistical analysis, it was evident that respondents have KM experience, consider themselves fairly knowledgeable about KM, and are involved in KM initiative decision making. Finally, their roles and responsibilities appear to be consistent with their organizational profiles.

Of the organizations represented, 31.5% have equal to or fewer than 100 employees, 36.2% have 2,500 to 10,000 employees, and 24.8% have 10,000 or more employees. In terms of revenue, 47% of organizations have more than $1 million revenue, with 21% having more than $1 billion. Revenue is not applicable for 37% of organizations. Since all the respondents indicated that they have KM experience and that they have answered KM-related questions, we can assume that most of these organizations are involved in implementing KM.

The mean value and standard deviation of importance and effectiveness of each criterion is computed and compiled in Table 5. Both importance and effectiveness have been used.

Both the importance and effectiveness measures have identical scales, with 5 representing very high and 1 representing very low, thus values closer to 5 indicate higher importance or effectiveness. Table 6 lists the most and least useful criteria based on quartile values, with the first quartile representing high importance/high effectiveness of criteria and the last quartile representing low importance/low effectiveness of criteria.

It is interesting to note that the least useful criteria can be quantified and easily measured, whereas the most useful criteria are difficult to measure and cannot be easily tied to bottom-line results. It can be concluded that KM efforts have internal focus and may have indirect impact on business results, specifically market performance.

Other criteria that are associated with business results—increased profits, reduced costs, improved new product development, return on investment of KM efforts, and enhanced product or service quality—are not among the most or least useful criteria. It is important to understand that KM efforts can also lead to results associated with the least useful criteria.

It was possible for respondents to employ one or more criteria not listed among the 26 criteria

Table 6. Survey results of KM criteria

Most Useful Criteria	**Least Useful Criteria**
• Enhanced collaboration	• Increased share price
• Improved communication	• Increased market size
• Improved employee skills	• Increased market share
• Improved productivity	• Entry into different market type
• Better decision making	• Increased profits
	• Better staff attraction/retention
	• Return on investment of KM efforts

presented in the survey. To address this issue, respondents were asked to provide any other criteria that they consider important for measuring KM success. Only 28% of respondents answered this question, which implies that the majority of the respondents (72%) found their useful criteria in the Table 2 list of criteria. Since there were no omissions in the criteria list, and not a single criterion was mentioned more than twice as a response to this open-ended question, they were not included in the results of the study.

KM CRITERIA AND TYPES OF ORGANIZATIONS

While a majority of the respondents agreed that the criteria for measuring KM success are based on an organization's mission, objectives, and goals, the pair-wise correlation analysis indicated that the aligned criteria are not necessarily the most useful criteria. Some of the criteria related to business performance and growth are easily measurable and aligned with the mission, objectives, and goals of an organization.

Pair-wise correlation analysis suggested that top management support is aligned with factors relating to business performance and the delegation of power. Participation of functional managers in KM efforts is aligned with many criteria effectiveness, which signifies its value to KM efforts. Respondents were asked to identify their organization from the options below; the percentage of responses for each is summarized as well.

- Federal or state government—21%
- Non-profit organization—26%
- For-profit organization—48%
- Other, please specify—5%

Responses to option 4 (Other) were eliminated for the analysis, as they are not relevant to the study, and a one-way ANOVA was attempted to determine whether the sample mean values of criteria (both importance and effectiveness) are different for each type of organization. Results showed significant difference in the sample mean value for only 6 and 4 variables of criteria importance and criteria effectiveness respectively

Table 7a. ANOVA – criteria importance

Criteria	Government		Non-profit		For-profit		Probability
	size	mean	Size	mean	size	mean	
Increased profits	16	2.250	20	3.000	54	3.963	<0.0001
Increased market share	15	1.667	21	2.953	49	3.429	<0.0001
creation of new business	18	3.055	28	3.536	58	4.156	0.0004
Increased share price	15	1.800	19	2.211	43	2.954	0.0116
Increased market size	16	2.062	25	2.800	44	3.205	0.0106
Entry to different market	16	2.250	22	3.046	44	3.364	0.0224

Table 7b. ANOVA – criteria effectiveness

Criteria	Government		Non-profit		for-profit		probability
	size	Mean	Size	mean	size	mean	
Increased profits	15	3.667	19	3.210	49	3.368	0.009
Increased market share	13	1.693	20	2.850	45	3.089	0.000
creation of new business	17	2.923	27	3.186	54	3.704	0.013
increased empowerment	22	3.318	27	3.334	48	3.917	0.035

(Tables 7a and 7b). The differences of mean value are not significant for 20 and 22 (out of 26) criteria importance and effectiveness, respectively, for different types of organizations.

While the differences of mean value are significant, their mean values are not. Except for the criterion, creation of new business opportunities, which has a mean value of 4.156 for for-profit organizations, all others have lower mean values. Table 8 uses a similar methodology to that used for Table 6 to identify the most useful criteria for each type of organization.

These results indicate that criteria for measuring KM efforts are different for different types of

Table 8. KM criteria for different types of organizations

Government	Non-profit	For-Profit
• Improved communication • Improved productivity	• improved communication • Enhanced collaboration within organization • Improved learning, adaptation capability	• Enhanced collaboration within organization • Improved employee skills • Improved communication • Enhanced product or service quality • Sharing best practices • Better customer handling • Better decision making • Creation of more value to customers

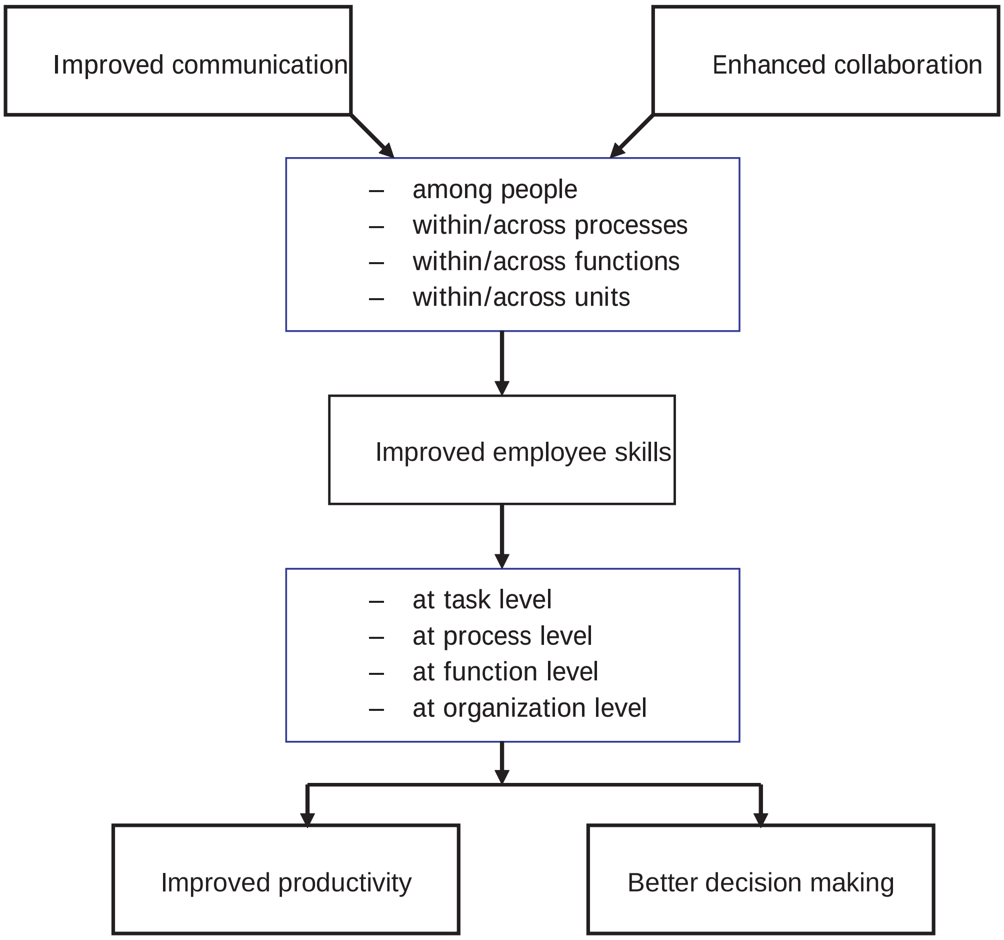
organizations. While government and non-profit organizations focus on internal performance only, for-profit organizations focus on both internal and external performance.

MEASURES OF THE MOST USEFUL OUTCOMES

Through this research, both the most useful and the least useful criteria are established for outcomes of KM initiatives. While the most useful outcomes are difficult to measure, the least useful outcomes can be quantified and are easily measurable. The research identified enhanced collaboration within organization, improved communication, and improved employee skills as the top three outcomes overall, followed by improved productivity and better decision making. As these criteria are difficult to measure, it is important that they need to be further broken down to different levels to develop detailed measures as shown in Figure 1.

Developing measures for improved communication and enhanced collaboration requires

Figure 1. Significant KM outcomes



critical thinking. Some of the suggested methods to develop measures for these criteria are discussed below.

Improved Communication

- A gap survey to determine communication effectiveness is a first step. Once these gaps are identified, organizations should address these issues through KM initiatives and tools, which could be organization specific. Impact of these actions can be measured by using controlled groups or by conducting a similar gap survey later. Some of the tools to address communication gap are newsletters, kiosks, and news desks. However, these tools should be designed to communicate key business knowledge, with a focus on improving organizational performance.
- Constant and continuous transformation of individual learning to organizational learning and vice versa is a source of effective communication. To facilitate this transformation, organizations must encourage both formal and informal communication channels and monitor their performance. Communities of practice, electronic yellow pages, intranets, and best-practice database systems should help this transformation, and their effectiveness measures in terms of business performance can be developed.
- Organizations must develop skill development workshops and employee training development seminars to improve communication and ensure transformation of explicit knowledge to tacit knowledge and vice versa. Effectiveness measures of these workshops and seminars can be easily developed.
- Quantification of organizational or explicit knowledge and developing measures for their usefulness is another way of measuring communication. For example, a number of documented and well-defined processes, project management practices, and decision-making procedures can be developed; frequency of reference and number of revisions could be guiding factors for measuring the effectiveness of these communication tools.

Enhanced Collaboration

- Opportunities for individuals to participate in management activities such as decision making should be designed to improve collaboration, and it should be aimed at improving organizational performance. The effectiveness of these actions can be measured by controlled group studies.
- Formation of committees at several levels of management to develop new problem-solving methods and resolve management problems will ensure enhanced collaboration. It is relatively easy to measure the effectiveness and contribution of these committees.
- Constant and continuous transformation of individual learning to organizational learning and vice versa is a source of effective communication and enhanced collaboration as well. Some of the measures discussed above are applicable for enhanced collaboration also.
- Delegation of authority and accountability to encourage individuals would result in greater collaboration at lower levels of management. It would lead to increased employee morale, motivation, and individual performance, which can be measured.

Improving employee skills can be achieved by improved communication and enhanced collaboration. In addition, recognition programs—such as employee of the month, years of service, and attendance awards—would create incentives for employees to improve their individual performance. There are many ways to measure improved productivity and better decision making, which can be judged by results associated with decisions.

CONCLUSION

Knowledge, as a source of competitive advantage, will continue to gain strategic importance, and organizations will be compelled to implement KM initiatives to improve organizational performance. KM will continue to evolve to develop industry and organization-specific systems and processes. Through future research efforts, the most useful outcomes identified through this research can be further developed into detailed measures of KM success. The author is presently engaged in expanding these research findings and in developing detailed metrics for KM initiatives.

Limitations of the Study

As mentioned earlier, the number of experts and the number of organizations they represent limit Delphi Technique results. The survey questionnaire is similar to a one-time case study in which all the respondents were asked to respond to the questionnaire only once.

Of the internal and external validity factors (Campbell & Stanley, 1963), only statistical regression and biases are relevant to the survey and the Delphi Technique. Others are relevant for controlled experimental studies. External validity factors are no threat to the research study. Statistical regression, which is concerned about selection of groups on the basis of their extreme scores, is part of the research design, as responses from KM professionals and experts are sought for this research and its findings are limited to KM initiatives only.

Bias, which results in differential selection of respondents for the comparison groups, is not directly related to the current research, as there are no comparison groups. However, selection bias is a possibility for the Delphi Technique. To avoid this, the Delphi Technique group was selected by a leading KM expert and professor, who is not directly involved with the study.

The study grouped organizations into government, non-profit, and for-profit organizations, and research data was separated using these groups to examine hypotheses using statistical analysis. The underlying assumption is that within each group, organizations have similar KM purpose and focus, which may or may not be true.

Incomplete responses were ignored for the statistical analysis. Of the valid responses received, 48% of responses represent for-profit organizations, whereas responses from government and non-profit organizations constitute 21% and 26% respectively. Due to this imbalance in organizational representations, the results may be biased towards for-profit organizations.

Some respondents chose to not answer questions associated with importance and effectiveness of the criteria that they did not use. As a result, responses to criteria importance and effectiveness varied from 75 (criteria effectiveness—increase in share price) to 135 (criteria importance—sharing best practices). However, more than 80% of responses were in the range of 105-135. Since not all respondents provided their contact information, it was not possible to do a follow-up mailing or phone call to get full responses.

Research findings and conclusions of this research must be seen in the context of the profiles of the respondents and organizations they represent. Specifically, these findings are not tied to any specific geographical region.

Suggestions for Future Research

Statistical analysis and research findings helped to identify the criteria for measuring KM efforts, which in turn can be described as desired outcomes. The research study also helped in identifying new areas of interest for further research. Some of these gray areas and new areas of interest are:

- The most useful criteria identified through this research can be further developed into detailed measures of KM success, as discussed briefly in the previous section. The research questions—What are the detailed measures for enhanced collaboration within an organization? What are they for improved communication and improved employee skills?—are required to be answered in this effort. The research effort would entail establishing detailed measures for each useful criterion, validating their relation to the criteria, and validating their effectiveness through research.
- Based on geographical location as well as industry type, the differences in KM criteria can be analyzed using multiple factors. The research questions—What are the differences in KM criteria based on geographical location? Are they industry specific?—will have to be addressed in a follow-up research effort. However, using data similar to those obtained from this research, the differences in KM criteria can be examined for Europe and the U.S.

Relationships among all the 26 criteria can be explored to establish associations and classifications among these criteria by factorial analysis. KM criteria and outcomes may be classified based on business results, market results, customer service, and internal performance.

REFERENCES

Abramson, T., Tittle, C., & Cohen, L. (1979). *Handbook of vocational education evaluation*. Beverly Hills, CA: Sage.

Ahn, J., & Chang, S. (2002). Valuation of knowledge: A business performance-oriented methodology. *Proceedings of the 35th Hawaii International Conference on System Sciences, HICSS35*. IEEE Computer Society.

Allee, V. (1997). *The knowledge evolution: Expanding organizational intelligence*. Newton, MA: Butterworth-Heinemann.

Anantarmula, V. (2004). *Criteria for measuring knowledge management efforts in organizations.* UMI Dissertation Services (3123064): ProQuest.

Anderson, D. R. (1990, September). Increased productivity via group decision making. *Super-Vision*, *52*(9), 6.

Austin, R., & Larkey, P. (2002). The future of performance measurement: Measuring knowledge work. In A. Neely (Ed.), *Business performance measurement.*

Baldanza, C., & Stankosky, M. (2000) Knowledge management: An evolutionary architecture toward enterprise engineering. *INCOSE*, 13.2-1 - 13.2-8.

Bassi, L., & Van Buren, M. (1999). Valuing investments in intellectual capital. *International Journal of Technology Management, 18*(5,6,7,8), 414-432.

BP Amoco (2001). Retrieved April 2001, from http://bp.com

Campbell, D., & Stanley, J. (1963). *Experimental and quasi-experimental designs for research*. Boston: Houghton Miffin.

Chourides, P., Longbottom, D., & Murphy, W. (2003). Excellence in knowledge management: An empirical study to identify critical factors and performance measures. *Measuring Business Excellence, 7*(2), 29-45.

Cline, A. (2000). *Prioritization process using Delphi Technique*. Carolla Development: White Paper. Retrieved June 2001, from http://www.carolla.com/wp-delph.htm

Davenport, T.H., DeLong, D.W., & Beers, M.C. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2).

Davenport, T., & Probst, G. (2001). *Knowledge management case book - Siemens best practice*. Germany: MCD Verlag and Wiley & Sons.

Drucker, P. (1994). *Post-capitalist society*. New York: Harper Business.

Ellis, K. (2003, November). K-span: Building a bridge between learning and knowledge management. *Training, 40*(10), 46.

Fairchild, A. (2002). Knowledge management metrics via a balanced scorecard methodology. *Proceedings of the 35th Hawaii International Conference on System Sciences.*

Fowles. (1978). The Delphi Method. Retrieved June 2001 from the Department of Civil and Arechitectural Engineering, Illinois Institute of Technology Web site: http:///www.iit.edu/~it/delphi.html

Griffin, H., & Houston, A. (1980, September). Self-development for managers: Making most of existing resources. *Personnel Management, London, 12*(9), 46.

Gubbins, M. (2003, November 27). Enterprise - conference call - Reap the long-term rewards of knowledge management. *Computing,* 20.

Holsapple, C.W., & Joshi, K.D. (1999). Description and analysis of existing knowledge management frameworks. *Proceedings of the 32nd Hawaii International Conference on System Sciences. HICSS32*. IEEE Computer Society.

Holsapple, C.W., & Joshi, K.D. (2001, May). Organizational knowledge resources. *Decision Support Systems, 31*(1), 39.

Jennex, M.E., & Olfman L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. *Proceedings of the 35th Hawaii International Conference on System Sciences. HICSS35*. IEEE Computer Society.

Jennex, M.E., Olfman, L., & Addo, T.B.A. (2003). The need for an organizational knowledge management strategy. *Proceedings of the 36th Hawaii International Conference on System Sciences. HICSS36*. IEEE Computer Society.

Jennex, M.E., & Olfman L. (2004). Accessing knowledge management success/effectiveness models. *Proceedings of the 37th Hawaii International Conference on System Sciences. HICSS37.* IEEE Computer Society.

Jiang, J., & Klein, G. (1999, August). Project selection criteria by strategic orientation. *Information & Management, 36*(2), 63-75.

Kelley, J. (2003). *Strategic premises and propositioyns for I-value growth*. Retrieved September 2003, from http://www.transformpartners.com

KPMG International, UK. (1999, November). *Knowledge management research report 2000.* UK: KPMG Consulting.

Longbottom, D., & Chourides, P. (2001, September 26-28). Knowledge management: A survey of leading UK companies. *Proceedings of the 2nd MAAQE International Conference. "Towards a Sustainable Excellence?"* Versailles, France (pp. 113-126).

Marr, B. (2003, February). Known quantities. *Financial Management,* 25-27.

Massey, A.P., & Montaya-Weiss, M. (2002). A performance environment perspective of knowledge management. *Proceedings of the 35th Hawaii International Conference on System Sciences. HICSS35*. IEEE Computer Society.

O'Dell, C., Jackson, C., & Grayson. (1998, spring). If only we knew what we know: Identification and transfer of internal best practices. *California Management Review, 40*(3), 154-174.

Ofek, E., & Sarvary, M. (2001, November). Leveraging the customer base: Creating competitive advantage through knowledge management. *Management Science INFORMS, 47*(11), 1441-1456.

Perkmann, M. (2002, July). *Measuring knowledge value?: Evaluating the impact of knowledge projects*. KIN Brief #7. Retrieved January 2003 from Warwick Business School, Leicester University, UK: http://www.ki-network.org

Ruggles, R. (1998, spring). The state of notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Simpson, J. A., & Weiner, E.S.C. (Prepared). (1989). *The Oxford English Dictionary* (2nd ed., Vols. 1-20). Oxford, UK: Oxford University Press.

Skyrme, D. (1997). *Knowledge networking: Creating the collaborative enterprise*. Boston: Butterworth-Heinemann.

Stankosky, M., & Baldanza, C. (2001). *A systems approach to engineering a KM system*. Unpublished manuscript.

Sveiby, K, (1997). *The new organisational wealth: Managing & measuring knowledge-based assets*. San Francisco: Berrett- Koehler.

Takeuchi, H. (1998, June). *Beyond knowledge management: Lesson from Japan*. Retrieved December 2001, from http://www.sveiby.com.au/Lessons Japan.html

The Delphi Method: Definition and Historical Background. (n.d.). Retrieved July 2001, from http://www.carolla.com/wp-delph.htm

Turban, E., & Aronson , J.E. (2001). *Decision support systems and intelligent systems* (6th ed.). Prentice Hall.

Van Buren, M. (1999, May). A yardstick for knowledge management. *Training Development, 53*(5), 71-77.

Wikramasinghe, N. (2002). Practising what we preach: Are knowledge management systems in practice really knowledge management systems. *Proceedings of the 35th Hawaii International Conference on System Sciences.*

Wiig, K. M. (1993). *Knowledge management foundations: Thinking about thinking – How people and organizations create, represent, and use knowledge*. Arlington, TX: Schema Press.

Wiig, K. M. (1999). What future knowledge management users may expect. *Journal of Knowledge Management, 3*(2), 155.

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Section 7
Critical Issues in Knowledge Management

This section contains 25 chapters addressing issues such as intellectual capital and knowledge management, communities of practice and critical social theory and ontology-supported web service composition. Within the chapters, the reader is presented with an in-depth analysis of the most current and relevant issues within this growing field of study while developing an excellent model for researchers and practitioners as attempts are made to simultaneously ease and expedite the transfer of knowledge from the private to the public sector. Forming frameworks in which to position the issues faced in this growing field are provided by research found in chapters that take the core psychological paradigms of sociology and translate them into applicable ideas within the exploding realm of information sharing. Crucial examinations serve to reinforce the ideas presented in this section while simultaneously enticing and inspiring the reader to research further and participate in this increasingly pertinent debate.

Chapter 7.1
Knowledge Creation

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INTRODUCTION

Knowledge management (KM) is a newly emerging approach aimed at addressing today's business challenges to increase efficiency and efficacy of core business processes, while simultaneously incorporating continuous innovation. The need for knowledge management is based on a paradigm shift in the business environment where knowledge is now considered to be central to organizational performance and integral to the attainment of a sustainable competitive advantage (Davenport & Grover, 2001; Drucker, 1993). Knowledge creation is not only a key first step in most knowledge management initiatives, but also has far reaching implications on consequent steps in the KM process, thus making knowledge creation an important focus area within knowledge management. Currently, different theories exist for explaining knowledge creation. These tend to approach the area of knowledge creation from either a people perspective—including Nonaka's Knowledge Spiral, as well as Spender's and Blackler's respective frameworks—or from a technology perspective—namely, the KDD process and data mining.

The following discusses each of these major theories on knowledge creation and suggests the benefits of taking a holistic approach to knowledge creation—namely, incorporating both the people and technology perspectives in all knowledge creation endeavors, and thereby facilitating the realization of a broader knowledge base, better knowledge inputs to impact on the consequent KM steps, and hence an increased likelihood in more successful knowledge management initiatives.

BACKGROUND

Knowledge Management

Knowledge management offers organizations many strategies, techniques, and tools to apply to their existing business processes so that they are able to grow and effectively utilize their knowledge assets. In essence then, knowledge management not only involves the production of

Figure 1. The KM Triad

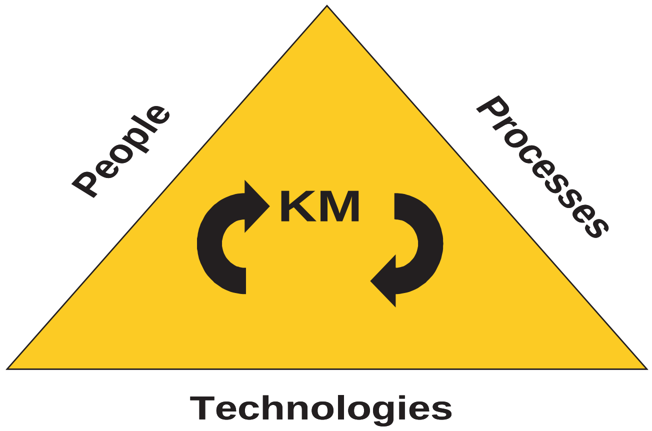
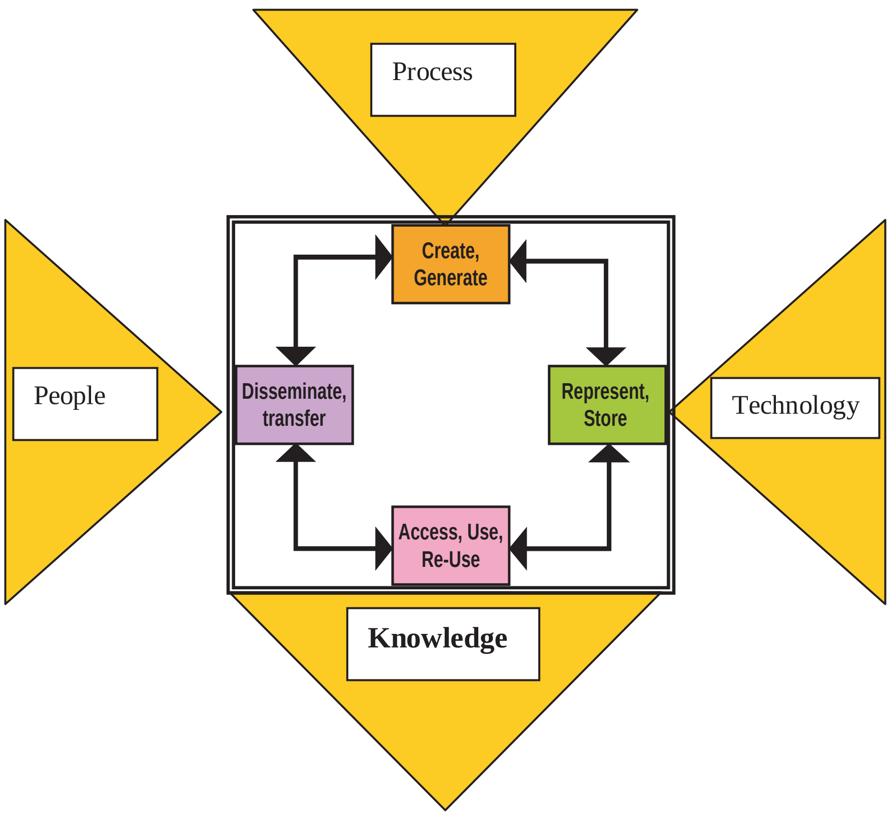


Figure 2. The KM Diamond



information, but also the capture of data at the source, the transmission and analysis of this data, as well as the communication of information based on or derived from the data to those who can act on it (Swan et al., 1999). Integral to knowledge management is incorporating the socio-technical perspective of people, processes, and technologies (Wickramasinghe & Mills, 2001). We can visualize this in terms of the KM Triad as shown in Figure 1. The significance of the KM Triad is to emphasize that knowledge can be created by people and/or technologies, and can also be embedded in processes.

Broadly speaking, knowledge management involves four key steps of creating/generating knowledge, representing/storing knowledge, accessing/using/re-using knowledge, and disseminating/transferring knowledge (Davenport & Prusak, 1998; Alavi & Leidner, 2001; Markus, 2001). By combining the KM Triad with these four key steps, it is possible to form the KM Diamond as shown in Figure 2. The KM Diamond highlights the importance of the impact of the three elements of KM—namely, people, process, and technology—on the four steps of knowledge management. In other words, successful KM initiatives require consideration and interactions among all of these components.

Knowledge creation, generally accepted as the first step for any knowledge management endeavor (as depicted in Figure 2), requires an understanding of the knowledge construct as well as its people and technology dimensions. Given that knowledge creation is the first step in any knowledge management initiative, it naturally has a significant impact on the other consequent KM steps (depicted in Figure 2), thus making knowledge creation a key focal point of many theories currently in the literature. In order to fully appreciate the need for taking a holistic approach to knowledge creation, it is important to first discuss the subtleties of the knowledge construct itself.

Table 1. Multiple perspective on knowledge (Wickramasinghe & Sharma, 2005)

School of Thought	*Basic Ideas on Knowledge*	*Some Proponents*
Positivism	Knowledge is gained from the observation of objective reality.	Comte
Constructivism	Knowledge is constructed in our minds, thus is not objective.	Erlangen School
Critical Theory	Uses knowledge to integrate the tension between reality of society and the real societal function of science.	Habermas, Horkheimer
Critical Rationalism	All knowledge must be open to empirical falsification before it can be accepted.	Popper
Empiricism	Knowledge can be created from experiments, and thus only mathematics and natural sciences can provide secure knowledge.	Locke, Russel
Sociology of Knowledge	Knowledge is a socially constructed reality.	Mannheim, Scheler
Pragmatism	Knowledge represents a local reality based on our experiences.	Dewey

Historical Understanding of Knowledge

We owe much of our current understanding of knowledge today to the discussions and debates of ancient Greek philosophers such as Socrates, Plato, and Aristotle. The knowledge construct and trying to pin it down, as well as define the process of knowing itself, dominated their thinking. For these ancient Greek philosophers, knowledge was a homogenous construct that ultimately was representative of the truth. Thus knowledge was truth. Other important challenges to what knowledge is then came in the 17th and 18th centuries when philosophers such as Decartes, Leibnitz, and Locke challenged the ideas of knowledge as faith and developed ideas of knowledge as accurate, provable facts, while other philosophers such as Hegel and Kant defined knowledge as divergent meaning or justified true beliefs. Since the 19th century, many different philosophical schools of thought have emerged, and they have all tried to once again pin down this elusive, yet important knowledge construct. Table 1 summarizes the major perspectives.

The Multifaceted Knowledge Construct

As with many concepts in organizational theory, the existence of duality as discussed by Orlikowski (1992) applies when we examine the knowledge construct. Traditionally researchers have turned to Burrell and Morgan's (Malhotra, 2000) well-established framework of objective and subjective characterizations, or a more recent approach elaborated on by Schultze and Leidner (2002) is Deetz's four discourses of organizational inquiry to highlight these dualities. In trying to manage knowledge, it is necessary first to understand the binary nature of knowledge—namely, its objective and subjective components (Malhotra, 2000) or consensus/dissensus dimensions (Schultze & Leidner, 2002). Knowledge can exist as an object, in essentially two forms: explicit or documented and formal knowledge—that is, "know-what"—and tacit or experiential—that is, "know-how" (Polyani, 1958, 1966; Nonaka & Takeuchi, 1995; Beckman, 1999). It is well established that while both types of knowledge are important, tacit knowledge is more difficult to identify and thus manage (Malhotra, 2000; Newell, Robertson, Scarbrough, & Swan, 2002). Of equal importance, though perhaps less well defined, knowledge also has a subjective component and can be viewed as an ongoing phenomenon, being shaped by social practices of communities (Boland & Tenkasi, 1995). The objective elements of knowledge can be thought of as primarily having an impact on process, while the subjective elements typically impact innovation. Both effective and efficient processes as well as the functions of supporting and fostering creativity and innovation are key concerns of knowledge management. Thus, we have an interesting duality in knowledge management (Wickramasinghe, 2001) that some have called a contradiction (Schultze, 1998) and others describe as the loose-tight nature of knowledge management (Malhotra, 2000).

The loose-tight nature of knowledge management comes to being because of the need to recognize and draw upon several distinct philosophical perspectives, including the Lockean/Leibnitzian stream and the Hegelian/Kantian stream. Models of convergence and compliance representing the tight side are grounded in a Lockean/Leibnitzian tradition. Such a perspective views the pursuit of knowledge and its management as necessary to provide the correct solution to a problem or decision, and thus enables organizational effectiveness and efficiencies to ensue (Wickramasinghe, 2005). This in turn leads to the development of models that are essential to support the information processing aspects of knowledge management, most notably by enabling efficiencies of scale and scope and thus supporting the objective view of knowledge management (Malhotra, 2000; Wickramasinghe, 2005). In contrast, the loose side provides agility and flexibility in the tradition of a Hegelian/Kantian perspective. Such models recognize the importance of divergence of meaning and the need to support discourse within communities of practice (Boland & Tenkasi, 1995), which is essential to support the "sense-making," subjective view of knowledge management. In terms of knowledge creation then, in order to ensure the creation of a rich, germane, and useful knowledge base, it is prudent to be mindful of these philosophical perspectives that highlight the key dynamics relating to different types of knowledge creation.

MAIN FOCUS: THEORIES ON KNOWLEDGE CREATION

The processes of creating and capturing knowledge, irrespective of the specific philosophical orientation (i.e., Lockean/Leibnitzian versus Hegelian/Kantian), is the central focus then of both the psycho-social and algorithmic theories of knowledge creation. However, to date knowledge creation has tended to be approached from one or the other perspective, rather than a holistic, combined perspective (Wickramasinghe, 2005).

The Psycho-Social Driven Perspective to Knowledge Creation

In this section three well-known psycho-social knowledge creation theories—Nonaka's Knowledge Spiral, and Spender's and Blackler's respective frameworks—are presented. Organizational knowledge is not static; rather it changes and evolves during the lifetime of an organization (Davenport & Prusak, 1998; Malhotra, 2000). Furthermore, it is possible to change the form of knowledge, that is, to transform existing tacit knowledge into new explicit knowledge and existing explicit knowledge into new tacit knowledge, or to transform the subjective form of knowledge into the objective form of knowledge (Nonaka & Nishiguchi, 2001; Nonaka, 1994).

This process of transforming the form of knowledge, and thus increasing the extant knowledge base as well as the amount and utilization of the knowledge within the organization, is known as the knowledge spiral (Nonaka, 1994). In each of these instances, the overall extant knowledge base of the organization grows to a new, superior knowledge base. According to Nonaka (1994):

1. Tacit-to-tacit knowledge transformation usually occurs through apprenticeship type relations where the teacher or master passes on the skill to the apprentice.
2. Explicit-to-explicit knowledge transformation usually occurs via formal learning of facts.
3. Tacit-to-explicit knowledge transformation usually occurs when there is an articulation of nuances; for example, as in healthcare if a renowned surgeon is questioned as to why he does a particular procedure in a certain manner, by his articulation of the steps the tacit knowledge becomes explicit.
4. Explicit-to-tacit knowledge transformation usually occurs as new explicit knowledge is internalized; it can then be used to broaden, reframe, and extend one's tacit knowledge.

These transformations are often referred to as the modes of socialization, combination, externalization, and internalization, respectively (Nonaka & Nishiguchi, 2001).

The following scenario serves to depict these knowledge transformations in the context of healthcare (Wickramasinghe et al., 2004). Specifically, the scenario outlines the application of the knowledge spiral in the domain of reconstructive orthopedic surgery. Advancing age often leads to the degeneration of a patient's knee and hip joints such that reconstruction of the joint with metal and plastic components is often required. Given the explosion of the population over the age of 65 over the next 40 years, these devices are being implanted in increasingly larger numbers during major surgical procedures in which the degenerative joint surfaces are removed and replaced with the artificial components. There are a multitude of variables in these reconstructions, ranging from the patient characteristics and healthcare status to the implant design and implantation methodologies. The surgeon's tacit knowledge determines the 'best' implant design and combinations and implantation methodologies that are used for each particular patient. The examination of the clinical results leads to the explicit knowledge that determines if those choices are appropriate for each patient population.

However, the examination of the results of these interventions has been limited at the very least to just a few of the thousands of clinical data points and rarely to more than one surgeon or one clinical site. Moreover, at each clinical site, the data of interest is often housed in divergent databases from administrative, clinical, financial, imaging, and laboratory sources. The complete and accurate examination of the clinical results of joint replacement requires an examination of each of these data sets for the relationships that may exist within and across databases. Post-operative and regular radiographs of these implanted devices are used by clinicians to determine if the implant methodologies, such as device alignment and bone-implant interface, are appropriate. Migration of the implant within the host bone or wearing of the plastic component can be visualized on the radiographs and is indicative of impending failure of the component. Combinations of the various data sources—that is, combinations of explicit knowledge—will assist with the handling of failures and complications, and offer the clinicians the opportunity to develop solutions to problems as or even before the problems develop into patient symptoms—that is, increase the existing knowledge base. The knowledge transformations of the knowledge spiral from extant explicit and tacit knowledge to the creation of new explicit and tacit will assist in the search of clinical perfection and ultimately lead to improved clinical outcomes and increased healthcare value. Thus, in this one simple scenario from healthcare, all four of Nonaka's knowledge transformations are being effected.

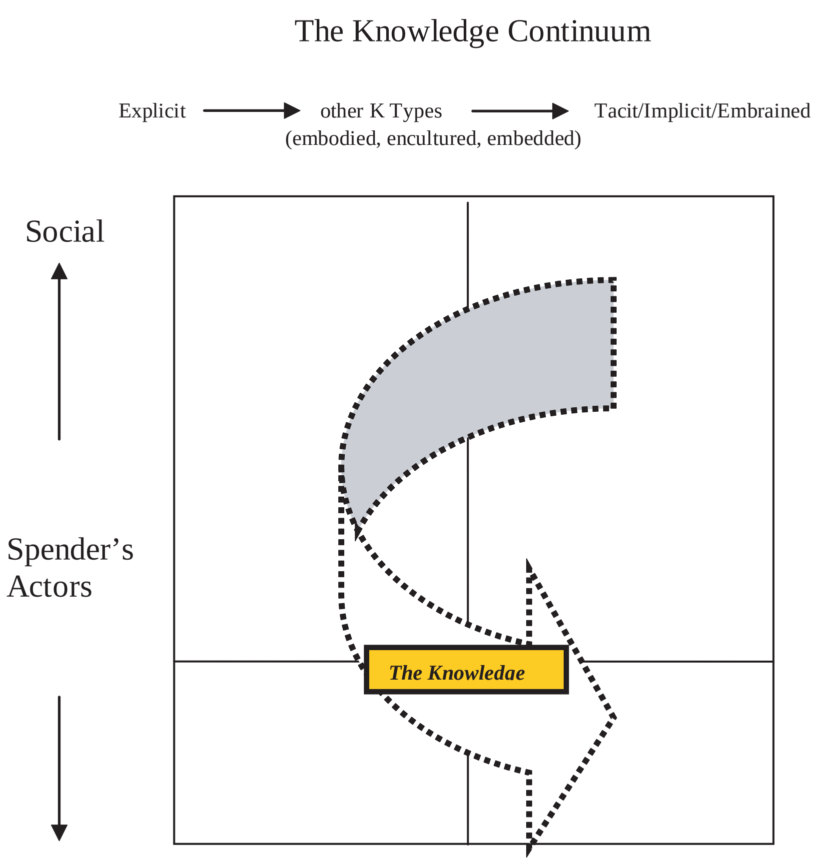
Integral to this changing of knowledge through the knowledge spiral is that new knowledge is created (Nonaka, 1994); this can bring many benefits to organizations, as seen in the above scenario of the orthopedic reconstruction of knee and hip joints. Specifically, in today's knowledge-centric economy, processes that effect a positive change to the existing knowledge base of the organization and facilitate better use of the organization's intellectual capital, as the knowledge spiral does, are of paramount importance. It is noteworthy that while the knowledge spiral is well discussed in the literature as a cornerstone in knowledge creation, few frameworks, if any, exist on how to actualize the transformations of the knowledge spiral as evidenced by extensive literature review studies (Schultze & Leidner, 2002; Alavi & Leidner, 2001).

Two other primarily people-driven theories that focus on knowledge creation as a central theme are Spender's and Blackler's respective frameworks (Newell et al., 2002). Spender draws a distinction between individual knowledge and social knowledge, each of which he claims can be implicit or explicit (Newell et al., 2002; Spender, 1998). From this framework we can see that Spender's definition of implicit knowledge corresponds to Nonaka's tacit knowledge. However, unlike Spender, Nonaka does not differentiate between individual and social dimensions of knowledge; rather he just focuses on the nature and types of the knowledge itself. In contrast, Blackler (Newell et al., 2002; Blackler, 1995) views knowledge creation from an organizational perspective, noting that knowledge can exist as encoded, embedded, embodied, encultured, and/

or embrained. In addition, Blackler emphasized that for different organizational types, different types of knowledge predominate and highlighted the connection between knowledge and organizational processes (Newell et al., 2002; Blackler, 1995).

Blackler's types of knowledge can be thought of in terms of spanning a continuum of tacit (implicit) through to explicit, with embrained being predominantly tacit (implicit) and encoded being predominantly explicit, while embedded, embodied, and encultured types of knowledge exhibit varying degrees of a tacit (implicit)/explicit combination. In other words, Blackler takes a more integral calculus perspective to the types of knowledge. An integrated view of all the three frameworks is depicted in Figure 3. What is important to note here is that this integrated view is not in conflict with any of the philosophical perspectives discussed earlier. This means that the existence of tacit and explicit knowledge, and more importantly the knowledge spiral itself, the most general of the three psycho-social frameworks, is relevant to both the Lokean/Leibnitzian and Hegelian/Kantian perspectives, as well as the other philosophical perspectives identified in Table 1. One key benefit of such an integrated view (as in Figure 3) is that it shows the inter-

Figure 3. People-driven knowledge creation grid/map



relationships among these three frameworks and how their respective views of knowledge map to each other.

Specifically, from Figure 3 we can see that Spender's and Blackler's perspectives complement Nonaka's conceptualization of knowledge creation and more importantly do not contradict his thesis of the knowledge spiral wherein the extant knowledge base is continually being expanded to a new knowledge base, be it tacit /explicit (in Nonaka's terminology), implicit/explicit (in Spender's terminology), or embrained/encultured/embodied/embedded/encoded (in Blackler's terminology). What is important to underscore here is that these three frameworks take a primarily people-oriented perspective of knowledge creation.

The Algorithmic Perspective to Knowledge Creation

In contrast to the above, primarily people-oriented frameworks pertaining to knowledge creation, knowledge discovery in databases (KDD), and more specifically data mining, approaches knowledge creation from a primarily technology-driven perspective. In particular, the KDD process focuses on how data is transformed into knowledge by identifying valid, novel, potentially useful, and ultimately understandable patterns in data (Fayyad, Piatetsky-Shapiro, & Smyth, 1996; Adriaans & Zantinge, 1996; Becerra-Fernandez, 2001; Chung & Gray, 1999). KDD is primarily used on data sets for creating knowledge through model building, or by finding patterns and relationships in data using various techniques drawn from computer science, statistics, and mathematics as illustrated in Figure 4 (Cabena, Hadjinian, Stadler, Verhees, & Zanasi, 1998).

From an application perspective, data mining and KDD are often used interchangeably. Figure 5 presents a generic representation of a typical knowledge discovery process. Knowledge creation in a KDD project usually starts with data collection or data selection, covering almost all steps (described above and illustrated in Figure 5) in the KDD process. As depicted in Figure 5, the first three steps of the KDD process (i.e., selection, preprocessing, and transformation) are considered exploratory data mining, whereas the last two steps (i.e., data mining and interpretation/evaluation) in the KDD process are considered predictive data mining.

The primary tasks of data mining in practice tend to be description and prediction. Description focuses on finding human-interpretable patterns describing the data, while prediction involves using some observations or attributes to predict unknown or future values of other attributes of interest. The relative importance of description and prediction for particular data mining applications can vary considerably. The descriptive and predictive tasks are carried out by applying different machine learning, artificial intelligence,

Figure 4. Key techniques involved in data mining (adapted from Wickramasinghe et al., 2004)

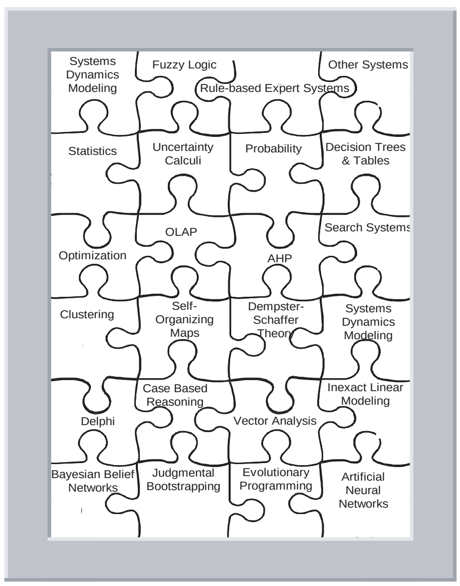
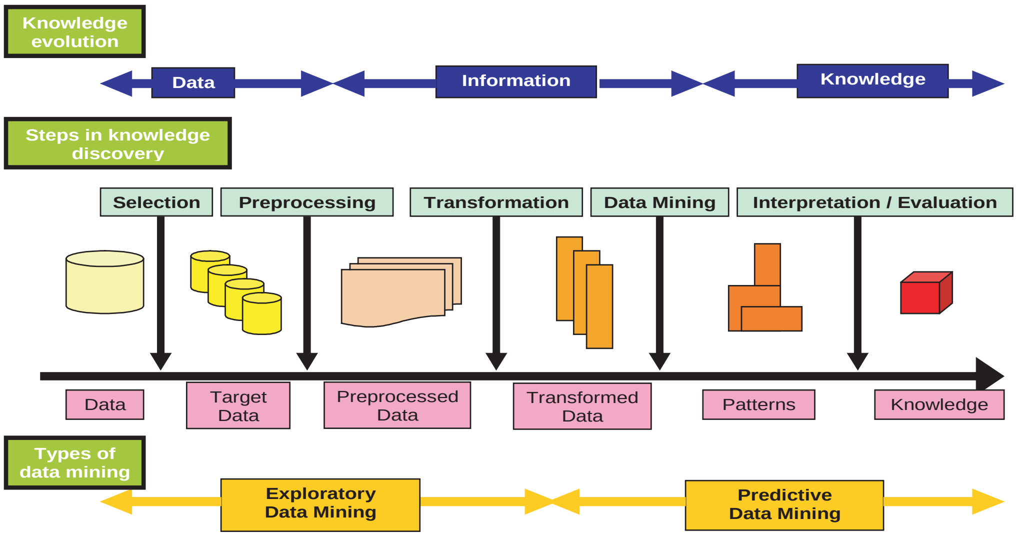


Figure5. Integrated view of the knowledge discovery process (adapted from Wickramasinghe et al., 2004)



and statistical algorithms. Irrespective of the type of data mining, knowledge creation is the ultimate goal.

Figure 5 captures all the major aspects connected with data mining and the KDD process, and emphasizes the integral role of the KDD process to knowledge creation showing how data is transformed into knowledge via information. However, unlike the frameworks discussed earlier, where knowledge is subdivided into various constituent parts, it is important to note that typically in the KDD process, the knowledge component itself is treated as a homogeneous block.

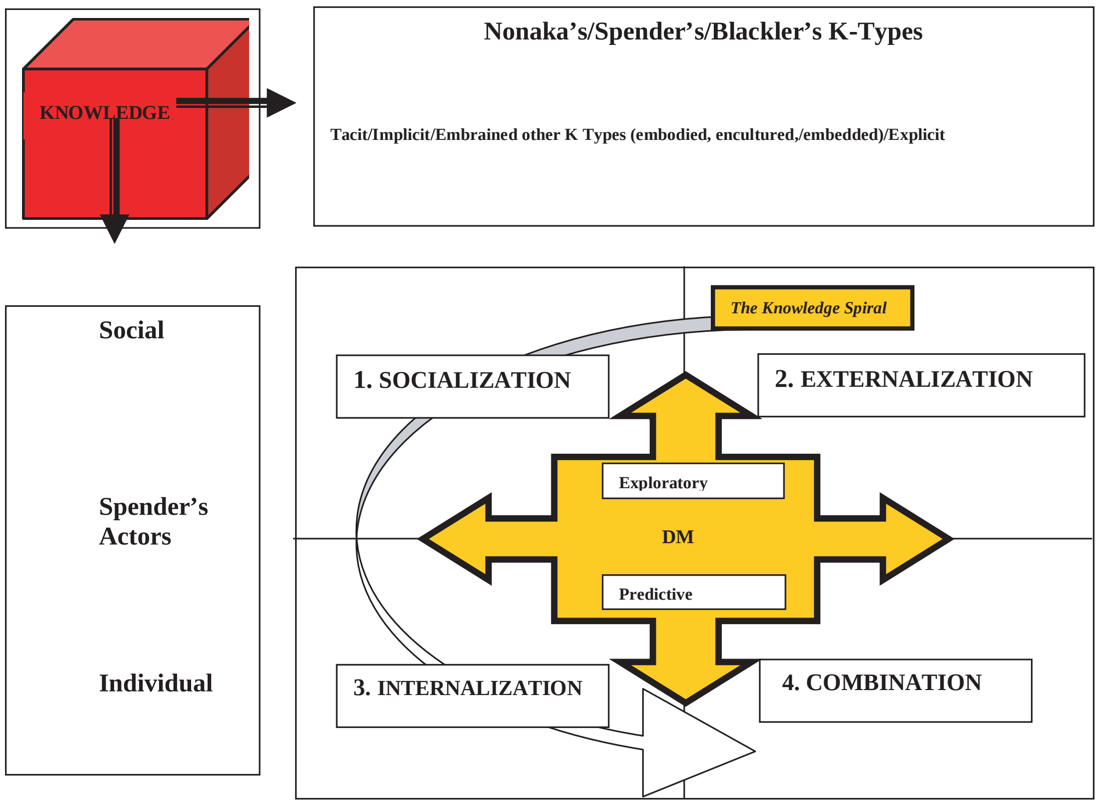
FUTURE TRENDS

"Land, labor, and capital now pale in comparison to knowledge as the critical asset to be managed in today's knowledge economy." Peter F. Drucker

The nations that lead the world into the next century will be those who can shift from being industrial economies, based upon the production of manufactured goods, to those that possess the capacity to produce and utilize knowledge successfully. The focus of the many nations' economy has shifted first to information-intensive industries such as financial services and logistics, and now toward innovation-driven industries, such as computer software and biotechnology, where competitive advantage lies mostly in the innovative use of human resources. This represents a move from an era of standardization to customization, to an era of innovation where knowledge, its creation and management hold the key to success (Bukowitz, & Williams, 1997; Drucker, 1993, 1999).

In today's knowledge economy, it is indeed vital to begin to take a holistic approach to knowledge creation, and thus combine the people-driven and technology-driven theories of knowledge

Figure 6. Holistic view of knowledge creation



creation into an integrative, all-encompassing meta framework in order to truly capture the subtle nuances and complexities of knowledge creation (refer to Figure 6). The two significant ways to create knowledge are: (1) synthesis of new knowledge through socialization with experts—a primarily people-dominated perspective, and (2) discovery by finding interesting patterns through observation and a combination of explicit data—a primarily technology-driven perspective (Becerra-Fernandez et al., 2004). By incorporating a people perspective into data mining, it becomes truly possible to support both these knowledge creation scenarios and thereby realize the synergistic effect of the respective strengths of these approaches in enabling superior knowledge creation to ensue.

DISCUSSION AND CONCLUSION

The preceding discussions have highlighted the key knowledge creation theories that focus on either a people-driven perspective or a technology-driven perspective. Irrespective of which knowledge creation perspective is adopted, it is important for effective knowledge creation to firstly realize that knowledge is a multifaceted construct and knowledge management is a multidimensional approach (consequently the individual steps of knowledge management also should exhibit this multidimensionality).

Given the importance of knowledge management in today's knowledge economy, it is indeed useful to combine the people-driven and technology-driven perspectives into an integrative, all-encompassing meta framework in order to truly capture the subtle nuances and complexities of knowledge creation, and hence realize the synergistic effect of the respective strengths of these frameworks. For example, from the KDD process perspective, we can see how knowledge is created from data, while from the people-driven perspective, we can see the various types of knowledge. Furthermore, such an integrative meta framework or holistic perspective to knowledge creation provides a broader scope and thus better accommodates the different possible knowledge creation scenarios. This is particularly important in today's competitive business environment, as KM is becoming more prevalent in organizations irrespective of the organizational structures or industry. For example, more structured organizations would be more likely to use explicit knowledge more than tacit knowledge, while dynamic and informal organizations are likely to use more tacit/implicit knowledge (Spiegler, 2003; Wickramasinghe & Mills, 2001). Similarly, technologically savvy organizations would be more likely to create knowledge (and consequently achieve a strategic advantage) by using the KDD process.

Thus, knowledge creation involves a people dimension, technology dimension, and the processes that link the people and technology. In addition, knowledge creation plays a catalytic role in effecting knowledge management. Hence, the need for an integrative meta framework and holistic perspective that serves to bring these two key dimensions together—that is, an amalgamation of data mining with the knowledge spiral.

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REFERENCES

Adriaans, P., & Zantinge, D. (1996). *Data mining.* Addison-Wesley.

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Becerra-Fernandez, I. et al. (2004). *Knowledge management.* Upper Saddle River, NJ: Prentice-Hall.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Beckman, T. (1999). The current state of knowledge. In Liebowitz (Ed.), *Knowledge management handbook.* London: CRC Press.

Blackler, F. (1995). Knowledge, knowledge work and organizations—an overview and interpretation. *Organization Studies, 16*(6), 1021-1046.

Boland, R., & Tenkasi, R. (1995). Perspective making, perspective taking. *Organizational Science, 6*, 350-372.

Bukowitz, W.R., & Williams, R.L. (1997). New metrics for hidden assets. *Journal of Strategic Performance Measurement, 1*(1), 12-18.

Cabena, P., Hadjinian, P., Stadler, R., Verhees, J., & Zanasi, A. (1998). *Discovering data mining from concept to implementation*. Englewood Cliffs, NJ: Prentice-Hall.

Chung, M., & Gray, P. (1999). Special section: Data mining. *Journal of Management Information Systems, 16*(1), 11-16.

Davenport, T., & Grover, V. (2001). Knowledge management. *Journal of Management Information Systems, 18*(1), 3-4.

Davenport, T., & Prusak, L. (1998). *Working knowledge*. Boston: Harvard Business School Press.

Drucker, P. (1999). Beyond the information revolution. *The Atlantic Monthly,* (October), 47-57.

Drucker, P. (1993). *Post-capitalist society.* New York: Harper Collins.

Fayyad, Piatetsky-Shapiro, Smyth. (1996). From data mining to knowledge discovery: An overview. In Fayyad, Piatetsky-Shapiro, Smyth, & Uthurusamy (Eds.), *Advances in knowledge discovery and data mining.* Menlo Park, CA: AAAI Press/MIT Press.

Malhotra, Y. (2000). Knowledge management and new organizational form. In Y. Malhotra (Ed.), *Knowledge management and virtual organizations.* Hershey, PA: Idea Group Publishing.

Markus, L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2002). *Managing knowledge work*. New York: Palgrave.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5,* 14-37.

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge emergence.* Oxford: Oxford University Press.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford: Oxford University Press.

Orlkowski, W. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science, 3*(3), 398-427.

Parent, M., Gallupe, R., Salisbury, W., & Handelman, J. (2000). Knowledge creation in focus groups: Can group technology help? *Information & Management, 38,* 47-58.

Polyani, M. (1958). *Personal knowledge: Towards a post-critical philosophy.* Chicago: University Press Chicago.

Polyani, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Schultze, U. (1998, December). Investigating the contradictions in knowledge management. *Proceedings of IFIP.*

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly, 26*(3), 212-242.

Spender, J. (1998). Pluralist epistemology and the knowledge-based theory of the firm. *Organization, 5*(2), 233-256.

Spiegler, I. (2003). Technology and knowledge: Bridging a "generating gap." *Information and Management, 40,* 533-539.

Swan, J., Scarbrough, H., & Preston, J. (1999). Knowledge management—the next fad to forget people? *Proceedings of the 7th European Conference on Information Systems.*

Wickramasinghe, N., & Mills, G. (2001). MARS: The electronic medical record system. The core of the Kaiser galaxy. *International Journal of Healthcare Technology Management*, *3*(5/6), 406-423.

Wickramasinghe, N. et al. (2004). Realizing the value proposition for healthcare by incorporating KM strategies and data mining techniques with use of information communication technologies. *International Journal of Healthcare Technology and Management*, forthcoming.

Wickramasinghe, N. (2005). The phenomenon of duality: A key to facilitate the transition from knowledge management to wisdom for inquiring organizations. In J. Courtney, J. Haynes, & D. Paradice (Eds.), *Inquiring organizations: Moving from knowledge management to wisdom*. Hershey, PA: Idea Group Publishing.

Wickramaisnghe, N., & Sharma, S. (2005). *The fundamentals of knowledge management*. Upper Saddle River, NJ: Prentice-Hall.

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Chapter 7.2
Intellectual Capital and Knowledge Management

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INTRODUCTION

Knowledge management (KM) and intellectual capital (IC) are not one and the same, and although some overlap is apparent, the relationship is far from trivial and requires exploration. Some intellectual capital such as brand is not knowledge, and some knowledge that cannot be transformed into value is not intellectual capital.

This article illustrates the paradigm of IC and its measurement, focusing then on tensions in the relationship of KM and IC and their origins.

Sullivan (2000) moves us toward the understanding of KM as value creation in all its aspects, vs. IC, or ICM (IC management), as value extraction (thus, measurement, accountability, explicability, etc.). He defines intellectual capital very briefly as "knowledge that can be converted into profit" (p. 192), implying that some quantification of the value of knowledge is required.

BACKGROUND

The history and development of intellectual capital and intellectual-capital management somewhat correlate to that of knowledge management, and it seems superfluous to elaborate on the practicality of intellectual capital, where practice was preliminary to theory. The IC movement is a paradigm derived from a practical need: to bridge the apparent gap between the firm's books and the classic accounting vehicle, and the actual market value. According to Petty and Guthrie (2000):

[t]he intellectual capital movement is undeniably grounded in practice (Roos et al., 1997; Larsen et al., 1999; Mouritsen, 1998). The development of intellectual capital reports, for instance, can be traced back to the desire for individuals working with or within businesses to improve their understanding of what comprised the value of the business so as to manage better those things

that generate value. (Sveiby, 1997; Edvinsson & Malone, 1997; Johanson et al., 1999)

They also say (p. 158; see also the definition of IC in "Key Terms"), "Often, the term 'intellectual capital' is treated as being synonymous with 'intangible assets.'"

The paradigm of IC is established rather commonly in the literature as divided into three subdomains: human capital, organizational capital, and customer capital (or human capital, structural capital, and relational capital; Bontis, 2002; Edvinsson & Malone, 1997; Stewart, 1997; Sullivan, 1998). This division is meaningful toward measurement, a focal point of the IC movement.

IC Measurement and Models

Valery Kanevsky and Tom Housel write, "Understanding how to accelerate the conversion of knowledge into money is the real challenge in the information age" (as cited in Von Krogh, Roos, & Kleine, 1998, p. 269). Tracking that process of conversion into value leads to measurement. Roos, Roos, Edvinsson, and Dragonetti (1998) emphasize that the definition of intellectual capital must be clear and measurable: In order to manage intellectual capital, it must be measured.

However, the measurement of knowledge assets triggers both great interest and great skepticism. Indeed, the measurement of IC is still being experimented with various models.

One of the ultimate goals of measuring intellectual capital is its proper acknowledgement and reporting, similar to the more familiar accounting and reporting system of tangible assets in firms. The perspective of the stocks and flows forms of knowledge (following the resource-based view of the firm) inspired a comparison to familiar forms of accounting reporting. According to Bontis, Dragonetti, Jacobsen, and Roos (1999):

In a way, the identification of stocks creates a series of still photos of the company's intangible resources, whereas the flows provide the animation. Adding a flow perspective to the stock perspective is akin to adding a profit and loss statement to a balance sheet in accounting. The two perspectives combined (or the two reporting tools, in the case of accounting) provide much more information than any single one alone.

Indeed, Lev (2000a, 2000b) says, "Accounting's 500 year exceptional durability is being severely tested…a major contributor to such asymmetries are the archaic accounting rules which treat most investments in knowledge as regular expenses."

As to the principle behind actually calculating intellectual capital, Mouritsen, Bukh, Larsen, and Johansen (2002, p. 11) say, "Authors such as Edvinsson and Malone, and Stewart suggest that intellectual capital is a combination of human, structural and customer capital, whose worth can be identified by subtracting the firm's book value from its market value."

Although measuring IC is recognized to be crucial, frameworks have not yet reached statutory recognition as paradigms, thus allowing us but a sample and flavour of some available models and tools implemented toward the metrics of "intangibles" within the scope of this article. This is not due to the lack of models, but to the lack of standards. Further literature reviews of the tools elaborate beyond the scope this theatre allows (Bontis et al., 1999).

According to Petty and Guthrie (2000), "it is the limitations of the existing financial reporting system for capital markets and other stakeholders [that] have motivated an evolving dialogue on finding new ways to measure and report on a company's intellectual capital." The product of this dialogue is a plethora of new measurement approaches that all have the aim, to a greater or lesser extent, of synthesising the financial and non-financial value-generating aspects of the company into one external report. Principal among the new reporting models are the intangible asset monitor (Sveiby, 1988; 1997; Celemi, 1998); the balanced scorecard (Kaplan and Norton, 1992; 1996); the Skandia value scheme (Edvinsson and Malone, 1997; Edvinsson, 1997); and the intellectual capital accounts (DATI, 1998).

It is interesting to compare the frameworks of several of the main classification schemas for reporting intellectual capital. These three principal ones, which emerge prominent in IC literature, show progress toward alignment within the IC paradigm (Table 1).

A conclusion from this comparison is that by now there are the first signs of an aligning idea in the perception of intellectual capital, hence, its measurement. There is clear identification in classification between capital relating to human assets, and capital relating to structure—be it internal or inclusive of the external values.

Moreover, entwined in all frameworks is the profound realization of the value and qualitative characteristics of the attempts to quantify the qualitative via various proxy indicators, as the nature of knowledge, and in particular the nature of its value, is qualitative.

But we must remember that there is no widely accepted standard, and firms may measure their intangible assets rather than be obliged to do so. What measure, metric, tool, or approach is preferable is purely dependent on the circumstances of the organization as there is no binding authoritative view or legislation in the matter (although the need for it is reoccurring in the literature; Bassi & Van Buren, 1999; Van Buren, 1999).

Tools that resemble the familiar accounting tools for reporting are being developed, such as intellectual-capital statements (Mouritsen et al., 2002; Mouritsen, Larsen, Bukh, & Johansen, 2001), and attempts through practice raise a lantern for future recognition and regularity (Wyatt, 2002).

THE RELATIONSHIP BETWEEN KM AND IC

To sum up intellectual capital, and in particular its possible measurement and reporting, it is possible to consider intellectual capital as the knowledge phase in accounting using the principle analysis of knowledge; that is, the accounting reports and balance sheets familiar to us consist merely of the information of the firm, whilst the intellectual-capital reports are in fact the actual accounting knowledge of the firm and its values.

Table 1. IC paradigm

Developed by	Framework	Classification
Sveiby (1997, 1998)	The intangible-asset monitor	Internal structure External structure Competence of personnel
Kaplan and Norton (1992)	The balanced scorecard	Internal-processes perspective Customer perspective Learning and growth perspective Financial perspective
Edvinsson and Malone (1997)	Skandia value scheme	Human capital Structural capital

We have so far taken "raw financial data" (Edvinsson & Malone, 1997, p. 77), the signals, and put them in formation in order to inform (hence it becomes information) in the accounting reports. The knowledge of the firm, mostly tacit, was created in the mind of the reader, be it an accountant, investor, or so on, using other various tacit and explicit sources to inform. The intellectual-capital movement is trying to make explicit as much of this knowledge as possible; much of it arrives as qualitative data and qualitative information.

Continuing the "IC equals firm's tree roots" metaphor (Edvinsson & Malone, 1997, p. 10), although such an effort is not futile, the full (tacit) underground nature of the roots as well as the effect of the soil (context) can never be exposed in full. Evermore, trying to examine the roots in depth by taking out the tree in full cannot be done without harming the roots, as is taking them out of their soil. Thus, we are left with data collected through secondary methods attempting to x-ray the roots from above ground, or inductively taking a sample of the roots. These inseparable connections are discussed further when we recall the dualities incorporated in the concept of value.

The empiric foundation of this article was research implementing grounded theory in a multiple-case study in three organizations (the National Health Service, National Transportation Authority, and the military), from which the illustrated theory emerged. The organizational creation of the paradigms of KM and IC and their relationship was examined by researching KM as a methodology toward IC (Ariely, 2003): an array of methods transformed into perceived value and intellectual capital.

Knowledge is first and foremost inherent in people and in interactions. Viewing knowledge as part of human capital leads to the idea that managing knowledge is part of the structural capital (although not limited to structure). So, successful KM is in itself part of the organization's intellectual capital in addition to the knowledge incorporated in it as a process and in its people. But in order to fully understand the relationship between KM and IC, which surrounds the transformation of knowledge and managing it into value, we must stop to consider the meaning of value within the dual contexts of KM and IC.

What Does Value Mean?

The duality in the definition of value (see "Key Terms") is crucial since the meanings of the word reflect on the quantitative—vs.—qualitative tensions incorporated in the concept of value. Patrick Sullivan (2000) writes,

Economists view value as the sum of a stream of benefits (or income) stretching into the future, summed and discounted to a net present value in dollars. Yet value has meaning for many others besides economists [p. 247]…The economics of information applies to any idea, expression of an idea, or fact that is known by one person and is potentially of value to another. (p. 271)

Any capital or currency is dependent upon its market: so is intellectual capital. Its value, as any currency, is in the eyes of the beholder. Diamonds may be worthless on a deserted, isolated island, or they may bring their worth as a tool to start a fire, multiplying perhaps their true value to our Robinson Crusoe beyond any market value.

The value of knowledge implemented toward action in one context (or having the potential to be) may be absolutely worthless in another. Sullivan (2000) further explores the concept of value, differentiating between defensive and offensive value types for the organization, and creating the organization's value chain.

The relative value placed on innovative ideas is largely dependent upon the firm's view of itself, and upon the reality of the marketplace. Put another way, each firm exists within a context that shapes the firm's view of what is or is not of value. (p. 247; see also Sullivan, 1998; Sveiby, 2001; Von Krogh, Nonaka, & Nishiguchi, 2000).

The perception of the value of the organization's intellectual capital is what becomes its intellectual property and intellectual assets. Assessing it is essential as is assessing the investment in intellectual capital (Bassi & Van Buren, 1999) similarly to any other capital. Furthermore, there is a different value to knowledge, and different behaviours of intellectual capital and intellectual property in different organizational contexts (Sullivan, 2000), for example, intellectual-capital development at a spin-off company (Manfroy & Gwinnell, 1998) in mergers and acquisitions (Sullivan, 2000). According to Joyce and Stivers (1999), "[r]esults indicate that firms…tend to differ in organizational structure and technology orientation, as well as in the perception of the value of various non-financial performance factors and intangible assets."

The operative meaning is that things that are valuable do not necessarily have intrinsic value. They are value-able, with the potential for value, perception making their value ability come true within the organization and in its environment.

Tension Between Production Factors

The tensions that lie beneath the surface between knowledge management and intellectual capital are derived from their basically different nature in relation to the conservative production factors (land, capital, labour). Intellectual capital relates to capital, whilst knowledge management relates to labour. Yet the behaviour of IC is not the same as capital. Mouritsen et al. (2002, p. 10) note that "[i]ntellectual capital is, even if it refers to 'capital,' not a conventional accounting or economic term." The rules for its depreciation, creation, and so forth are complex and irrelevant to "hard capital" (e.g., depreciation of knowledge occurs when it is not used, contrary to tangible assets).

The management of people as human resources has been dealt with within the division of labour. However, when arguing that knowledge is not just people, but their "cognitive contact with reality" (Zagzebski, 1999), their knowledge might be acknowledged, but not managed directly in the classic definition of management in the same way we manage resources within the division of labour. Streatfield and Wilson (1999, p. 70) say, "We cannot manage knowledge directly—we can only manage information about the knowledge possessed by people in organizations." Indeed, we can always manage the yellow pages, which are pointers to knowledge. These pointers accrue in themselves information about the formations of the knowledge.

As to the tensions between the division of knowledge and the division of labour, Klein and Scarbrough (2002) emphasize that:

[t]he very identification of knowledge as a factor of production as distinct from labour, and the irreducibility of the one to the other invites conflict between the two. While much of the literature on knowledge management seeks to legitimise and exploit knowledge as a quasi-autonomous resource of the organization, we see knowledge as simultaneously different from, but not wholly independent from labour.

Indeed, the management of resources such as knowledge in the postindustrial age suggests a much more permissive and updated approach to management.

Boisot and Griffiths (1999) note that "[i]n a 'post Marxist' world, knowledge workers are once more becoming the owners of the means of production," owning the most important production factors: knowledge and intellectual capital.

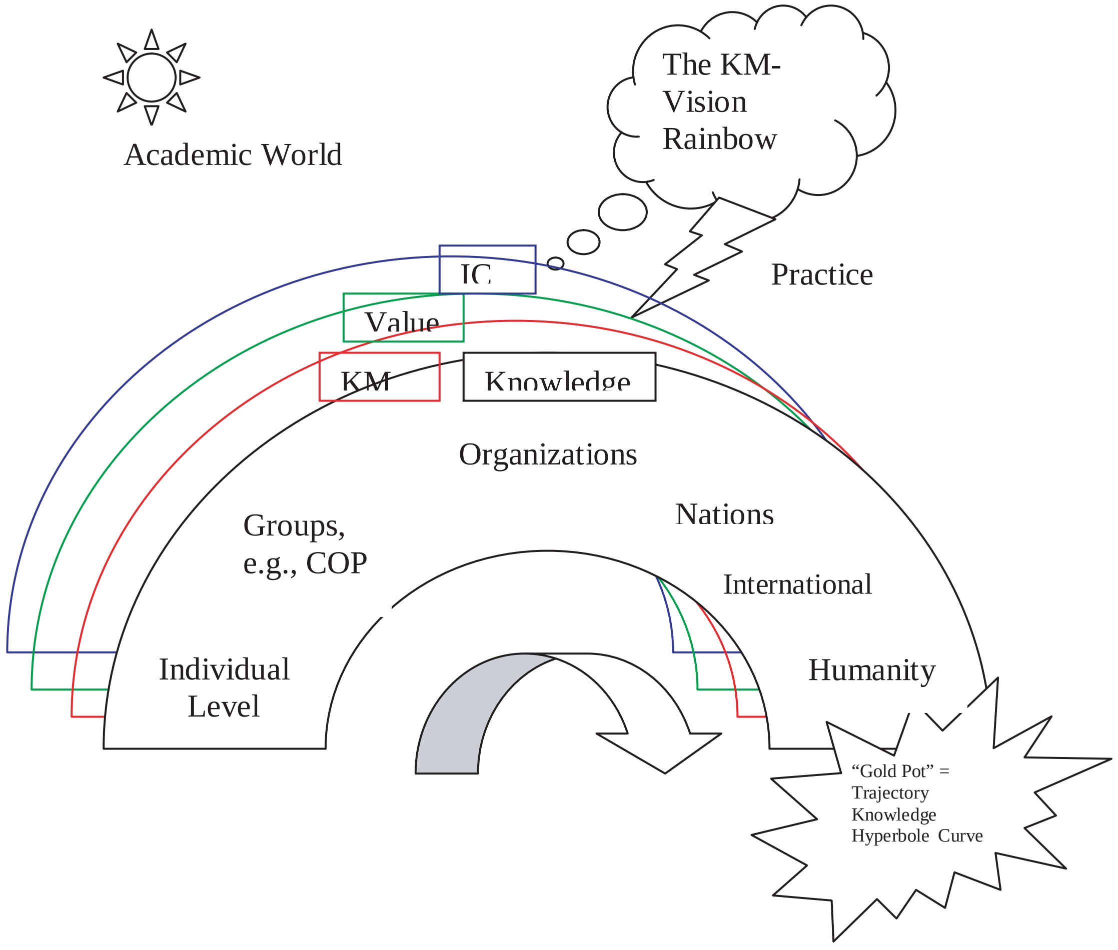
Epistemological Tensions

As our ground is knowledge, it is worth going into geological depth about the theoretical layers beneath it. There lies one more real foundation for the tension between these two domains of knowledge—knowledge management vs. intellectual capital—perhaps to a degree, between their correlating communities of practice (with the overlap that exists between the fields existing between the communities, too). Some tensions date, as geological issues tend to, as far in the past as the origins of that ground.

There is an epistemological diversity, as in many fields, amongst thinkers in the most intrinsic approaches to the world, knowledge, truth, and validity. However, it reflects on not only the derived methodological researching ideology, but rather on the core itself.

For instance, many approach the field of intellectual capital from the need to measure and quantify the organization's value (Petty & Guthrie, 2000), the very need that arouses interest in IC at first being the apparent gap between the firm's actual value and its "book value," by using conservative accounting measures. Accountants, as

Figure 1.



well as many managers, tend to derive from the epistemological foundations of positivism since positivism seems to have been management's mainstream (Johnson & Duberley, 2000) and the most appropriate for Taylor's scientific approach of the industrial age.

It is the same behaviour of knowledge as a differentiated production factor from the conservative ones in the industrial age (land, labour, capital) that justifies a different epistemological, philosophical approach.

Many approach the field of knowledge management from very different epistemological foundations and approaches, such as social constructivism. Wenger (1998, p. 141) says:

Knowing is defined only in the context of specific practices, where it arises out of the combination of a regime of competence and an experience of meaning. Our knowing—even of the most unexceptional kind—is always too big, too rich, too ancient and too connected for us to be the source of it individually.

Hence, "[k]nowledge is socially constructed" (Despres, 2002), which tends to form a real challenge for positivists' measurement.

It is that tension, derived from epistemological differences, that highlights the need for an attempt to approach the field of intellectual capital from a social constructivist's orientation. Also, the derived approach and methodology, in order not to neglect the real essence of value, which is interwoven with perceptions, is constructed socially.

Einstein reminded us that not all that can be counted counts, and not all that counts can be counted. Value and perception become components (or methods in the array) of the modeled methodology. It is perception that brings realization to the potential for value of value-ables.

The emotive theory of values, as one of the principles of logical positivism, acknowledges that "[s]tatements of value are neither true or false, but are simply expressions of attitude" (Cruise, 1997; Gross, 1970; Wedberg, 1984). We can extend that principle within the definitions of value. Thus, one type of value is dependent on the other—on values, perception, and attitude.

Indeed it follows that some tension is also derived from the very essence of the term measurement, which implicitly tries to quantify the very qualitative.

FUTURE

Viewing knowledge management as a catalyst for the creation of human knowledge moves us up the trajectory curve in the hyperbola of human-knowledge creation by allowing us to build better on past generations and current knowledge.

The importance of the connection to intellectual capital is a catalyst for the industry to invest in research and the implementation of KM and IC. This brings the short- and medium-term benefits that organizations and management so often seek, but brings us all the long-term benefits from the blossoming of KM, knowledge, and knowledge on knowledge. According to McElroy (2002, p. 30):

Not surprisingly, managers interested in getting their arms around intellectual capital are searching for ways to describe, measure, and manage their intangible assets with a particular emphasis on capturing their favorable effects on the bottom line and on shareholder values.

Indeed, through a different visualization from the hyperbola of knowledge creation, we can imagine a rainbow model on which the different dimensions are aligned (e.g., value) from an individual level to humanity.

While the academic world should shed light on the whole spectrum, practitioners tend to focus on organizational levels due to economic reasons. The benefits for humanity go beyond organizations, supporting a trajectory knowledge-creation hyperbola. Carrillo (1999) says:

In Post Capitalist Society, Peter Drucker wonders whether anyone will dare to undertake the intellectual manifesto of the Knowledge Economy, something like The K-Capital. One of the most distinctive challenges to the KM movement is the extent to which it is capable of gaining self-awareness and self-management capabilities. To the extent that this happens, it will be able to facilitate the process for achieving the best human account on the principles of knowledge economics.

It seems clear that the intellectual-capital movement picked up the glove dropped in 1993 by Peter Drucker.

CONCLUSION

Exploring the relationships between knowledge management and intellectual capital by incorporating epistemological tensions reveals one such relationship that can be modeled into an empirically grounded methodology.

Knowledge, and managing all of its elements (knowledge creation, sharing, and transfer, etc.), becomes part of the organization's intellectual capital. The intellectual capital is then transformed through its value to the organization (a matter of perception, as discussed, dependant on the eye of the beholder) into the organization's owned intellectual property so that it can be protected.

Explicitly exploring knowledge management as a mechanism that moves us toward intellectual capital and property allows the KM process to become part of the intellectual capital in itself.

According to Fahy (2000):

The management literature highlights that executives play a role in the process of converting resources into something of value to customers (Williams, 1992). This involves resource identification, development, protection and deployment (Amit & Schoemaker, 1993) and managerial skill in these activities is in itself a source of sustainable competitive advantage (Castanias & Helfat, 1991). It is important that future research finds suitable ways of operationalising this management role.

Knowledge management is indeed a suitable way, and managerial skill in KM and IC activities, and the activities themselves, are indeed yet another resource that is value-able, hence potentially another source of sustainable competitive advantage.

The proxy indicators used in different organizations to express the value of qualitative knowledge and of managing it are unique to each and even amorphous. The problem with their acceptance by the society in which they exist is the epistemological tension that results from past industrial-age managerial education and accounting systems that were dominated by positivism. Organizationally, these indicators are derived from the organization's perception of value in light of core competencies and the organizational mission and vision. Such an evolution of thought and of paradigms within the organizations occurred in a spiral manner, collecting and recollecting on previous evolution, and leading to an aligning idea that allows the perception of unification amongst paradigms.

Thus, an epistemological, evolutionary adaptation is required in managerial education complementing that of the postindustrial age rather than suffice for the positivistic approach.

Furthermore, the empiric results and the emerging theory support and accord the evolution of the KM and IC paradigms by and large and their relationship, aiming at an aligning idea, or perception of unification, between them as experienced in many domains in the history of science (Kuhn, 1962).

REFERENCES

Ariely, G. (2003). *Knowledge management as a methodology towards intellectual capital: A roadmap.* Paper presented at the KMAC2003 OR Society International Conference, Aston.

Bassi, L. J., & Van Buren, M. E. (1999). Valuing investments in intellectual capital. *International Journal of Technology Management, 18*(5-8), 414-432.

Boisot, M., & Griffiths, D. (1999). Possession is nine tenths of the law: Managing a firm's knowledge base in a regime of weak appropriability. *International Journal of Technology Management*, *17*(6), 662-676.

Bontis, N. (2001). Assessing knowledge assets: A review of the models used to measure intellectual capital. *International Journal of Management Reviews, 3*(1), 41-60.

Bontis, N. (2002). All aboard! Take a knowledge journey. *IICR*.

Bontis, N., Dragonetti, N. C., Jacobsen, K., & Roos, G. (1999). The knowledge toolbox: A review of the tools available to measure and manage intangible resources. *European Management Journal, 17*(4), 391-402.

Brennan, N., & Connell, B. (2000). *Intellectual capital: Current issues and policy implications.* Paper presented at the 23rd Annual Congress of the European Accounting Association, Munich, Germany.

Carrillo, F. J. (1999). *The knowledge management movement: Current drives and future scenarios.*

Committee on Intellectual Property Rights in the Emerging Information Infrastructure, N. R. C. (2000). *The digital dilemma: Intellectual property in the information age*. Retrieved from http://www.nap.edu/openbook/0309064996/html/1.html

Cruise, P. L. (1997). Are proverbs really so bad? Herbert Simon and the logical positivist perspective in American public administration. *Journal of Management History, 3*(4), 342-359.

Drucker, P. F. (1993). *Post-capitalist society* (1st ed.). New York: HarperBusiness.

Edvinsson, L., & Malone, M. S. (1997). *Intellectual capital* (1st ed.). New York: HarperBusiness.

Fahy, J. (2000). The resource-based view of the firm: Some stumbling-blocks on the road to understanding sustainable competitive advantage. *Journal of European Industrial Training, 24*(2), 94-104.

Gross, B. (1970). *Analytical philosophy: An historical introduction*. New York: Pegasus Press.

Johnson, P., & Duberley, J. (2000). *Understanding management research.* Sage.

Joyce, T., & Stivers, B. P. (1999). Knowledge and innovation focus. *International Journal of Technology Management, 18*(5-8), 500-509.

Kaplan, R.S., & Norton, D.P. (1992). The Balanced Scorecard. Measures that drive performance. *Harvard Business Review*, Jan-Feb.

Kaps, G., & Nohr, H. (2001). Measurement of success in knowledge management using balanced scorecards (Part 1). *Nfd Information-Wissenschaft Und Praxis, 52*(2), 89-97.

Klein, J., & Scarbrough, H. (2002). *Knowledge management and institutional failure*.

Kuhn, T. S. (1962). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Lev, B. (2000a). *Knowledge and shareholder value*.

Lev, B. (2000b). *New accounting for the new economy*.

Manfroy, W., & Gwinnel, H. (1998). Intellectual capital development at a spin-off company. In P.H. Sullivan (Ed.), *Profiting from intellectual capital: Extracting value from innovation*. New York: Wiley.

McElroy, M. W. (2002). Social innovation capital. *Journal of Intellectual Capital, 3*(1), 30-39.

Morey, D., Maybury, M. T., & Thuraisingham, B. M. (2000). *Knowledge management: Classic and contemporary works*. Cambridge, MA: MIT Press.

Mouritsen, J., Bukh, P. N., Larsen, H. T., & Johansen, M. R. (2002). Developing and managing knowledge through intellectual capital statements. *Journal of Intellectual Capital, 3*(1), 10-29.

Mouritsen, J., Larsen, H. T., Bukh, P. N., & Johansen, M. R. (2001). Reading an intellectual capital statement: Describing and prescribing knowledge management strategies. *Journal of Intellectual Capital, 2*(4), 359-383.

OECD. (1999). *Programme notes and background to technical meeting and policy and strategy forum*. Paper presented at Measuring and Reporting Intellectual Capital, An International Symposium.

Petty, R., & Guthrie, J. (2000). Intellectual capital literature review: Measurement, reporting and management. *Journal of Intellectual Capital, 1*(2), 155-176.

Roos, J., Roos, G., Edvinsson, L., & Dragonetti, N. C. (1998). *Intellectual capital: Navigating in the new business landscape*. New York: New York University Press.

Stewart, T. A. (1997). *Intellectual capital: The new wealth of organizations* (1st ed.). New York: Doubleday/Currency.

Streatfield, D., & Wilson, T. (1999). Deconstructing "knowledge management." *Aslib Proceedings, 51*(3), 67-71.

Sullivan, P. H. (1998). *Profiting from intellectual capital: Extracting value from innovation*. New York: Wiley.

Sullivan, P. H. (2000). *Value-driven intellectual capital: How to convert intangible corporate assets into market value*. New York: Wiley.

Sveiby, K.-E. (1997). *The new organizational wealth: Managing & measuring knowledge-based assets* (1st ed.). SanFrancisco: Berrett-Koehler Publishers.

Sveiby, K.-E. (1998). Intellectual capital: Thinking ahead. *Australian CPA* , June, pp. 18-22.

Sveiby, K.-E. (2001). A knowledge-based theory of the firm to guide in strategy formulation. *Journal of Intellectual Capital, 2*(4), 344-358.

Taylor, F.W. (1911). *Principles of scientific management*. New York: Harper Row.

Van Buren, M. E. (1999). A yardstick for knowledge management. *Training & Development, 53*(5), 71-.

Von Krogh, G., Nonaka, I. O., & Nishiguchi, T. (2000). *Knowledge creation: A source of value*. New York: St. Martin's Press.

Von Krogh, G., Roos, J., & Kleine, D. (1998). *Knowing in firms: Understanding, managing, and measuring knowledge*. London: Sage.

Wedberg, A. (1984). *A history of philosophy*. Clarendon Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. New York: Cambridge University Press.

Wyatt, A. (2002). Towards a financial reporting framework for intangibles: Insights from the

Australian experience. *Journal of Intellectual Capital, 3*(1), 71-86.

Zagzebski, L. (1999). What is knowledge? In *The Blackwell guide to epistemology* (pp. 92-116).

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Chapter 7.3
Mathematical Knowledge Management

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INTRODUCTION

Mathematical knowledge is significantly different from other kinds of knowledge. It is abstract, universal, highly structured, extraordinarily interconnected, and of immense size. Managing it is difficult and requires special techniques and tools.

Mathematicians have developed (over the last two or three millennia) many techniques for managing mathematical knowledge. For example, there is a large collection of techniques based on the use of special symbols and notations. Although these techniques are quite effective and have greatly advanced mathematical practice, they are primitive in the sense that the only tools they require are pencil and paper, typesetting machines, and printing presses.

Today mathematics is in a state of transition. Mathematicians are using the Internet in new ways to find information and to share results. Engineers and scientists are producing new kinds of mathematical knowledge that is oriented much more to practical concerns than to theoretical interests. This is particularly true in the field of software development where software specifications and code are forms of mathematical knowledge. Computers are being pushed to perform more sophisticated computations and to mechanize mathematical reasoning. Mathematical knowledge, as a result, is being produced and applied at an unprecedented rate.

It is becoming increasingly difficult to effectively disseminate mathematical knowledge, and to ascertain what mathematical results are known and how they are related to each other. Traditional ways of managing mathematical knowledge are no longer adequate, and current computer and communication technology do not offer an immediate solution. Since mathematical knowledge is vital to science and technology, and science and technology is vital to our society, new ways of managing mathematical knowledge based on new technology and new theory are needed.

This article introduces the main issues of managing mathematical knowledge. It is organized as follows. The Background section describes mathematics as a process of creating, exploring, and connecting mathematical models. The special characteristics of mathematical knowledge and the four main activities that constitute the management of mathematical knowledge are discussed in the Main Focus of the Article. The Future Trends section introduces Mathematical Knowledge Management (MKM), a new field of research, and discusses some of the challenges it faces. The article ends with a conclusion, references, and a list of key terms.

The management of mathematical knowledge is an emerging field of research. Researchers are just starting to build a foundation for it. This article focuses on the core concerns of the field. Except for a few remarks, it does not discuss the parallels between mathematical knowledge management and mainstream knowledge management. Nor does it discuss how techniques for managing mathematical knowledge can be applied to the management of other kinds of knowledge. These are important topics for future research.

BACKGROUND

People often associate mathematics with a body of knowledge about such things as numbers, spatial relationships, and abstract structures. However, this view of mathematics is misleading. It suggests that mathematics is something static and dead, but mathematics is actually the opposite—dynamic and alive. It is more productive and accurate to view mathematics as a process for comprehending the world that consists of three intertwined activities (Farmer & von Mohrenschildt, 2003).

The first activity is the creation of mathematical models that represent mathematical aspects of the world. Mathematical models come in many forms. A well-known and important example is the model of real number arithmetic composed of the set of real numbers, and operations and relations involving the real numbers such as +, ×, and <. Real number arithmetic includes various submodels such as arithmetic of the natural numbers 0,1,2,... and arithmetic of the rational numbers like 2/3, 31/17, and so forth. Real number arithmetic and its submodels capture the essential elements of counting, measurement, motion, and much more. Real number arithmetic itself is a submodel of complex number arithmetic and many other mathematical models.

The second activity is the exploration of mathematical models to learn what they say about the mathematical aspects of the world they model. There are several means of exploration. The explorer can state a conjecture about a model and then attempt to prove that the conjecture is true by virtue of being a logical consequence of the defining properties of the model. The explorer can also formulate a problem concerning the model and then compute a solution to it by mechanically manipulating a representation of the problem using rules determined by the model. A third approach, which is sometimes very effective, is to visualize some facet of the model with a diagram, picture, or animation.

The last activity is the connection of mathematical models by identifying and recording relationships between models. Models can be related to one another in various ways. Examples includes two models being equivalent in a certain sense, one model containing another as a submodel, and one model generalizing another model. A collection of interconnected models facilitates the creation and exploration of new models. New models can be built from old models, and then the results about the old models can be applied to these new models according to how they are connected. Thus, models rarely need to be developed from scratch.

MAIN FOCUS OF THE ARTICLE

Mathematical knowledge is knowledge about mathematical models. Each piece of mathematical knowledge is understood relative to a context of a mathematical model or group of mathematical models. For example, the statement "there is no square root of -1" is true in the model of real number arithmetic, but actually false in complex number arithmetic (the square root of -1 is the complex number i). Although a piece of mathematical knowledge is not meaningful without its context, the context of mathematical knowledge is often not explicitly stated. For example, one might say that as a mathematical fact, "every nonzero number has a multiplicative inverse" without mentioning the context of the statement. Of course, this statement is true for rational number arithmetic and real number arithmetic, but false for natural number arithmetic.

The context for understanding mathematical knowledge is analogous to the context for understanding other kinds of knowledge. Knowledge, mathematical or otherwise, that is applied out of its proper context is not reliable. The context of a piece of knowledge, mathematical or otherwise, is often imprecise or not fully articulated. However, a context for mathematical knowledge, unlike a context for many other kinds of knowledge, can be made as precise as is desired.

Mathematical knowledge is direct knowledge about mathematical models, but it is also indirect knowledge about the mathematical aspects of the world which are being modeled. As indirect knowledge, mathematical knowledge is useful, often even vital, to engineers and scientists. It is routinely used to help solve real-world problems.

Mathematical knowledge has several characteristics that sharply distinguish it from other kinds of knowledge. These characteristics make managing mathematical knowledge significantly different from managing other kinds of knowledge.

Abstractness

A mathematical model is an abstraction of the world; it ignores everything about the world except some part of the world's underlying mathematical structure. Other kinds of knowledge can be abstract, but mathematical knowledge is inherently abstract. Moreover, mathematics is, to a large degree, the study of abstractions.

Universality

Direct knowledge about a mathematical model is indirect knowledge about any situation in the world that exhibits the mathematical structure captured by the model. For example, it is true in the model of rational number arithmetic that, for any two integers m,n, if m/n is an integer, then m = m/n + ... + m/n (n times) is sum of equal integers. As a result, any set of m objects can be divided into n subsets of equal size if m is divisible by n. Mathematical knowledge is thus universal in the sense that it can be applied to every domain of interest that exhibits the right kind of mathematical structure.

Language

Mathematical knowledge is usually expressed in a language with a carefully controlled syntax and a precise, unambiguous semantics. The language allows one to express statements about a certain collection of objects. The language may be an informal language based on a natural language such as English in which ordinary words such as "implies" and "function" have special meanings. The language may also be a formal language that can be read, analyzed, and presented by software.

Semantics

Unlike other kinds of knowledge, mathematical knowledge can be given a precise semantics. This is usually done by representing the context of the mathematical knowledge as a “mathematical theory.” For example, an axiomatic theory is a pair T = (L,A) where L is a language and A is a set of statements of L called axioms. The axioms express properties that the objects of L are assumed to possess. A mathematical model is a model of T if it has the same objects as L and it satisfies each axiom in A. T thus represents “axiomatically” the context composed of the models of T. A piece of mathematical knowledge about the context represented by T can then be expressed as a statement of L that is true in each model of T.

Representation

A body of mathematical knowledge can be represented in different ways. It can be represented declaratively as an explicit set of statements or as the set of logical consequences of a mathematical theory. It can be represented procedurally as the knowledge that is embodied in a computation system such as a calculator. It can be represented visually by diagrams and animations. A body of mathematical knowledge can also be represented by a combination of declarative, procedural, and visual means.

Proof

Most knowledge is obtained by empirical observation and experimentation. Mathematical knowledge is usually not obtained empirically. One way that it is obtained is by proving a conjecture within a context. A proof is an argument that shows that a statement S of a language L is a logical consequence of the axioms of an axiomatic theory T = (L,A), and therefore, that S is true in each model of T. In other words, a proof verifies a conjecture by logical reasoning alone.

Computation

Another way that mathematical knowledge is obtained is by computing a solution to a problem. A computation from an expression A of a language L to an expression B of L is a sequence of meaning-preserving, mechanical manipulations that transform A into B. A expresses a problem to be solved and B expresses a solution to the problem. For example, A could be the equation

x2 - 3x + 2 = 0,

B could be the statement

x = 1 or x = 2,

and a computation of A from B could be the sequence of manipulations that are used to algebraically solve a quadratic equation like A.

Interconnectedness

The body of mathematical knowledge is extraordinarily interconnected. The same piece of knowledge may appear in many different places and in many different forms. For example, the models of real number arithmetic and rational number arithmetic—which are quite different in certain ways—both satisfy a common set of properties about +, ×, and <.

Size

The body of mathematical knowledge is unimaginably immense. It can even be argued that it is inherently infinite and thus possibly even bigger than the physical world. For instance, the model of natural number arithmetic, which is relatively simple, includes facts about each of the infinitely many natural numbers.

Mathematical Knowledge

Mathematical knowledge is produced by exploring mathematical models by means of proof, computation, and visualization. Mathematicians and other mathematics practitioners have traditionally been more concerned about its production than its management. As a result, the management of mathematical knowledge has historically been a collection of loosely related activities and for the most part not a highly disciplined process. In our opinion, there are four major activities—articulation, organization, dissemination, and access—that would be crucial components of any disciplined approach to the management of mathematical knowledge.

Articulation

Mathematical knowledge cannot be communicated unless it is articulated. An articulated body of mathematical knowledge has three components. The first is the language in which it is expressed. The second is the context of mathematical models within which it is understand. And the third is the representation by which it is conveyed.

Most mathematical knowledge is not articulated at all or only partially articulated. Many mathematical details have never been articulated; they reside only in the minds of mathematicians.

Mathematicians rediscover the details using hints provided by the original discoverer. Since fully articulating mathematical knowledge is burdensome, in most cases the language, context, and representation are only partially presented. The user of the knowledge is expected to be able to fill in what is missing as needed. This works well with human users who have strong mathematical skills. It does not work as well with students and average human users, and it does not work at all when the user is a computer program.

Organization

The prodigious size and interconnectedness of mathematical knowledge is a huge obstacle to effective management. Articulated mathematical knowledge needs to be carefully organized to avoid redundancy, to capture connections, and to express results in a compact form. This requires identifying and abstracting common structure and then formalizing it as a mathematical theory.

Mathematicians have always been very interested in organizing mathematical knowledge. However, their interest in the organization of mathematical knowledge is usually motivated by research or education and not by the practical management of mathematical knowledge. To be effectively managed, mathematical knowledge must be organized in a more practical way.

Dissemination

After mathematical knowledge is articulated and organized, it needs to be disseminated. The traditional modes of dissemination are as natural language text in journals and textbooks, and as computation procedures in calculators and mathematical software. Emerging modes of dissemination are as digital information that is accessible on the World Wide Web, and as formally represented declarative and procedural knowledge that is incorporated in mechanized mathematics systems such as computer algebra systems and computer theorem proving systems.

Historically, only the most general and widely applicable mathematical knowledge has been disseminated to the public. Mathematical knowledge generated by engineering and scientific endeavors, such as software development, is usually not widely disseminated even though it would be of value to many mathematics practitioners. New approaches and technology are needed to disseminate this latter, more practical kind of mathematical knowledge.

Access

People need software tools for finding the mathematical knowledge they require in a body of knowledge that has been disseminated. Tools are needed for doing searches and making queries, for performing deductions and computations with mathematical software systems, and for understanding how the knowledge has been articulated and organized. These software tools need to be much more sophisticated and easier to use than current tools. For example, search engines must understand the semantics of mathematical languages and, for example, when syntactically distinct expressions such as x2+1 and 1+x.x are semantically equivalent.

How effectively mathematical knowledge can be accessed strongly depends on how the mathematical knowledge is previously formed. Mathematical knowledge needs to be articulated, organized, and disseminated so that access is facilitated.

FUTURE TRENDS

Mathematical Knowledge Management (MKM) is a new interdisciplinary field of research in the intersection of mathematics, computer science, library science, and scientific publishing. The objective of MKM is to develop new and better ways of managing mathematical knowledge using sophisticated software tools. MKM is expected to serve mathematicians, scientists, and engineers who produce and use mathematical knowledge; educators and students who teach and learn mathematics; publishers who offer mathematical textbooks and disseminate new mathematical results; and librarians and mathematicians who catalog and organize mathematical knowledge.

The challenges facing MKM researchers are daunting. The following are some of the major issues (expressed as questions) that are challenging researchers in MKM:

1. What kind of tools are need to put mathematical knowledge on the World Wide Web? (see, e.g., the MathML (www.w3.org/Math), MoWGLI (www.mowgli.cs.unibo.it), and Open-Math (Dalmas, Gaëtano, & Watt, 1997) programs)
2. What kind of software support is needed to convert an informal articulation of mathematical knowledge into a formal articulation? (see, e.g., Davenport, 2003)
3. How should the context of mathematical knowledge be expressed?
4. How should mathematical knowledge be organized? (see, e.g., Brownie & Stanway, 2003)
5. How can libraries of mathematical knowledge be searched? (see, e.g., Bancerek & Redneck, 2003)
6. How can mathematical knowledge be shared between mathematical systems? (see, e.g., Carette, Farmer, & Wajs, 2003)
7. How can declarative representations of mathematical knowledge be integrated with procedural representations? (see, e.g., Farmer & von Mohrenschildt, 2003)
8. What role should universities, governments, professional societies, and publishers play in disseminating mathematical knowledge?
9. Who should own and administer mathematical knowledge?
10. How should the role of mathematicians differ from the role of librarians in the task of organizing mathematical knowledge?
11. How should disseminated mathematical knowledge be certified?
12. What mechanism should be used to standardize and integrate MKM software tools?

The grand challenge of MKM is to develop a universal digital mathematics library (UDML). Composed of many heterogeneous, intercommunicating systems, it would be easily accessible via the World Wide Web. It would be constructed in an open, cooperative fashion in the same way that the Internet was constructed. Never finished, it would continuously grow and in time would contain essentially all mathematical knowledge (intended for the public). It would also be continuously reorganized and consolidated as new connections and discoveries were made.

A UDML would contain a highly structured and interconnected mixture of axiomatic, algorithmic, diagrammatic, and other kinds of mathematical knowledge. Each piece of mathematical knowledge in it would carry a certification of its correctness (relative to a specified set of assumptions). It would also include an integrated collection of tools for exploring its contents. It is important to note that a UDML would be a library and not an archive. That is, its primarily purpose would be to make mathematical knowledge widely accessible, not just to store and catalog mathematical knowledge.

Creating a UDML will be a Herculean project requiring the development of many new kinds of technology. Some of this technology is being developed now on current formal mathematics library projects including the NIST Digital Library of Mathematical Functions (dlmf.nist.gov), the Formal Digital Library (www.nuprl.org/FDLproject), Hypatheon (DiVito, 2004), Logosphere (www. logosphere.org), Mizar (mizar.org), and the Wolfram Functions site (functions.wolfram.com).

As a new field of research, MKM was launched by the First International Workshop on MKM (www.risc.uni-linz.ac.at/institute/conferences/MKM2001) in September 2001 in Hagenberg, Austria. Organized by Bruno Buchberger and Olga Caprotti, MKM 2001 led to the founding of the MKM Consortium in December 2001 under the leadership of Michiel Hazewinkel and to a special issue (Buchberger, Gonnet, & Hazewinkel, 2003) of the Annals of Mathematics and Artificial Intelligence dedicated to MKM.

The MKM Consortium is an international group of researchers dedicated to the promotion of research and interest in MKM. It has organized two subsequent international MKM conferences: the Second International Conference on MKM (www.cs.unibo.it/MKM03) was held in February 2003 in Bertinoro, Italy, and the Third International Conference on MKM (mizar.org/MKM2004) was held September 19-21, 2004, in Bialowieza, Poland. The MKM Consortium currently consists of a European Chapter (monet.nag.co.uk/mkm/index.html) and a North American Chapter (imps.mcmaster.ca/na-mkm).

CONCLUSION

Mathematical knowledge has special characteristics that require management techniques and technology different than the techniques and technology needed for other kinds of knowledge.

Researchers in the new field of MKM are beginning to develop new and better software for managing mathematical knowledge. Since mathematical knowledge is universal knowledge about mathematical aspects of the world, this software, and certainly the ideas on which it is based, may be applicable to the abstract and mathematical parts of other kinds of knowledge.

REFERENCES

Bancerek, G., & Redneck, P. (2003). Information retrieval in MML. In A. Asperti, B. Buchberger, & J.H. Davenport (Eds.), *Mathematical knowledge management. Proceedings of MKM 2003,* (pp. 119-132). Berlin: Springer-Verlag (LNCS 2594).

Brownie, J., & Stanway, T. (2003). Managing digital mathematical discourse. In A. Asperti, B. Buchberger, & J.H. Davenport (Eds.), *Mathematical knowledge management. Proceedings of MKM 2003*, (pp. 45-55). Berlin: Springer-Verlag (LNCS 2594).

Buchberger, B., Gonnet, G., & Hazewinkel, M. (Eds.). (2003). Mathematical knowledge management. *Annals of Mathematics and Artificial Intelligence, 38*(Special Issue), 1-232.

Carette, J., Farmer, W.M., & Wajs, J. (2003). Trustable communication between mathematics systems. In T. Hardin & R. Rioboo (Eds.), *Calculemus 2003* (pp. 58-68). Rome: Arcane.

Dalmas, S., Gaëtano, M., & Watt, S.M. (1997). An Open-Math 1.0 implementation. *Proceedings of the International Symposium on Symbolic and Algebraic Computation (ISSAC-97)* (pp. 241-248). ACM Press.

Davenport, J.H. (2003). MKM from book to computer: A case study. In A. Asperti, B. Buchberger, & J.H. Davenport (Eds.), *Mathematical knowledge management. Proceedings of MKM 2003* (pp. 45-55). Berlin: Springer-Verlag (LNCS 2594).

DiVito, B.L. (2004). *Hypatheon: A mathematical database for PVS users.* Retrieved from http://imps.mcmaster.ca/na-mkm-2004/proceedings/pdfs/divito.pdf

Farmer, W.M., & von Mohrenschildt, M. (2003). An overview of a formal framework for managing mathematics. *Annals of Mathematics and Artificial Intelligence, 38,* 165-191.

Chapter 7.4
Communities of Practice and Critical Social Theory

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INTRODUCTION AND BACKGROUND

In philosophical terms, a key issue of communities of practice (CoPs) can be located within one of the key philosophical debates. The need for CoPs is traceable to the inadequacy in certain contexts of the so-called scientific or problem-solving method, which treats problems as independent of the people engaged on them. Examples of this can be drawn from the management domains of information systems development, project management, planning, and many others. In information systems development, for example, the whole basis of traditional systems analysis and design requires such an approach. In essence, in undertaking problem solving, the world is viewed as though it is made up of hard, tangible objects, which exist independently of human perception and about which knowledge may be accumulated by making the objects themselves the focus of our study. A more human-centered approach would, by contrast, see the world as interpreted through human perceptions: the reason why the problem cannot be solved is precisely because it lacks the objective reality required for problem solving. In taking this perspective, it may or may not be accepted that there exists a real world "out there", but in any event, the position adopted is that our world can be known only through the perceptions of human participants.

This question of objective reality is one with which philosophers have struggled for at least 2,500 years, and an understanding of it is essential to determining the need for, and purpose of, CoPs. The next section therefore discusses some of the philosophical issues relevant to the subjective-objective debate: a search for what, in these terms, it is possible for us to know and how we might know it.

A FOUNDATION IN KANTIAN CRITICAL PHILOSOPHY

Kant's critical problem, as first formulated in the letter to Herz (February 21, 1772) (Gardner, 1999, pp. 28-29), concerns the nature of objective reality. Prior to Kant, all philosophical schema took objective reality as a given and sought to explain how it was that we could have knowledge of this reality. If this were taken as definitive, it is easy to see how we might build (empirical) knowledge in the way suggested by Locke (1632-1704): that we are born with a "tabula rasa", or blank slate, on which impressions are formed through experience. This explains the pre-Kantian debate of reason vs. experience as the source of our knowledge: the rationalist view was that, by reason alone, we are able to formulate universally valid truths (for example, around such issues as God and immortality); empiricists, by contrast, see experience as the only valid source of knowledge.

Kant's insight and unique contribution was to bring together rationalism and empiricism in his new critical transcendental philosophy, the basis of which is his Copernican Revolution in philosophy. Loosely stated, this says that objective reality may be taken as existing, but that, as human beings, we have access to this only through our senses: we therefore see this objectivity not as it is but as we subjectively construct it. Unlike Berkeley (1685-1753), Kant does not claim that objects exist only in our subjective constructions, merely that this is the only way in which we can know them: objects necessarily conform to our mode of cognition.

For this to be so, Kant's philosophy has to contain a priori elements: there has to be an object-enabling structure in our cognition to which objective reality can conform and thereby make objects possible for us. This is what lies at the heart of Kant's Transcendental Idealism.

- While objects may exist (be "empirically real"), for us, they can be accessed only through their appearances (they are "transcendentally ideal").
- Our cognition does not conform in some way to empirical reality, rather this objectivity should be seen as conforming to our modes of cognition. In this way, we construct our objective world.
- Objects of cognition must conform to our sense experience. So, in this sense, knowledge is sensible, or the result of experience.
- These objects must conform to the object-enabling structures of human cognition. The resultant transcendental knowledge is (at least) one stage removed from objective reality, and is, according to Kant, governed by a priori concepts within human understanding.

This brief review of some key philosophical ideas has led neatly back to the subjective-objective debate. Seen from a Kantian perspective, we simply have no access to objective reality. (Interestingly, and again quite uniquely, Kant did not maintain there to be no objective reality; on the contrary, he argued that there must be real objects, or we would be in the ludicrous position of having perceptions of a world, but there being nothing to give rise to those perceptions.)

What objects may be in themselves, and apart from all this receptivity of our sensibility, remains completely unknown to us. We know nothing but our mode of perceiving them—a mode which is peculiar to us….Even if we could bring our intuition to the highest degree of clearness, we should not thereby come any nearer to the constitution of objects in themselves. (Kant, 1787, p. 82)

In summary:

1. Objectivity is conceivable only from the perspective of a thinking subject.

2. Central to Kantian philosophy is the question of how it is possible for subject and object to be so joined—what conditions must apply in order that this might be so?
3. In the Transcendental Deduction, Kant argues that subject and object make each other possible: neither one could be represented without the other.
4. All of this rests on their being: (a) a world of objects which is unknowable to us and (b) a priori concepts in understanding which enable representation of this world of objects.

A WAY FORWARD THROUGH CRITICAL THEORY

Theoretically, this philosophical position leads to a grounding in those theories relevant to human understanding and interaction, which are to be found in the social and cognitive domains. Given that in CoPs we are seeking a pluralistic, human perspective, those theories which best explain social interaction might be seen as especially relevant. Drawing again on the stream of social inquiry emanating from Kantian philosophy, this leads through the critical social theory of the early 20th century Frankfurt School to contemporary social theorists such as Foucault and Habermas (see, for example, Habermas, 1971, 1987).

Key concerns within Habermasian critical social theory are issues such as social inclusion, participation, and a view of how we ought to undertake intervention in social domains, all of which are fundamental to the functioning of CoPs. Habermas (1971, 1976, 1987) follows Kant in arguing that reliable knowledge is possible only when science assumes its rightful place as one of the accomplishments of reason. While the achievements of scientific study are not disputed, the problem perceived through the route followed by Kant and Habermas is that the methods of science which have grown out of modernity are effectively self referential: that scientific study sets up rules and then tests itself against its own rules is a procedure which has given considerable advances to modern society, but to regard this as representing all knowledge is mistaken. Habermas refers to the worst excesses of this as scientism: that we must identify knowledge with science.

Habermas further argues that the scientistic (positivist) community is unable to perceive self-reflection as part of its process, and that such reflection must be built into an understanding of knowledge. As with Kant, Habermas' challenge is whether knowledge is reducible to the properties of an objective world, leading him to a definition of knowledge which is based on perception but only in accordance with a priori concepts that the knowing subject brings to the act of perception. Since the knowing subject is a social subject, all knowledge is mediated by social action and experience, leading to Habermas' grounding certain theories in communicative interaction.

In the study of CoPs, this leads us to the following problems:

1. Accepting all human actions as mediated through subjective understanding leads to the possibility of a pluralist basis for CoPs.
2. There is no longer a dichotomy between subject and object.
3. The difficulty now left to resolve is essentially a practical one, of how to incorporate these ideas into a pluralistic foundation for CoPs.

From the position of viewing all human interactions with the so-called objective world as perceptual and subject to the a priori understanding that we, as human actors, bring to the act of perception, we begin to see CoPs as part of our normal social interaction. Research into problem analysis within the domain of management science, where communicative action theory has been used to further develop the concepts, is helpful in making sense of this. The ability to communicate by use of language is something that human beings bring to the world by nature of their existence: that is to say, it is not developed empirically but is a priori. To the extent that any theoretical position can be grounded on such an a priori ability, such a position may be seen as fundamental to us as communicative human actors.

To the extent that communication, at least partially, may be oriented toward mutual understanding, it might be argued as the foundation of CoPs, insofar as all such analysis is seen (after Kant) as perceptual. In these terms, CoPs never relate directly to the properties of an objective world but can be defined both objectively and according to the a priori concepts that the knowing subject brings to the act of perception. This knowing subject, being social, mediates all knowledge through social action and experience: subject and object are linked in the acts of cognition and social interaction.

In essence, then, it is argued that our difficulties disappear once a scientific basis for our thinking is denied. This echoes Habermas' view that science should be seen as just one form of knowledge, which in any case is simply a convenient human perception of how the world works. Now, all human endeavor becomes mediated through subjective understanding, leading to the possibility of a basis for CoPs in the universal characteristics of language. The difficulty is now essentially a practical one, of how to incorporate these ideas into CoP practice.

Within Habermas' (1976, 1987) theory of communicative action is presented a universal theory of language. Oliga (1996) summarizes this from its basis in locutionary, illocutionary, and perlocutionary speech acts, based on Austin (1975). Locutionary speech acts are concerned with saying something in a meaningful form which can be understood and are effectively a necessary precondition for communication. Perlocution is concerned with communication "strategically oriented toward individual success over [an] opponent" (Oliga, 1996, p. 246). According to Habermas (1984), only illocutionary speech acts "count as communicative action." The logic of this should not be lost in relation to the objectives of this research in relation to CoPs. The remaining tasks may be summarized as:

1. CoPs are an enactment of the perspective that objective reality is questionable and that we see our world according to our own views and perceptions (Oliga, 1996).
2. To the extent that these views are communicated by language, communicative action theory can help with the process.
3. The communication undertaken, both as spoken and as documented, can be tested for its locutionary (i.e., it should be meaningful and understandable) and its perlocutionary content, that is, it should not be concerned with "influencing the decisions of a rational opponent" (Oliga, 1996).
4. The primary test is then to deconstruct illocutionary speech, which is oriented toward understanding.

Illocutionary speech acts are oriented toward three fundamental validity claims: truth, rightness, and sincerity. What is most compelling about this theory, however, is that all three validity claims are communicatively mediated. This viewpoint is most radically seen in respect of the truth claim, where it is proposed that such a claim results not from the content of descriptive statements, but from the Wittgensteinian approach casting them as arising in language games which are linked to culture: truth claims are socially contextual and are therefore to be assessed not by reference to fact, but by reference to communication. Rightness is about norms of behavior, which are culturally relevant and are therefore to be determined by reference to that which is acceptable to those involved and affected in the system of concern as a cultural group. Finally, sincerity is about the speaker's internal world: his/her internal subjectivity.

These ideas can now be taken forward to provide an approach to CoPs which is theoretically grounded and closer to that which is experienced in (communicative) action.

AN APPLICATION FRAMEWORK FOR COPS

It is now possible to design an application framework containing these concepts; revisiting CoPs from a philosophical and theoretical perspective dictates that an interventionist must always pay heed to the following:

- All problem analysis is perceptual; any approach to it must therefore be conducted through the views and opinions of participants, since only through these can objectivity be seen.
- An explicitly critical perspective must be maintained with a particular focus on normative ("ought") positions to counter factual ("is") claims.
- Critique must be applied to both content and the material conditions (norms and values) within which the content is set.
- Communicative action should be used as the social medium through which values are judged.

In order to make judgments about communicative action, it is necessary to first record and then deconstruct the communications that have taken place. Recording is less problematic than might be imagined: while it is not uncommon for group sessions to be recorded and transcribed, this is only one of the ways in which conversations can be documented. Recent work by Alford (see Future Trends), investigating virtual tourism, used the Internet as the medium through which conversations were conducted and enabled not only transcription but also sound and vision recording. From this and other data, the process of deconstructing the conversations has been started with, at its core, the need to determine communication as:

- Meaningful and understandable to all concerned.
- Not oriented toward coercively influencing the decisions of others.
- Truthful: the "ought" test.
- "Right": acceptable to those involved and affected as a cultural group.
- Sincere: related to the speaker's internal subjectivity.

FUTURE TRENDS

An essential precursor to applying the framework is the recognition that (after Kant and Habermas) problem analysis is not possible without participant involvement and that CoPs are a medium for achieving this.

Making judgments about communicative action is more complex, but there are some existing guidelines to help with this. There are, of course, numerous ways in which conversations can be both set up and recorded, some of which have already been mentioned earlier in this entry. Technology is proving particularly helpful in this respect, and, perhaps unsurprisingly, the domain of information systems is one in which significant progress has been made. Lyytinen (1992), for example, cites conferencing technology, which could encourage discursive activity, and information technology, which would allow the anonymous submission of "radical change proposals", while Kemmis (2001, p. 100) argues there to be considerable potential for IT to create "communicative spaces" in which communicative action can take place.

Research carried out in the field of critical qualitative research (Carspecken, 1996; Carspecken & Apple, 1992; Forester, 1992) provides guidance toward a framework for analyzing the validity claims raised during communicative action. A detailed analysis of this is beyond the scope of this article, but these and other ideas (some examples of which are given below) are now being applied to develop techniques which adhere to the guidelines provided by communicative action theory.

Validity claims relating to truth are concerned with defining perceptions of reality. Participants all have access to the "world of truth" but will have different interpretations of it. While this may to some seem esoteric, nowhere is this more important than in the often highly pragmatic domain of information systems. Frequently, in a systems development exercise, truth will be colonized by a powerful group, and issues important to the success of the development will be ignored (see, for example, Bentley, Clarke & Lehaney, 2004; Clarke, Lehaney & Evans, 2004).

Rightness is about the cultural acceptability of the claimant's position. One of the most powerful ways to challenge these claims is by a critically normative approach. Ulrich's (1983) Critical Systems Heuristics is helpful here: asking "ought" questions about an "is" position is something worth perfecting.

Sincerity relates to the subjective position of the claimant. Carspecken (1996) suggests ways in which the researcher can check this sincerity: checking recorded interviews for discrepancies and asking the interviewee to explain them; comparing what a person says with what they do and seeking clarification; or showing the person a summary of your reconstruction and ask them to comment on its accuracy.

In the Centre for Systems Studies at Hull, these ideas are used to inform research into information systems. One such development is headed by Paul Drake (see, for example, Clarke & Drake, 2002; Drake & Clarke, 2001), a research student attached to the center. Paul is applying Habermas' systems/lifeworld concept and theory of communicative action to develop a deeper understanding of information security. Similarly, Philip Alford is looking at communicative action as a means of deconstructing conversations in the development of virtual tourism. Phil's conversations are collected mostly through Internet-based discussion forums, and the tests for communicative competence are proving to be of considerable value in understanding a way forward for this highly dynamic domain.

CONCLUSION

Seeing CoPs from a perspective based in critical theory gives us a new perspective. From this theoretical and philosophical basis can be derived a view of CoPs as based fundamentally on the perceptions of those involved in and affected by the system of concern. Any truly pluralist method must embrace this and must therefore pursue an approach which takes subject and object each to be a condition of possibility for the other.

Following this stream of thought, CoPs enable us to define our world both objectively and according to the a priori concepts that the knowing subject brings to the act of perception. This knowing subject, being social, mediates all knowledge through social action and experience: subject and object are linked in the acts of cognition and social interaction.

From this research project, a framework has been developed for implementing these ideas, based on theories of communicative action drawn from Austin and Habermas, and an approach to how this might be implemented in practice has been outlined. To the extent that CoPs involve communication through language, evidence of this communication can be gathered, and, from the documentation, communicative validity can be tested. All of this provides a wider framework within which methodological application can be undertaken.

REFERENCES

Austin, J. L. (1975). *How to do things with words*. Cambridge, MA: Harvard University Press.

Bentley, Y., Clarke, S., & Lehaney, B. (2004). A critical approach to the investigation of a UK university's information system. *Proceedings of the European and Mediterranean Conference on Information Systems: EMCIS 2004*. Hôtel Golden Tulip Carthage Tunis, Avenue de la Promenade, B.P 606.

Carspecken, P. F. (1996). *Critical ethnography in educational research*. New York: Routledge.

Carspecken, P. F., & Apple, M. (1992). Critical qualitative research: Theory, methodology, and practice. In J. Preissle (Ed.), *The handbook of qualitative research in education* (pp. 507-553). San Diego: Academic Press.

Clarke, S., & Drake, P. (2002). A social perspective on information security: Theoretically grounding the domain. In S. A. Clarke, et al. (Ed.), *Socio-technical and human cognition elements of information systems*. Hershey, PA: Idea Group Publishing.

Clarke, S. A., Lehaney, B., & Evans, H. (2004). Human issues and computer interaction: A study of a UK police call centre. In A. Sarmento (Ed.), *Issues of human computer interaction* (pp. 291-320). Hershey, PA: IRM Press.

Drake, P., & Clarke, S. A. (2001, May 20-23). Information security: A technical or human domain? In M. Khosrow-Pour (Ed.), *Managing information technology in a global economy, 2001 Information Resources Management Association Int. Conf.*, Toronto, Canada (pp. 467-471). Hershey, PA: Idea Group Publishing.

Forester, J. (1992). Critical ethnography: On fieldwork in a Habermasian way. In H. Willmott (Ed.), *Critical management studies* (pp. 46-65). London: Sage.

Gardner, S. (1999). *Kant and the critique of pure reason*. London: Routledge.

Habermas, J. (1971). *Knowledge and human interests*. Boston: Beacon Press.

Habermas, J. (1976). On systematically distorted communication. *Inquiry, 13*, 205-218.

Habermas, J. (1984). *The theory of communicative action*. Cambridge, UK: Polity Press.

Habermas, J. (1987). *Lifeworld and system: A critique of functionalist reason* (Vol. 2). Boston: Beacon Press.

Kemmis, S. (2001). Exploring the relevance of critical theory for action research: Emancipatory action research in the steps of Jurgen Habermas. In P. Reason & H. Bradbury (Eds.), *Handbook of action research* (pp. 91-102). London: Sage.

Lyytinen, K. (1992). Information systems and critical theory. In M. Alvesson & H. Willmott (Eds.), *Critical management studies* (pp. 159-180). London: Sage.

Oliga, J. C. (1996). *Power, ideology, and control*. New York: Plenum.

Ulrich, W. (1983). *Critical heuristics of social planning: A new approach to practical philosophy*. Berne: Haupt.

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Chapter 7.5
Facilitating and Improving Organisational Community Life

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INTRODUCTION: A CHANGE OF PARADIGM

The growth in importance of communities within organisational settings is a sign of a change in paradigm. When management and organisational theory introduce the critical notion of communities, in parallel to the concepts of collaborative work and of knowledge sharing, there is an internal revolution going on. Therefore, communities of practice theory (Lave & Wenger, 1991; Wenger, 1999; Wenger, McDermott & Snyder, 2002; Brown & Duguid, 1991) has a critical role to play in today's development of management and organisation theory.

At a broader level, there is an ongoing metamorphosis that is highly visible through the vertiginous development of technology, the globalisation of markets, and the acceleration of the increase in complexity. Equally important are the less visible, and thus harder to acknowledge, changes in the way we think, reason, communicate, and construct our image of ourselves and of the world.

The changes brought by the knowledge society of the information age (Kearmally, 1999) triggered the development of theoretical approaches to management. Among these, knowledge management and organisational learning have developed. These theories have acknowledged the importance of information and communication technology within organisations, and have explored alternative insights into mainstream management approaches. The knowledge management and organisational learning sub-disciplines represent an innovation effort that affect areas of organisational life which had been marginalised or ignored under traditional management theory. Communities of practice is the single most important example. Therefore, communities of practice represent a critical aspect of the present understanding of the complexity of organisational life.

Within the broad and varied development of organisational theories, semiotic learning emerges as a particular approach to organisational learning. Semiotic learning may be described as a dynamic practice. It incorporates theoretical contributions from social philosophy and adapts them to a specific approach to facilitate learning at the organisational level. It is a learning and development tool for action at the organisational level. The central aspect of the semiotic learning approach is the focus on the quality of community life at the organisational level.

Through a semiotic learning approach to organisational learning and development, it is possible to intensify and to unleash the true potential of current challenges at personal, organisational, and societal levels. By focusing on the social practices, structures, and processes which underlay human interaction, and by calling attention to the way we construct ourselves and our image of the world through those interactions, it enables the development of a rationale that supports collaborative as well as transformative forms of work and learning.

BACKGROUND: SUBTLE AND HIDDEN NEEDS

The contribution of the semiotic learning approach to the fields of organisational learning, knowledge management, and communities of practice is that it offers an integrative theoretical approach. The organisational learning, knowledge management, and communities of practice theories deal with issues which they cannot themselves explain, or rather with issues which they cannot yet explain. The call for a greater depth and breadth in terms of theoretical grounding may be achieved by the semiotic learning perspective. This approach consists of an organisational design and organisational development instrument to be implemented in parallel with other existing initiatives. The rationale is simple and direct: it aims at recovering the balance between the necessary functionalistic efforts, and the subtle and hidden needs of the organisation's community life. It is the projection of powerful insights arising from philosophy mediated, translated, and adapted to organisational reality. It is based on both theory and practice, as it is through its application that it becomes reified. The theory, the description, the narrative is just a means to an end, an end which is an action-based and action-led organisation.

The semiotic learning approach rests on three broad groups of theories: social semiotics, critical realism, and action theory. The semiotic learning approach works as a cascade, so that within social semiotics, it includes Bakhtin Circle's social theory of discourse; within critical realism, it takes a pragmatic perspective; and within action theory, it questions current epistemological positions and recovers an ontological and hermeneutic perspective. The breadth of theory is directed at informing and illustrating how rich and diverse the universe of options is in terms of approaches that directly answer to the 'subtle and hidden' needs of organisational life. This diversity could even be extended, never reduced. It is this diversity which expands our thought horizons so that it becomes a kind of didactic or pedagogic process, thus the word "learning" in semiotic learning. This corresponds to the "thought-possibilities" and "action-possibilities" that Jaspers explored.

Heidegger's disciple, Karl Jaspers, explored thought-possibilities and action-possibilities following the guide of Max Weber's approach as an historian:

…in order to grasp reality, we must see the possibilities…Weber employs the category of 'objective possibility' in his historical appraisal of past situations. The historian considers a situation. His knowledge enables him to construct the possibilities of the day. By these constructions he first measures the possibilities of which protagonists were aware. And then, by the possibilities, he measures what really happened, in order to ask: for what

specific reason did a particular possibility among several materialise? (Young-Bruehl, 1981)

Theoretical approaches such as critical realism (Archer, Bhaskar, Collier, Lawson & Norrie, 1998), complex systems theory (Chekland, 1999), social semiotics (Halliday, 1978; Lemke, 1984, 1995), or hermeneutics (Ricoeur, 1998) did not develop as an answer to today's virtual, fast-paced, and often chaotic communication forms. However, their insights represent a powerful tool in order to understand, cope with, and enable one to profit from the opportunities that are being opened by the knowledge society. Similar to the implicit unity between the individual and the social, there is a close connection between theory and practice. All these theoretical approaches have an intrinsic pragmatic nature and therefore do not separate the individual from the social or the theory from the practice.

It is within communities that organisations continually create and redefine meaning, and it is this meaning-making capacity that conditions the organisational identity, degree of cohesion, and potential to innovate. Meaning-making is part of the action- and thought-possibilities, part of the horizon of possibilities that is open through the practices and processes of organisational community life. Semiotic theory is unavoidably related to meaning—and therefore the importance of the term "semiotic" in semiotic learning.

MAIN FOCUS: MEANING-MAKING AND SOCIAL SEMIOTICS

Social semiotics developed out of the work of sociologists interested in language issues and of linguistics interested in the social influences within language use. Under this perspective, human development is as much the development of individuals as that of the social communities to which they belong, and language is the working tool and enabler of this process. Semiotics is commonly related to language, though it covers all forms of communication or rather 'characterisation' of a practice so that dressing, teenage gear, wrestling, or cooking have a semiotic content. Barthes (1996) developed this approach, including studies of advertising, media, and cinema. From another perspective and according to Umberto Eco, the implicit domain of semiotics is the whole history. Sebeok (1994) and other authors study semiotics in all life forms, because the ability to manufacture and recognise signs is a basic survival strategy. So they study biosemiotics, zoosemiotics, semiochemistry, and phytosemiosis. Semiotics was already present in ancient Greece through the works of Plato and Aristotle. In the Middle Ages, it continued to develop through the works of Augustine in the fourth and fifth centuries, and Ockham in the fourteenth century. Locke, in the seventeenth century, also focused on signifying processes.

Semiotics as a discipline is simply the analysis of signs or the study of sign systems. The idea that sign systems are of great consequence is easy enough to grasp. Yet the recognition of the need to study sign systems belongs to the modern age. A full-blown semiotic awareness arose at the turn of the century, and in the early 20th century, through the works of Saussure in Europe and Peirce in North America. Different schools of thought emerged from these roots, giving rise to diverse currents that deeply influenced both the linguistic turn and the context turn throughout the twentieth century. From Saussure's work, structuralism developed, as well as different branches, including one that would give rise to social semiotics. From Peirce's work, pragmatism developed, which was one of Peirce's creation, later followed by James, Dewey, Popper, Morris, Sellars, Putman, and others (Delanty & Strydom, 2003).

Jay Lemke is a contemporary social semiotitian who started as a physicist. According to Lemke (1995), Bourdieu's and Bernstein's work as sociologists, between 1970 and 1990, and Halliday's and Gunther Kress' work as a linguists, during more or less the same period, gave rise to that which is known today as social semiotics.

Halliday's social theory of discourse suggests that our uses of language are inseparable from the social functions, the social contexts of actions and relationships in which language plays its part…This is what is meant by seeing language as a social semiotic, a resource to be deployed for social purposes. (Lemke, 1995, p. 27; emphasis used in original text)

Lemke also relates the origins of social semiotics with the work on discursive formations by Foucault and, most importantly, to the early works of the Russian Bakhtin's Circle starting in 1918 (Lemke, 1984, 1995).

The works of Bakhtin and his colleagues introduced highly rich and complex terms and concepts which capture meaning, or cultural and semiotic related issues within texts, which can be literary texts, or else any social reality that may be read and interpreted as a text (Brandist, 2002). Bakhtin's work became known internationally in the 1970s; in the 1980s it spread within the areas of literary and cultural theory, and since then it has continued to disseminate, now influencing social theory, philosophy, and psychology. Bakhtin's four essays (1984), edited by Holquist, with 12 prints until 2000, were published in Moscow in 1975, after his death, and were written in the late 1920s and in the 1930s. Concepts such as heteroglossia, intertextuality, chronotope, dialogue, and dialogic relationships are some of the key concepts of Bakhtin's group of thinkers. Lemke (1995) refers to five major theories of discourse which have emphasised its social dimension: M. Bakhtin was the first one, then M. Foucault, M. Halliday, B. Bernstein, and finally P. Bourdieu, though he was not a discourse theorist.

Although semiotics is a wide area, enabling the coexistence of radically different approaches, including reminiscences of past positivist trends, social semiotics represents the cultural, historical, political, and social readings, interpretations, and meaning-making processes present in all symbolic systems. It is this richness as well as this complexity which makes social semiotics an attractive and powerful theoretical framework for organisational learning initiatives.

FUTURE: THE MEDIATION ROLE OF SEMIOTIC LEARNING

Social semiotics, together with hermeneutics and critical realism, acknowledge the importance of social structures in determining social practices and vice-versa. The notions of self and agency are intrinsically connected with how individuals are determined, and how they themselves determine the social contexts to which they belong. Pragmatism stresses the importance of integrating the individual and social dimensions into a single whole. The semiotic learning approach takes into account these contributions and mediates their insights by adapting them to an organisational context.

Critical realism is a multidisciplinary movement in philosophy and the human sciences which started with Roy Bhaskar's publication in 1975 of A Realist Theory of Science (Archer et al., 1998). The term 'critical' suggests affinities with Kant's idealism and rationalism, though the term 'realism' indicates that there are fundamental differences. Bhaskar's philosophy is reflexive as transformatively practical, or presents a transformational model of social activity. According to this theory, social life has a recursive character, as agents reproduce and transform the social structures they use and are constrained by in their substantive activities.

…actors' accounts are both corrigible and limited by the existence of unacknowledged conditions, unintended consequences, tacit skills and unconscious motivations…but, in opposition to the positivist view, actors' accounts form the indis-

pensable starting point of social enquiry. (Archer et al., 1998, p. xvi)

Critical realism, as a theory of science, presents three distinctive features:

(i) it recognises science as a social practice, and scientific knowledge as a social product; (ii) it recognises the independent existence of the objects of scientific knowledge; (iii) it has an account of scientific experiment and discovery as simultaneously material and social practices, in virtue of which both (i) and (ii) are sustained. (Benton & Craib, 2001, p. 130)

The fundamental links between individual and social arenas is a central issue to an organisational learning initiative. On one hand, individual action and thought—and the social structures and practices that contributed in the shaping and moulding of that action and that thought—and, on the other hand, the human agency capacity to strike back—to reconfigure or sustain those social structures and practices—may be acknowledged and recognised through the use and application of social philosophy theory.

The semiotic learning approach focuses on four philosophical categories: action, language, knowledge, and meaning. It claims that knowledge and meaning are already prefigured by action and language. Communities of practice theory implicitly acknowledges the social embeddeness of individual cognitive processes. In order to further develop the importance of the relations between social and individual processes, the semiotic learning approach uses six working concepts that are derived from the works of six social philosophers. These are Bakhtin's concept of dialogism (1981), Halliday's notion of grammar, Wittgenstein's idea of language-games (1958), Foucault's discursive formations (1972), Heidegger's instance of being-in-the-world (1996), and White's master tropes (1978). These philosophical contributions are introduced into four learning steps that represent the practical and applied nature of the semiotic learning approach. These are: ice-break—raising key issues; experiencing—confronting reality; action horizons—transformative learning; and innovative practice—open dynamism. There is a mediation between central notions of philosophical inquiry and key organisational issues. These key issues are: appreciative inquiry, open complex systems, socio-technical systems, collaborative work and learning, knowledge creation and sharing, reflexive practice and double-loop learning, and trust and social capital.

CONCLUSION

To finalise, two comments: Probably the best image to describe the subtle and hidden issues that the semiotic learning approach claims to tackle in order to facilitate organisational learning is that of the gap between what an organisation is supposed to be, its formal and public discourses, and the way it is felt and lived by the people actually involved, both directly and indirectly, from within and from without, from above and from below. The second issue is that the semiotic learning perspective reflects and projects a continual questioning and a work in progress—not in the sense of an unfinished work but in terms of its internal dynamic; its furthest aim is the broadening of horizons and the revolution of mentalities.

The subtle and hidden thought revolution starts within communities in general, and within communities of practice in particular. It is through communities that it reaches people at an individual level. If knowledge is in people's heads, communities of practice tell us how it got there.

REFERENCES

Archer, M., Bhaskar, R., Collier, A., Lawson, T., & Norrie, A. (1998). *Critical realism*. London: Routledge.

Bakhtin, M. (1981). *The dialogic imagination*. University of Texas Press.

Barthes, R. (1996). *Mythologies*. London: Vintage.

Benton, T., & Craib, I. (2001). *Philosophy of social science*. UK: Palgrave.

Brandist, C. (2002). *The Bakhtin Circle: Philosophy, culture and politics*. London: Pluto.

Brown, J., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Press.

Brown, J., & Duguid, P. (2001). Knowledge and organisation: A social-practice perspective. *Organisational Science, 12*(2), 198-213.

Chekland, P. (1999). *Soft systems methodology: A 30-year perspective*. West Sussex, UK: John Wiley & Sons.

Delanty, G. (2003). Michel Foucault. In A. Elliot & L. Ray (Eds.), *Key contemporary social theorists*. Oxford, UK: Blackwell.

Delanty, G., & Strydom, P. (2003). *Philosophies of social science*. Berkshire, UK: McGraw-Hill.

Foucault, M. (1970). *The order of things: An archaeology of the human sciences*. London: Tavistock.

Foucault, M. (1972). *The archaeology of knowledge*. London: Tavistok.

Halliday, M. (1978). *Language as social semiotic*. Victoria, Australia: Open University.

Heidegger, M. (1996). *Being and time*. Albany: State University of New York. Original publication [1927] Max Niemeyer Verlag, Tübingen, Germany.

Kearmally, S. (1999). *When economics means business*. London: Financial Times Management.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate and peripheral participation*. Cambridge: Cambridge University Press.

Lemke, J. (1984). *Semiotics and education*. Toronto: Victoria College/Toronto Semiotic Circle Monographs.

Lemke, J. (1995). *Textual politics, discourse and social dynamics*. London: Taylor & Francis.

McHoul, A., & Grace, W. (1993). *A Foucault primer: Discourse, power and the subject*. New York: New York University Press.

Ricoeur, P. (1998). *Hermeneutics and the human sciences*. Cambridge, UK: Cambridge University Press.

Sebeok, T. (1994). *Signs: An introduction to semiotics*. Toronto, Canada: University of Toronto Press.

Wenger, E. (1999). *Communities of practice: Learning, meaning and identity*. Cambridge, MA: Cambridge University Press.

Wenger, E., McDermott, M., & Snyder, W. (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.

White, H. (1978). *Tropics of discourse: Essays in cultural criticism*. Baltimore: Johns Hopkins University Press.

Wittgenstein, L. (1958 [1953]). *The blue and brown books. Preliminary studies for the "philosophical investigations."* G. Anscombe (trans.). London: Basil Blackwell.

Young-Bruehl, E. (1981). *Freedom and Karl Jaspers philosophy*. Alpine.

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Chapter 7.6
Knowledge Management Systems Acceptance

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INTRODUCTION

Knowledge management is a set of systematic actions that organizations can take to obtain the greatest value from the knowledge available to it (Davenport & Prusak, 1998). Systematic means that knowledge management is made up of intentional actions in an organizational context. Value means that knowledge management is measured according to how knowledge management projects contribute to increased organizational ability (see for example Prieto & Gutiérrez, 2001; see Goldkuhl & Braf, 2002, on the subject of organizational ability). The motivation for knowledge management is that the key to competitive advantage for organizations in today's business world is organizations' ability to manage knowledge (Nonaka & Takeuchi, 1995; Davenport & Prusak, 1998). Knowledge management as an intentional and value-adding action is not easy to accomplish in practice (Scarbrough & Swan, 1999). Scarbrough and Swan (1999) present several case studies in knowledge management, successful and unsuccessful in their respective knowledge management projects. A major point and lessons learned from the case studies is that prevalent approaches in knowledge management overstate technology and understate how technology is implemented and applied.

To succeed with knowledge management, encompassing development of information technology-based information system, some requirements have to be fulfilled. An important aspect in the development process is system acceptance. Implementation is at large a process of acceptance. Implementation is the process where the system becomes an integrated part of the users' or workers' work practice. Therefore implementation is essential to make a knowledge management project successful in order attain an increased organizational ability and to succeed with knowledge management.

ISSUES OF KNOWLEDGE MANAGEMENT—SYSTEMS AND ACCEPTANCE

In this section we provide broad definitions and discussion of the topics to support our positions on the topics of knowledge management and systems acceptance.

MANAGING KNOWLEDGE

Work in knowledge management has a tendency to omit social or technological aspects by taking on one of two perspectives on knowledge management, the anthropocentric or the technocratic view (Sveiby, 2001; Swan, 1999). The anthropocentric and the technocratic views represent two contradictory views on knowledge management and can be summarized as technology can or technology cannot. The gap between the anthropocentric and technocratic view depends on a difference of opinions concerning the notion of knowledge. The technocratic view conceives knowledge to be some organized collection of data and information, and the anthropocentric view conceives knowledge to reside in humans, not in the collection (Churchman, 1971; Meredith & Burstein, 2000). Our conception of knowledge is that of the anthropocentric view. Taking on an anthropocentric view on knowledge management does not mean that we discard knowledge management technologies; we rather take on a balanced view on the subject. Information technology can support knowledge management in an organization through a number of different technological components, for example intranets, extranets, data warehouses, and database management systems (Borghoff & Pareschi, 1998; Tiwana, 2000; Ericsson & Avdic, 2002). The point in taking on an anthropocentric view of knowledge management is not to lose sight of the knower who gives meaning to the information and data found in IT-based knowledge management systems.

KNOWLEDGE MANAGEMENT SYSTEMS

Information systems can include either operative or directive and decision support information (Langefors, 1966; Yourdon, 1989). Operative systems provide system users with information necessary in workers' daily work, while directive and decision support systems provide system users with information that improves the quality of decisions workers make in daily work. Knowledge managements systems are systems developed to manage knowledge directly or indirectly to give support for an improved quality of a decision made in workers daily work, and as an extension, an increased organizational ability. A knowledge management system typically includes directive information, for example in guiding a user's choice in a specific work situation. Such systems are often optional in the sense that users can deliberately refrain from using the system and/or refrain from taking the directed action. Accordingly, user acceptance is crucial for the degree of usage of knowledge management systems.

ACCEPTANCE OF TECHNOLOGICAL SYSTEMS

Technology acceptance has been subject of research by, for example, Davis, Bagozzi, and Warshav (1989), who developed the well-known

Technology Acceptance Model (TAM) and later a revised version of the original model, TAM2 (Venkatesh & Davis, 2000). TAM is an explanative model explaining user behavior of computer technologies by focusing on perceived ease of use, perceived usefulness, attitude towards use, and behavioral intentions as determinants of user behavior. TAM2 is an extension of the original model including external factors related to perceived usefulness.

The framework for system acceptance, Requirements of Acceptance Model (RAM) have some resemblances with TAM and the later TAM2. RAM is in comparison with TAM descriptive in nature. Workers' work practice is treated as an integrated element of RAM, compared with not being treated as a determinant of system use in the original TAM and as an external factor in TAM2. Further, RAM covers acceptance of knowledge management systems, and TAM/TAM2 cover a broad range of computer technologies. RAM systematically acknowledges factors important in implementation of knowledge management systems to gain acceptance of such systems.

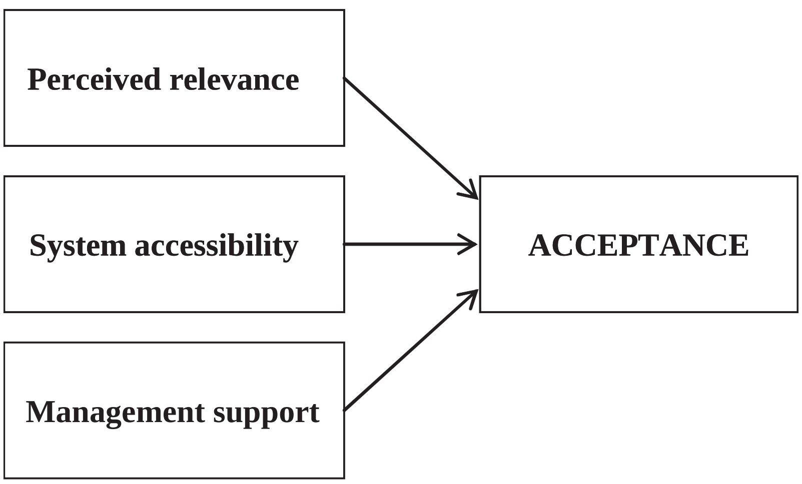
REQUIREMENTS OF THE ACCEPTANCE MODEL

We perceive acceptance to be a function of perceived relevance, systems accessibility, and management support. Together these elements constitute our framework RAM. In this section we present the requirements of acceptance in RAM. The Requirements of Acceptance Model is illustrated in Figure 1.

PERCEIVED RELEVANCE

The workers, who are to use the system, must perceive the knowledge management system as relevant. Since it is possible for workers to work without using the system, it has to be obvious that usage of the system implies adding value to the work result. An additional aspect of relevance related to perceived relevance is how the system should be integrated in running work, that is, to make the system an integrated part of the workers' work practice.

Figure 1. Requirements of acceptance model (Ericsson & Avdic, 2003)



In summary, perceived relevance is about workers, who are to use the system, perceiving the system as (Ericsson & Avdic, 2003)

- adding value to the work results; and
- being integrated in running work.

ACCESSIBILITY

To obtain acceptance of knowledge management systems, accessibility has to be satisfactory. It must be accessible to the workers who are to use the system. Accessibility is a question of who is to be the user (type of workers concerning organizational position), what action and work the system is to support (daily work, product development, innovation, etc.), where users get access to the system (the physical access), when the system is ready to use, and how the system's interface fulfills the goal of the system.

In summary, systems accessibility is about (Ericsson & Avdic, 2003):

- knowing who the user is;
- systematizing the actions workers perform in the work practice the system is to support;
- deciding the system's physical access;
- securing a certain degree of usage before the system is put into operation; and
- ensuring the system's design meets the goals of the system.

MANAGEMENT SUPPORT

Management support is vital according to many models on information systems development, especially when the system is a directive/decision support system (Yourdon, 1989). Knowledge management systems are typically directive systems, and workers have a choice in deciding whether to use the system or not. Management support is important to stress the value for workers to use the system and to make conditions for workers to do so.

DEVELOPMENT IS A PROCESS OF ACCEPTANCE

There must be a fit between workers' work practice and technology to get acceptance of knowledge management systems. The technology used to create a knowledge management system must fit the actions workers perform in their work practice. On an overall level there must be a fit between technology and actions performed by individual workers, and between individual workers and the organization as a whole, thus forming a coherent whole. It is in the development of knowledge management systems that the requirements of acceptance are fulfilled. A common conception concerning information systems development is that it constitutes analysis, design, construction, and implementation of information systems (Hirschheim, Klein & Lyytinen, 1996).

The groundwork for acceptance is made during the design, but foremost when implementing the system. Workers who are to use the system should be engaged at an early stage of the development process. The point of including workers at an early stage is to acquaint users with the system and the purpose of the system. Further, this is an opportunity for workers to influence the system's design and content. The most prominent aspect addressed when involving workers at an early stage is that of choosing and determining the meaning of crucial concepts managed by the system. Crucial concepts managed by the system are the knowledge represented in the system, and by determining concepts, knowledge represented in the system takes on a systematized character. Further, by involving the workers in the process of choosing and determining the meaning of crucial concepts managed by the system, the knowledge represented in the system does not lose its origin or meaning. The point is to keep the knowledge represented in the system within a frame of understanding or meaning, as perceived by workers. A knowledge management systems should be seen as a tool developed to support workers in learning and acquiring knowledge about actions taking place at work. This requires closeness between how concepts are perceived by workers and how such concepts are represented in a system.

FUTURE TRENDS

Research on technology acceptance (i.e., Davis et al., 1989; Venkatesh & Davis, 2000) has focused on user behavior of computer technologies. RAM is developed for and is used to assess acceptance of knowledge management systems. Acceptance has not been a crucial issue within the knowledge management area. A problem with knowledge management systems is that they work in theory, but seldom in practice (Wickramasinghe, 2003). A contributing factor to that picture may very well be that of having overlooked usage-related problems connected to knowledge management systems. In that sense, knowledge management systems acceptance can be expected to be an area for further research in the future.

CONCLUSION

Acceptance of knowledge management systems is a function of perceived relevance, systems accessibility, and management support. Together these elements constitute our framework RAM. RAM is summarized in Table 1.

The Requirements of Acceptance Model point towards several important aspects concerning relevance, accessibility, and support. The groundwork for system acceptance is the development

Table 1. Summary of RAM (Ericsson & Avdic, 2003)

Perceived relevance—Workers, who are to use the system, have to perceive the system as:

- Adding value to work results
- Being integrated in running work

Systems accessibility—System accessibility is about:

- Knowing who the user is
- Systematizing actions workers perform in the work practice the system is to support
- Deciding the physical location where users get physical access to the system
- Securing usage of the system before it is put into operation
- The systems' design must meet up to the goals of the system

Management support—Fundamental because management authorizes development of systems process. Development is very much a process of acceptance as a process of developing the system itself. Through requirements of acceptance, knowledge management systems can remain and continue to be a contributing factor for the organization's ability to do business.

REFERENCES

Borghoff, U.M. & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management*. Berlin, Heidelberg: Springer-Verlag.

Churchman, C.W. (1971). *The design of enquiring systems: Basic concepts of systems and organization*. New York: Basic Books.

Davenport, T. & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School.

Davis, F.F., Bagozzi, R.P. & Warshaw, P.R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982-1003.

Ericsson, F. & Avdic, A. (2002). Information technology and knowledge acquisition in manufacturing companies: A Scandinavian perspective. In E. Coakes, D. Willis & S. Clarke (Eds.), *knowledge management in the socio-technical world. The grafitti continues.* London: Springer-Verlag.

Ericsson, F. & Avdic, A. (2003). Knowledge management systems acceptance. In E. Coakes (Ed.), *Knowledge management: Current issues & challenges* (pp. 39-51). Hershey, PA: Idea Group Publishing.

Goldkuhl, G. & Braf, E. (2002). Organisational ability: Constituents and congruencies. In E. Coakes, D. Willis & S. Clarke (Eds.), *Knowledge management in the socio-technical world. The grafitti continues* (pp. 30-42). London: Springer-Verlag.

Hirschheim, R., Klein, H.K. & Lyytinen, K. (1996). Exploring the intellectual structures of information systems development: A social action theoretic analysis. *Accounting, Management & Information Technology, 6*(1/2), 1-64.

Langefors, B. (1966). *Theoretical analysis of information systems*. Lund: Studentlitteratur.

Meredith, R. & Burstein, F. (2000). Getting the message across with communicative knowledge management. *Proceedings of the Australian Conference on Knowledge Management and Intelligent Decision Support (ACKMID'2000)* (pp. 43-55). Melbourne: Australian Scholarly Publishers.

Nonaka, I. & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Prieto, I.M. & Gutiérrez, E.R. (2001). A contingency perspective of learning and knowledge management in organizations. In D. Remenyi (Ed.), *Proceedings of the 2nd European Conference on Knowledge Management* (pp. 487-502). Slovenia: Bled School of Management.

Scarbrough, J. & Swan, J. (Eds.). (1999). *Case studies in knowledge management*. London: Institute of Personnel and Development.

Sveiby, K.-E. (2001, April). *What is knowledge management?* Retrieved June 28, 2002, from www.sveiby.com.au.

Swan, J. (1999). Introduction. In J. Scarbrough & J. Swan (Eds.), *Case studies in knowledge management*. London: Institute of Personnel and Development.

Tiwana, A. (2000). *The knowledge management toolkit. Practical techniques for building a knowledge management system*. Upper Saddle River, NJ: Prentice-Hall.

Venkatesh, V. & Davis, F.D. (2000). A theoretical extension of the Technology Acceptance Model: Four longitudinal field studies. *Management Science, 46*, 86-204.

Yordon, E. (1989). *Modern structured analysis*. Englewood Cliffs, NJ: Prentice-Hall.

Wickramasinghe, N. (2003). Do we practice what we preach? Are knowledge management systems in practice truly reflective of knowledge management systems in theory? *Business Process Management Journal, 9*(3), 295-316.

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Chapter 7.7
Organizational Communication

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INTRODUCTION

All organizations depend on communication. Communication is the exchange of information between two or more people with the intent that the sender's message be understood and considered by the receivers in their cognition, affect, and behavior. As organizations are designed for action, most organizational communication eventually leads to action and to working relationships between actors. Indeed, communication plays a pivotal role in organizations and may even be seen as the foundation for most organizational action (Galbraith, 1977; Weick, 1979).

KM and communication go hand in hand. On the one hand, communication is the basis for knowledge sharing, which is a necessary component of successful knowledge management. On the other hand, knowledge is crucial for effective communication, and KM is therefore potentially central in facilitating communication. This article concentrates only on the latter direction, namely, the role of KM in promoting effective communication, although as we shall see, the two directions are interrelated. (For literature on the former, i.e., the role of communication in knowledge sharing, see numerous resources in Alavi & Liedner, 2001). Furthermore, our discussion is restricted to computer-based knowledge management, as well as computer mediated communication. Therefore, the terms KM and communication, whenever used here, imply that these functions involve computer support.

Despite the central role of communication in organizations, organizational communication is unfortunately susceptible to numerous obstacles and barriers to effective communication. Barriers to communication occur at the individual and organizational level. At the individual level, interpersonal dynamics interfere with communication, individuals choose inappropriate channels and media, the sender and receiver use different semantics, making it difficult to communicate, and people send conflicting cues in different messages and channels. At the organizational level, different functions and departments see things differently, power and politics interfere with open and sincere exchanges, and organizational norms or policies dictate ineffective channels and inappropriate forms of messages. KM can help overcome these barriers and improve organizational communication, and, in particular, KM can enhance computerized communication support systems such as structured e-mail, video conferencing, listservs, and so forth. However, to do so, designs of KM systems must be based on an understanding of communication.

BACKGROUND

Our understanding of communication, and particularly computer-mediated communication in the organizational context, has developed dramatically in the last few decades. The classical information-transmission model introduced by Shannon and Weaver (1949) has transformed into more active, psychological, and social models of communication (Axley, 1984). See, for example, Riva and Galimberti (1998) for an overview of these transformations in theories and metaphors of communication. In the interest of brevity and in order to identify the role of KM in enhancing communication, we select one model of organizational communication (Te'eni, 2001) that helps to define the link between KM and communication. The model has three main factors, each of which includes several attributes:

1. Inputs to the communication process include (a) distance between sender and receiver, (b) values and norms of communication, and (c) attributes of the task that is the object of the communication;
2. A cognitive-affective communication process of exchanging a message that describes the choice and implementation of (a) one or more communication strategies used to transmit the message, (b) the form of the message and (c) the medium through which it is transmitted; and
3. The communication impact: (a) the mutual understanding and (b) the relationship between the sender and receiver.

Consider the following example. A product designer in an industrial plant may send a message to the marketing director about a new product under development, explaining the bill of materials expected for the product. This information is useful to the marketing director when pricing the product. The communication (semantic) distance between the communicators may be large due to their different background disciplines (engineering and marketing). However, working for the same company, they accept the same communication norms by which information in the organization is always openly shared as early as possible. The sender may choose to communicate the message by a typed letter (choice of medium) and using the formal template for internal budgeting (choice of message form). Additionally, the sender sends an informal memo in the form of a story describing how this product has been developed at home by one of the engineers. This story provides contextual information about the product and explains the rather expensive list of required materials (this is an example of a communication strategy). Finally, the impact of the communication is essentially that the marketing director understands the message and prices the product accordingly. This example demonstrates how organizational communication can take on different forms and media and how the communication situation and people involved adapt these communication parameters to ensure effective communication. This article explores how KM can help communicators achieve this goal.

KM FOR SUPPORTING COMMUNICATION: A FRAMEWORK

Four concepts in this model are especially relevant to the link with KM: context, levels of abstraction, adaptation, and organizational memory. The idea of context is central to the model. We assume that in any communication there is a core message that the sender wishes to convey to the receiver. Senders add contextual information to the core message to increase the likelihood that the receiver will understand their intentions. Whatever information receivers choose to use (from the information available to them) in reasoning about the core message can be regarded as context. Part of this context is in the receivers' heads or in other available sources and part needs to be provided to the receivers by the senders as contextual information to ensure mutual understanding. Some first steps toward a formal treatment of context can be found in Ghidini and Giunchiglia, 2001.

Contextual information refers to several possible aspects of the core message: the situation in which the message was produced, the situation in which it is anticipated to be received, an explanation about a statement, an explanation how to go about executing a request for action, or the underlying assumptions about an argument. Providing the contextual information to explain the core message is a common communication strategy called contextualization. Contextual information can be seen as layers of information around the core message and contextualization can be seen as the act of adding more coats of information. KM techniques capable of determining and identifying context, retrieving or generating the information, providing the information in effective message forms and through effective media, and testing its impact may play a crucial role in enriching communication with appropriate contextual information.

The second idea involves levels of abstraction in the core and contextual information communicated. In thinking and communicating, people represent action at multiple levels of abstraction, and at any one moment, one of these levels is their focal level (Vallacher & Wegner, 1987; Berger, 1998). Moreover, people tend to remain on higher rather than lower levels of abstraction, but shift their attention to a lower level of abstraction when communication complexity increases and breakdowns occur. The lowest levels of abstraction in communication concern the lexicon and syntax (i.e., the terminology and grammar of the language). A higher level is the semantics (i.e., meaning of the message). Finally, the highest levels concern the task or pragmatic aspects of the message (i.e., the impact of the message on thought and action). A failure of communication at any level will hinder mutual understanding. KM techniques capable of identifying communication breakdowns and correcting them must rely on knowledge of communication at all levels of abstraction (such knowledge may be modeled as a multi-level model of communication analogous to the Open Systems Interconnect seven-layered protocol model). These KM techniques would be essential for ensuring effective communication and correcting lower levels of communication in order to enable communicators to concentrate on higher levels.

Another concept is that of adaptation in communication. Effective communicators match the medium, the message form, and the communication strategies to the communication situation, and the dynamics of the dialog. For example, communication between heterogeneous communicators should include more contextual information and may be more effective when richer, rather than leaner, media is selected. Knowledge of the communication situation (e.g., the relationships between communicators) as well as knowledge of how to communicate can be used to generate more effective communication. Communication complexity can be seen as a systemic measure of the communication situation and its susceptibility to communication breakdowns (Te'eni, 2001). It can therefore act as a sensor to trigger adaptation. KM techniques capable of detecting the need to adapt and also capable of adapting the system parameters can play an important role in facilitating communication support systems that provide tailored communication.

The last concept is the role of organizational memory (OM) in communication (Anand, Manz, & Glick, 1998). OM is a general term for the collection of information and knowledge "known" to the organization, as well as the KM necessary to acquire, store, and utilize this knowledge. Therefore, OM is essential for communication not only because it is a source of contextual information but also because it embodies the knowledge of how to communicate effectively in the organization (e.g., who knows, or should know, what). Furthermore, the information known to the organization is, in a substantial part, represented in organization communication on digital media such as e-mail and bulletin boards. It follows that computer-mediated communication can be a major source of the information stored in the OM. In other words, communication is a major provider of knowledge as well as being an essential enabler of KM. Referring to Figure 1, while the focus of this article is the arrow flowing from the OM to communication; we also see how communication injects knowledge into the OM. The relationship between communication and KM is bidirectional. Indeed, KM techniques are needed to store, organize, and make the information embodied in the communication available, via the OM, for distribution in future communication. Very often the core message of today becomes the context of tomorrow.

These four concepts (context, levels of abstraction, adaptation, and OM) are interrelated. In particular, OM should be modeled to enable effective contextualization, comprehensive support for all levels of abstraction and a basis for adaptation. OM will need to encompass a wide range of message forms (e.g., formal as well as informal materials and structured as well as unstructured information) and utilize a mix of media such as text, voice and video. Without such a mix, computer-supported communication will fall short of the flexible and adaptive nature of effective organizational communication. Moreover, OM will need to include information organized along levels of abstraction in order to support communication that fluctuates between levels, for instance, design OM to store and retrieve episodic memories (e.g., in the form of stories) as well as abstract rules generalizing the episodes. We return to the design of OM later on.

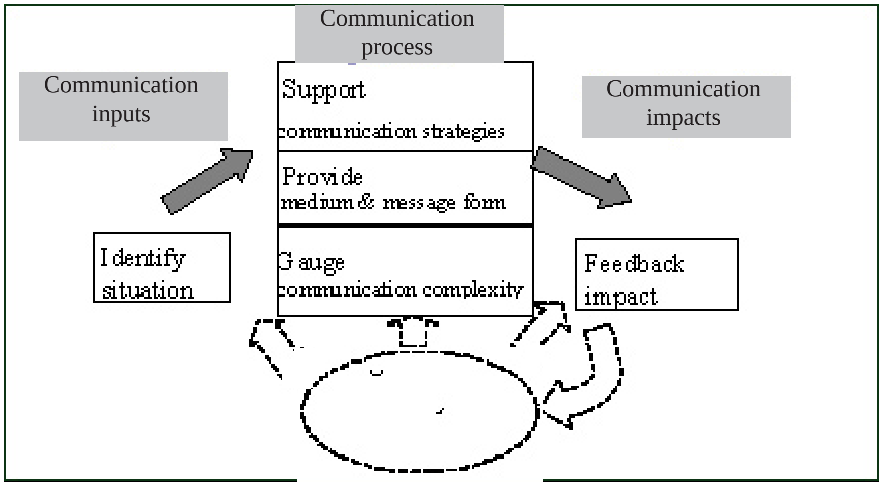
The three factors of the communication model, along with the four concepts discussed, create a framework for analyzing the role of KM in communication (see Figure 1). One can conceive of KM technologies that: (1) identify the inputs (e.g., the initial distances between communicators); (2) support the formulation of goals and the choice of communication strategies, choose and provide medium and message form, and gauge the complexity of communication in order to adapt it; and (3) provide the user with feedback on impact. Organizational memory is a key resource in supporting each of these types of functionality, but it also builds on the information and feedback from the communication.

APPLICATIONS AND FUTURE TRENDS

Following Figure 1, we examine several demonstrations of the potential roles of KM in the support of computer-mediated communication. First is the identification of the communication situation as well as the partners to communication. Groupware that helps the user identify "who knows what" and "who knows whom" in the workplace are examples of systems that employ KM techniques to identify whom to communicate with (e.g., Moreland, 1999). For example, IKNOW (Contractor, Zink, & Chan, 1998) is a program that organizes information about a network of colleagues and what knowledge each one has. In other words, the software attempts to answer the question: "Who knows who knows what?"

Given that two communicators are about to communicate, the relation between them can be characterized using organizational and personal

Figure 1. Communication enhanced by organizational memory (adapted from Te'eni, 2001)



knowledge. For example, knowledge of the organizational structure or of personal ontologies is the basis for computing the linguistic distance between the communicators (Maedche & Staab, 2001). Similarly, systems that employ collaborative filtering based on user profiles can compute a measure of similarity between profiles to decide what information to provide. For example, electronic media is personalized on the basis of user profiles (e.g., www.crayon.net), and similarly Intranet-based communication can be personalized according to internal employee profiles.

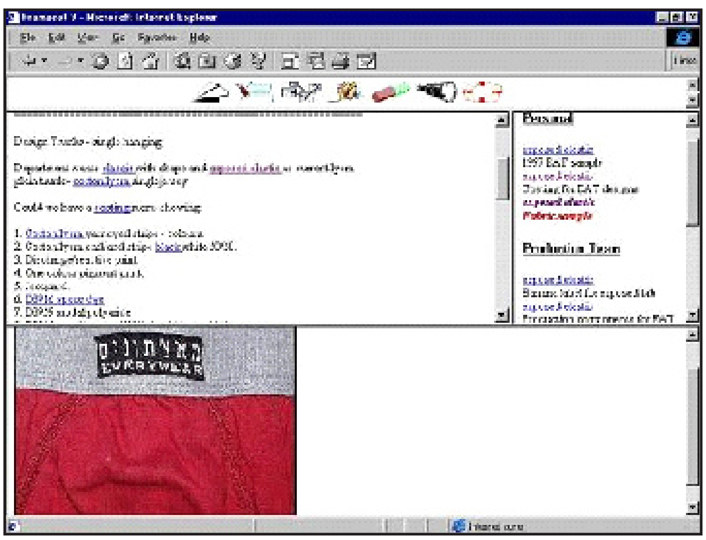
Finally, the information included in senders' signature files also can be used to define work relations between communicators (e.g., levels of expertise). As users may use different signatures, depending on the role they wish to assume in a particular communication, knowledge of the organizational structure combined with the user's choice of signature is particularly informative. When a sender from one department communicates with a colleague from the same department, a communication support system based on an OM that includes the organizational structure will be able to recognize the communicators as presumably sharing the same terminology. When the receiver is from a different organization, the signature could provide some clues on the semantic distance between the communicators. On the basis of such information, the communication support system can adapt the communication process to provide more or less contextual information.

KM can enhance the communication process in several ways. First, the initiation and control of the communication process relies on knowledge. For example, organizational maps can determine who should be contacted on what occasion. LiveMaps (Cohen, Jacovi, Maarek, & Soroka, 2002) tracks and analyzes colleagues using the same information. Another example is the early work on Coordinator (Winograd & Flores, 1986), which shows it is possible to assign to each message its purpose. A related communication support system is CHAOS (De Cindio, Simone, Vassallo, & Zanaboni, 1986), which organizes communications as a bank of conversations that serves as the basis for supporting communication and action. It includes a knowledge builder that observes messages and updates the bank of conversations accordingly.

Contextualization is perhaps the prime meeting point between communication and KM. First, the smart organization of messages (e.g., intelligent categorization of messages into folders and keywords) and then the advanced retrieval of information (e.g., text mining techniques) are crucial for effective contextualization. A knowledge-based mailer called kMail is an example of contextualization in communication support systems (Schwartz & Te'eni, 2000). The system builds links to relevant information automatically by parsing outgoing messages to detect possible information that elaborates the message. Indeed, contextualization highlights the role of knowledge management techniques in computer mediated communication. Such techniques are essential for detecting relevant knowledge, linking it to the core message and delivering it in context and in time.

Moreover, different people hold different views of context for the same core message. For instance, a production manager will think of a particular product, such as men's trunks, in terms of a production specification and the resulting product. In contrast, the marketing manager's mental model of the same product may be a packaged set of 10 pairs of colored trunks, with its associated sales and customer information. In kMail, the different views, owned by different communicators, are indexed so that people can see a message in light of alternative perspectives (see Figure 2). While the current picture of the trunks is part of the marketing view (mental model), an alternative view may depict a sketch with dimensions and other production specifications such as color options. Being able to depict the different views of the same product so that the communicators can appreciate the different

Figure 2. Contextualization based on organizational memory, showing on the right hand side different perspectives of different communicators



context held by their partners requires advanced KM. Another communication support system is Spider (Boland, Tenkasi, & Te'eni, 1994), which is designed to present context in a variety of forms so that it can lead more efficiently to better and richer communication. The system displays the different rationales behind an issue in the form of cognitive maps that highlight the similarities and differences in the communicators' perspectives. This requires KM that is not only capable of maintaining individuals' ownership over their own perspectives but also KM techniques that can compare and contrast perspectives (e.g., by comparing cognitive maps).

Contextualization can very quickly overload and needs to be prioritized according to the communicators, task, norms, and situation (see Figure 1). Prioritizing contextual information found in the OM so as to show only the most relevant information or enable the user to select, say, the 10 most relevant items requires advanced KM techniques such as those employed in search engines. For example, if knowledge in the OM is organized according to levels of abstraction, context can be presented at higher levels and expanded to lower levels only when needed. In kMail, knowledge items in the OM were classified as either a definition or a related item. A definition of a term (such as "BOM-bill of materials") can be shown at the highest priority, while lower abstraction levels of context can provide guidelines and templates for preparing a BOM and also may include examples of previous cases. KM is needed to organize the knowledge and provide it according to a hierarchy of levels. kMail also relies on the organization's communication maps to determine the likelihood of the communicators using the same or different terminologies, and accordingly recommending high or low levels of contextualization. A more recent system based on a Formal Language for Conversations, which also relies on previous messages in organizational memory, builds threads of associated messages and provides them as the context of the message sent (Takkinen, 2002).

Organizational knowledge can be managed so as to preserve the progression of information items from low to high formality (e.g., stories, facts, and abstract principles). Cleverly designed KM could be used to enable communication systems to supply the right level at the right time. Clearly, some knowledge sharing involves close human-to-human interaction and cannot rely on automatic processes for storing and retrieving data via structured databases. KM must therefore not only maintain knowledge in different forms but also enable their exchange through different media to support rather than replace human-to-human communication. Some messages such as stories are best sent as texts but accompanied by voice messages highlighting or interpreting some complex or sensitive point. In other words, human knowledgeability combines with predefined rules embodied in the KM systems to provide more effective communication. Furthermore, complex, tentative, and fuzzy ideas are often communicated informally and safely between colleagues (friends) in the form of conversations or ongoing dialog. Communities of practice (Wegner, 1998) are an essential enabler of meaningful conversations, and knowledge-based software (sometimes called "communityware") helps organize such conversations (Wellman, 2001).

Ultimately, feedback on the impact of communication must come from the user's own reaction, but future systems may effectively channel this feedback back to the sender. The OM can be designed to include results of successes and failures of communication that are provided to the sender at the appropriate time. For example, in a multinational organization, a history of poor communication between certain departments in two different nations should be fed back to these communicators in order to take the necessary precautions such as a higher level of information redundancy and more detailed feedback. Little research has been carried out in this area but as communication support systems become more common, the importance of informing senders of the communication impact will grow. Some form of feed-forward may be possible, for example, a simulation of probable errors due to a high semantic distance between communicators (e.g., communicators speaking different languages.) Furthermore, advanced computer support may be able to dynamically sense fluctuations in communication complexity and adapt the communication accordingly to ensure effective communication. Clearly, there is still much to do in terms of developing ways of identifying and reporting on communication failures.

CONCLUSION

In conclusion, KM is becoming a crucial element in the design and enhancement of organizational communication. The model shown in Figure 1 provides a framework for understanding the different types of enhancement to computer-mediated communication contribution that can build on knowledge (stored in OM) and KM. The knowledge is of two types: knowledge about the issue communicated and knowledge about how and with whom to communicate. KM must be designed to utilize both types of knowledge to enhance communication. It does so through techniques such as content and document management, contextualization, profiling people in the organization, finding contextual information through text and data mining, categorizing information, and more. Several of the systems described use these techniques to capitalize on organizational knowledge for enhancing communication.

Not all knowledge, however, can be communicated explicitly. Some forms of knowledge sharing are inherently tacit. KM techniques that rely on explicit information are therefore necessarily limited to part of organizational communication. Nevertheless, as computer-mediated communication accounts for a growing part of organizational communication, KM is rapidly becoming a necessary component of computer-supported communication systems. Moreover, our discussion has focused on cognitive aspects of communication and KM. Future research will need to expand to include cultural and political aspects as well as affective aspects of organizational communication. Future communication systems will learn to adapt to the communicators' emotions as well as their genres of communication. KM will undoubtedly be called on again.

As computer support for organizational communication expands within organizations, including dispersed organizations, and extends to different forms of knowledge (data, stories, policies, best practices, etc.) and different media (synchronous and asynchronous text, voice, multimedia, etc.), KM will have to invent new ways to organize and integrate the multiple sources of knowledge available in the organization. Communication relies on knowledge regardless of its form and medium and KM will have to rise to the occasion.

REFERENCES

Alavi, M., & Liedner, D. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Anand, V., Manz, C.C., & Glick, W.H. (1998). An organizational memory approach to information management. *Academy of Management Review, 23*(4), 796-809.

Axley, S.R. (1984).Managerial and organizational communication in terms of the conduit metaphor. *Academy of Management Review, 9*(3), 428-437.

Berger C.R. (1998). Message plans, communication failure and mutual adaptation during social interaction. In M.T. Palmer & G.A. Barnett, *Progress in Communication Sciences, Volume XIV, mutual influence in interpersonal com-*

munication: Theory and research in cognition, affect and behavior (Chapter 5, 1998, pp. 91-111), Stamford, CO, Ablex Publishing,

Boland, R., Tenkasi, R., & Te'eni, D. (1994). Designing information technology to support distributed cognition. *Organization Science*, *5*(3), 456-475.

Cohen, D., Jacovi, M., Maarek, YS., & Soroka, V. (2002). LiveMaps for collection awareness. *International Journal of Human-Computer Studies*, *56*(1), 7-23.

Contractor N., Zink D., & Chan M. (1998). Community computing and support systems. In T. Ishida (Ed.), *Lecture notes in computer science*, (pp. 201-217). Berlin: Springer-Verlag.

De Cindio, F., Simone, C, Vassallo, R., & Zanaboni, A. (1986, December 3-5). *CHAOS as a coordination technology. Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW' 86)*, 325-342, ACM Press.

Galbraith, J.R. (1977). *Organization design*. Reading, MA: Addison-Wesley.

Ghidini, C., & Giunchiglia, F. (2001). Local models semantics, or contextual reasoning – locality + compatibility. *Artificial Intelligence, 127*(2), 221-259.

Maedche, A., & Staab, S. (2002). Ontology learning for the Semantic Web. *IEEEE Intelligent Systems*, *16*(2), 72-79.

Moreland, R.L. (1999). Transactive memory: Learning who knows what in work groups and organizations. In L. Thompson, D. Messick, and J. Levine (Eds.). *Sharing knowledge in organizations* (pp. 3-31). Mahwah, NJ: Lawrence Erlbaum.

Riva, G., & Galimberti C. (1998). Computer-mediated communication: Identity and social interaction in an electronic environment. *Genetic, Social and General Psychology Monographs*, *124*, 434-464.

Schwartz, D.G., & Te'eni, D. (2000). Tying knowledge to action with kMail. *IEEE Intelligent Systems, 15*(3), 33-39.

Shannon, C.E., & Weaver, W. (1949). *The mathematical theory of communication*. Urbana, IL: University of Illinois Press.

Takkinen, J. (2002). *From information management to task management in electronic mail*. Dissertation No. 732, Institute of Technology, Linkopings University, Sweden.

Te'eni, D. (2001). A cognitive-affective model of organizational communication for designing IT. *MISQ (Review) 25*(2), 251-312.

Vallacher, R.R., & Wegner D.M. (1987). What do people think they're doing? Action identification and human behavior. *Psychological Review*, (94)1, 3-15.

Weick, K.E. (1979). *The social psychology of organizing*. Reading, MA: Addison-Wesley.

Wenger, E. (1998). *Communities of practice*. Cambridge University Press.

Wellman, B. (2001). Computer networks as social networks. *Science*, *293*, 2031-2034.

Winograd, T., & Flores, F. (1986). *Understanding computers and cognition: A new foundation for design*. Reading, MA: Addison Wesley.

Chapter 7.8
Organizational Attention

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INTRODUCTION

Attention is a term commonly used in education, psychiatry, and psychology. Attention can be defined as an internal cognitive process by which one actively selects environmental information (i.e., sensation) or actively processes information from internal sources (i.e., stored memories and thoughts; Sternberg, 1996). In more general terms, attention can be defined as an ability to focus and maintain interest in a given task or idea, including managing distractions. Attention is selective by its nature. According to Pashler (1998, p. 37), "The process of selecting from among the many potentially available stimuli is the clearest manifestation of selective attention."

Why do firms respond to certain events or stimuli in their environment while neglecting others? It seems that organizations, just like individuals, have limited attention capacity. Hence, they must select from among the many potentially available stimuli and respond to these selected stimuli only. Organizational attention is defined as the socially structured pattern of attention by decision makers within the organization (Ocasio, 1997). Organizational attention, like human attention, is a limited resource: "Attentional limits filter or screen incoming information such that a great deal of data pertinent to strategic decision may never get processed" (Corner, Kinicki, & Keats, 1994, p. 296). Garg, Walters, and Priem (2003) show that the extent to which CEOs (chief executive officers) are selective in their attention to sectors of the environment is a significant predictor of performance.

Knowledge management (KM) models and process theories, almost without exception, incorporate a stage or phase in which a given knowledge item is brought to bear on a current decision or action. This stage, referred to alternatively as externalization (Nonaka, 1994) or awareness (Schwartz, Divitini, & Brasethvik, 2000), is of crucial importance in any knowledge-management cycle. The flow of knowledge in and out of an awareness stage is not merely a function of the universe of available organizational memory or the technological tools available to filter and identify such knowledge. It is influenced to a large degree by organizational attention. The second area in which organizational attention is key is knowledge acquisition and creation as discussed by Ocasio (1997), and Yaniv and Elizur (2003).

Successful knowledge management requires attention. Davenport and Volpel (2001) argues that attention is the currency of the information age. Knowledge consumers must pay attention to knowledge and become actively involved in the knowledge-transfer processes. This is particularly important when the knowledge to be received is tacit (Nonaka, 1994). Knowledge can be part of the organization's repository, however, if it does not get the attention of decision makers or other knowledge workers, it is not effective. This knowledge can be very important and relevant to the organization, but since it does not get attention, it does not become useful. Organizational attention is crucial in the context of knowledge management as it lays the infrastructure for knowledge acquisition and transfer.

Like human attention, organizational attention is limited in its capacity. Davenport and Volpel (2001) terms this as the attention-deficit principle: "Before you can manage attention, you need to understand just how depleted this resource is for organizations and individuals." Organizational attention limits the ability of organizations to process knowledge and thus it should be of major concern when knowledge management is discussed.

The limited organizational attention span reduces the number of sources that the organization can use as knowledge sources. The organization has to pay attention to some sources while ignoring or paying less attention to others. An increased likelihood of missing key information when making decisions is the direct result of this selective attention. In this article, organizational attention is discussed in the context of organizational knowledge flow and processing.

BACKGROUND: ORGANIZATIONAL ATTENTION AND KNOWLEDGE PROCESSING

The fact that a situation demands information to fill cognitive gaps, to support values and beliefs, or to influence affective states, and that sources of information are available and accessible to the decision maker is no guarantee that the information will be processed (that is, incorporated into the users' framework of knowledge, beliefs, or values) or used (that is, lead to changes in behavior, values, or beliefs).

Mintzberg's (1973) model of the managerial use of information includes information acquired from the external environment. In his conceptualization of top managers as information-processing systems, the managers' interpersonal roles provide access and exposure to information from a large number of external and internal information sources. The manager in the informational role of monitor "continually seeks and receives information from a variety of sources in order to develop a thorough understanding of the organization and its environment" (p. 97).

Ocasio (1997) developed a framework for an attention-based view of the firm. He defines corporate strategy as "a pattern of organizational attention, the distinct focus of time and efforts by the firm on a particular set of issues, problems, opportunities, and threats, and on a particular set of skills, routines, programs, projects and procedures" (p. 188). Simon (1947) describes organizational behavior as a complex network of attentional processes. Ocasio argues that since the environment of a firm's decision is of infinite complexity and firms are bounded in their capacity to attend to all environmental stimuli, decision makers are selective in those aspects of the environments of the decisions that they attend to. Different environmental stimuli are noticed, interpreted, and brought into conscious consideration. According to this view, attention is the noticing, encoding, interpreting, and focusing of time and effort by organizational decision makers on both issues and answers. Issues are problems, opportunities, and threats, and answers are action alternatives, such as proposals, routines, projects, programs, and procedures.

A basic example of organizational attention in action is as follows. Consider a cellular service provider in a very dynamic, competitive environment. Decision makers are faced with an overwhelming number of problems to deal with: competitive rivalry, customers' demands, technological innovation, and so forth. Their sources of information about these issues are diverse. Competitors' behavior and expected moves can be determined to a certain degree from public sources, such as newspapers and conferences, or by business intelligence activities. Different evaluations of the future behavior of competitors are available. Customers' demands are also based on different sources of information. Technological news come both from internal and external sources. Decision makers are bombarded with more information than they can effectively attend to and assimilate as their attention capacity is bounded. They have to select which problems, issues, and inputs they can deal with among the infinite available sources. Organizational attention is the pattern that is derived from decision makers' selections. The organization as a whole responds, according to this pattern, to certain issues while paying less attention to others. In our cellular example, the firm might ignore signals about the intention of a competitor to launch a new technology if the source that provides this information is not in the attention focus of the firm.

Durand (in press) investigates organizational attention in terms of the firms' investment in internal and external information, and finds that higher relative investments in market information appear to reduce errors and bias in forecasting.

Organizational attention affects both the forward and backward search for information in order to solve organizational problems and acquire new knowledge (Cyert & March, 1963), and to perceive opportunities or threats in the environment (Gavetti & Levinthal, 2000).

Decision makers differ in their knowledge of alternatives and consequences (March & Simon, 1958), their values, and their cognitive styles (Hambrick & Mason, 1984). These factors may contribute significantly to managers' focus of attention.

Ocasio (1997, p. 204) stresses that "the focusing of attention by organizational decision makers allows for enhanced accuracy, speed, and maintenance of information-processing activities, facilitating perception and action for those activities attended to." As stated by Cockburn, Henderson, and Stern (2000, p. 1142):

Ex post, it is clear that some firms actively identify, interpret, and act upon early signals from their external and internal environment, and so position themselves to effectively exploit these opportunities well in advance of others' demonstration of the pay-off from the strategies which emerge later on as best practices.

Two major aspects of human attention are capacity and selection. These aspects are adaptable and applicable to the discussion of organizational attention. Contemporary research discusses attention within the framework of the information-processing approach (Pashler, 1998). At the individual level, capacity is the amount of stimuli that can be noticed and processed in a given time. Kahneman (1973) suggests that the allocation of finite resources might account for a broad range of limitations people have in doing different activities at the same time. Due to these limitations, the individual has to select from the available stimuli those she or he will focus on and process. According to Kahneman focused attention facilitates perception and actions toward issues and activities being attended to, while inhibiting perception and action toward those that are not.

MAIN FOCUS: THE IMPORTANCE AND IMPACT OF ORGANIZATIONAL ATTENTION IN A KNOWLEDGE-MANAGEMENT SETTING

In the organizational context, capacity can be defined as the amount of issues that can be processed by decision makers, and selection refers to the specific issues that were selected and are being processed by the firm and its decision makers. These two dimensions complement each other. According to Ocasio (1997), "The environment of decisions is of infinite complexity and firms are bounded in their capacity to attend to all (or even most) environmental stimuli that impinge, directly or indirectly, upon any particular situation." Within the constraint of limited capacity, organizations have to select the issues that they can attend to while filtering the rest. Organizations differ in both factors. They differ in attention capacity and they select different issues or stimuli to deal with (Yaniv, 2004; Yaniv & Elizur, 2003). As organizational attention is the socially structured pattern of attention by decision makers, the attention capacity of the organization is a function of the decision makers' attention capacity and the organizational knowledge-flow structure.

The organizational knowledge-flow structure is an intangible resource that is part of the organizational tacit knowledge that embodies strategic advantage (Baumard, 1999; Eisenhardt & Santos, 2002). The knowledge-flow structure is a major factor in creating new knowledge (Corner et al., 1994). This structure creates differences between firms when they absorb and create new knowledge. Even more interesting is how this structure hinders the exploitation of available knowledge that might be very valuable.

In the context of knowledge processing, organizational attention is a filter mechanism that enables focusing on some of the available inputs while suppressing the rest. While organizational attention is rarely discussed in the literature, some related terms depict organizational limits. Absorptive capacity and bounded rationality can be mapped to the above attention-related constructs selection and attention capacity, respectively.

Absorptive Capacity

Cohen and Levinthal (1990) describe the ability of the firm to evaluate and utilize new knowledge to the evolving knowledge base already accumulated by the firm. They define absorptive capacity as the idea that prior related knowledge confers an ability to recognize the value of new information, assimilate it, and apply it to commercial ends. Cohen and Levinthal argue that when a firm wishes to acquire knowledge that is unrelated to its ongoing activity, the firm must dedicate efforts to creating or increasing absorptive capacity.

Since absorptive capacity affects the ability of the firm to recognize the value of new knowledge, it acts as a knowledge filter. The firm's existing knowledge influences the absorption of new knowledge and filters unrelated knowledge. In other words, the existing knowledge directs the firm's attention to new related knowledge. Absorptive capacity is an organizational situational feature that determines which knowledge sources the firm will choose to focus on. In terms of organizational attention, absorptive capacity is akin to selection. Absorptive capacity explains some aspects of accumulating new knowledge by the organization and considerably influences selection, yet it does not fully explain selection behavior. There are more factors to be considered.

Bounded Rationality

The limited attentional capability of humans results in their bounded capacity to be rational (Simon, 1947). The bounded-rationality problem (Simon, 1955) is the inability of firms to maximize over the set of all conceived alternatives when dealing with real-life decision problems. These problems are often too complex to comprehend. Based on the bounded-rationality problem, Nelson and Winter (1982) focus on the evolution of simple, stable routines that are used to guide action. Because of the bounded-rationality problem, these routines cannot be too complicated and cannot be characterized as optimal since they are taking into account only partial information. However, Nelson and Winter claim that “they may be quite satisfactory for the purposes of the firm given the problems the firm faces” (p. 35).

The bounded rationality of the individual is parallel in many ways to organizational attention. It is based on the limited ability of decision makers to pay attention to all aspects of the problems they deal with. Their attention capacity is limited, and they therefore make shortcuts. Bounded rationality is akin to attention capacity. What causes decision makers to choose certain knowledge to focus on and ignore other knowledge? They do have a limited capacity, but they still could choose to use this capacity in different ways and focus on different sets of knowledge.

The two filters discussed here—bounded rationality and absorptive capacity—are closely related to organizational attention. Bounded rationality is the result of attention’s limited capacity, while absorptive capacity is a major factor that affects attention selection. The following section discusses the affect of attention selection on the creation of new knowledge.

Organizational Attention and Knowledge Creation

Gavetti and Levinthal (2000) present an iterative process of knowledge creation, illustrated in Figure 1. The influence of the outcome on knowledge is mediated by the reinforcement of routinized patterns of action.

Building on this model, organizational attention can be incorporated into the process of new knowledge creation. The new knowledge is not

Figure 1. Knowledge creation (Gavetti & Levithal, 2000)

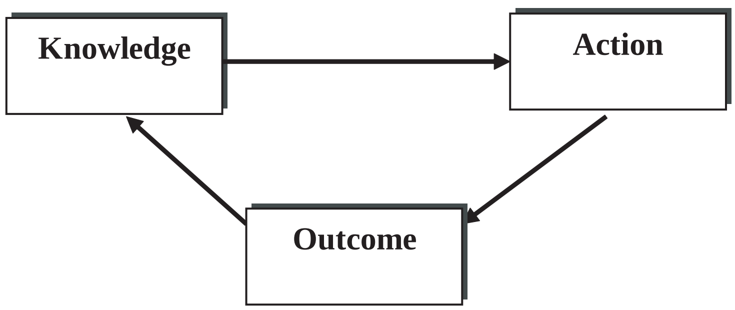
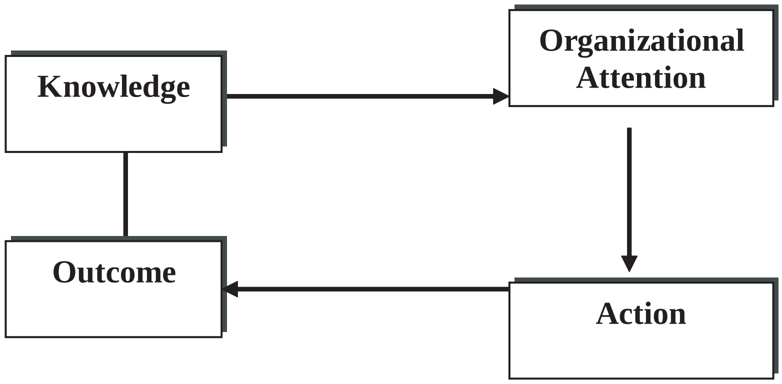


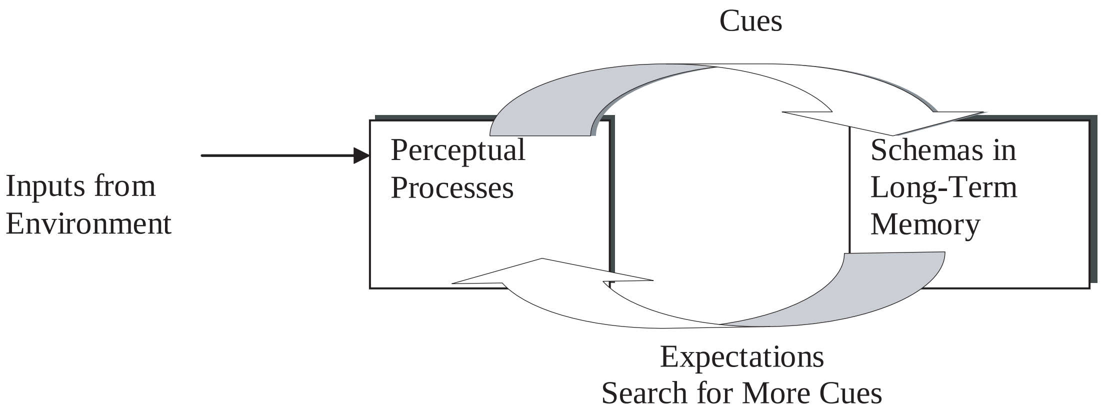
Figure 2. Knowledge creation mediated by organizational attention



derived automatically from the outcomes, but filtered and directed by organizational attention. The process is illustrated in Figure 2.

Organizational attention mediates knowledge and actions. Since not all the available knowledge can be noticed and used by the firm for its actions, organizational attention affects the creation of new knowledge. In other words, the creation of new knowledge depends on the knowledge that penetrates the organizational attention filter.

Figure 3. The perceptual cycle (Neisser, 1976)



Neisser (1976) describes the human perceptual cycle. He suggests that perceptual processes produce a preliminary and temporary representation of input features that act as cues to activate knowledge-schema representations, which in turn can direct attention to a more detailed analysis of cue features. The perceptual process is depicted in Figure 3.

The organizational processes of acquiring and accumulating knowledge can be characterized by a similar cycle. These knowledge-transfer processes are cyclic, thereby the existing knowledge directs the organizational attention to certain knowledge and ignores others. The organization receives inputs from its environment, both internal and external, and processes them according to its existing knowledge. The organizational existing knowledge is stored in organizational memory (Ackerman, 1996; Tuomi, 1999; Walsh & Ungson, 1991). Knowledge is stored in several physical locations (Simon, 1947), individuals (Argyris & Schon, 1978), procedures (Cyert & March, 1963), and culture (Ackerman; Barney, 1986). Walsh and Ungson posit the existence of five storage bins that compose the structure of organizational memory and one external source. The storage bins include individuals, culture, transformations (procedures), structures (roles), and the ecology (physical plant). By external source, they refer to external archives.

FUTURE DIRECTIONS

The knowledge-seeking behavior of an organization is not simply the sum of the parts of its individual members. In order to better understand how organizational attention influences the knowledge-management cycle, there are two main areas that require additional research and development.

First is the development of analysis techniques that can effectively identify and quantify organizational attention. By understanding the detailed elements within an organization that impact and influence attention, we can begin to harness it.

Second is the use of models of organizational attention as an intervention tool to help modify and steer the direction of KM in an organization. Viewing organizational attention as a systemic part of a firm's KM processes opens the door to focusing that attention in more effective ways.

SUMMARY

Organizational attention is an important concept that can explain organizations' knowledge-seeking and -awareness behavior. Organizational attention affects a firm's behavior by controlling organizational knowledge flow and knowledge processing. Explaining firms' behavior is a basic issue of strategic management (Rumelt, Schendel, & Teece, 1994), and strategy formulation is a process of guided evolution (Lovas & Ghoshal, 2000). The firm can be viewed as a collection of discrete organizational activities (Porter, 1985; Sigglekow, 2002), and the mechanism that guides the evolution of the strategy within the firm is organizational attention. Organizational attention is guided by the selective attention to organizational issues and initiatives (March & Olsen, 1976; Ocasio, 1997).

Like individual attention, the capacity of organizational attention is bounded. Nevertheless, organizational attention capacity is varied as a function of the organizational decision structure. Efficiency of decision processes and knowledge flow in the organization can result in the extended attention capacity of the organization. This limited capacity determines the amount of information inputs that can be effectively handled by the firm's decision makers.

The selection of inputs to be considered in knowledge-intensive tasks depends, of course, on the available attention capacity. Since the capacity is limited, this process must be economical, and being economical in the context of knowledge processing means optimizing the use of processing resources. One way of doing so is to select inputs that are easier to deal with: often inputs that are related to existing knowledge as they are easier to perceive and process. This notion is compatible with Cohen and Levinthal's (1990) definition of absorptive capacity, where existing knowledge plays a critical role in the ability of the organization to absorb new knowledge. Both attention capacity and existing knowledge predispose the organization's selection of knowledge inputs from available sources, and an improved understanding of the factors that affect organizational attention will lead to better use of these scarce resources.

REFERENCES

Ackerman, M. S. (1996). Definitional and contextual issues in organizational and group memories. *Information Technology and People, 9,* 10-24.

Argyris, C., & Schon, D. A. (1978). *Organizational learning: A theory of action perspective*. Reading, MA: Addison-Wesley.

Barney, J. B. (1986). Organizational culture: Can it be a source of sustained competitive advantage? *Academy of Management Review, 11,* 656-665.

Baumard, P. (1999). *Tacit knowledge in organizations.* London: SAGE.

Bettis, R. A., & Prahalad, C. K. (1995). The dominant logic: Retrospective and extension. *Strategic Management Journal, 16,* 5-14.

Cockburn, I. M., Henderson, R. M., & Stern, S. (2000). Untangling the origins of competitive advantage. *Strategic Management Journal, 21,* 1123-1145.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35,* 128-152.

Conner, K. R., & Prahalad, C. K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science, 7,* 477-501.

Corner, P. D., Kinicki, A. J., & Keats, B. W. (1994). Integrating organizational and individual information perspectives on choice. *Organization Science, 5*, 294-308.

Cyert, R. M., & March, J. G. (1963). *A behavioral theory of the firm.* Englewood Cliffs, NJ: Prentice-Hall.

Davenport, T. H., & Volpel, S. C. (2001). The rise of knowledge towards attention management. *Journal of Knowledge Management, 5,* 212-221.

Durand, R. (2003). Predicting a firm's forecasting ability: The roles of organizational illusion of control and organizational attention. *Strategic Management Journal*, *24*(9), 821-838.

Eisenhardt, K. M., & Santos, F. M. (2002). Knowledge-based view: A new theory of strategy? In A. Pettigrew, H. Thomas, & R. Whittington (Eds.), *Handbook of strategy and management* (pp. 139-164). London: Sage Publications.

Garg, V. K., Walters, B. A., & Priem, R. L. (2003). Chief executive scanning emphases, environmental dynamism, and manufacturing firm performance. *Strategic Management Journal, 24,* 725-744.

Gavetti, G., & Levinthal, D. (2000). Looking forward looking backward: Cognitive and experimental search. *Administrative Science Quarterly, 45*, 113-137.

Hambrick, D. C., & Mason, P. A. (1984). Upper echelons: The organization as a reflection of its top management. *Academy of Management Review, 9,* 193-206.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs, NJ: Prentice Hall.

Lovas, B., & Ghoshal, S. (2000). Strategy as guided evolution. *Strategic Management Journal, 21*, 875-896.

March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*, 71-78.

March, J. G., & Olsen, J. P. (1976). *Ambiguity and choice in organizations*. Bergen: Universitetsforlaget.

March, J. G., & Simon, H. A. (1958). *Organization*. New York: Wiley.

Mintzberg, H. (1973). *The nature of managerial work*. New York: Harper and Row.

Neisser, U. (1976). *Cognition and reality.* San Francisco: Freeman.

Nelson, R. R., & Winter, S. G. (1982). *An evolutionary theory of economic change*. Cambridge, MA: Harvard University Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*, 14-37.

Ocasio, W. (1997). Towards an attention-based theory of the firm. *Strategic Management Journal, 18,* 187-206.

Pashler, H. E. (1998). *The psychology of attention*. Cambridge, MA: The MIT Press.

Porter, M. E. (1985). *Competitive advantage*. New York: Free Press.

Rumelt, R. P., Schendel, D., & Teece, D. (1994). *Fundamental issues in strategy.* Cambridge, MA: Harvard Business School Press.

Schwartz, D. G., Divitini, M., & Brasethvik, T. (2000). On knowledge management in the Internet age. In D. G. Schwartz, M. Divitini, & T. Brasethvik (Eds.), *Internet-based organizational memory and knowledge management* (pp. 1-23). Hershey, PA: Idea Group Publishing.

Sigglekow, N. (2002). Evolution toward fit. *Administrative Science Quarterly, 47,* 125-159.

Simon, H. A. (1947). *Administrative behavior: A study of decision-making processes in administrative organizations.* Chicago: Macmillan.

Simon, H. A. (1955). A behavioral model of rational choice. *Quarterly Journal of Economics, 69*, 99-118.

Stehr, N. (1992). *Practical knowledge*. London: Sage Publications, Inc.

Sternberg, R. J. (1996). *Cognitive Psychology.* Harcourt Brace College Publishers.

Tuomi, I. (1999). Data is more than knowledge: Implication of the reversed knowledge hierarchy for knowledge management and organizational memory. *Journal of Management Information Systems, 16,* 103-117.

Walsh, J. P., & Ungson, G. R. (1991). Organizational memory. *Academy of Management Review, 16*, 57-91.

Yaniv, E. (2004). *Organizational attention as a knowledge filter: The influence of organizational attention on exploiting knowledge as a strategic resource*. Unpublished PhD dissertation, Bar Ilan University, Israel.

Yaniv, E., & Elizur, D. (2003). The structure of organizational attention: A Radex representation of multiple knowledge sources. In S. Levi & D. Elizur (Eds.), *Facet theory: Towards cumulative social science.* Ljubljana: University of Ljubljana.

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Chapter 7.9
Tacit Knowledge Sharing

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INTRODUCTION

When people solve complex problems, they bring knowledge and experience to the situation, and as they engage in problem solving they create, use, and share tacit knowledge. Knowing how context emerges and transforms is central if we want to understand how people create, use, and share tacit knowledge. Consequently, this article focuses on the three questions: What is context? How does context emerge and transform? What is the relationship between context and tacit knowledge sharing?

Initially the article describes how context is conceptualized in the theory of the firm as a knowledge-creating entity, and it argues that this theory lacks a detailed account for how context emerges and transforms. Thereafter, we define context, and based on the writings by the Austrian sociologist Alfred Schütz, a theory of how context emerges and transforms is put forward. This theory is illustrated with an empirical case describing the Carbon Dioxide filtering problem, which occurred during the ill-fated Apollo 13 mission. The article concludes by explaining how a theory of context helps us to understand the role of context in tacit knowledge sharing.

BACKGROUND: CONTEXT IN THE THEORY OF THE FIRM AS A KNOWLEDGE-CREATING ENTITY

Knowledge management scholars have put forward ideas for a theory of the firm as a knowledge-creating entity, and suggest that the firm can be conceptualized as a dynamic configuration of 'ba' (roughly means place) (Nonaka, Toyama, & Nagata, 2000a). More precisely, 'ba' is defined as the context shared by those who interact with each other, and 'ba' is the place where they create, share, and use knowledge.

Putting knowledge in context is important as "knowledge creating processes are necessarily context-specific, in terms of who participates and how they participate in the process. The context here does not mean "a fixed set of surrounding conditions but a wider dynamical process of which the cognition of an individual is only a part" (Hutchins, 1995, p. xiii). Hence, knowledge needs a physical context to be created, as "there is no creation without place" (Casey, 1997, p. 160; Nonaka et al., 2000a, p. 8).

The initial step towards a theory of the firm as a knowledge-creating entity (Nonaka et al., 2000a) has given many insights to knowledge creation in organizations, and with the introduction of the 'ba'-concept, a step towards a conception of context has been taken. However, it remains unclear what exactly 'ba' is, how 'ba' emerges, and what exactly happens inside 'ba'. The definition of 'ba' offered by Nonaka et al. (2000a) is unclear or ambiguous at best. On the one hand they note: "Knowledge needs a physical context to be created, as 'there is no creation without place'" (p. 8). On the other hand they note that "'Ba' does not necessarily mean a physical space. Rather, it is a specific time and space" (p. 9). Furthermore, 'ba' seems to be a very inclusive concept. According to Nonaka and Konno (1998, p. 40), "'Ba' can be thought of as a shared space for emerging relationships. This space can be physical, virtual, mental, or a combination of them." We therefore think it is fair to ask: What is not included in 'ba'?

Concerning the emergence of 'ba' then it seems that on the one hand 'ba' is created spontaneously. "'Ba' is constantly in motion. 'Ba' is fluid, and can be born and disappear quickly" (p. 9). On the other hand 'ba' can be built intentionally (Nonaka, Toyama, & Konno, 2000b). According to Nonaka et al. (2000a, p. 12): "…building 'ba' such as project teams or functional departments, and determining how such 'ba' should be connected to each other, is an important factor in determining the firm's knowledge creation rate." In addition, it is worth noting that "the boundary for 'ba' is fluid and can be changed quickly as it is set by the participants. Instead of being constrained by history, 'ba' has a 'here and now' quality. It is constantly moving; it is created, functions and disappears according to need" (Nonaka et al., 2000b, pp. 15-16).

Finally, regarding the question: What exactly happens inside 'ba'? The closest we get to an answer to this question is provided by Nonaka and Toyama (2000, p. 3) who write "…'ba' is…an open space where participants with their own contexts can come and go and the shared context (that is, 'ba') can continuously develop." Therefore, although the concept of 'ba' (Nonaka & Konno, 1998; Nonaka et al., 2000a) represents an attempt to define context, we are still far from an explanation of how context emerges and transforms, and thus, we have yet to understand what happens inside 'ba'.

MAJOR FOCUS I: DEFINING CONTEXT

We maintain that contexts are not 'just there' as static entities, but that they are emerging phenomena. A similar perception is put forward by Erickson and Schultz (1997), who describe context as a mutually constituted, constantly shifting, situation definition emerging through the interaction of the involved individuals. "Contexts are not simply given in the physical setting…nor in combinations of personnel…Rather, contexts are constituted by what people [do and where and when they do it]. As McDermott puts it succinctly (1976), "People in interaction become environments for each other" (p. 22), and Dilley agrees (1999): "Context is both constitutive of social action and itself the outcome of social action, it is both a generative principle and a resulting outcome" (p. 19). Yet, neither of these authors make clear if they perceive context as an collective or individual construct. Based on Polanyi's (1962) statement that all knowledge is personal knowledge, we suggest that context is an individual construct. Furthermore, we propose that context emerges as an individual encounters a situation, including others and artifacts, as it is the individual's interpretation of a situation that results in a context. After its emergence the context transforms as the situation evolves, for example, as a result of the acting of the individual and the others involved.

By claiming that the individual interpretation of a situation results in a context, we imply that the context emerging for an individual in a specific situation is based on that individual's previous experiences. As two individuals never have fully similar experiences, the contexts emerging for two individuals can never be similar, yet similarities among individual experiences might result in contexts with many similarities. Another important implication of our context definition is that if individual X encounters situation Y in both t=1 and t=2, then the contexts emerging for individual X at these two points in time will differ as individual X brings a different set of experiences to the two instances of the situation Y.

By defining context as an emergent and individualistic construct, we are in agreement with Rapport (1999, p. 190) who writes:

Context is determined by the questions which people ask of events…Just as many questions can be asked of events, so there will be many contexts; just as different people can ask different questions of events, so different people will determine different contexts; just as people can ask a number of different questions of events at the same time, questions of which other people may or may not be aware, so different people can simultaneously create and inhabit multiple contexts, contexts whose commonality is questionable.

Further, Ackerman and Halverson (1998) emphasize that "To reuse a memory, the user must then recontextualize that information. The information, if not supplied by the same individual, must be reunderstood for the user's current purpose" (p. 47). Hence, assuming that the questions individuals ask of events are determined by their experience, then there can be little doubt that contexts emerge and transform during acts of interpretations. In the following section we therefore take a closer look at acts of interpretations.

MAJOR FOCUS II: INTER-SUBJECTIVITY, TYPICALITY, IDEAL TYPES, AND CONTEXT

We recognize Schütz (1962, 1964, 1967), as a major focus in his research was on how cooperation evolves among actors who are more or less anonymous to each other (Ebeling, 1987). Thereby, his research can be used to provide insight into the emergence of contexts for sets of individuals with different degrees of similarities among their experiences. Schütz explains (Augier, 1999, pp. 158-159):

…that our 'life world' consists of a multitude of others, with whom we live and interact, although our knowledge about them is scarce. That is, we are more or less 'anonyme' to each other, despite the fact that the life world in which we are both is full of structures containing inter-subjective knowledge (see Schütz & Luckmann, 1973, 1989). This knowledge is used by imputing 'typical' 'course of action-types' and 'personal ideal types' to the individuals to analyze what happen if he/she follow[s] particular 'roles' (personal ideal types) or pursue[s] certain ends ('course of action-type').

Ideal types are used when we act and interpret events in the social world, and ideal types are abstractions from the particulars and the idiosyncrasies of the world; thus, they produce statements of general validity. Ideal types can be:

…arranged according to the degree of increasing anonymity of the relationship among contemporaries involved and therewith of the context needed to grasp the other and his behavior. It becomes apparent that an increase in anonymity involves a decrease in fullness of content. The more anonymous the [ideal type] is the more detached is it from the uniqueness of [other individuals involved] ... If we distinguish between (subjective) personal ideal types and (objective) course-of-action types we may say that increasing [anonymity] of the construct leads to the superseding of the former by the latter. (Schütz, 1962, pp. 17-18)

In addition to our ideal typical knowledge, we possess more specialized information about particular kinds and groups of others. If we formerly had direct experience of the particular other facing us now, we can use the specialized information extracted in these experiences (Schütz, 1964, p. 30).

The individual brings ideal typical knowledge and more specialized information about others, artifacts, and situations, to a situation. Here they constitute the basis for the individual's interpretation of the situation, including others and artifacts, and thereby for the individual's conception of context. Consequently, specialized information and ideal types are the basic elements from which context emerges.

We, Thou, and They Relations

When we encounter others in the social world, they do not appear to us in identical perspectives, and our relations with them have different degrees of intimacy and anonymity (Schütz, 1964, p. 22). It is possible to distinguish among three types of relations: they, thou, and we relations (Schütz, 1967). In we relations individuals are aware of each other and of the awareness, and they are able to obtain understanding of each other's motives. In thou relations no such reciprocal awareness exists, and understanding involves more anonymous types of meaning. Finally, in they relations individuals use ideal types in order to impute 'typical' motives into each other and thereby understand each other's actions.

In we relations we experience others directly, we and they share a common sector of time and space, and thus we and they age together. The sharing of a common sector of space implies that we and others appear to one another in person as ourselves and nobody else (Schütz, 1964). "In the ongoing experiences of the we relation I check and revise my previous knowledge about my partner and accumulate new [specialized] knowledge about him. Thereby my general stock of knowledge also undergoes a continuous modification" (p. 30).

In they relations our partners are not concrete and unique individuals, but types, and "the experiences of contemporaries appear to [us] more or less anonymous processes" (p. 43). As a result we obtain relatively little specialized information about their motives and actions. Also, in they relations my experience of my contemporaries is not continuously modified and enriched. "Each new experience of contemporaries adds, of course, to my stock of knowledge; and the ideal types by which I am oriented to others in a they relation do, indeed, undergo modifications…But these modifications remain minimal as long as a given situation and my interests in it—which have determined the original application of a given typifying scheme—remain constant" (p. 55).

Even if the ideal typical knowledge and the more specialized information that we obtain in our relations with others enable us to interpret and give meaning to the behavior by others, then these meanings may not correspond to the meanings of the others, as "…the subjective meaning of another person's behavior need not to be identical with the meaning which his perceived external behavior has for…an observer" (Schütz, 1967, p. 20).

In we relations we can assign our meaning to others with greater confidence, as the world within their reach coincides with ours. In they relations this reciprocity of experiences is replaced by acts of reflection on the typifying scheme which presumably orients the conduct of both they and us. The validity of our assumption that they share a given typifying scheme with us cannot be verified, since they are not present (Schütz, 1964, p. 54). "I cannot presuppose, for example, that my partner in a they relation will grasp a nuance of a word or that he will place a statement of mine in the proper context unless I explicitly and 'objectively' refer to that context. The direct evidence that I have been understood, which I have if my partner is present in the community of space and time, is lacking in a they relation" (Schütz, 1964, pp. 55-56).

From above it follows that individuals who have prior experience from a range of we relations with each other are likely to establish contexts with many similarities. In contrast, individuals who have little prior experience from we relations with each other are likely to establish contexts with few similarities. Therefore, as a group begins problem solving, the members of the group are not necessarily in the position to understand one another. Yet, as individuals we assume that everybody takes the world around us for granted in essentially the same way as we do ourselves, and thus we orient our actions towards other people, assuming that they will behave in a 'typical' manner. Consequently, it might take time before we register that this is not the case, and thereby register that little common understanding has emerged.

MAJOR FOCUS II: PEOPLE SOLVING COMPLEX PROBLEMS

We illustrate the emergence and transformation of context with a case where a complex problem is solved within a constrained timeframe, as we believe it is in such problem-solving processes that emergence and transformation of context are most visible. We build this belief on Ciborra, who some years ago suggested that "people improvise when they are overwhelmed by the world, and thus, is forced to read the world in a different way."1 Improvisation "is purposeful human behavior which seems to be ruled at the same time by intuition, competence, design, and chance" (Ciborra, 1999, p. 78). Thus, it is the lack of time to solve complex problems that leads people to improvise. Furthermore, improvisation is grounded in memory of the past (Weick, 1998, p. 547), and thereby, in the ideal typical knowledge and more specialized information that individuals bring to the process.

Complex Problem Solving During the Ill-Fated Apollo 13 Mission

The Apollo 13 mission was on schedule when the message "Okay, Houston, we've got a problem here..." came from the Apollo 13 Command Module. An oxygen tank had exploded, damaged the Service Module, and left the Command Module without power and air. After a health assessment of the spacecraft, it was decided to abandon the mission, move the three astronauts to the Lunar Module, and attempt a loop around the moon in order to get the spacecraft back to the planet earth.

Soon after the explosion, the assessment of life-support systems determined that although oxygen supplies were adequate, the system for removing Carbon Dioxide in the Lunar Module was not. The Lunar Module was designed to support two men for two days and was being asked to care for three men nearly four days. Thus, removal of Carbon Dioxide in the Lunar Module became a concern. The system in the Lunar Module used canisters filled with Lithium Hydroxide to absorb Carbon Dioxide as did the system in the Command Module. Unfortunately the canisters were not interchangeable between the two systems, so the astronauts were faced with plenty of capacity for removing Carbon Dioxide but no way of using it.

Facing this potentially fatal problem, a ground crew team at NASA Mission Control in Houston brought into a room all the items available on board the spacecraft, including the space suits originally planned for use during the visit to the moon. Using these items the team worked on a solution and constructed a device it believed could be implemented by the astronauts. After a test in the spacecraft simulator, the solution was verified and the instructions were transmitted to the astronauts on board the spacecraft. The astronauts succeeded in assembling the two carbon dioxide removal devices:

There was, of course, a fix; and it came in the form of an ingenious combination of suit hoses, cardboard, plastic stowage bags, and Command Module canisters—all held together with a liberal application of gray duct tape. As was usual whenever the Apollo team had to improvise, engineers and astronauts on the ground got busy devising ways around the problem and then checked out the new procedures. A day and a half after the Apollo 13 accident, the ground team had designed and built a filtering device that worked to their satisfaction. They promptly radioed instructions to the crew, carefully leading them through about an hour's worth of steps. As Lovell wrote later: 'the contraption wasn't very handsome, but it worked.'

Emergence and Transformation of Context in the Apollo 13 Case

We draw three inferences about the emergence and transformation of context in the Apollo 13 case. We show how the need for problem solving by improvisation emerged, we interpret how the ground crew responded to the problem, and finally, we discuss the conditions for their success with problem solving.

The explosion on board the spacecraft created a novel problem and forced the NASA Mission Control Team into action. The team was overwhelmed by the urgency of the crisis, as the challenge was to create a solution that could be implemented by using the items available on board the spacecraft. Hence, the ground crew had to move beyond their ex ante knowledge, and include and create knowledge useful in the present situation.

In our interpretation of the ground crews' response, we claim that as soon as the Carbon Dioxide filtering problem was known, each of them produced a personal interpretation of what it meant and how it could be solved. As a result a context emerged for each of them, with their individual contexts including their knowledge about how each of the other ground crews could contribute. This knowledge was based both on ideal types of these others and on more intimate experiences from past we relations with them.

Realizing that the solution could not be found within the potential solutions available on ground, but should be created from the items available on board the spacecraft, the ground crew experienced a transformation of their contexts, as now they had to perceive their knowledge about Carbon Dioxide filtering within the permutations of possibilities that existed within the scope of items available on board the spacecraft. By acknowledging this as a constraint, they adapted their contexts to the complexity of the problem situation. We assert that when adapting their contexts, they took into account what they knew about the fellow team members' knowledge about Carbon Dioxide filtering and the possibility of applying it within the constraints imposed by the situation. Consequently, they experienced that knowledge previously irrelevant to the Carbon Dioxide filtering problem might be relevant in this particular situation.

Reviewing the Carbon Dioxide filtering problem-solving process, we suggest that the ground crew experienced that none of them held sufficient knowledge to solve the problem on their own. Hence, they realized that knowledge sharing was necessary for creating a solution. It is our assertion that knowledge sharing required that the problem solvers took on we orientations towards each other, and thereby established we relations in the problem-solving process, as otherwise they could not obtain verifications of similarities in typifying schemes among themselves and their partners, and had not been able to solve the problem.

Establishment of we relations in problem solving is however not sufficient to give way for effective knowledge sharing. Also, the intimacy of we relations is important—that is, how easy problem solvers experience it to follow each other's lines of thoughts. We suggest that the intimacy of we relations is a result of the extent to which the context emerging and transforming for each of the problem solvers exhibits similarities with the contexts emerging and transforming for the other problem solvers. In turn the emergence of contexts with many similarities requires that problem solvers have shared many common sectors of time and space prior to the problem solving in situ. Consequently, the less anonymous problem solvers are to each other, the fewer obstacles to tacit knowledge sharing they will experience. These preconditions existed in the Apollo 13 case where the ground crew and the astronauts held similar experiences from prior training and collaboration. Had this not been the case, then we assert that the ground crew had experienced difficulties in following each other's line of thought and in gaining a common ground for problem solving.

In sum, we find that problem solving in the Apollo 13 case was conditioned on: (a) the ability of the ground crew to register the world and form novel views of the available resources (the suit hoses, cardboard, plastic bags, tape, etc.) as possible components of a new Carbon Dioxide filtering devices; and (b) the establishment of we relations, which allowed for the emergence of contexts with many similarities and thereby for tacit knowledge sharing. Accordingly, it is the ability to create contexts with many similarities as well as the possession of in-depth knowledge about the items available for the creation of a solution that enables people to solve complex problems.

CONCLUSION AND FUTURE TRENDS

In the introduction we asked: What is context? How does context emerge and transform? What is the relationship between context and tacit knowledge sharing?

First, using Polanyi (1962) as our point of departure, we defined context as an individual construct, which emerges as an individual encounters and interprets a situation, and therefore contexts are not "just there" as static entities.

Second, building on the theories of Schütz (1962, 1964, 1967), we argued that an individual's interpretation of a situation happens as that individual brings his experience in the form of ideal typical knowledge and more specialized information to the situation. Subsequently, his context transforms over time, as he is confronted with other problem solvers and constraints imposed on the problem-solving process.

Third, we argued that sharing of tacit knowledge in complex problem solving requires the emergence of contexts with many similarities, as otherwise the problem solvers cannot obtain verifications of similarities in understandings. We also argued that contexts with many similarities solely emerge if problem solvers have shared many common sectors of time and space prior to the problem solving in situ.

Having established the relationship between context and tacit knowledge sharing, we argue that the salience of context will become increasingly important to problem solvers as they face compressed timeframes for problem solving, while at the same time the complexity of problems to be solved requires bringing together knowledge from experts in several specialized domains. For success with such problem solving, the possibility of establishing intimate we relations is of paramount significance, and therefore, organizations must consider if there are areas for which it makes sense for them to invest in preparation for emergence of contexts with many similarities, as only such contexts allow for tacit knowledge sharing. For these areas, we relations among experts should be fertilized as only these, and for example not they relations, will breed the ground tacit knowledge sharing.

In this article we have showed that contexts are not just there, and even more important we have moved beyond the highly general conceptions of context and provided insight into the processes that result in the emergence of contexts, which allow for tacit knowledge sharing. Now returning to the initial discussion of the context concept 'ba' provided by Nonaka and peers, we remember that they acknowledged the importance of context, because knowledge-creating processes are necessarily context specific. Yet, from their writings, for example Nonaka and Konno (1998) and Nonaka and Toyama (2000), it was unclear what context is and how it emerges. In this article these two questions were addressed and answered, and thus the article provided new insights of significance to future knowledge management research. Our definition of context, its emergence and transformation do not go against Nonaka et al. (2000b), as for example they note that "…'ba' has a here and now quality, and that it is constantly moving, it is created, functions and disappear according to need" (pp. 15-16). However, a verification of our theory of context calls for more empirical studies of complex problem solving, and thus, such studies must be the next step in the research focusing on context and its implication for tacit knowledge sharing.

REFERENCES

Ackerman, M.S., & Halverson, C. (1998, November). Considering an organization's memory. *Proceedings of the ACM Conference on Computer Supported Cooperative Work (CSCW '98)* (pp. 39-48).

Augier, M. (1999). Some notes on Alfred Schütz and the Austrian School of Economics: Review of Alfred Schütz's collected papers (vol. IV). In H. Wagner, G. Psathas, & F. Kersten (Eds.). (1996), *Review of Austrian Economics*, *11*, 145-162.

Casey, E.S. (1997). *The fate of place: A philosophical history*. Berkeley, CA: University of California Press.

Ciborra, C.U. (1999). Notes on improvisation and time in organizations. *Accounting, Management and Information Technology, 9*(1), 77-94.

Dilley, R. (Ed.). (1999). *The problem of context*. New York: Berghahn Books.

Ebeling, R. (1987). Cooperation in anonymity. *Critical Review, 1*, 50-59.

Erickson, F., & Schultz, J. (1997). When is a context? Some issues and methods in the analysis of social competence. In M. Cole, Y. Engeström, & O. Vasquez (Eds.), *Mind, culture and activity—seminal papers from the Laboratory of Comparative Human Cognition* (pp. 22-31). Cambridge, UK. Cambridge University Press.

Hutchins, E. (1995). *Cognition in the wild*. Cambridge, MA: MIT Press.

McDermott, R.P. (1976). *Kids make sense: An ethnographic account of the interactional management of success and failure in one first-grade classroom*. Unpublished dissertation, Stanford University, USA.

Nonala, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Nonaka, I., & Konno, N. (1998). The concept of "ba": Building foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

Nonaka, I., & Toyama, R. (2000, May 25-26). What is a good ba? Providing shared context-in-motion for organizational knowledge creation.

Proceedings of the Conference on Knowledge and Innovation (pp. 1-20), Helsinki, Finland.

Nonaka, I., Toyama, R., & Nagata, A. (2000a). A firm as a knowledge creating entity: A new perspective on the theory of the firm. *Industrial and Corporate Change, 9*(1), 1-20.

Nonaka, I., Toyama, R., & Konno, N. (2000b). SECI, ba, and leadership: A unified model of dynamic knowledge creation. *Long Range Planning, 33*(1), 5-34.

Polanyi, M. (1962). *Personal knowledge: Towards a post-critical philosophy*. Chicago: Chicago University Press.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Rapport, N. (1999). Context as an act of personal externalization. In R. Dilley (Ed.), *The problem of context* (pp. 187-211). New York: Berghahn Books.

Schütz, A. (1962). Common sense and scientific interpretation of human action. In M. Natanson (Ed.), *Collected papers I—the problem of social reality* (pp. 3-47). Dordrect, The Netherlands: Kluwer Academic Publishers.

Schütz, A. (1964). The dimensions of the social world. In A. Brodersen (Ed.), *Collected papers II—studies in social theory* (pp. 20-63). The Hague, The Netherlands: Martinus Nijhoff.

Schütz, A. (1967). *The phenomenology of the social world*. Evanston, IL: Northwestern University Press.

Schütz, A., & Luckmann, T. (1973). *The structures of the life-world* (vol. 1). London, UK: Heinemann.

Schütz, A., & Luckmann, T. (1989). *The structures of the life-world* (vol. 2). Evanstone, IL: Northwestern University Press.

Weick, K.E. (1998). Improvisation as a mindset for organizational analysis. *Organization Science, 9*(5), 543-555.

ENDNOTE

[1] From a talk given by Claudio Ciborra at the Academy of Management Meetings in Toronto, 2000.

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Chapter 7.10
Epistemology and Knowledge Management

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INTRODUCTION

This article surveys and explores the relationship between epistemology and knowledge management (KM). Epistemology is the branch of philosophy concerned with the nature and extent of human knowledge (Klein, 1998b). Knowledge management is clearly deeply indebted to many ideas derived from epistemology. Much of the seminal work in KM discusses epistemology in a fair amount of detail, and explicitly appeals to insights from epistemology in developing a theoretical account of KM. In particular, the groundbreaking works by Sveiby (1994, 1997, 2001), Nonaka (1994), and Nonaka and Takeuchi (1995) make explicit appeal to the philosophical insights in epistemology, which has provided the groundwork for much of their pioneering work in knowledge management. One would thus expect there to be a fairly intimate connection between epistemology and knowledge management. The relationship between these two fields, however, is far from straightforward.

This article argues that traditional philosophical discussions about epistemology are generally quite limited in their application to KM. This is because they focus mainly on the production of individual or personal knowledge, rather than sharing and use of knowledge in a collaborative context. Thus many of the insights from traditional epistemology are largely irrelevant for the enterprise of KM.

There are, however, recent developments in epistemology which seem more promising for KM. This article ends with a brief overview of some of these developments, looking at recent work in both the philosophy of science and social epistemology. These approaches seem extremely promising for developing a sounder philosophical and methodological basis for KM.

BACKGROUND: KNOWLEDGE IN EPISTEMOLOGY

Epistemology—the theory of knowledge—is one of the core branches of philosophy. It is concerned with exploring the nature, sources, and limits of human knowledge (Klein, 1998a). With a history tracing back to Plato and Aristotle, the field of epistemology has attempted to provide an analysis of what the concept of knowledge is—a definition of knowledge. Epistemology also attempts to specify what legitimates knowledge, so that we can distinguish genuine knowledge from false or spurious knowledge. To a lesser degree epistemologists have also inquired into how we acquire knowledge, and whether there are limitations on the scope of our knowledge (Pappas, 1998). Some have even adopted a position of extreme scepticism, claiming that genuine human knowledge is impossible (Cohen, 1998).

The focus of contemporary debates in epistemology essentially traces back to the work of Descartes and his method of doubt. In his Meditations on First Philosophy, Descartes (1640) undertakes an inquiry into the nature of knowledge. Here Descartes attempts to find the foundational principles upon which our knowledge rests, by trying to identify some sort of fact that we can be entirely certain of. Thus he advocates that we need "to demolish everything completely and start again right from the foundations" (Descartes, 1996, p. 12). For Descartes the real challenge here is scepticism—if there is any possibility of doubt about so-called knowledge being true, then it cannot be genuine knowledge. Descartes' inquiry tries to ascertain just what facts about the external world are beyond scepticism, in order to discover the basis of all our knowledge. Following this methodology Descartes famously arrives at the proposition "cogito ergo sum"—I think, therefore I exist—which he claims puts the proposition "I exist" beyond doubt. Contemporary epistemology has followed strongly in this Cartesian tradition, focusing of the question of the justification of knowledge in the face of scepticism. Because of this, questions about the actual generation of knowledge, and of the uses and contexts of knowledge, have been of peripheral concern for the majority of theorists in epistemology.

In this respect, epistemology has typically defined knowledge as an essentially personal item that concerns true facts about the world: knowledge is an individual's true, justified belief.1 Additionally, the majority of research in epistemology has generally been concerned solely with propositional knowledge: factual knowledge that can be expressed in a sentence, and can be evaluated for truth or falsehood. Thus traditional approaches to epistemology are concerned primarily with what knowledge is and how it can be identified, rather than how knowledge is created or used.

KM AND EPISTEMOLOGY

The traditional approach to defining knowledge in epistemology contrasts markedly with the definitions typically proposed in the KM literature. For example, Rumizen defines knowledge as "Information in context to produce actionable understanding" (Rumizen, 2002, pp. 6, 288). Similarly, Davenport and Prusak define knowledge thus:

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in the documents or repositories but also in organisational routines, processes, practices, and norms. (1998, p. 5)

These definitions do not view knowledge as essentially personal, true, justified belief, but instead have a notion of knowledge as a practical tool for framing experiences, sharing insights, and assisting with practical tasks. For KM, knowledge is something other than just an individual's understanding of the true facts of the world—it is a pragmatic tool for manipulating and controlling the world. It is in this sense that Iivari proposes that knowledge is communal, activity-specific, distributed, and cultural-historical (Iivari, 2000).

Compared to traditional epistemology, KM focuses not so much on the justification knowledge, but instead on understanding the uses of knowledge in order to effectively deal with the practical tasks that involve knowledge-based activity. Thus KM is primarily concerned with knowledge as it is generated, shared, stored, and used within a collaborative environment. KM is also concerned with all aspects of knowledge within an organisational framework: the factual knowledge of the individuals within the organisation, as well as their practical knowledge, tacit knowledge, and technological knowledge. Thus for KM, knowledge must be far more than just personal certainty about the world—it must involve practical ability as well as conceptual understanding. More importantly, KM is concerned with far more than just the justification of knowledge—it is concerned with the production, storage, and processing of knowledge in a group or shared sense. Thus the relevance of the concept of knowledge for KM is quite different to its relevance for philosophers.

The important point here is that, as far as KM is concerned, there are significant limitations in traditional approaches to epistemology. Traditional epistemology is not concerned with the production and processing of knowledge in a group or shared sense—it is not really concerned with the pragmatics of knowledge production and use. The main issue in epistemology is the status of the final product rather than the process of getting there and what happens after knowledge is acquired. Yet these are precisely the factors that are of interest for KM.

The upshot of this is that, beyond an initial analysis of what knowledge is, the traditional approach to epistemology offers very little in the way of useful insights for KM. Epistemology may offer some assistance when dealing with some forms of explicit knowledge, but beyond that it is of little use. Thus we must look beyond standard epistemology to find useful contributions from philosophy.

On the other hand we also should not stray too far from standard epistemology: KM should not dismiss the importance of the insights of traditional epistemology into the nature of knowledge. Although the different disciplines have fundamentally different interests in the concept of knowledge, the concepts in each discipline are still very closely related. The standard approach in epistemology may be too limited and too narrow for KM, but it also is not totally irrelevant. At its foundation the KM conception of knowledge should at least be compatible with the epistemological definition, since even thought the disciplines have different interests in the concept, at its base it is still essentially the same idea. Factual, tacit, practical, technical, and other forms of knowledge must still all meet certain criteria in order to be genuine knowledge: they must correspond to some aspect of the world, accurately reflect a reliable way of manipulating the world, and stand up to the harshest of pragmatic tests. Although precisely what it takes to meet these criteria is the topic of vigorous debate, it is clear that genuine knowledge must have some standards.

FUTURE TRENDS: RELEVANT PHILOSOPHICAL INSIGHTS FOR KM

This article has argued that traditional epistemology can only be of limited use to KM since it focuses on the origins and justification of personal knowledge, rather than the pragmatics of knowledge use, sharing, and dissemination. Since

KM is primarily concerned with knowledge as it is generated, shared, stored, and used within a collaborative environment, if we are to look to epistemology to provide a foundation for the tasks of KM, we must look for those areas that can deal with these practical issues, as well as provide insights into these differing forms of knowledge and the relationships between them. The philosophical theory must also help our understanding of the underlying processes that are relevant for KM.

The suggestion here is that the most fruitful places to look for relevant philosophical insights for KM is in recent work in both the philosophy of science and the emerging field of social epistemology. Although there are still limitations associated with these philosophical theories, these areas are engaged with fairly similar questions to those that interest knowledge management, and can thus provide insights into these issues. Thus they should be able to provide some useful theoretical tools that can be applied to building a theoretical account of knowledge work.

Philosophy of Science

There is already a strong tradition within KM of applying insights from the philosophy of science. In particular the works of Kuhn (1970, 1977) and Popper (1959, 1972) have been of great interest to a number of KM theorists. Kuhn's notion of a paradigm, a particular world view, has played a pivotal role in understanding how a community of thinkers—or knowledge workers—need to share certain base beliefs in order to work together effectively. Kuhn's ideas on incommensurability have also been extremely important for many KM theorists. Popper's insights into the basis of scientific knowledge, and his distinction between Worlds 1, 2, & 3, have also helped enrich the understanding of KM. However KM has paid relatively little attention to more recent developments in the philosophy of science which take a quite different approach in their investigations.

The trend in the philosophy of science over recent years has been to shift from trying to develop a general account of what science is (as evident in the work of Popper and Kuhn), to looking more closely at the fine detail of science. These fine details concern the complex methods by which scientific theories are developed, in terms of how scientists work, reason, experiment, collaborate, and so forth. In this way, the emphasis of recent work has been less about the justification of knowledge claims, and more about the creation and use of knowledge.

There have been two general approaches taken to this type of work. The first falls loosely under the banner of Social Studies of Science (SSS), and includes the work of Latour and Woolgar (1979), Latour (1986, 1987, 1998), Charlesworth, Farrall, Stokes, and Turnbull (1989), Knorr Cetina (1981, 1999), and Law and Mol (2001, 2002). This work focuses on sociological investigation into the world of the scientist, looking closely how scientists construct knowledge through their shared understanding of language and observational phenomena, which drives their interpretation of observation and experiment and facilitates their creation of ontological categories. This body of work explores the social details of these processes, uncovering how knowledge plays a pragmatic role in our understanding and manipulation of the world. As such it has provided rich material for application in KM contexts. For example, Latour's (1986) notion of inscription plays an important role in Burstein and Linger's (2003) task-based approach to KM.

The second body of work that looks at the details of scientific knowledge construction is more in the tradition of standard philosophy of science. Unlike SSS, this work is not so well known outside the philosophy of science community, and many of its ideas have yet to filter in to other disciplines. This work is closely related to SSS in that it similarly looks at the details of how scientists work, and how knowledge claims are constructed and used. However, unlike SSS, where ideals such as realism and truth are largely eschewed in favour of more social constructivist modes of thought, this work maintains a connection with realist metaphysical intuitions. Thus Cartwright (1989, 1999) emphasises the importance of causal capacities in science, and Dupré (1993) explores the metaphysical implications of the disunity of perspectives that coexist across the ranges of sciences. The detailed work of Galison (1996, 1997) looks at the role of social dynamics and politics in the theoretical life of nuclear physicists. Hacking (1999) also explores these issues in some detail, showing how the social construction of the world does not entail losing contact with traditional epistemological ideals such as accuracy and truth. Finally, Kitcher (1993) develops a complex model of scientific reasoning in a collaborative environment, which factors in the interactions between different researchers in building up a detailed picture of knowledge production in group context.

In science these forms of inquiry can deliver powerful predictions and detailed explanations, by rejecting the central importance of fundamental laws, by being open to the possibility of disunity, and by focussing on solving particular problems in particular contexts rather than developing generally applicable theories. This methodology is particularly applicable in the realms that involve complex physical systems in complex environments, where this approach has significant heuristic power, derived from uncovering and modelling the properties and processes that underlie the complex systems. This approach thus provides powerful insights for guiding our understanding, manipulation, and management of these systems. For these reasons these second set of approaches seem particularly suitable for analysing other types of complex systems, such as those involved in complex organisational environments. They should be directly applicable to these knowledge-based settings, thus providing a methodology for managing and supporting knowledge work. These approaches thus provide a good framework for KM, since they aim to provide a clear account of the underlying processes at work in knowledge production and knowledge-using environments. In doing so they strive to maintain the link between knowledge and truth, and thus provide a good metaphysical foundation for KM research. They also take into account all the relevant cognitive factors, including social dynamics and collaborative factors, providing a complete analysis of knowledge production in these contexts. They thus go some way to providing just the sort of pragmatic approaches to knowledge required by KM, over and above the conception of explicit knowledge provided in traditional epistemology.

Social Epistemology

Another promising area of philosophical inquiry is the emerging field of social epistemology (Schmitt, 1998). Work in this area is closely related to the above approaches in philosophy of science, with many of the same people working in this field. Some of the most significant works in this field include Goldman (1999), Longino (2001), Solomon (2001), and Turner (1994, 2002).

Social epistemology is an extension of traditional epistemology, which adds in the relationship between the social and rational factors in its analysis of the knowledge production process. Social epistemology looks at the social context of knowledge, and posits that knowledge may be a collective rather than an individual entity, and may be distributed amongst individuals. Social epistemology focuses on the shared aspect of knowledge, as well as the social situatedness of the knowers. Thus it moves away from the Cartesian paradigm of individual knowledge and the associated challenge of scepticism, and instead views knowledge as being a shared product of groups of individuals.

This reconceptualisation of knowledge as a collaborative entity has obvious advantages for KM. In particular, it is directly appropriate to many of the contexts that concern KM, since these are generally complex collaborative settings, such as in large organisations. Additionally, the closer look at the dynamics of collaborative knowledge in social contexts, as provided by social epistemology, can provide invaluable insights of great relevance to KM. For example, understanding the dynamics involved in the distribution of cognitive labour on a complex task, as discussed by Kitcher (1993), can provide clear guidance for how to provide added support in the form of a KM support system.

The closely related field of social metaphysics (Schmitt, 2003) has delved into very similar issues, including conceptions of joint actions, the autonomy of different social levels, and the relationship between individual and group knowledge. This area of research aims to build an account of the nature of social relations, social entities and institutions, and sociality more generally. As such it can, for example, provide an account of the metaphysical difference between individuals, groups, and the whole of a society. It can also be used to unpack the core theoretical notions of KM and specify the details of its framework. For example, the philosophical tools provided by social metaphysics can give a detailed account of what constitutes practice in a collaborative environment (Schatzki, Knorr Cetina, & von Savigny, 2001). Thus it can provide an account of what constitutes a task within an organisation, and describe the collaborative nature of the task, and how the task is conceptualised and constituted at different structural levels of an organisation: the individual, group, and enterprise level. In this way the insights from social metaphysics and epistemology can be applied to the particular domain of KM, and can lead to more effective approaches to KM methodology.

CONCLUSION

The conception of knowledge as developed in recent philosophy of science and social epistemology is of great relevance to the pursuits of KM. In particular, it seems that these areas could be very useful for developing a theory of collaborative knowledge work. It also seems clear that these approaches can support this theory within a realist and pluralist metaphysical framework (as outlined in Cartwright, 1999), and are consistent with the principles of naturalism (Quine, 1969). These approaches acknowledge the significant social dimension in knowledge production, while retaining the idea of knowledge being deeply connected to real properties and processes. Thus, applying insights from the social epistemology will make it possible to build a theory of knowledge work that is grounded in reality, but also incorporating the relevant social, practical, and pragmatic concerns that are central to the tasks of knowledge management. The starting point of such an analysis would be to determine precisely what aspects of knowledge are relevant to the enterprise of knowledge management, and to give an account of the factors that underlie these knowledge components. This will involve assessing the relevant cognitive, social, and pragmatic factors involved in KM projects. This will develop into a theoretical foundation for the practical work done in KM that maintains a connection with real-world processes and properties. Such a foundation will avoid the problematic conclusion that knowledge is purely socially constructed, and thus will present a powerful analysis of knowledge work.

However, in terms of the aims of knowledge management, current approaches in the philosophy of science and social epistemology are still somewhat lacking. As they stand they provide a detailed account of knowledge production, but little or no account of knowledge use. Thus, at present, they have little to say about the pragmatics of knowledge storage, knowledge sharing, and knowledge dispersal, all essential aspects of knowledge management projects.

Part of the problem here is that philosophers typically do not seem to be interested in the sorts of questions that are essential for KM. Epistemology in particular is still largely stuck in the Cartesian paradigm, obsessed with understanding the origins and justification of knowledge rather than the dynamics of knowledge as a process. Here we can actually turn things around and look to KM to provide some inspiration for philosophy. The challenges posed by KM projects can be used to show how these issues are indeed significant ones that need to be investigated in detail. The insights gained from current KM projects can also be fed back into the philosophical theory. This will involve extending the accounts of collaborative knowledge production, as provided by philosophy, to broader accounts of collaborative knowledge use. This is where the practical dimension of KM can actually help to enrich our philosophical understanding of the nature of knowledge, and thereby lead to stronger approaches to KM that are grounded in coherent and sound philosophical theory.

REFERENCES

Baker, A.J. (1998). Anderson, John. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved October 6, 2004, from http://www.rep.routledge.com/article/DD003SECT2

Burstein, F., & Linger, H. (2003). Supporting post-Fordist work practices: A knowledge management framework for dynamic intelligent decision support. *Journal of Information Technology & People (Special Issue on KM), 16*(3), 289-305.

Cartwright, N. (1989). *Nature's capacities and their measurement*. Oxford: Clarendon Press.

Cartwright, N. (1999). *The dappled world*. Chicago: University of Chicago Press.

Charlesworth, M., Farrall, L., Stokes, T., & Turnbull, D. (1989). *Life among the scientists: An anthropological study of an Australian scientific community.* Melbourne: Oxford University Press.

Cohen, S. (1998). Scepticism. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved June 23, 2004, from http://www.rep.routledge.com/article/P045

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organisations manage what they know*. Boston: Harvard Business School Press.

Descartes, R. (1996). *Meditations on first philosophy* (translated by John Cottingham; originally published 1640). Cambridge: Cambridge University Press.

Dupré, J. (1993). *The disorder of things: Metaphysical foundations of the disunity of science*. Cambridge, MA: Harvard University Press.

Galison, P. (1996). Computer simulations and the trading zone. In P, Galison & D. Stump (Eds.), *The disunity of science: Boundaries, contexts, and power* (pp. 118-157). Stanford, CA: Stanford University Press.

Galison, P. (1997). *Image and logic*. Chicago: University of Chicago Press.

Gettier, E.L. (1963). Is justified true belief knowledge? *Analysis, 23*, 121-123. Retrieved June 2004 from http://www.ditext.com/gettier/gettier.html

Goldman, A.I. (1999). *Knowledge in a social world*. Oxford: Clarendon Press.

Hacking, I. (1983). *Representing and intervening.* Cambridge: Cambridge University Press.

Hacking, I. (1999). *The social construction of what?* Cambridge, MA: Harvard University Press.

Hume, D. (1888). *A treatise of human nature* (1960 facsimile reprint, edited by L.A. Selby-Bigge). Oxford: Oxford University Press.

Iivari, J. (2000). Reflections on the role of knowledge management in information economy. In F. Burnstein & H. Linger (Eds.), *Knowledge Management for Information Communities. Australian Conference for Knowledge Management and Intelligent Decision Support*. Melbourne, Australia.

Kitcher, P. (1993). *The advancement of science*. Oxford: Oxford University Press.

Klein, P.D. (1998a). Epistemology. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved June 15, 2004, from http://www.rep.routledge.com/article/P059

Klein, P.D. (1998b). Knowledge, concept of. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved June 15, 2004, from http://www.rep.routledge.com/article/P031

Knorr Cetina, K.D. (1981). *The manufacture of knowledge: An essay on the constructivist and contextual nature of science*. Oxford: Pergamon Press.

Knorr Cetina, K.D. (1999). *Epistemic cultures: How the sciences make knowledge*. Cambridge, MA: Harvard University Press.

Kornblith, H. (Ed.). (1985). *Naturalizing epistemology*. Cambridge, MA: MIT Press.

Kuhn, T. (1970). *The structure of scientific revolutions*. Chicago: University of Chicago Press.

Kuhn, T. (1977). *The essential tension: Selected studies in scientific tradition and change.* Chicago: University of Chicago Press.

Latour, B. (1986). Visualisation and cognition: Thinking with eyes and hands. In H. Kuklick (Ed.), *Knowledge and society studies in the sociology of culture past and present* (vol. 6, pp. 1-40). Jai Press.

Latour, B., & Woolgar, S. (1979). *Laboratory life: The social construction of scientific facts.* Beverly Hills, CA; London: Sage Publications.

Latour, B. (1987). *Science in action: How to follow scientists and engineers through society*. Milton Keynes: Open University Press.

Latour, B. (1998). *Pandora's hope: Essays on the reality of science studies*. Cambridge, MA: Harvard University Press.

Law, J., & Mol, A. (2001). Situating technoscience: An inquiry into spatialities. *Society and Space*, *19*, 609-621.

Law, J., & Mol, A. (Eds.). (2002). *Complexities: Social studies of knowledge*. Duke University Press.

Longino, H. (2001). *The fate of knowledge*. Princeton, NJ: Princeton University Press.

Nonaka. (1994). A dynamical theory of organizational knowledge creation. *Organization Science*, *5*(1).

Nonaka & Takeuchi. (1995). *The knowledge creating company*. Oxford: Oxford University Press.

Pappas, G.S. (1998). Epistemology, history of. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved June 15, 2004, from http://www.rep.routledge.com/article/P018

Polanyi, M. (1966). *The tacit dimension*. Gloucester, MA: Peter Smith (Reprinted 1983).

Popper, K. (1959). *The logic of scientific discovery.* London: Hutchinson.

Popper, K. (1972). *Objective knowledge*. Oxford: Oxford University Press.

Quine, W.V. (1969). Epistemology naturalized. In *Ontological relativity & other essays*. New York: Columbia University Press.

Rumizen, M. (2002). *The complete idiot's guide to knowledge management*. Indianapolis, IN: Alpha.

Schatzki, T.R., Knorr Cetina, K., & von Savigny, E. (Eds.). (2001). *The practice turn in contemporary theory*. London: Routledge.

Schmitt, F. (1998). Social epistemology. In E. Craig (Ed.), *Routledge encyclopaedia of philosophy*. London: Routledge. Retrieved June 15, 2004, from http://www.rep.routledge.com/article/P046

Schmitt, F. (Ed.). (2003). *Socializing metaphysics: The nature of social reality*. Rowman & Littlefield.

Solomon, M. (2001). *Social empiricism*. Cambridge, MA: MIT Press.

Sveiby, K.-E. (1994). *Towards a knowledge perspective on organisation*. Doctoral Dissertation, University of Stockholm S-106 91, Sweeden. Retrieved June, 2004, from http://www.sveiby.com/articles/Towards.htm

Sveiby, K.E. (1997). *The new organizational wealth—managing & measuring knowledge based assets*. San Francisco: Berrett Koehler.

Sveiby, K.E. (2001). *What is knowledge management*. Accessed May 2003 from http://www.sveiby.com/articles/KnowledgeManagement.html

Turner, S. (1994). *The social theory of practices: Tradition, tacit knowledge and presuppositions*. Chicago: University of Chicago Press.

Turner, S. (2002). *Brains/practices/relativism*. Chicago: University of Chicago Press.

ENDNOTE

1 This formal definition of knowledge is quite controversial and is the subject of ongoing vigorous debate (Gettier, 1963). However, most analytic philosophers tend to agree that this definition is roughly correct, and the controversy is mainly over the fine details of this approach—especially on the question of what constitutes an adequate justification.

Chapter 7.11
Ontology-Supported Web Service Composition:
An Approach to Service-Oriented Knowledge Management in Corporate Financial Services

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ABSTRACT

Web service composition can enhance the efficiency and agility of knowledge management by composing individual Web services together for complex business requirements. There are two main research streams in knowledge representation for Web service composition: syntactic-based and semantic-based approaches. Despite the promises brought by each approach, the two streams are largely separated from each other. In this paper, we propose an integrated ontology-supported Web service composition framework, which provides a novel solution to organizational knowledge management. By synergistically leveraging both syntactic-based and semantic-based approaches, this framework provides dual modes to perform service composition. Ontologies are employed to enrich semantics at both service description and composition levels. The proposed conceptual framework has been implemented in the corporate financial services domain. It is demonstrated that the shared ontology helps fulfill automated and on-the-fly service composition in particular and knowledge management in general.

INTRODUCTION

The competition in today's business world requires significant involvement of organizations' intangible assets. Innovative approaches to knowledge management can provide competitive advantages to organizations. Although a variety of information technologies for knowledge management, such as information retrieval, databases, data mining, and knowledge representation, have considerably advanced, organizations are still facing challenges in automated and dynamic knowledge discovery, sharing, reuse, and consumption.

A Web Service is a software system designed to support interoperable machine-to-machine interaction over a network (W3C, 2003), which emphasizes such essences as: (1) componentization guarantees platform- and programming language-independency; (2) interoperability benefits communication and collaboration; (3) the architecture involves three basic roles: service provider, service broker, and service consumer; and (4) fundamental technologies include WSDL, SOAP, UDDI, and so on (Zhang, 2005). The latest Web services standards and technologies make it a reality to compose individual Web services into more complex services for e-businesses. Unfortunately, current approaches to service composition are rigid, time- and resource-consuming, ad hoc, and error-prone (Cardoso, Bussler, Sheth, & Fensel, 2002; Medjahed, Bouguettaya, & Elmagarmid, 2003; Papazoglou & Georgakopoulos, 2003).

This research contributes to the body of knowledge management research by proposing an ontology-supported and service-oriented approach to organizational knowledge management. We introduce an integrated framework for Web service composition by synergistically leveraging both syntactic-based and semantic-based approaches. It takes advantage of the Semantic Web technology to enrich semantic representation of domain knowledge and complements traditional syntactic service composition methods. We have applied the proposed conceptual framework to a corporate financial service application. The prototype shows that the framework can support semantic, dynamic, and automated Web service composition effectively.

The rest of the paper is organized as follows. First, we briefly introduce the concept of Web service composition and syntactic-based and semantic-based approaches. Then, an ontology-based integrated conceptual framework for Web service composition is presented. Next, we illustrate the proposed framework with a prototype system, followed by the discussion of implications of our research. Finally, we conclude the paper with future work.

WEB SERVICE COMPOSITION AND RELATED WORK

Web service composition (WSC), namely choreography of Web services, is to construct higher level services based on existing multiple individual services in order to fulfill more sophisticated business requirements (W3C, 2002). It is viewed as a step-stone through which to reach the Mecca of Web services, and even the vision of the Semantic Web (Berners-Lee, Hendler, & Lassila, 2001; Medjahed et al., 2003). A typical example of Web service composition is to generate a comprehensive conference travel plan, including conference registration, flight ticket booking, hotel reservation, car rental, map request, and so on, from existing services. Depending on whether a composition decision is made at design time or run time, it falls into either static or dynamic composition, respectively (Cardoso et al., 2002). From a process standpoint, service composition can be done horizontally, vertically, or both. The aforementioned example involving flight and lodging reservations belongs to vertical composition, because hotel booking cannot be carried out until the flight ticket is issued. However, car rental and map request can be performed simultaneously in a horizontal way.

WSC poses challenges from multiple aspects along the composition course (Cardoso et al., 2002): (1) description or representation of Web services; (2) discovery of Web services; (3) integration of interoperable or composable individual services; (4) quality of services (QoS) or efficiency of composed services; (5) execution and supervision of composite services, as well as other issues. The syntactic-based and semantic-based approaches to WSC that address these issues with distinct technologies are discussed as follows.

The syntactic-based service composition approach has already been widely used by the industry (Srivastava & Koehler, 2003). Business Process Execution Language for Web Services (BPEL4WS) supplements XML with more vocabularies (e.g., Process, Partner, Container, Sequence, Flow, and Receive) to support composition of processes (Andrews et al., 2003). Web Service Choreography Interface (WSCI) describes the flows of messages involved in service choreography (W3C, 2002). Although more vocabularies are added for service description, messaging, and registry, those constructs are still mainly concerned with document structure or syntax. The service discovery, matching and integration primarily utilize keyword searching, which has been proved ineffective in many cases by information retrieval researchers.

The semantic-based service composition addresses the semantics-absent problem of the syntactic-based approach. This method exploits the vision of the Semantic Web (Berners-Lee et al., 2001). In the WSC context, the Semantic Web, especially RDF+OWL technology, can help service description, advertisement, discovery, integration, interoperation, invocation, execution, and monitoring, which all converge at service composition (Cardoso et al., 2002). RDF (Resource Description Framework) uses a triple <*resource, property, value*> to describe and exchange resources or metadata. OWL (Web Ontology Language) is built to represent ontology on the Web with richer vocabularies and more expressive syntax. An ontology is generally defined as "shared formal conceptualizations of particular domains, providing a common understanding of topics that can be communicated between people and application systems" (Decker et al., 2000, p. 63). In the context of service composition, ontologies can be employed to distill all concerned concepts in a certain domain as a centralized repository, which shows superiority for on-the-fly service choreography by specifying semantic relationships between service terms.

Ankolekar et al. (2002) proposed a semantic service description model, where a service contains three objects: profile, model, and grounding. The service profile describes what a service does (functionalities, parameters, etc.); the service model indicates how the service works (process flow); and the service grounding tells how to access the service (binding, protocol, RPC, etc.). Based on this semantic service specification, along with semantics-enriched vocabularies, RDF and OWL can benefit service composition. For example, a profitability report service combines sales, cost, administrative expense, and even currency exchange rate information. It can be defined as a subclass of both *CompositeProcess* and *Sequence* using RDF constructs, and then uses an OWL construct, *unionOf*, to specify all individual services.

In comparison with the syntactic approach, semantic specifications are still evolving. Another challenge is that there are no systematic rules to follow in ontology engineering (Green & Rosemann, 2004; Weber, 2003). Therefore, the answer to which approach is applicable depends on the application, domain, resource availability, and so on. As a matter of fact, the current status of both syntactic-based and semantic-based service composition requires a certain level of manual coding of composition process (Srivastava & Koehler, 2003). It is promising to combine syntactic-based and semantic-based methods for service composition.

There are four lines of research that are related to this study. The first one centers on frameworks or architectures for Web service description and composition. Recently, some researchers have started incorporating ontologies into conceptual modeling and service frameworks (Kim & Karp, 2004; Milton & Kazmierczak, 2004; Pahl & Casey, 2003; Solanki, Cau, & Zedan, 2004; Tsai et al., 2003). The second line of research aims to map syntactical service description to semantic specifications (Patil, Oundhakar, Sheth, & Verma, 2004; Shen, Yang, & Lalwani, 2004). The third line of related work is concerned with ontology development for Web services (Lozano-Tello & Gomez-Perez, 2004; Mika, Oberle, Gangemi, & Sabou, 2004; Williams, Padmanabhan, & Blake, 2003). The fourth stream is called compositional modeling (Ba, Lang, & Whinston, 1997; Falkenhainer & Forbus, 1991). Their knowledge description framework includes both models' conditions and domain theories, which are analogous to the semantic description scheme and business rules in our proposed framework, respectively.

ONTOLOGY-SUPPORTED WEB SERVICE COMPOSITION

An Ontology-Supported Framework for Web Service Composition

We propose an integrated conceptual framework for dual-mode Web service composition. This framework exploits the advantages of both syntactic and semantic composition approaches, powered by ontologies at both service description and composition levels. We keep fundamental syntactic-based Web service building blocks in that those industry standards can fulfill most straightforward requirements for service development, discovery, and composition. Building on top of that, we introduce an ontology-based semantic approach. First, the semantic Web service specification model (Ankolekar et al., 2002) provides a mechanism to enrich atomic services with more semantics than does syntactical method. Second, the intrinsic correlation between the syntactic-based and semantic-based approaches helps materialize the above semantic service specification model. Third, mapping atomic services and other relevant concepts into a centralized shared ontology offers a knowledge repository for service choreography. The objective of semantic enhancement is not to perform the base level service related operations, but to support ontological heuristics so as to enable automated and dynamic service composition. The proposed framework is shown in Figure 1.

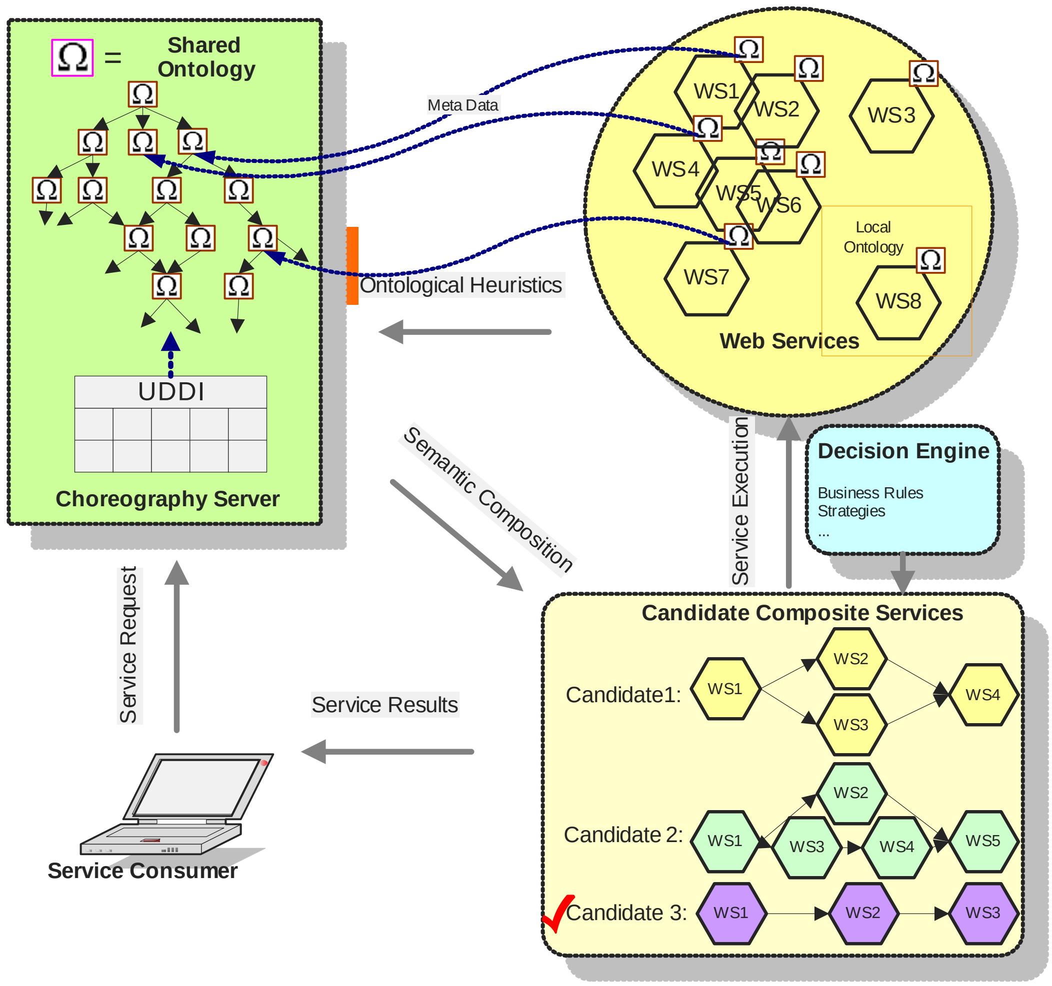
When a service-oriented business application receives a service request from a consumer, it first searches an ontology-based choreography server. This server enhances the traditional UDDI with a shared ontology (the upper part in the choreography server in Figure 1). This centralized ontology represents relevant services and concepts in a specific domain, constructed by mapping and integrating (denoted by the dotted arrows in Figure 1) individual local ontologies for Web services. In this paper, we refer to ontological heuristics as applying heuristics to ontology applications, serving as guidelines to respond to a service request.

After using ontological heuristics on the shared ontology, the choreography server generates a number of alternative solutions to service composition. These alternatives are then evaluated against a set of criteria specified by the service consumer and a decision engine. Such criteria may include QoS requirements, business rules and strategies, resource availability, and so on. A selected optimal composition scheme is then executed.

Semantic Service Description

At the service description level, we integrate syntactic service description in WSDL with se-

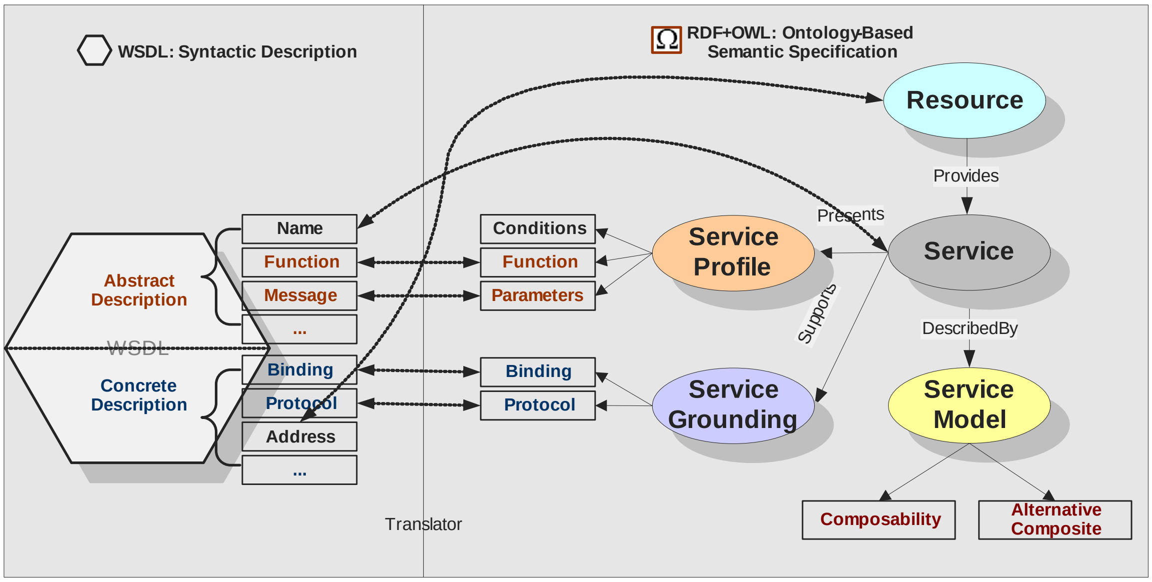
Figure 1. An ontology-supported framework for Web service composition



mantic specification (Ankolekar et al., 2002) in RDF+OWL, as shown in Figure 2, which zooms in the local ontology square in Figure 1.

When combining both service description methods, the correlations between them can be sketched. The proposed framework emphasizes those relationships because certain types of translators can be employed to convert service description back and forth. As illustrated in Figure 2, the main information contained in the abstract and concrete description in a WSDL document matches the service profile and service grounding subjects on the ontology side, respectively. One step further, the elements in the WSDL file link to the corresponding properties in the ontology. For example, the *message* element in the WSDL file

Figure 2. Ontology-enabled semantic service description



corresponds with the *parameters* property in the RDF+OWL, both of which contain information about input and output of this service. Although the matching is not strictly parallel (e.g., *address* in the WSDL corresponds to the *resource* class in the ontology), the linking paths are still structured and can be predefined, given the widely accepted WSDL standard.

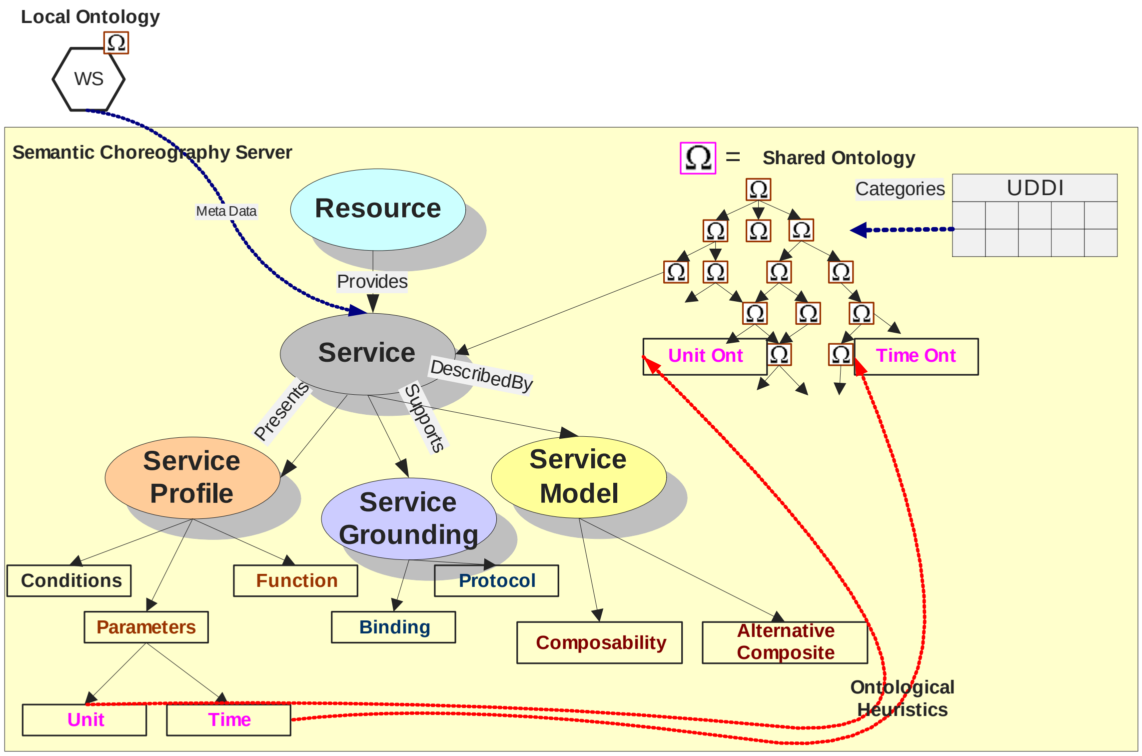
As for the semantic side (the right part in Figure 2), we employ RDF+OWL to develop a local ontology for each service, which allows enriched semantics. For example, the service profile subclass for each service has a property called *conditions*, which specifies pre- and post-conditions for execution. Similarly, the service model subclass is especially beneficial for composition. The proposed framework utilizes the service model class in two ways. For base services, a service model keeps information about *composability*, which specifies when the service can be used in a composite service. For composite services, a service model maintains *alternative composite* solutions incrementally for reuse. This semantic enrichment provides a self-learning capability of service composition.

Semantic Service Choreography

Local ontologies are consolidated in the choreography server by ontology mapping and integration. As a result, all relevant concepts and services in a domain are registered in the shared ontology, as shown in Figure 3.

In Figure 3, a local ontology for a service is mapped into the shared ontology (denoted by the dotted arrow in the upper left part of Figure 3), appearing as a node in the ontology tree. How to organize all services into the centralized reposi-

Figure 3. Semantic service choreography

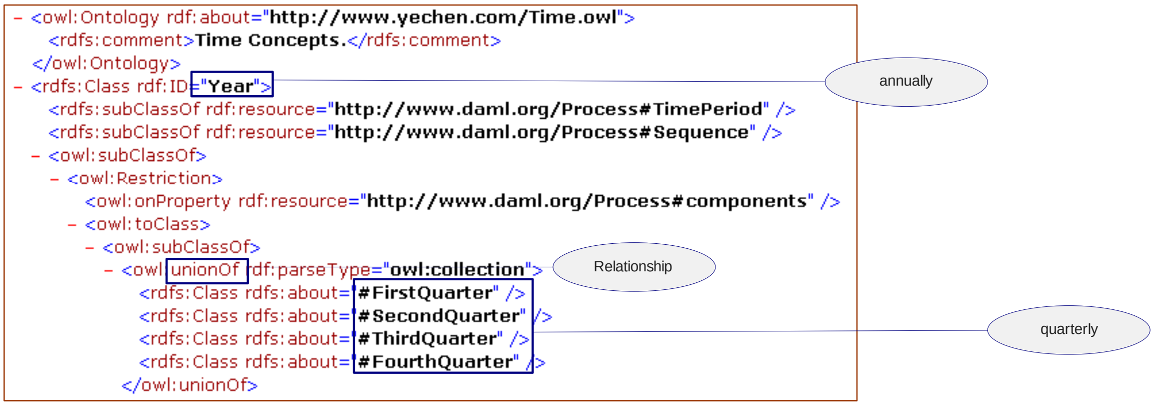


tory depends on specific domains or application requirements, and the category information in UDDI as well. For example, for corporate finance, the *financial planning* service can have such subclasses (services) as *budgeting* and *forecasting.* In this way, we can maintain semantic relationships (e.g., hierarchical and sibling relationships) between financial operations.

The shared ontology also represents other application-specific concepts for mapping and integrating services. The mapping and integration (denoted by the dotted arrows in the lower right side of Figure 3) not only unite service descriptions and concepts, but also add more semantics. For example, the difference between *budgeting* and *forecasting* services can be found by mapping both to the *time* ontology: *budgeting* is performed *annually*, while *forecasting* is a *quarterly* task. *Annual* and *quarterly* are subclasses of the *time period* node (the other sibling class might be *time point*), which in turn belongs to the *time* ontology.

Moreover, the shared ontology enables ontological heuristics, thus facilitating dynamic service composition. For example, we can analyze composability of services based on some generic concepts. As discussed above, *budgeting* and *forecasting* are conducted at different periodical levels: *annual* and *quarterly.* At the first glance, these two services cannot be composed if *time*

Figure 4. Annually and quarterly semantics in RDF+OWL



period is a parameter. However, the relationship between *annual* and *quarterly* is revealed in the *time* ontology: one *year* equals to four *quarters*. The RDF+OWL document excerpt in Figure 4 shows how OWL uses *unionOf* vocabulary to represent this relationship.

In an enterprise context, a dedicated team would be responsible for the specification of local and shared ontologies. This team mainly consists of IT professionals and domain experts. From a system development life cycle (SDLC) perspective, the functional side should focus more on the analysis part (e.g., determine the domain and scope of ontologies; consider reusing the existing ontologies; and enumerate important terms in ontologies), while the technical side takes charge of the implementation (e.g., define classes and the class hierarchy; define properties of classes; define facets of the slots; and create instances). The ontologies developed should be reviewed periodically.

Our proposed ontology-supported framework represents an innovative approach to organizational knowledge management. The shared ontology systematically incorporates relevant knowledge into a centralized repository, which is a combination (explicit to explicit) from a knowledge conversion perspective. Knowing that management changes may have substantial impact on production yield and marketing strategy is tacit. By including a *controller* subclass of *manufactory*, we capture a clue to this know-how, thus externalize, to some extent, this tacit knowledge to explicit knowledge. The agreed ontologies can also facilitate knowledge socialization (tacit to tacit) and internalization (explicit to tacit) (Bonanno, 2003). For example, the knowledge represented in the shared ontology can be accepted by other parties besides the knowledge owner (financial experts) and be further used as a basis to create other higher-level knowledge, such as how to make use of market changes to optimize inventory management and logistics.

WEB SERVICE COMPOSITION IN FINANCE

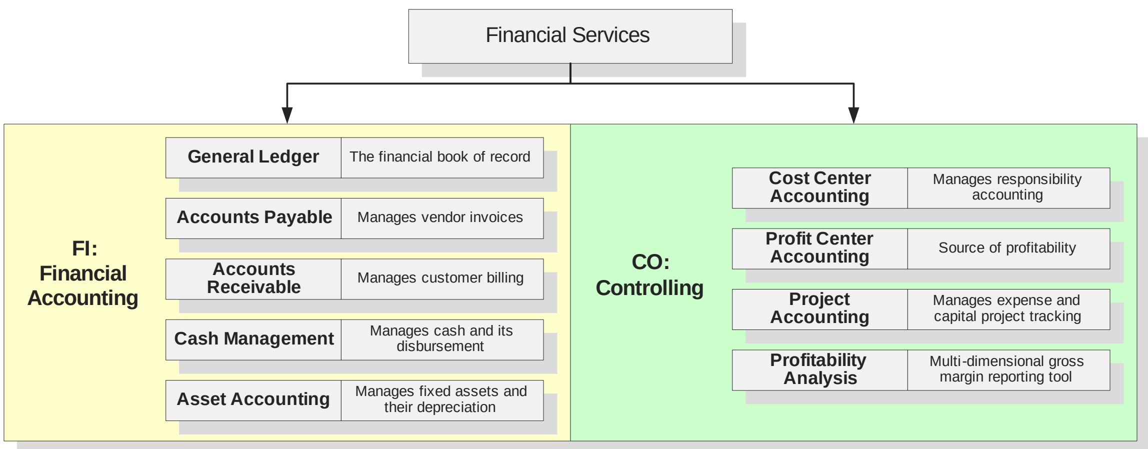
In this section, we present a prototype system for corporate financial service composition, which is developed based on the proposed ontology-supported Web service composition framework. We use several scenarios to illustrate how this framework can facilitate automated and dynamic service composition. We simplify some business problems for presentation purpose.

Domain Service Description

The selected application is financial operations at Motorola Asia, where the first author worked as a system analyst for three years. The major financial services in this organization are summarized in Figure 5, following the SAP R/3 ERP Financial service scope (SAP, 2004). The domain and scenario examples are extracted from real business cases. The Web services and ontology development examples used in our illustration are fictitious but address real business problems. In addition, the business data is constructed in a way that suffices to demonstrate the proposed framework but conceals the real business scale.

In general, the financial accounting modules (the left part of Figure 5) are responsible for accounting for public reporting, while the CO (Controlling) modules (the right part of Figure 5) are designed for internal accounting for enterprise management. For example, General Ledger (GL) is a financial service that records a book for financial data, which is organized by account; Accounts Payable (AP) provides information about payments for material purchasing; Accounts Receivable (AR) tracks sales and cost information through customer billing; Cost Center Accounting (CCA) is the accounting for factories; and Profit Center Accounting (PCA) is to control a sales center or representative. All these financial services will be represented as local ontologies, and then mapped into a shared ontology. The scenarios for illustration will focus on AR, CCA, and Currency Exchange (CurEx) services.

Figure 5. Organization of financial services



Web Service Development

Before we deploy the entire prototype system architecture for service choreography, we first need to develop some individual Web services for later composition. We have developed three individual Web services for AR, CCA, and CurEx using Microsoft Visual Studio.NET 2003, particularly ASP.NET, ADO.NET and Visual Basic.NET. As for database, the prototype uses Microsoft SQL Server 2000. The Web server is Microsoft IIS 5.1.

The AR service allows clients to query sales related information. The inputs to this service include period (beginning date and ending date), product, factory, and customer. The outputs are sales, material cost (direct cost), and booking currency. The input and output screens are shown in Figure 6.

In Figure 6, the input arguments are <*4/21/2004, 4/30/2004, Mobile Telephone, Motorola ESG China, PCSCN*>. The outputs are sales *8600* and cost *5000*, in *USD* (US Dollar). We define outputs in an XML-based format, which can be easily parsed and retrieved later.

Similarly, the CCA service can answer questions like how much administrative cost (indirect cost) is committed for producing a certain product at a certain factory during a specified period. For example, between *4/21/2004* and *4/30/2004*, to produce mobile telephones at the *Motorola ESG China* factory, the administrative cost was 326 *RMB* (Chinese currency Renminbi). The CurEx service is for clients to retrieve the exchange rate

Figure 6. The AR service

Figure 6.1. Input arguments

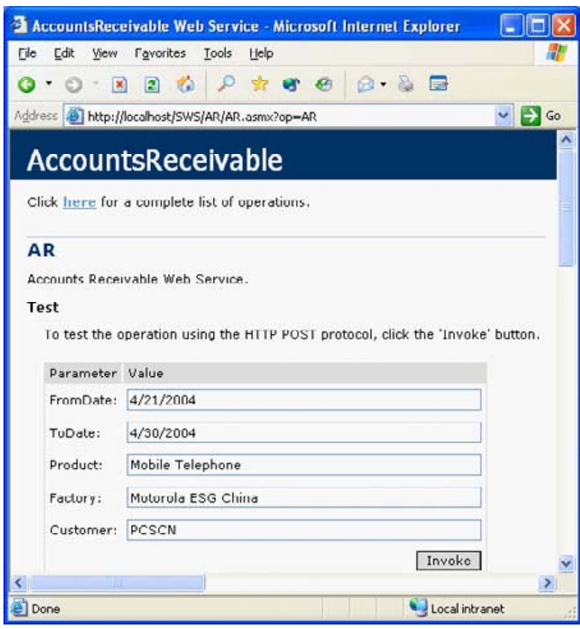
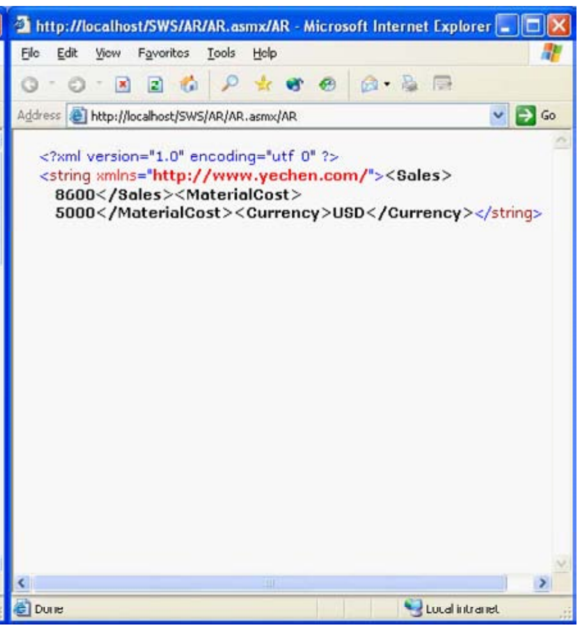


Figure 6.2. Outputs



of a specific foreign currency to *USD*. If the input currency is *RMB*, the retrieved exchange rate is *0.1194* to *USD*. Once all individual services are available, the next step is to enrich semantics about them.

Semantic Enrichment by Ontological Engineering

Based on the developed services, ontologies for both individual services and centralized choreography server are built. Our prototype system employs W3C recommended standards (namely RDF+OWL) for semantic description and ontological engineering. The software utilized for this task is Protégé 2.1 beta (Protégé, 2004).

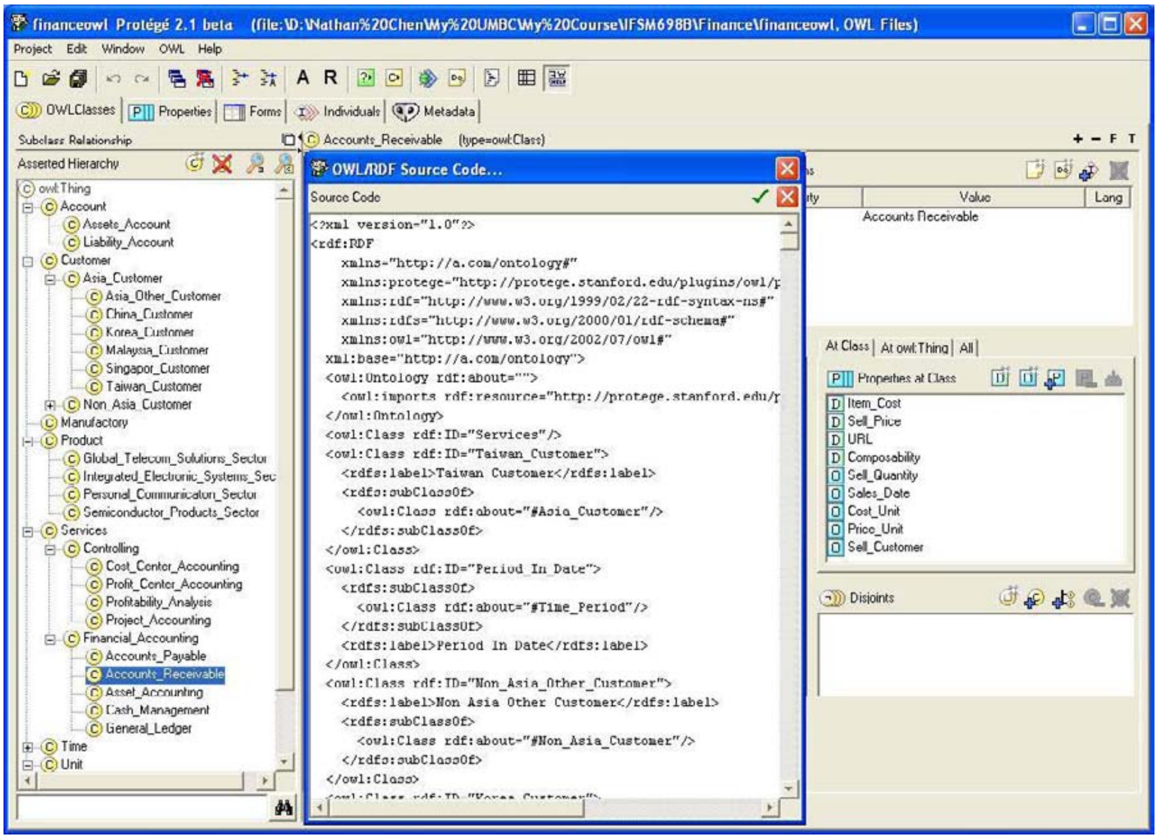
At the service description level, the prototype system translates service descriptions from WSDL to RDF+OWL, and then adds more semantics in the service model class. The *composability* property of the service model class can have values denoting possible ways for service composition. Taking the AR service as an example, its *composability* contains a list of possible parameter flows (from inputs to outputs): *period*→*sales*, *period*→*cost*, *period & product*→*sales*, *period & customer*→*sales & cost*, and so on, each of which can be a part of an alternative path in a composite service. Another way to exploit *composability* is to first attach *composability* to other properties with concrete meanings, then associate *composability* with composition rules. For example, assuming *composability* is a property of *time*. If a financial service is *time period* based, while another one is *time point* based, these two services should not be composed together. As a result, the value of the *composability* property for the *time* of the former financial service can be ¬*time point*.

At the service choreography level, all designed local ontologies are mapped together following the aforementioned SAP R/3 ERP financial services organization, appearing as nodes or subclasses in the shared ontology, as each service or group of services has a registry in UDDI. For example, the *AR service* is a subclass of the *services* class. The prototype can extract some metadata from local ontologies and map into the shared one. Also, the shared ontology can be developed based on UDDI category information. After organizing those base financial services into a shared knowledge repository, the prototype adds other concepts relevant to financial operations, either domain-specific or generic, such as *account*, *customer*, *manufactory, product*, *time*, and *unit*. One thing worthy to mention is that the *currency* class is a subclass of the *unit* class.

The semantics obtained so far are limited to hierarchical and sibling relationships. Ontological mapping and linkage supplement a richer set of semantics, which can be performed through the *value type* constraint and *inverse* property, among others. For example, the AR service has a property called *price unit*, whose *value type* is *currency* class. As for the *inverse* property, the *product* class has properties '*produced by*' and '*sold to*', which are inverse properties of *produces* under *manufactory* and *buys* under *customer*, respectively. These mappings reveal the interrelationships among customer, product, and manufactory. Although such relationships can also be maintained in a relational database, ontology emphasizes shared knowledge more than specific details of individual transactions. Collectively, the shared ontology for financial services is shown in Figure 7.

The left part of Figure 7 shows the tree view of the shared ontology. The highlighted *Accounts Receivable* service is under the *services*→*financial accounting* hierarchy. It has sibling classes (services) including *Accounts Payable*, *Asset Accounting*, and so on. Besides services, this ontology maintains concepts of *account*, *customer, manufactory, product, time*, and *unit*. The middle section is the RDF+OWL source code of the ontology. The right part of Figure 7 illustrates property definitions of the AR service. Among those properties, *composability* is used to describe the service model; *URL* is a part of the service

Figure 7. Shared ontology for financial services



grounding and indicates the resource of the service; other properties such as *sales date* and *sell customer* belong to the service profile.

Usage Scenarios

To demonstrate the potential of the proposed ontology-supported service composition framework, we will go through two usage scenarios in this section. The first scenario is to answer a financial management question, and the second one is to address an ad hoc business query.

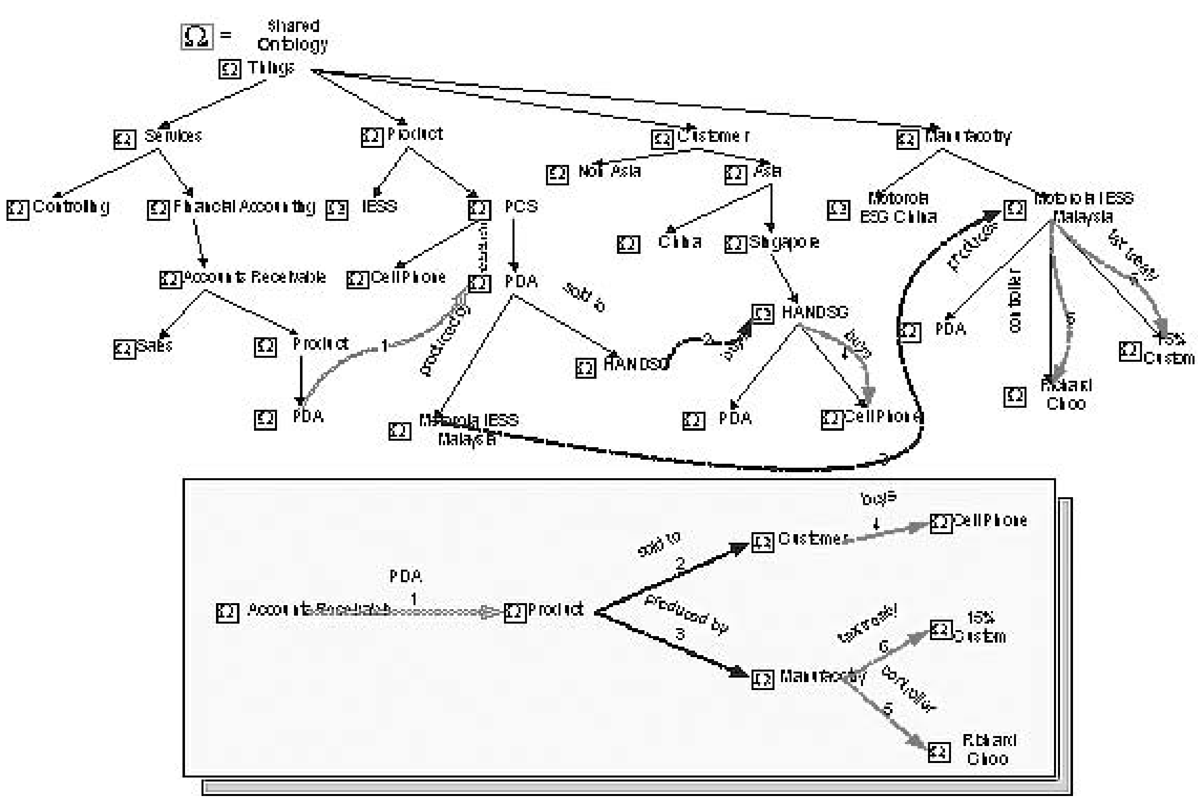
Scenario 1: Why were the sales in the last month extraordinarily high?

This question is exploratory in nature and cannot be answered by a single query. There are many possible reasons for sales growth, such as supply push, demand pull, or even tax treaty change. The question can be addressed by ontological heuristics capability of the framework. The starting point is the key word *sales*. From the shared ontology, the prototype system learns that *sales* is an output of the AR service. There might be some other services providing sales information, such as PCA. The prototype can select candidate services based on different criteria, including query constraints, business rules, and service consumption cost, etc. For example, the AR service guarantees that the sales data are first-hand. Thus it is selected first and supplemented with values of input parameters such as the *last month*. The analysis of results from the AR service reveals that the product *PDA* had an irregularly high sales amount last month. Such an explanation is useful, but is still not able to answer the original question conclusively.

Given the above information, the question is transformed into: *Why did PDA have high sales in the last month?* The prototype shifts to the *product* ontology (class) in the shared ontology (denoted by Arrow 1 in Figure 8). The *product* class has two properties: *sold to* and *produced by*, inversely mapping to the *customer* and the *manufactory* classes, respectively. Therefore, the prototype has at least two directions to investigate the intermediate puzzle: *Was the PDA sales growth caused by customer demand pull or factory supply push?*

Along the *customer* direction, the *customer* class is linked through the property *sold to* (denoted by Arrow 2 in Figure 8). It is found that the customer *HANDSG* (Handheld Singapore) purchased a large amount of PDAs last month.

Figure 8. Ontological heuristics to answer an exploratory question



Then the question is further changed to: *Why did HANDSG buy so many PDAs last month?* The examination of other products purchased by this customer may show that *HANDSG* had large purchases for almost all products it used to buy, such as *cell phone* (denoted by Arrow 4 in Figure 8). At this point, we can provide one possible answer to the original question: *The sales growth benefits from Handheld Singapore's business expansion.*

Along the *factory* direction, the *manufactory* ontology is triggered via the property *produced by* (denoted by Arrow 3 in Figure 8). A search on manufactories of PDA may reveal that *Motorola IESS Malaysia* assembled much more *PDAs* last month. The follow-up question is: *Why did Motorola IESS Malaysia produce so many PDAs last month?* Thus, two properties of the manufactory class, *tax treaty* and *controller,* are activated (denoted by Arrows 5 and 6, respectively). If it is found that the Malaysia factory just changed its financial controller, by comparing with the historical report or tracking the time stamp of the updates, the final answer might be: *The strategic adjustment in the Malaysia factory might account for the sales growth.* If the truth is that Malaysia government just favorably altered the tax treaty for foreign companies, the final explanation will be: *The Malaysia factory increases its production to take advantage of the tax benefits, thus promoting the sales.*

As illustrated in the scenario, an exploratory business question can be investigated through all possible dimensions by performing heuristics along the shared ontology. According to the results of ontological heuristics, an applicable service composition solution can be executed to answer the question. The final answer can come from service execution results along one or more dimensions. Such an ontological heuristics procedure is illustrated in Figure 8. The ontological heuristics paths are displayed at the bottom of the diagram. We will use the second scenario to highlight the composability analysis before and during the service composition using heuristics of the shared ontology.

Scenario 2: How much was the gross profit for the mobile telephone, produced at Motorola ESG China, sold to PCSCN (PCS China), during 4/21/2004 through 4/30/2004?

This is an ad hoc financial managerial question, which cannot be answered using a predefined query either. It needs dynamic service composition based on ontological heuristics to answer this question.

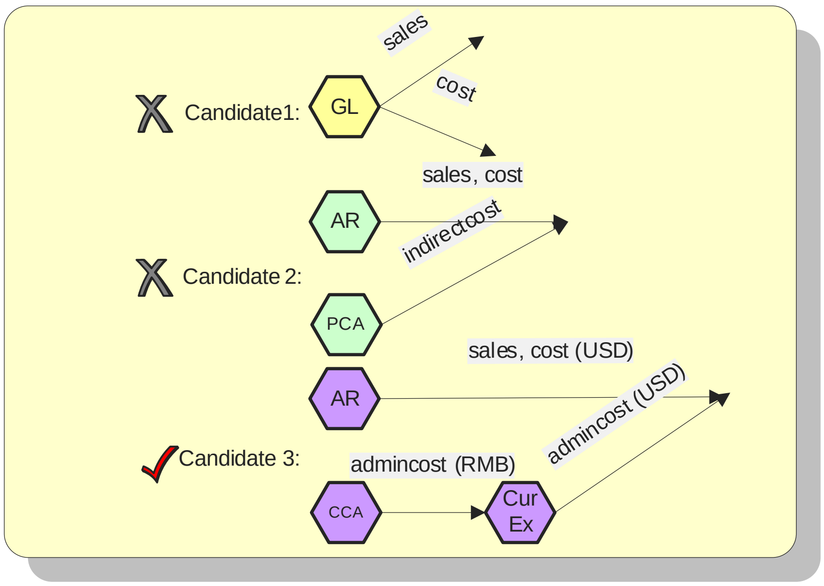
The investigation still starts with a keyword phrase in the question: *gross profit*. According to accounting knowledge, *gross profit = sales – direct cost – administrative cost*. After examining the *function* property of individual services, it is found that no single service can provide all required information, but composing some of them can fulfill the request.

As for *sales* and *direct cost,* both GL and AR services can produce those outputs. However, the scenario question needs financial data to be reported at a *date* level, not by *month* or by *quarter*. The prototype checks the *time* and related *composability* properties of GL and AR services, along with their mappings to the *time* ontology. The GL service is at a *month* level, and its *composability* has a value like ¬*time period.date*. Therefore, the system chooses AR to provide sales and direct cost information, given that all other properties (e.g., *booking currency*) are composable.

To obtain *administrative cost,* the candidate services include CCA, PCA, and AP, because all of them provide information about indirect cost. But the composability analysis reveals that some cost information is redundant between CCA and AP, and PCA's cost is not production related. Thus, the CCA service is selected for *administrative cost* information.

The system preliminarily invokes AR and CCA services separately and gets *sales 8,600, direct*

Figure 9. Service composition to answer an ad hoc question



cost 5,000, both in *USD*, as shown in Figure 6, and *administrative cost 326*, but in *RMB*. Due to the difference in currency units, these two services cannot be composed directly to calculate the gross profit.

To find out if these two services are composable in this scenario, the prototype system tracks their *unit* properties to the *unit* ontology (denoted by one dotted arrow in the lower part of Figure 3). The latter reveals a relationship between *USD* and *RMB*, and provides a currency exchange rate service called CurEx to bridge the gap. Therefore, the system relies on CurEx to help compose AR and CCA services. This on-the-fly service composition decision is made based on the shared ontology and business rules.

Figure 9 shows that candidate 3 is the final service composition solution. The system composes these atomic services to develop a Profitability composite Web service, called *ProfitComp*. Then, the management can answer the original question using this composite Web service. The result indicates that gross profit is *$3,561.08* (to verify: $8600 - 5000 - 326 \times 0.1194 = 3{,}561.08$).

DISCUSSION AND CONCLUSIONS

In this paper, we have proposed an integrated ontology-supported Web service composition framework by leveraging both syntactic-based Web services building blocks and semantics-oriented technologies. The semantic enrichment to the syntactical approach shows superiority for automated and on-the-fly service composition. As demonstrated in the usage scenarios, new lists of candidate services are generated along the course of problem solving. In most cases, the direction of the next step is dynamically determined based on the results of current service execution. The proposed framework has theoretical and practical implications for organizational knowledge management. Ontologies are beneficial to knowledge representation, discovery, and sharing, while Web services facilitate knowledge integration, delivery, and consumption. To demonstrate the benefits of the proposed framework, we have applied it to the financial services and provided a solution to knowledge management in that domain.

However, cautions should be taken when extending the framework to other areas. First, we assume that the shared ontology is accepted by all parties within an organization or a community, which is not always the case in a public domain. Similarly, in a situation where service description and domain knowledge cannot be easily translated into concepts represented in ontologies or ambiguities may arise from the conceptualization, task-specific solutions can be undertaken. But the ideal measure of conceptualization should rely on industry-wide standardization, such as more formalized financial and manufacturing ontologies. Second, the use of ontological heuristics through the shared ontology tree may consume substantial computational resources, especially when the ontology tree grows very large. More efficient ontology structures and searching algorithms need to be developed. Third, some other approaches to service composition, such as AI planning techniques and workflow technology (Ganesarajah & Lupu, 2002; Petrie et al., 2003; W3C, 2002), might provide further solutions and insights, although they are beyond the scope of the current study.

We believe that this integrated framework is an effective approach towards automated and dynamic service composition. Furthermore, implementing such an enterprise-wide knowledge management system that is based on the proposed framework offers an innovative approach to knowledge extraction, representation, organization, conversion, and creation. It also has advantages in addressing unstructured and unpredictable business management issues. In this sense, what are embodied in ontologies are of strategic importance.

Some future work needs to be done to fully realize the potential of the proposed framework. First, from a theoretical perspective, we need to address what relationships between the syntactical layer and the semantic layer are, and how to couple these two layers. Second, as a technical extension, software tools have to be developed to translate WSDL specification to RDF+OWL representation and to integrate local ontologies into a shared ontology. Third, service composition deals with data at a conceptual level, while service consumption also needs data from an instance level. How to organize and link these two levels of the ontology? What level of knowledge should local and shared ontologies encompass? Those questions have not been fully investigated yet. Finally, formal evaluation of the proposed framework will be conducted using a set of business problems with different levels of complexity.

REFERENCES

Andrews, T., Curbera, F., Dholakia, H., Goland, Y., Klein, J., Leymann, F., Liu, K., Roller, D., Smith, D., Thatte, S., Trickovic, I., & Weerawarana, S. (2003). *Specification: Business Process Execution Language for Web Services Version 1.1.* Retrieved on May, 2004, from http://www-106.ibm.com/developerworks/webservices/library/ws-bpel/

Ankolekar, A., Burstein, M., Hobbs, J. R., Lassila, O., Martin, D., McDermott, D., McIlraith, S. A., Narayanan, S., Paolucci, M., Payne, T., & Sycara, K. (2002). *DAML-S: Web Service Description for the Semantic Web.* Paper presented at the ISWC'02, Seattle, WA.

Ba, S., Lang, K. R., & Whinston, A. B. (1997). Enterprise decision support using intranet technology. *Decision Support Systems, 20*(2), 99-134.

Berners-Lee, T., Hendler, J., & Lassila, O. (2001). The Semantic Web: A new form of Web content that is meaningful to computers will unleash a revolution of new possibilities. *Scientific American, May, 2001,* 36-43.

Bonanno, K. (2003). Knowledge Management: People empowering people. *In Proceedings of the ASLA/CBCA Joint National Conference*, Hobart, Tasmania.

Cardoso, J., Bussler, C., Sheth, A., & Fensel, D. (2002). Semantic Web Services and Processes: Semantic Composition and Quality of Service. In *Proceedings of the Federated Conferences on the Move to Meaningful Internet Computing and Ubiquitous Computer 2002*, Irvine, CA.

Davenport, T., & Prusak, L. (2000). *Working knowledge: How organizations manage what they know*. Boston, MA: Harvard Business School.

Decker, S., Melnik, S., Van Harmelen, F., Fensel, D., Klein, M., Broekstra, J., Erdmann, M., & Horrocks, I. (2000). The Semantic Web: The roles of XML and RDF. *IEEE Internet Computing*, September/October, *2000*, 63-74.

Falkenhainer, B., & Forbus, K. D. (1991). Compositional modeling: finding the right model for the job. *Artificial Intelligence, 51*(1-3), 95-143.

Ganesarajah, D., & Lupu, E. (2002). Workflow-based composition of web-services: a business model or a programming paradigm? In Proceedings of the 6th International Enterprise Distributed Object Computing Conference (EDOC 2002), Lausanne, Switzerland.

Green, P., & Rosemann, M. (2004). Ontological Analysis, Evaluation and Engineering of Business Systems Analysis Methods. *Journal of Database Management, 15*(2), 1-2.

Kim, W., & Karp, A. H. (2004). *Customizable description and dynamic discovery for web services.* Paper presented at the 5th ACM conference on Electronic commerce, New York, NY, USA.

Lozano-Tello, A., & Gomez-Perez, A. (2004). ONTOMETRIC: A Method to Choose the Appropriate Ontology. *Journal of Database Management, 15*(2), 1-18.

Medjahed, B., Bouguettaya, A., & Elmagarmid, A. K. (2003). Composing Web services on the Semantic Web. *The VLDB Journal-The International Journal on Very Large Data Bases, 12*(4), 333-351.

Mika, P., Oberle, D., Gangemi, A., & Sabou, M. (2004). *Foundations for service ontologies: aligning OWL-S to dolce*. Paper presented at the 13th conference on World Wide Web, New York, NY, USA.

Milton, S. K., & Kazmierczak, E. (2004). An Ontology of Data Modelling Languages: A Study Using a Common-Sense Realistic Ontology. *Journal of Database Management, 15*(2), 19-38.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company*. Oxford: Oxford University Press.

Pahl, C., & Casey, M. (2003). Ontology support for web service processes. In *Proceedings of the 9th European software engineering conference held jointly with 10th ACM SIGSOFT international symposium on Foundations of software engineering*, Helsinki, Finland.

Papazoglou, M. P., & Georgakopoulos, D. (2003). Service-Oriented Computing: Introduction. *Communications of the ACM, 46*(10), 24-28.

Patil, A. A., Oundhakar, S. A., Sheth, A. P., & Verma, K. (2004). Meteor-s web service annotation framework. In *Proceedings of the 13th conference on World Wide Web*, New York, NY, USA.

Petrie, C., Genesereth, M., Bjornsson, H., Chirkova, R., Ekstrom, M., Gomi, H., Hinrichs, T., Hoskins, R., Kassoff, M., Kato, D., Kawazoe, K., Min, J. U., & Mohsin, W. (2003). Adding AI to Web Services. In *Proceedings of ICWS-Europe'03*, Erfurt, Germany.

Protégé. (2004). *Protégé Project*. Retrieved on May, 2004, from http://protege.stanford.edu/

SAP. (2004). *SAP R/3 Enterprise*. Retrieved on May, 2004, from http://www.sap.com/solutions/r3/

Shen, J., Yang, Y., & Lalwani, B. (2004). Mapping Web Services Specifications to Process Ontology: Opportunities and Limitations. In *Proceedings of the 10th IEEE International Workshop on Future Trends of Distributed Computing Systems (FTDCS'04)*, Suzhou, China.

Solanki, M., Cau, A., & Zedan, H. (2004). *Augmenting semantic web service descriptions with compositional specification.* In *Proceedings of the 13th Conference on World Wide Web,* New York, NY, USA.

Srivastava, B., & Koehler, J. (2003). Web Service Composition: Current Solutions and Open Problems. In *Proceedings of the ICAPS 2003 Workshop on Planning for Web Services*, Trento, Italy.

Tsai, T. M., Yu, H. K., Shih, H. T., Liao, P. Y., Yang, R. D., & Chou, S. T. (2003). Ontology-mediated integration of intranet Web services. *Computer, 36*(10), 63-71.

W3C. (2002). *Web Service Choreography Interface (WSCI) 1.0*. Retrieved on May, 2004, from http://www.w3.org/TR/wsci/

W3C. (2003). *Web Services Glossary*. Retrieved on May, 2004, from http://www.w3.org/TR/ws-gloss/

Weber, R. (2003). Conceptual Modelling and Ontology: Possibilities and Pitfalls. *Journal of Database Management, 14*(3), 1-20.

Williams, A., Padmanabhan, A., & Blake, M. B. (2003). Local consensus ontologies for B2B-oriented service composition. In *Proceedings of the 2nd international joint conference on Autonomous agents and multiagent systems*, Melbourne, Australia.

Zhang, D. (2005). Web Services Composition for Process Management in E-Business. *Journal of Computer Information Systems, XLV*(2), 83-91.

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Chapter 7.12
Ontology

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INTRODUCTION

An ontology comprises the explicitly articulated and shared concepts of a knowledge community or domain. These concepts are arranged formally in a taxonomy and are governed by specifically defined rules and axioms. Ontologies often play an important role in knowledge management information technology (KMIT). An enterprise knowledge management IT system, for example, may use an ontology "to facilitate communication, search, storage, and [knowledge] representation" (O'Leary, 1998, p. 58). A general survey of the literature suggests that ontologies are capable of improving performance in a large variety of knowledge management IT functions, especially relative to knowledgebases for best practices, lessons learned, human resource skills, Help Desks, FAQs, document collections, standards and regulations, products, services, proposals, and the like. In addition, as we look to the future, ontologies will function centrally in agent-mediated knowledge management (AMKM), distributed knowledge management (DKM), and the Semantic Web (Daconta, Obrst, & Smith, 2003; Fensel, 2001; Heflin, Volz, & Dale, 2002; McGuiness, 2002), as these technologies become pervasive in a global economy that distributes KM knowledgebases across companies and cultures.

The term ontology is rarely used in knowledge management circles. In fact, after researching "the KM literature both in print and online" and visiting KM Europe for "two consecutive years," Mika and Akkermans (2004) only "found prototypes of ontology-based KM applications in the ontology literature, [and] very few of the KM sources even mentioned the use of ontologies." When ontologies were mentioned, they were termed "future KM technologies." In the opinion of Mika and Akkermans, "The relation between KM and technology is only superficially developed in the business-oriented side of KM" (p. 6). Holsapple and Joshi (2004) are in the process of remedying this situation by developing a high-level, general knowledge management ontology that "provides a unifying view of KM phenomena" that will help researchers, educators, and practitioners (p. 593) "to characterize KM technologies,…structure

KM case studies, and…develop a KM model for competitive analysis" (p. 594). To provide a deeper understanding of just such an ontology, and to offer a general sense of the ontological aspect of IT in KM, this article defines the history, purpose, scope, and function of the term ontology.

Ontology has its origins in philosophy, and to this day informs a vital approach to philosophical inquiry. Philosophical ontology deals with metaphysical aspects of the nature of existence, touching upon the various meanings, relationships, and instances of the abstract, the concrete, the general, and the specific. It could be said that historically much of philosophy has been devoted to constructing a high-level ontology, an abstract model of reality, its primary constituents, their essential/accidental characteristics, and the various relationships that pertain among them.

Ontological philosophers often examine existence by delineating its parts categorically in accordance with an explicit theory. Aristotle's categories, syllogisms, definitions, and axioms, for example, form the basis of identifying, classifying, and theorizing about existence in just this way. So too have modern philosophers such as Kant, Peirce, Husserl, Whitehead, and Heidegger (Sowa, 2000, pp. 56-77) attempted to understand reality through categorization and logic. Much of their philosophical groundwork, in fact, forms the basis of ontology as it is presently understood in practical applications for computerized systems of information. Additionally, the mathematician and logician Stanislaw Lesniewski supplied a key component of the computerized sense of ontology when he used "an artificial formal language to represent his formal theory of parts (mereology)." He thereby "inaugurated philosophy's use of artificial languages and formal logic in expressing ontologies" (Mayhew & Siebert, 2004, pp. 1-2). Thus, the philosophical sense of the word ontology, with its long and rich history, forms much of the theoretical and logical base of the computer sense of the word. The relatively modern use of ontology, as applied to computerized information systems, appears first in 1967 in G.H. Mealy's "Another Look at Data," a paper dealing with "the foundations of data modeling" (Smith, 2004, p. 22).

Today's computerized ontologies attempt to capture some aspect of the explicit knowledge of a specific domain, such as medicine, accounting, finance, or engineering. With this knowledge, the ontology helps a computer agent or program function in some practical way to operationalize the key concepts made explicit and constrained by highly specified rules. An agent operating on the Semantic Web, for example, could theoretically consult various ontologies distributed on the Web to gather the meaning of key terms, assertions, processes, and actions that would allow the agent to shop for your dinner, buy your favorite wine, get the best price available for both, make sure that everything is delivered at a specified time, charge your credit card, and have your garage door open when you arrive home for dinner. Only an agent with a brain could perform all these activities. But computerized agents do not have brains. They have ontologies—ontologies to consult in carrying out your instructions for dinner. Computers cannot understand as humans do; but ontologies help to create the illusion that they can.

Within the last 40 years, ontology has become a central component in computerized information processing, especially in constructing large databases (sometimes termed knowledgebases). Ontologies have also figured predominantly in software application development, Artificial Intelligence initiatives, Web services, e-business, information and document retrieval, e-commerce, decision-support, medical informatics, the Semantic Web technologies, and, of course, in various IT applications of knowledge management. Within all these areas, the highly theoretical (philosophical) view of the term ontology undergirds the very pragmatic outcomes sought in computerized knowledge systems. Ontologies, formal and informal, will continue to be major functional elements in the design, maintenance, handling, and implementation of the large-scale information stores at the heart of knowledge management initiatives.

BACKGROUND: ONTOLOGY DEFINED

While never pretending to duplicate exactly the workings of the human imagination or experience, ontologies attempt to capture conceptually the rational building blocks of the mind by modeling our knowledge of reality. The whole purpose of this is to give the computer humanlike, albeit modest, thinking ability, by providing an explicit vocabulary for things, ideas, actions, relations, and approved behaviors. Ontologies with the expressive power that provides these capabilities are generally termed formal ontologies.

FORMAL ONTOLOGY

A formal ontology seeks to capture the essence of selected aspects of existence by stating explicitly and formulaically the concepts of the various constituents of the domain being modeled and the relationships that pertain among them. Ontologies are said to be "formal" or "formalized" when they are capable of being rendered into a computer programming language. Probably the single most famous definition of ontology is offered by Gruber (1993), who defines ontology simply as "an explicit specification of a conceptualization." Concepts, Gruber notes, are abstract, "simplified view[s] of the world" (p. 1) that become the models for the objects and ideas of some part of the world as we know it. Guarino and Giaretta (1995), emphasizing that purpose determines how these concepts are specified, note that an ontology can give only a "partial account of a conceptualization" (p. 7). Knowledge, after all, is in the mind of the beholder, and an ontology will necessarily represent only the point of view of the ontology builder. An ontology, in short, will never be omniscient nor all-encompassing.

What follows examines two inherent aspects of Gruber's classic ontology definition: explicitly specified concepts and the relationships among them.

Explicitly Specified Concepts

The concepts, which represent selected aspects of reality in a formal ontology, are variously termed entities, objects, or elements. Concepts can represent concrete entities (books, cameras, toads, clouds), abstract notions (fictional places, ideas, theories), beliefs, processes, tasks, goals, events, states, or methods—in short, anything that needs to be modeled in the knowledge domain (the universe of discourse). Entities can further be specified to make explicit some chosen characteristics or attributes, such as color, size, price, manufacturer, location, name, and the like. Ontologists thus work with declarative representations, also termed declarative knowledge or declarative formalisms, because they are using descriptive logic to represent symbolically a selected set of real-world objects and events in their abstract models or knowledge representations.

Ontologies formally express concepts, not just words. For example, the word "cell" in an ontology must clearly represent its concept; ambiguity is not allowed. To disambiguate "cell," a polyseme or word with multiple meanings, the ontologist needs to create an unequivocal nomenclature that reflects accurately the usage context and the purpose of the ontology. The nomenclature must also be formalized, that is, rendered to allow the ontology to be set into formal notations used in first-order predicate logic that can be translated into any suitable programming language. Thus, the various possible meanings of cell, from biological (AnimalCell, PlantCell), to jail (JailCell), to phone (CellPhone), to electronic engineering (BatteryCell), must be indicated overtly and succinctly in the nomenclature of the concept itself.

In addition, the ontology should supply concept definitions in Natural Language sentences, and if appropriate declare the physical attributes of the elements being modeled. Thus, a communication ontology could focus on CellPhone attributes such as Manufacturer, UnitPrice, BatteryLife, Color, HasVideoCamera, ServiceProvider, CountryOfOrigin, and the like.

Relationships Among Concepts

The semantic relationships of the concepts must be clearly determined, and the antecedents or parents, as well as the children, of each concept must be established. Ontologies establish concept relationships primarily as is-a or part-of. Some further possible relationships could include isMemberOf, subscribesTo, overseesJointly, isAuthorOf, isCausedBy, and the like. This article focuses on the two primary relationships, is-a and part-of, as they form the core hierarchy of the ontology.

Is-a

In a truly formal ontology, the categories (classes) of aggregated concepts are related hierarchically in a specialization taxonomy: lower categories fall under higher categories in subsumption relationships. The backbone of an ontology is its taxonomy (Guarino & Welty, 2002; Daconta et al., 2003, p. 150), as that ineluctably establishes the concept relationships which must be rigorously enforced.

Historically, the epitome of practical categorization is the 18th century taxonomy of Linnaeus. The Linnaean principles of organization, relationship, and inheritance today inform our use of ontologies. Linnaeus classified plants and animals in taxa (groups or classes) with various delineated properties inherited by the organisms residing (instantiated) in the lowest taxa. The eight major categories proceed from the most general down to the instance of a species (instantiation): Kingdom, Phylum, Class, Subclass, Order, Family, Genus, and Species. Each category in the taxonomy inherits the qualities or attributes of its parent category (inheritance through nesting). For example, a human being (Genus: Homo, Species: Sapiens) inherits all the characteristics of its superordinate category "mammal," which inherits all the characteristics of its ultimate superordinate category "animal" (Daconta et al., 2003, p. 148). This process of going from the particular to the general is known as traversing a specialization hierarchy, going from the species to the genera, from the special case to the general case. A specialization hierarchy, then, is nothing more than a collection of carefully arranged is-a relationships. Thus, homo sapiens is a (belongs to the category) primate; a primate is a (belongs to the category) mammal; and a mammal is a(n) (belongs to the category) animal.

The same kind of taxonomy can be constructed using the concept vehicle, where instances of vehicle can be grouped a number of ways relevant to the domain of discussion. For example, vehicles could be classified as operating on land, sea, in the air, or in outer space. Land vehicles could be classified as trains, trucks, trolleys, automobiles, bicycles, scooters, and the like. Automobiles could be classified by make, model, year, and country of origin. What is happening in this classification process is that a concept or model is being explicitly "realized" as the classification becomes less abstract and more concrete. Ambiguity is eliminated by deriving explicit attributes that allow us to articulate clearly exclusive differences. Once these mutually exclusive differences are made explicit, various objects can be appropriately categorized. When categorized, the objects can be further defined to the point where a human being, computer program, or agent could perform simple or complex logical operations on the categorized instances. For example, if it is known that a Toyota Celica is a type of automobile, it is also known by inference that a Toyota Celica is a land vehicle and that land vehicles do not float or fly. Thus, it is categorically illogical—indeed silly—to express the hope to land a man on the moon using a Renaissance Red 1997 Toyota Celica GT Convertible.

Formal ontologies seeking rigor must be composed of concepts whose instances exist exclusively in their class location in the hierarchy. In defining a class, the ontologist seeks the necessary and sufficient characteristics or exclusive differentia that define the set of members in that class. An instance of one class should never reside simultaneously in other classes at the same level in the hierarchy (sibling classes). Often in fact, out of desperation, taxonomists will opt for this kind of polyhierarchy (placing a single instance in numerous sibling classes), but the purist tries always to avoid polyhierarchy, as the power of the specification is weakened. For example, in a taxonomy of fruits and vegetables, a truly rigorous ontology would classify the entity "tomato" as either a fruit or a vegetable, but not both. In defining the classes fruit and vegetable, the ontologist would be careful to articulate a definition, supply attributes, and provide constraints that would unequivocally differentiate fruits from vegetables. Then all members of each class would inherit these characteristics. If too many individual members of the class sets can live in either class (tomato is a fruit, tomato is a vegetable), then the ontology is ambiguous—less rigorous and less useful in describing the domain. A computer agent, forced to make a single choice, would not know how to proceed, simply because the agent cannot tolerate ambiguity. You might get a scoop of ice cream plopped on your tomato if the computer agent infers that tomatoes are fruits.

Part-of

Besides the is-a relationship, hierarchies can also express part-of relationships. This type of hierarchy is sometimes called an aggregation taxonomy (Daconta et al., 2003, p. 149), but more strictly speaking it should be termed a partonomy or composition hierarchy. Here is how an ontology of geography could represent hierarchically the part-of relationships of concepts.

The relationships in this partonomy are known as part-of relationships because lower elements in the hierarchy are part of higher elements; that is, a lot is part of a street, which is part of a neighborhood, which is part of a city, and so forth. In formal notation, this could be expressed as (is Part Of Street Lake Neighborhood 10) which in Natural Language is saying that Lake Street is located in neighborhood 10. This monocline subsumption of named concepts moves from the largest and most general term (World) in a progression that becomes increasingly and logically narrower until the smallest conceptual unit is reached (Lot). Note that every larger concept preceding a given concept must have characteristics or attributes that allow it to contain properly every concept lower and to the right. Thus, streets have as their direct parents neighborhoods and as their direct children lots. A city is subsumed under a county which is subsumed under a state.

What makes all of these relationships work ineluctably is the agreement among the ontology engineers about nomenclature (class names), lexicon (explicit definitions for what to include and exclude in each class—the differentia, based upon various qualities or attributes), and mereology (establishing a whole-part relationship from parent to child that pertains in the formalized partonomy). Partonomical hierarchies or mereologies (Simons, 1987) are used extensively in ontologies for medical informatics, bioinformatics, genetics, chemistry, and physics—any domain that must aggregate concepts according to their parts and constituents.

Other Key Elements of a Formal Ontology

As we have seen thus far, formal ontologies are characterized by their rigorous use of explicit definition and logical structure, which makes it possible for them to be shared and reused in various computer applications that need accurate and succinct information models for processing. To make computer processing possible, terms and their relationships in a formal ontology are often expressed in a first-order logic predicate calculus language such as Knowledge Interchange Format (KIF) or related languages such as LOOM, CycL, Classic, Flogic, KRIS, Ontolingua, or OWL. The ontology is encoded in such a way that computerized agents can access its knowledge representations to carry out some specified practical action. Figure 1 shows how an axiom stated in natural language might be encoded in KIF.

Sowa (2000) has further delineated formal ontologies into two subgroups: axiomatized and prototype based. The axiomatized ontology is characterized by its logical definitions and axioms (assumed truths) that ultimately have great power because they "can support more complex inferences and computations" (p. 493). As examples, Sowa cites "formal theories in science and mathematics, the collections of rules and frames in an expert system, and specifications of conceptual schemas in languages like SQL." In modeling a concept of reality, the axiomatized ontology carefully presents well-named concepts (the nomenclature) and well-defined concepts (the lexicon) arranged hierarchically to expose the ineluctable relationships of the concepts. Rules in the ontology allow for inferences to be drawn from the explicitly defined terms and relationships (Perez & Benjamins, 1999, p. 2).

Figure 1. Example of an axiom in KIF

This natural language statement:

If any two animals are siblings, then there exists someone who is the mother of both of them.

When axiomatized in KIF looks like this:

```
(=> (sibling ?sib1 ?sib2)
    (exists (?mom) (and (has-mother ?sib1 ?mom)
                        (has-mother ?sib2 ?mom)))
```

Source of KIF: Knowledge Systems Laboratory (KSL), Stanford University. *A Glossary of Ontology Terminology*. http://www-ksl-svc.stanford.edu:5915/doc/frame-editor/glossary-of-terms.html

The axiomatized ontology, as a "statement of a logical theory" (Gruber, 1993, p. 2), also contains some number of assertions, axioms (Figure 1), rules, constraints, theorems, functions, explanations in Natural Language, instances, or anything else that expresses descriptively what is allowed and disallowed to obtain in the ontology of the domain being specified.

Sowa's prototype-based ontology tends, unfortunately, to complicate the definition of formality. The prototype-based ontology does not contain axioms nor does it rely necessarily on logical definitions or theories. It is by and large simply a hierarchical arrangement of categories with sets of "typical instances or prototypes" (Sowa, 2000, p. 495). Prototype-based ontologies are commonly devoted to categorizing (cataloging) products, books, computer files, music, and the like. They fulfill an important function in e-business, e-commerce, the Internet, and the Semantic Web. Helping to clarify a specific distinction between formal and informal ontology, Gruber (1993) maintains more strictly than Sowa that all formal ontologies claiming "to specify a conceptualization" must have "axioms that do constrain the possible interpretations for the defined terms" (p. 2, note 1).

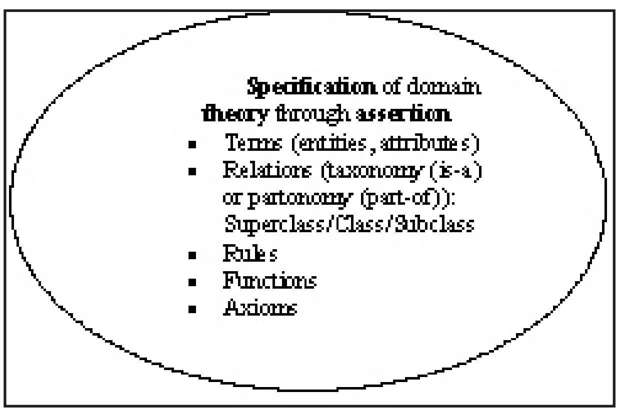
Much confusion about ontologies can be avoided if Gruber's distinctions are maintained. This strict definition of a formal ontology is depicted in Figure 2, a simplified schematic of a formal (axiomatized) ontology that specifies a universe of discourse (anything one chooses to model). The conceptualization of this domain is being specified through explicit assertion of the truths of the universe. Specification of a conceptualization in a formal ontology usually consists of all the bulleted items (and even more, if desired).

Sample Formal Ontologies

Formal ontologies are often divided into two basic types: foundational (also known as upper-level or top-level) and applied.

Foundational (upper- or top-level) ontologies specify conceptualizations that are more general and have universal applicability. They may focus on defining logical concepts, relationships, human understanding, and the like. Good examples of foundational ontologies include:

Figure 2. The conceptualization of a knowledge domain (Universe of Discourse)



- CYC top-level ontology: http://www.cyc.com/
- DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering): http://www.loa-cnr.it/DOLCE.html
- Generalized Upper Model (GUM): http://www.darmstadt.gmd.de/publish/komet/gen-um/newUM.html
- GOLD (General Ontology for Linguistic Description): http://emeld.douglass.arizona.edu:8080/index.html
- PhysSys (The Physical Systems Ontology):
  http://ksi.cpsc.ucalgary.ca/KAW/KAW96/borst/node2.html
- IEEE SUMO (Suggested Upper Merged Ontology): http://ontology.teknowledge.com/

Applied ontologies, which are domain specific, more strictly focus on a functional application related to a particular domain, such as enterprise modeling, knowledge management, chemistry, law, e-commerce, medicine, botany, and zoology. A few representative application fields and their actual ontologies include:

- Biology: Ontologies for Ethology—http://www.mesquiteproject.org/ontology/
- Business: The Open Source Business Process Management Ontology, BPMO—http://www. bpiresearch. com/Resources/RE_OSSOnt/re_ ossont. htm
- Knowledge Management: KM Ontology (under development), which "provides researchers with a relatively comprehensive, organized foundation and common language for studying KM. It gives practitioners a frame of reference for assessing KM practices and recognizing KM opportunities. It points toward a structure and content for developing a formal KM curriculum." (Holsapple & Joshi, 2004, p. 2)
- Manufacturing: The Process Specification Language Ontology, PSL—http://www.mel.nist.gov/psl/ontology.html
- Math: An Ontology for Engineering Mathematics—http://www.ksl.stanford.edu/knowledge-sharing/papers/engmath.html
- Medicine: Systematized Nomenclature of Medicine, SNOMED—http://www.snomed.org/

The vast majority of applied ontologies are proprietary and unavailable to the general public.

INFORMAL ONTOLOGY

"Informal ontologies" (Sowa 2000, p. 493), to a greater or lesser degree, have some of the characteristics of formal ontologies, particularly selected groups of terms or labels relevant to some topic or area of interest (a document collection, Web site, product catalog, or business area). When the components of the informal ontology are arranged hierarchically, they are often termed taxonomies (Verity's Classifier, http: // www.ultraseek.com /products /vcc/;InmagicClassifer,http://www. esprit soutronpartnership . com /Products /Classifier. asp), directories (Yahoo, http://www.yahoo.com; DMOZ, http://www.dmoz.com), subject-heading lists (Library of Congress Subject Headings, http://www.loc.gov/), or thesauri (Medical Subject Headings, MeSH®, http://www.nlm.nih.gov/mesh/). When including definitions, they may be called lexicons (WordNet, http://www.cogsci.princeton.edu/~wn/) or glossaries (Information Architecture Glossary, http://argus-acia.com/white_papers/iaglossary.html). If they are simply computer files containing sets of controlled terms, they may be called controlled vocabularies or synonym rings.

Informal ontologies, because of their weak semantics (term meanings), are incapable of rich expression (McGuiness, 2002; Daconta et al., 2003, pp. 157-167); they simply do not provide enough significant meaning about a knowledge domain. Compare the semantic richness, for example, of a well-explained scientific theory to the semantic poverty of a mere listing of chemistry terms.

While offering some control over the knowledge domain, informal ontologies cannot by themselves be used for automated purposes. Computer programs, agents, and applications may refer to them for various reasons, but the informal ontology itself does not have the power of a formal ontology. Informal ontologies are not driven overtly by logical constraints, are not formalized in a knowledge representation language, are not axiomatized—in short, they do not have the expressive power that may need to be harnessed for sophisticated purposes in academia, business, medicine, law, or government.

ISSUES, CONTROVERSIES, AND PROBLEMS

The literature has tried for years to define exactly what constitutes an ontology (Chandrasekaran, Josephson, & Benjamins, 1999; Daconta et al., 2003; Gruber, 1993; Gruber, 2003; Guarino & Welty, 1995; Heflin et al., 2002; McGuiness, 2002; Noy & McGuinness, 2001; Sheth & Ramakrishnan, 2003; Smith, 2004; Sowa, 2000). While this article has presented the consensus view as depicted in the literature, the concept of ontology is still very slippery. For example, vendors, IT professionals, knowledge management experts, and technicians often erroneously equate simple taxonomies with formal ontologies. While a formal ontology contains a taxonomy or partonomy in expressing the relationships of the concepts, a taxonomy or partonomy is only a part of the formal ontology. A formal ontology also includes community-shared definitions, rules, and axioms.

Ontology has also been equated with Web directories such as DMOZ and Yahoo, neither of which is, strictly speaking, a formal ontology. Both employ rough classification schemes (loose aggregations) to order groups and subgroups of Internet resources, but again they do not provide concept definitions, rules, or axioms. Thus, to see those very rough schemes as formal ontologies is to abuse the term. They are simply directories. Lists of controlled words, glossaries, and thesauri are also often erroneously termed formal ontologies, but should be seen more properly only as potential parts of formal ontologies.

People often confuse terminological ontologies (Sowa, 2000) with formal ontologies. Thus, WordNet and Sensus are lexicons, not strictly formal ontologies. They contain words, their definitions, their relationship to other words in the hierarchy (in WordNet these are synonym sets), and part-whole (mereological) distinctions, but the definitions are not always complete, the taxonomic structure is faulty at many points (Guarino & Welty, 2002), and the collections are usually not axiomatized. Terminological ontologies have their uses, certainly, but primarily as starting points for more rigorous and limited formal ontological applications.

Formal ontological rigor is not easy to establish. One of the main stumbling blocks in establishing rigor is modeling the formal ontology to reflect strict and mutually exclusive is-a relationships in a specification hierarchy and not confusing is-a relationships with part-of relationships. The work of Guarino and Welty (2002) is dedicated to exposing these kinds of identity and subsumption weaknesses in formal ontologies. The less rigor a formal ontology has, the less value it has in accurately and unambiguously depicting a knowledge domain. This is not to say, however, that informal or semi-formal ontologies have no value; indeed, they may well meet many general and large-scale information needs, especially as we look forward to increasing numbers of ontology applications on the Semantic Web (Sheth & Ramakrishnan, 2003; Gruber, 2003).

Because so much of formal ontology building is still an art rather than a science (Abou-Zeid 2003; Gruber 1993; Gruninger & Fox, 1995; Guarino & Giaretta, 1995; Perez & Benjamins, 1999), even formal ontologies are selectively based on subjective choices. Ontologies, therefore, are capable only of representing the knowledge (specifying the concepts) that humans provide. If the ontology builders are not domain experts; if they make knowledge representation choices for political, organizational, or personal reasons rather than sound ontological reasons; if they omit important elements, attributes, or axioms because they rush to publication; if they construct the ontology based on the limitations of the programming language with which they are familiar (encoding bias); if they do not adequately understand the purpose and the audience for the ontology; if they fail to standardize their nomenclature; if they choose to model too much or model too little, their ontology is very likely doomed to fail.

How might these issues be avoided and these problems be solved? Only by establishing and following clear guidelines and standards in constructing ontologies will we ever hope to realize the full potential of the major initiatives in which ontologies play such a fundamental role. Much work remains to be done in standardization and implementation technologies, but much is at stake. If the Semantic Web, distributed global knowledge management initiatives, and the various application projects underway in areas such as e-business, government, publishing, Artificial Intelligence, and medical informatics are to be successful on a large scale, they will have to be buttressed by well-designed ontologies.

CONCLUSION

This article discusses the philosophical origins and modern practical implementations of ontology. For easier understanding, approaches to ontology building were divided into formal and informal. Formal ontologies were explained, focusing in particular on specifying concepts by establishing relationships through is-a and part-of approaches. The other components of a formal ontology were briefly mentioned. Informal ontologies were defined and contrasted with formal ontologies. Finally, issues, controversies, and problems in the implementation of ontologies were briefly explored.

Ontologies will continue to play an important role in the development of large-scale, computer mediated, and global knowledge management projects. Communicating knowledge within an organization, and among organizations worldwide, will be facilitated by ontologies, as they create a knowledge layer critical to the automated sharing and reuse of essential explicit knowledge.

The research agenda in ontologies includes solving many of the technical problems that bedevil organizations at the application level, developing stable and standard methodologies and tools to move ontology construction out of the area of art and into that of science (ontological engineering), and continuing to hone the theoretical insights that will allow construction and implementation of rigorous high-level and application-level ontologies.

REFERENCES

Abou-Zeid, E. (2003). What can ontologists learn from knowledge management? *The Journal of Computer Information Systems, 43*(3), 109-118.

Chandrasekaran, B., Josephson, J.R., & Benjamins, V.R. (1999). What are ontologies, and why do we need them? *IEEE Intelligent Systems & Their Applications, 14*(1), 20-26.

Daconta, M.J., Obrst, L.J., & Smith, K.T. (2003). *The Semantic Web: A guide to the future of XML,* *Web services, and knowledge management*. Indianapolis: John Wiley & Sons.

Fensel, D. (2001). *Ontologies: A silver bullet for knowledge management and electronic commerce*. Berlin: Springer-Verlag.

Gruber, T. (1993). Toward principles for the design of ontologies used for knowledge sharing. In N. Guarino & R. Poli (Eds.), *Formal ontology in conceptual analysis and knowledge representation*. Dordrecht: Kluwer Academic. Retrieved November 24, 2004, from http://www-ksl.stanford.edu/kst/what-is-an-ontology.html

Gruber, T. (2003). It is what it does: The pragmatics of ontology. *Proceedings of Sharing Knowledge—International CIDOC CRM Symposium*, Washington, DC. Retrieved November 24, 2004, from http://cidoc.ics.forth.gr/docs/symposium_presentations/gruber_cidoc-ontology-2003.pdf

Gruninger, M., & Fox, M.S. (1995). *Methodology for the design and evaluation of ontologies*. Retrieved November 24, 2004, from http://www.eil.utoronto.ca/enterprise-modelling/papers/gruninger-ijcai95.pdf

Guarino, N., & Giaretta, P. (1995). Ontologies and knowledge bases: Towards a terminological clarification. "Slightly amended version of a paper" published in N. Mars (Ed.), *Towards very large knowledge bases*. Amsterdam: IOS Press. Retrieved November 24, 2004, from http://www.loa-cnr.it/Papers/KBKS95.pdf

Guarino, N., & Welty, C. (2002). Evaluating ontological decisions with Ontoclean. *Communications of the ACM, 45*(2), 61-65.

Heflin, J., Volz, R., & Dale, J. (2004, February 10). *OWL Web Ontology Language use cases and requirements: W3C recommendation*. Retrieved November 24, 2004, from http://www.w3.org/TR/webont-req/

Holsapple, C.W., & Joshi, K.D. (2004). A formal knowledge management ontology: Conduct, activities, resources, and influences. *Journal of the American Society for Information Science and Technology, 55*(7), 593-612.

Knowledge Systems Laboratory (KSL). (n.d.). *A glossary of ontology terminology*. Retrieved November 24, 2004, from http://www-ksl-svc.stanford.edu:5915/doc/frame-editor/glossary-of-terms.html

Mayhew, D., & Siebert, D. (2004). Ontology: The discipline and the tool. In G. Büchel, B. Klein, & T. Roth-Berghofer (Eds.), *Proceedings of the First Workshop on Philosophy and Informatics* (pp. 57-64). Deutsches Forschungszentrum für künstliche Intelligenz, Cologne. Retrieved November 24, 2004 from http://www.ifomis.de/Research/Publications/Mayhew_Siebert__OntologyDisciplineAndTool.pdf

McGuiness, D. (2002). Ontologies come of age. In D. Fensel, J. Hendler, H. Lieberman, & W. Wahlster (Eds.), *Spinning the Semantic Web: Bringing the World Wide Web to its full potential*. Cambridge, MA: MIT Press. Retrieved November 24, 2004, from http://www.ksl.stanford.edu/people/dlm/papers/ontologies-come-of-age-mit-press-(with-citation).htm

Mika, P., & Akkermans, H. (2004). Towards a new synthesis of ontology technology and knowledge management. Submitted to *Knowledge Engineering Review*, (April). Retrieved November 24, 2004, from http://www.cs.vu.nl/~pmika/research/papers/IR-BI-001.pdf

Noy, N.F., & McGuinness, D. (2001). *Ontology development 101: A guide to creating your first ontology*. Retrieved November 24, 2004, from http://www-smi.stanford.edu/pubs/SMI_Reports/SMI-2001-0880.pdf

O'Leary, D. (1998). Enterprise knowledge management. *IEEE Computer, 31*(3), 54-61.

Sheth, A., & Ramakrishnan, C. (2003). Semantic (Web) technology in action: Ontology driven information systems for search, integration and analysis. *Making the Semantic Web Real in IEEE Data Engineering Bulletin*, *26*(4), 40-48. Retrieved November 24, 2004, from http://wwwt.semagix.com/documents/SemanticWeb Techin-Action.pdf

Simons, P. (1987). *Parts: A study in ontology.* Oxford: Oxford University Press.

Smith, B. (2004). *Ontology and information systems.* Retrieved November 24, 2004, from http://ontology. buffalo.edu/ontology.doc

Sowa, J. (2000). *Knowledge representation: Logical, philosophical, and computational foundations.* Pacific Grove, CA: Brooks/Cole Thomson Learning.

Van der Vet, P.E., & Mars, N.J.I. (1998). Bottom-up construction of ontologies. *IEEE Transactions on Knowledge and Data Engineering, 10*(4), 513-526.

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Chapter 7.13
A View on Knowledge Management:
Utilizing a Balanced Scorecard Methodology for Analyzing Knowledge Metrics

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ABSTRACT

IT professionals who want to deploy foundation technologies such as groupware, CRM or decision support tools, but fail to justify them on the basis of their contribution to Knowledge Management, may find it difficult to get funding unless they can frame the benefits within a Knowledge Management context. Determining Knowledge Management's pervasiveness and impact is analogous to measuring the contribution of marketing, employee development, or any other management or organizational competency. This chapter addresses the problem of developing measurement models for Knowledge Management metrics and discusses what current Knowledge Management metrics are in use, and examines their sustainability and soundness in assessing knowledge utilization and retention of generating revenue. The chapter discusses the use of a Balanced Scorecard approach to determine a business-oriented relationship between strategic Knowledge Management usage and IT strategy and implementation.

INTRODUCTION

"Knowledge has become the key economic resource and the dominate — and perhaps even the

only- source of competitive advantage." Peter Drucker, Managing in a Time of Great Change (1995)

Knowledge Management may be defined as a set of processes for transferring intellectual capital to value – processes such as innovation and knowledge creation and knowledge acquisition, organization, application, sharing, and replenishment (Knapp, 1998). Enterprises work in generating value from knowledge assets by sharing them among employees, departments and even with other companies in an effort to devise best practices.

From the point of view of information technology (IT) investment, it is important to note that the definition itself says nothing about technology; while Knowledge Management is often facilitated by IT technology, by itself it is not Knowledge Management.

"Now that knowledge is taking the place of capital as the driving force in organizations worldwide, it is all too easy to confuse data with knowledge and information with information technology." Peter Drucker, Managing in a Time of Great Change (1995)

The definition of knowledge is a complex and controversial one, and 'knowledge' can be interpreted in many different ways. Much of the Knowledge Management literature defines knowledge in broad terms, covering basically all the "software" of an organization. This involves the structured data, patents, programs and procedures, as well as the more intangible knowledge and capabilities of the people. It may also include the way that organizations function, communicate, analyze situations, come up with novel solutions to problems and develop new ways of doing business. Knowledge Management in an organization can also involve issues of culture, custom, values and skills as well as the enterprise's relationships with its suppliers and customers. Knowledge Management is a strategic, systematic program to capitalize on what an organization "knows" (Knapp, 1998).

Managerial interest in Knowledge Management stems from a number of economic facts about knowledge utilization in today's environment. These facts are shown in Figure 1.

- Long-run shifts in advanced industrial economies which have led to the increasingly widespread perception of knowledge as an important organizational asset.

Figure 1. Economic reasons for the interest in knowledge management (KPMG Consulting, 2000)

- Long-run shifts in advanced industrial economies that have led to the increasingly widespread perception of knowledge as an important organizational asset.
- The rise of occupations based on the creation and use of knowledge.
- Theoretical developments -- for example, the resource-based view of the firm -- which emphasize the importance of unique and inimitable assets such as tacit knowledge.
- The convergence of information and communication technologies, and the advent of new tools such as Intranets and groupware systems.
- A new wave approach to packaging and promoting consultancy services in the wake of the rise and fall of Business Process Reengineering (BPR).

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Organizational requirements for Knowledge Management involve leveraging intellectual capital, not just retaining it, which requires attention to what have been recognized as "knowledge enablers", i.e., structures and attributes that must be in place for a successful Knowledge Management program. Besides technology, these enablers include content, learning, culture and leadership (KPMG Consulting, 2000). In order to measure Knowledge Management, some attention needs to be paid to measurement of the enabling factors as well.

The chapter discusses two possible sets of metrics, containing both qualitative and quantitative components, to aid management in understanding Knowledge Management initiatives and the necessary IT investments in relation to the company's strategic direction. This chapter addresses the question: What set of industry standard metrics, containing both hard and soft elements, can be adapted for use in Knowledge Management initiatives?

The chapter first explores literature on current Knowledge Management metrics. It then examines, from published research, how Knowledge Management is viewed in organizations to examine the sustainability and soundness in metrics that assess knowledge utilization and retention of generating revenue. It then creates an extension of the Balanced Scorecard framework in terms of two possible perspectives, so as to address Knowledge Management metrics. The conclusion of the chapter ties the Knowledge Management perspectives suggested in this research to the original intent of a Balanced Scorecard so as to show the relationship to strategy.

BACKGROUND ON KNOWLEDGE MANAGEMENT

How is Knowledge Management Measured?

A number of Knowledge Management thought leaders, such as Larry Prusak and Thomas Davenport, have stated a belief that it is impossible to develop direct, meaningful measures of knowledge assets. They believe it is possible to measure only the outputs of knowledge, given that knowledge is, by definition, intangible and therefore unobservable. But by developing an understanding of what makes a "unit" of knowledge, one might be able to create the necessary relationship between knowledge and the value it creates for the organization.

Although the focus on corporate culture and organizational change may extend the timeframe for a Knowledge Management program, only measurable benefits justify increased duration and cost in the eyes of senior management. Those benefits include better preparation for implementation and the ability to take advantage of existing technology.

Knowledge Management investments are thus likely to include the extension of existing enterprise software to eliminate barriers between transactional applications and repositories of corporate knowledge. Increasingly, companies will exploit corporate knowledge and provide it to users within the context of business problems, a more effective alternative to simply storing this content in and accessing it from a centralized knowledge repository (Dyer & McDonough, 2001). Given that there is no clear single activity that is Knowledge Management, it is more how and when Knowledge Management is integrated into organizational activities that can be measured.

In general, however, intellectual and knowledge-based assets fall into one of two categories: explicit or tacit. Included among the former are assets such as patents, trademarks, business plans, marketing research and customer lists. Generally, explicit knowledge consists of anything that can be documented, archived and codified, often with the help of IT. Much harder to grasp is the concept of tacit knowledge, or the know-how contained in people's heads. The challenge inherent with tacit knowledge is figuring out how to recognize, generate, share and manage it. While IT in the form of e-mail, groupware, instant messaging and related technologies can help facilitate the dissemination of tacit knowledge, identifying tacit knowledge in the first place is a major hurdle for most organizations (Surmacz & Santosus, 2001).

A recent Platinum Technologies study found that only 20% of Knowledge Management programs have used some form of metrics on how business performance is influenced. This may be that traditionalist management who use ROI for calculations have to find an appropriate equation for Knowledge Management (Shand, 1999). Platinum Technologies developed a method that was two parts hard, or quantifiable, measurement and one part soft, or more qualitative, measurement. By consolidating and better managing the different delivery channels for sales and marketing, Platinum significantly reduced the costs of maintaining and distributing collateral. This represents a hard and indisputable measure. The other third (the "soft" measure) resulted from increases in sales productivity, a measure with less clear impact on revenue. Senior management appreciated the difference between these hard and soft measures, especially the lesser emphasis on a metric that could be easily contested. This appreciation needs to be considered when assessing harder metric methods like return on investment (ROI) (Shand, 1999).

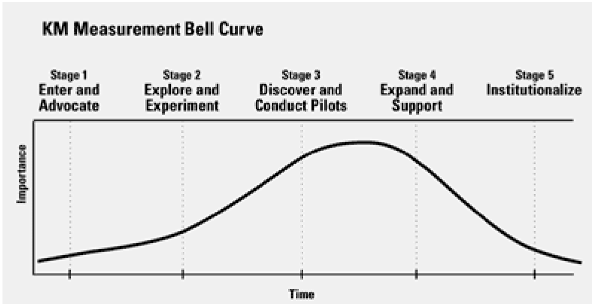
When is Knowledge Management Measured?

Figure 2 emerged from observing the numerous organizations that participated in an American Productivity and Quality Center (APQC) project (2001) and how they measure the value of Knowledge Management. During its 2000 consortium learning forum entitled 'Successfully Implementing Knowledge Management', APQC focused on how some of the most advanced early Knowledge Management adopters implement a Knowledge Management initiative, mobilize resources, create a business case, and measure and evolve their Knowledge Management programs. This multi-client benchmarking project helped APQC and project participants identify measurement approaches, specific measures in use, and how measures impact and are impacted by the evolution of Knowledge Management.

In the earliest stages of Knowledge Management implementation, formal measurement rarely takes place, nor is it required (APQC, 2001). As Knowledge Management becomes more structured and widespread and companies move into Stages Two, Three, and Four, the need for measurement steadily increases. As Knowledge Management becomes institutionalized — a way of doing business — the importance of Knowledge Management-specific measures diminishes, and the need to measure the effectiveness of knowledge-intensive business processes replaces them.

According to the APQC, the key is to begin to ensure that direct business value is perceived by the organization as a result of the knowledge-enabling projects. During its 2000 consortium learning forum entitled 'Successfully Implementing Knowledge Management', APQC focused on how some of the most advanced early Knowledge Management adopters implement a Knowledge

Figure 2. APQC project



Management initiative, mobilize resources, create a business case, and measure and evolve their Knowledge Management programs. This multi-client benchmarking project helped APQC and project participants identify measurement approaches, specific measures in use, and how measures impact and are impacted by the evolution of Knowledge Management.

The APQC Knowledge Management Measurement Bell Curve can be seen to parallel the five stages of the IT Balanced Scorecard (BSC) Maturity Model developed by Van Grembergen and Saull (2000), in that as the use of Knowledge Management matures in the organization, defined and managed measurement processes develop and become linked to business process cycles. The Van Grembergen and Saull (2000) IT BSC Maturity Model highlights five maturity levels (Initial, Repeatable, Defined, Managed and Optimized) to classify to what extent the IT BSC Maturity Model is integrated into the strategic and operational planning and review systems of the business and IT.

As seen from the APQC data, it is important to establish a mechanism to capture the hard and soft lessons learned in the Knowledge Management pilots with their initial IT investments, as these will be the building blocks for the later Knowledge Management implementations (APQC, 2001).

CHALLENGES IN DEVELOPING KNOWLEDGE MANAGEMENT METRICS

Knowledge Management Diversity of Practice

The economic facts listed in the Introduction section may help to explain the breadth of interest in Knowledge Management ranging across many different industrial sectors. They also can help to explain the diversity in the actual practices which have been labeled as Knowledge Management (KPMG Consulting, 2000). Although such practices share a common interest in targeting knowledge rather than information or data, they tend to perform distinctively different functions depending on the business context. Therefore, measuring the impact of these different functions on the business potentially requires different approaches.

One may distinguish between at least four different types of Knowledge Management (Business Process Resource Centre, 2001; Sveiby, 2001a):

Valuing Knowledge. This approach is of interest in consulting firms and financial institutions — for example, the Skandia organization — and in management accounting areas. Knowledge is viewed as 'intellectual capital', and the focus is on quantifying and recognizing the value of the organization's knowledge-base.

An example of this approach would be PLS-Consult in Denmark, who categorizes customers according to value of knowledge contribution to the firm and follows up in its management information system.

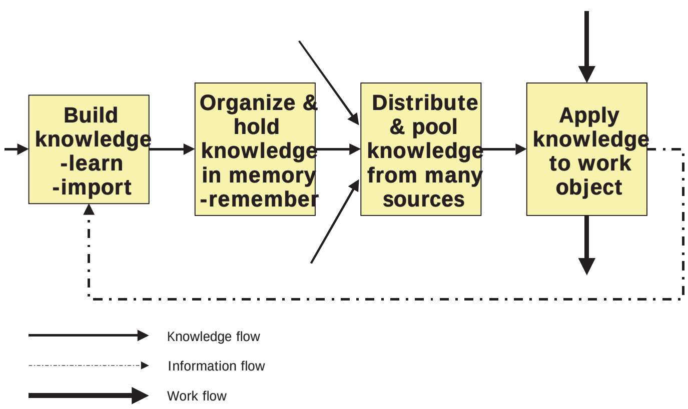
Exploiting Intellectual Property. This approach appeals to firms with a strong science and R&D base — typified by a number of pharmaceutical firms, the Buckman Labs organization, and so on — which are looking beyond the conventional approach based on patents, etc. to more effective ways of tapping into the commercial value of their existing knowledge-base.

An example of this approach would be the development of the Boeing 777, which was the first "paperless" development of aircraft. It included customers in design teams, with more than 200 teams with a wide range of skills who both designed and constructed sub parts, rather than the usual separated organization of design team and construction team. Suppliers world-wide used the same digital databases as Boeing.

Capturing Project-Based Learning. As firms increasingly move towards innovation and project-based organization, many are recognizing the need to capture the learning from individual projects and make it available throughout the organization. Consultancies, professional service firms, aerospace companies, etc., are in the vanguard of developing systems to codify and communicate such knowledge. The client who initiated this research effort also looks at Knowledge Management in this respect.

An example of this approach can be seen in the use of Knowledge Management by firms such as McKinsey and Bain & Co. These two management consulting firms

Figure 3. Four stages of knowledge transition (Wiig, 1997)



have developed 'knowledge databases' that contain experiences from every assignment, including names of team members and client reactions. Each team must appoint a 'historian' to document the work.

Managing Knowledge Workers. The shift towards knowledge work in many sectors creates problems for traditional ways of managing and motivating employees. In many firms, Knowledge Management reflects managers' desire to increase the productivity of knowledge workers, breaking down some of the barriers to knowledge-sharing which are associated with 'professionalism' (BPRC, 2001).

An example of this approach can be seen at Analog Devices in the US. CEO Ray Stata initiated a breakdown of functional barriers and competitive atmosphere and created a collaborative knowledge sharing culture from the top down. The company encourages a 'community of inquirers' rather than a 'community of advocates'.

Why the different methods of viewing Knowledge Management is important is related to the knowledge, information and work flows associated with each type of Knowledge Management, as shown in Figure 3.

Knowledge Management and IT Investment

The impact of Knowledge Management on IT investment can be related to the effect that each Knowledge Management initiative will have on increased costs of deployed services and technology tools. Based on a 2001 survey of 566 respondents done together by KM magazine and market research firm IDC, these survey results estimate that an average Knowledge Management budget will increase from $632,000 in 2000 to more than $1 million in 2002. These figures fall lower than expected, according to IDC, because two-fifths of the respondents represented companies with 500 or fewer employees, which shows the pervasiveness of the Knowledge Management concept into the reaches of the small and medium size businesses. Past data that emphasized larger companies showed an average budget of $2.7 million in 2000.

IDC believes from this survey that the budgets specifically designated for "Knowledge Management" initiatives decrease as these efforts become part of other technology or business process investments (Dyer & McDonough, 2001). For example, a company may perceive itself as investing in a customer service solution, though one with significant Knowledge Management capability, rather than categorize this investment as a Knowledge Management initiative. This again shows a need for measuring Knowledge Management and associated IT investment in a way to show its role in the organizational structure, benefiting business processes.

Measuring these roles via the Balanced Scorecard approach has already been established for evaluating IT and its investments, as Gold (1992) and Willcocks (1995) have already indicated in a conceptual manner and that has been further developed by Van Grembergen and Van Bruggen (1997), Van Grembergen and Timmerman (1998) and Van Grembergen (2000). Extending this Balanced Scorecard approach to the Knowledge Management environment would assist companies in understanding the use of Knowledge Management in relation to their knowledge capital resources, including IT implementation.

CONNECTION BETWEEN KNOWLEDGE MANAGEMENT METRICS DEVELOPMENT AND A BUSINESS PROCESS VIEW OF KNOWLEDGE MANAGEMENT

Irrespective of the terms used, the practical management objectives of measuring Knowledge

Management are similar: to find out how well the organization has converted human capital (individual learning/team capabilities) to structural capital (organizational knowledge or 'what is left when people go home', such as documented processes and knowledge bases) and thereby moved from tacit to explicit knowledge, and reduced the risk of losing valuable knowledge if people leave the organization. Loss of 'corporate memory' as a result of downsizing is one of the prime reasons given for adopting formal Knowledge Management practices. Other factors often mentioned include global competition and the pace of change; organizations see Knowledge Management as a means of avoiding repetition of mistakes, reducing duplication of effort, saving time on problem-solving, stimulating innovation and creativity, and getting closer to their customers (Corrall, 1999).

For all the interest and money spent on Knowledge Management there seems to be relatively few attempts to actually quantify the impact and results in business terms. The rationale is that knowledge exists in the context of its use (Svoika, 2001). Superior Knowledge Management frees companies to operate on fewer assets, collect their cash faster and have less volatility. The challenge is to make sure that the scope and the goal of the process is clear and focused, by providing a method to display indicators that measure objectives and are focused on the mission as set by the management. Given that Knowledge Management requires a mix of technical, organizational and interpersonal skills, the mix and emphasis varies according to responsibilities, but everyone involved needs to be able to understand the business and communicate business needs effectively, one approach to do this for Knowledge Management could be the Balanced Scorecard.

Van Grembergen and Timmerman (1998) and Martinsons, Davison and Tse (1999) were some of the first to have suggested that the Balanced Scorecard can be the foundation for the strategic management of information systems in organizations. Martinsons et al. (1999) use the Balanced Scorecard metrics to guide attainment of efficiency and effectiveness not only of information systems development but also of the use of the resulting information systems products in the operation of the business. They propose adaptations of the Balanced Scorecard framework based on the premise that IT is essentially an internal support function within an organization in contrast to the original framework, which focused on the impact of the business on the external market. The same analogy might be used for Knowledge Management, given that knowledge supports the activities of the organization.

POSSIBLE SOLUTION OF UTILIZING BALANCED SCORECARD TO KNOWLEDGE MANAGEMENT METRICS

Rationale for Balanced Scorecard in Knowledge Management

In their book, The Balanced Scorecard, Kaplan and Norton (1996) set forth a hypothesis about the chain of cause and effect that leads to strategic success. Kaplan and Norton (1996) have introduced the Balanced Scorecard at an enterprise level. Their fundamental premise is that the evaluation of a firm should not be restricted to a traditional financial evaluation but should be supplemented with measures concerning customer satisfaction, internal processes and the ability to innovate. Kaplan and Norton (1996) distinguish Financial, Internal, Customer, and Learning and Growth perspectives on organizational processes essential to an overall strategy. In looking at the original Kaplan and Norton (1996) implementation, Knowledge Management clearly fits within, if it does not define, the Learning and Growth aspect of their framework. If this is true, Knowledge Management outputs will impact on other processes. This is one reason why the significance in measuring Knowledge Management benefits or costs to other processes in organizations is an important area for extending the present Kaplan and Norton work (Firestone, 1998). Managers can track measures as they work toward their objectives, and measurement metrics aid in showing how to build internal capacity, such as human capital, tacit knowledge, and a knowledge culture. And a metrics framework keeps measures from being ad hoc, providing a reference point for Knowledge Management measurement after an implementation.

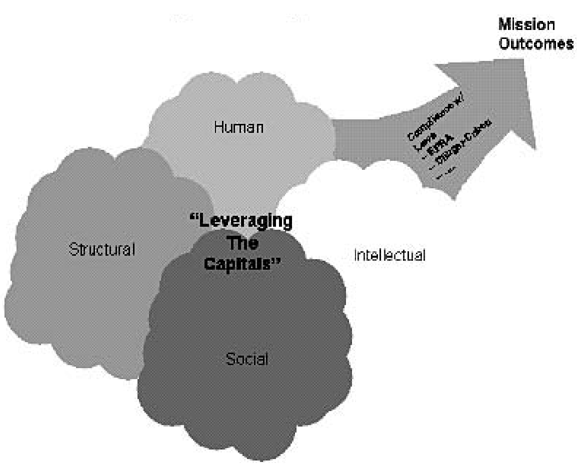
Use of Perspectives in Knowledge Management

Perhaps the key to proper initiatives and drivers is selecting the right perspectives, to use the Kaplan and Norton phrase, to view the interaction between Knowledge Management and the organizational strategy. This paper suggests that there might be two unique approaches to perspectives that would enhance the measurement of Knowledge Management in the organization.

First Approach. The first approach would be to use the different types of capital available in an organization, as shown in Figure 4, to be the four different scorecard perspectives of how Knowledge Management is leveraged in the organization. This approach is already in use in areas such as the US government, who is empowered to these Knowledge Management initiatives by the Clinger-Cohen Act of 1996 (Public Law 104-106), formerly known as the IT Management Reform Act. This Act requires CIOs in government to focus on the core competencies which represent skills and knowledge needed for effective mission support using information technologies. The four capitals which make up a knowledge-centric organization (KCO) are (Neilson, 2000):

- Human capital is all individual capabilities, the knowledge, skill and experience of the employees and managers.
- Intellectual capital includes the intangibles such as information, knowledge and skills that can be leveraged by an organization to produce an asset of equal or greater importance than land, labor and capital.
- Structural capital includes the processes, structures and systems that a firm owns less its people.
- Social capital is the goodwill resulting from physical and virtual interchanges between people with like interests and who are willing to share ideas within groups who share their interests.

Figure 4. Leveraging knowledge management with balanced scorecard



The dynamic mixing of human, intellectual, social and structural capital provides the fuel for creating and using knowledge. As retention and recruitment are major concerns in both public and private industry, an organization's success in leveraging its knowledge capital will ensure an organization remains competitive. The four capitals shown in the diagram can be directly related to the traditional Balanced Scorecard method in the following manner, shown in Table 1.

As seen in financial and other 'hard' measurements, when it comes to numbers, all sorts of

Table 1. KCO method

Balanced Scorecard Perspective	Generic measures	Intellectual Capital Perspective	Generic measures
Financial	ROI, EVA	Intellectual	A wide variety of measures exist. See Table 2.
Customer	Satisfaction, retention, market and account share	Social	Social capital was originally defined and measured by the World Bank in terms that related entirely to density of horizontally organized social networks, subsequent investigations have resulted in complicating any such straightforward measurement. A variety of measures exist, one interesting one from Cap Gemini Ernst & Young and Henley College is called the KOPE survey. This covers the following categories: Knowledge Management strategy and link to business (K), organizational and cultural enablers (O), process enablers (P) and enabling technologies (E). For each of these categories there are between 10 and 13 dimensions. The survey has been designed to allow organizations to identify strengths and weaknesses in their Knowledge Management practices (Truch, 2001).
Internal	Quality, response time, cost and new product introductions	Structural	Andriessen & Tiessen's (2000) Value Explorer™ is an accounting methodology proposed by KPMG for calculating and allocating value to 5 types of intangibles: (1) Assets and endowments, (2) Skills & tacit knowledge, (3) Collective values and norms, (4) Technology and explicit knowledge, (5) Primary and management processes.
Learning and Growth	Employee satisfaction, IS availability	Human	From the work of Jac Fitz-Enz (1994), Human Capital Intelligence sets of human capital indicators are collected and benchmarked against a database. Similar to HRCA (Johansson, 1996), which calculates the hidden impact of HR related costs that reduce a firm's profits.

measurements come out of the woodwork. Table 2 is a listing of various IC measurements compiled by Karl Erik Sveiby, one of the predominant academics in this field.

Edvinsson and Malone (1997) measure intellectual capital with an 'all-encompassing' reporting model. They assume that if enough aspects of intellectual capital can be captured, one can have a 'complete' understanding on the utilization. What is missing from their approach is an integrated framework to show how the indicators are related. This is where an approach such as Balanced Scorecard can be useful. However, Sveiby (1997) claims his Intangible Asset Monitor is a more suitable approach for Knowledge Management than Balanced Scorecard, based on its notion of a 'knowledge perspective' of a firm. Thus he believes his Intangible Asset Monitor becomes

Table 2. Types of intellectual capital measurement (Sveiby, 1997)

Authors	Name of Measurement	Description
Edvinsson and Malone (1997)	Skandia Navigator™	Intellectual capital is measured through the analysis of up to 164 metric measures (91 intellectually based and 73 traditional metrics) that cover five components: (1) financial; (2) customer; (3) process; (4) renewal and development; and (5) human.
Lev (2001)	Value Chain Scoreboard™	Matrix of non-financial indicators arranged into three categories according to the cycle of development: Discovery/Learning, Implementation, and Commercialization.
Roos, Roos, Dragonetti and Edvinsson (1997)	IC-Index™	Consolidates all individual indicators representing intellectual properties and components into a single index. Changes in the index are then related to changes in the firm's market valuation.
Pulic (2000)	Value Added Intellectual Coefficient (VAIC™)	Measures how much and how efficiently intellectual capital and capital employed create value based on the relationship to three major components: (1) capital employed; (2) human capital; and (3) structural capital.
Sveiby (1997)	Intangible Asset Monitor	Management selects indicators, based on the strategic objectives of the firm, to measure four major components of intangible assets: (1) growth; (2) renewal; (3) efficiency; and (4) stability.

a more demanding option for a management team; to get the best value, one should start by redesigning the strategy to be more 'knowledge focused'. Both approaches are fine for firms such as consulting houses and other service-oriented industries that focus on utilizing human capital. It is difficult to assume that other firms will have been converted enough to Knowledge Management to be knowledge-centric in their strategy. Therefore, we turn to our other suggestion, using a resource-based management approach.

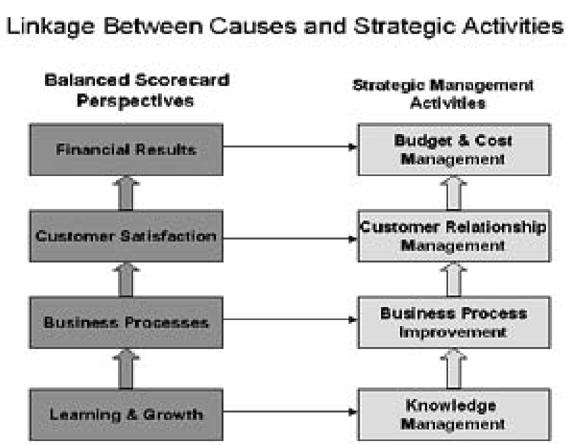
Second Approach. The other approach possible in viewing the role of Knowledge Management in organizational strategy via a Balanced Scorecard would be to use a resource management-based approach, focusing on intellectual capital resources combined with business processes of the organization. This is based on the work of Mouristen et al. (2001) at the Copenhagen Business School, using the work on intellectual capital balance statements of Sveiby (1997). Table 3 correlates this approach to the Balanced Scorecard perspectives of Kaplan and Norton (1992).

To tie the use of Knowledge Management into an organization, using either method, the relationship between Knowledge Management and organizational strategy must be understood and goals clearly defined. Figure 5 demonstrates the relationship between business processes in Balanced Scorecard terminology, and the use of Knowledge Management in an organization.

Table 3. Intellectual capital resources in a balanced scorecard approach

Balanced Scorecard Perspective	Generic measures	Intellectual Capital Statements (Mouristen et al., 2001)	Generic measures
Financial	ROI, EVA	Employees	Measurement of intellectual capital, as discussed above in Table 3.
Customer	Satisfaction, retention, market and account share	Customers	Customer satisfaction with 'quality of service' and product, related to Knowledge Management efforts
Internal	Quality, response time, cost and new product introductions	Processes	Internal hours on Knowledge Management process improvement, average response times for information gathered using Knowledge Management
Learning and Growth	Employee satisfaction, IS availability	Technology	Investment in Knowledge Management technology, number of hits on Knowledge Management project web sites, employee satisfaction with Knowledge Management project sites

Figure 5. Knowledge management linkage: Cause and activity



Correlating Knowledge Management Metrics to Strategy

Both of the suggested approaches above make use of such concepts as intellectual capital and the value of core processes in the organization. The rationale for this is that intellectual capital as a concept says more about the future earning capabilities of a company than any of the conventional performance measures we currently use (Roos, 1996). Kaplan and Norton (1996) discuss using Balanced Scorecard measures for assessing potential investment. In creating a mechanism that ties long-term objectives into measurable metrics, they claim that executives can see the relationship between investment and strategic plans. But should knowledge be considered a cost element, or a revenue generator? This is one challenge in using the Balanced Scorecard versus other mechanisms in industry. Until we view business processes in other ways than the traditional production function (input, output), approaches such as the Balanced Scorecard are still valid in the knowledge economy.

But there is also an element of debate of whether Balanced Scorecard mechanisms help promote the use of knowledge in organizations. Kaplan and Norton (1996) in their approach did not question the foundation of 'what constitutes a firm', but regard the notion of the firm as given by its strategy. They just want managers to take a more 'balanced view'. As they argue in their book (1996, p. 8): "The Balanced Scorecard complements financial measures of past performance with measures of the drivers of future performance. The objectives and the measures of the Scorecard are derived from an organization's vision and strategy." If Knowledge Management is not part of the firm's strategic view, then investment and management of intellectual assets will not take priority. Use of Knowledge Management requires firms to think about knowledge as a production element, but trends in Knowledge Management lead us to believe that knowledge will be viewed as a service economy, therefore with more intangible measurement. This is also true in the education field, where universities such as Manchester Metropolitan University's business school are examining how to measure their own use of Knowledge Management, and are exploring these two approaches discussed in the chapter as possible metric views.

Many corporations have not clearly articulated a need to manage knowledge. Of the 158 companies surveyed by the Conference Board (Beyond Knowledge Management: New Ways to Work and Learn, 2000), 80% had launched some kind of Knowledge Management activity, but only 15% had specific, stated Knowledge Management objectives and goals. Competitive necessity dictates that executives understand how Knowledge Management and knowledge sharing impact the bottom line, but many do not. KPMG Consulting reports that while most of those it surveyed understand that Knowledge Management can boost profits and reduce costs, less than 30% expected it to help increase their company's share price. The most important and useful metrics are those that directly inform the improvement of business performance and that can best be considered within the context of a learning process that embeds the metrics within the work process.

One Learning process, as an example, is that used by BP - Amoco (BP) as a central part of their Knowledge Management strategy — 'Learn Before, Learn During, Learn After'. Essentially BP - Amoco embeds Knowledge Management within the everyday work process by making it a normal part of doing business. At the beginning of any project they conduct a 'Peer Assist' (alternatively known as 'Prior Art'), where they get knowledgeable colleagues together to consider all that BP - Amoco knows about this particular subject. 'Learn During' involves a version of the US Army's well-known 'After Action Review' (AAR). BP - Amoco use the AAR after each 'identifiable event' rather than at the end of a project; thus it becomes a 'live' learning process that constantly informs the direction of the project. The third part is what BP - Amoco call a 'Retrospect', which is a team meeting designed to identify 'what went well', 'what could have gone better' and 'lessons for the future'.

By ensuring that time is made available within the actual project and that this learning process does not become extra work, BP - Amoco has managed to make it a normal part of doing business. The results have been real tangible business benefits visible in dollar terms that have turned around critics: "the Schiehallen oil field, a North Sea field considered too expensive to develop until a team spent six months pestering colleagues to share cost-saving tips. They were called wimps for not rushing out to 'make hole', but the learn-before-doing approach saved so much time on the platform (at $100,000 to $200,000 a day, not counting drilling costs) that they brought the field into production for $80 million less than anyone thought possible." Indeed, Tom Stewart recently stated about the CKO of BP: "Greenes is, as best I can figure, Knowledge Management's top moneymaker" (World Bank, 1999). This Learning Cycle then becomes the facilitating infrastructure for developing a process of Knowledge Management Metrics which allow the identification of real business value in each aspect of the necessary IT and other investments.

SUMMARY

Measurement has always been perceived as a science of precision; however, the measurement practice in most organizations today is anything but precise. Indeed, the issues looked for in scorecards, such as customer and employee satisfaction, and in intellectual capital, tend to require less precision and entertain more interest in trends than in exact figures. Kaplan and Norton's (1996) cause-and-effect hypothesis could be essential to understanding Knowledge Management metrics in a way that the Balanced Scorecard prescribes. Although the Balanced Scorecard can form the foundation for organizational strategic success, it is, however, not sufficient in itself. Along with strategies, there must be initiatives, such as business process improvement efforts, to steer the organization in the right direction and improve Knowledge Management implementation.

At the heart of an ideal definition of knowledge capital is the creation and provision of 'value'. Without linkage to strategic initiatives reflected through forms of measurement or recording of value, whether simply anecdotal or more quantifiable, Knowledge Management might degenerate into superficial business management hype. A conscious effort in conceptualizing, designing and putting to practice metrics like the ones described above may, however, assist in realizing the true worth of Knowledge Management.

As regards IT investment in particular, information technology may help growth and the retention of organizational knowledge if care is taken to continuously recall that IT is only a part; corporate culture and work practices being equally relevant to the whole. Information technologies best suited for this purpose should be expressly designed with Knowledge Management and organizational capital in view. Thus, while technology can support Knowledge Management, it is not the starting point of a Knowledge Management program.

REFERENCES

Andriessen & Tiessen (2000). *Weightless weight – Find your real value in a future of intangible assets.* Pearson Education London.

APQC. (2001). How to measure the value of Knowledge Management. *Knowledge Management Review*, March/April. Available online at http://www.apqc.org/free/articles/APQCKMR.pdf

Business Process Resource Centre [BPRC]. (2001). *Defining knowledge management.* Warwick Business School, Business Process Resource Centre. Available online at http://bprc.warwick.ac.uk/Kmweb.html

Corrall, S. (1999). Are we in the knowledge management business? *Knowledge Management, 18.* Available online at http://www.ariadne.ac.uk/issue18/knowledge-mgt/

Drucker, P. F. (1995). *Managing in a time of great change*. New York: Truman Talley Books/Dutton.

Dyer & McDonough. (2001). *The state of KM*. Knowledge Management, (May). Available online at http://www.destinationkm.com/articles/default.asp? ArticleID=539

Edvinsson, L., & Malone, M.S. (1997). *Intellectual capital: Realizing your company's true value by finding its hidden brainpower.* New York: Harper Business.

Firestone, J. (1998). *Knowledge management metrics development: A technical approach*. Executive Information Systems, Inc. White Paper No. Ten, (June). Available online at http://www.dkms.com/dkmskmpapers.htm

Fitz-Enz, J. (1994). *How to measure human resource management.* McGraw-Hill.

Gold, C. (1992). *Total quality management in information services – IS measures: A balancing act.* Boston: Research Note Ernst & Young Center for Information Technology and Strategy.

GSA. (1996). *Performance-based management: Eight steps to develop and use information technology performance measures effectively* (p. 106). Washington: GSA.

Johansson, U. (1996). *Increasing the transparency of investments in intangibles.* Available online at http://sveiby.konverge.com/articles/oecdartulfjoh.htm

Kaplan, R. S., & Norton, D. P. (1992). The balanced scorecard - measures that drive performance. *Harvard Business Review, 70*(1), 71-79.

Kaplan, R. S., & Norton, D. P. (1996). *The balanced scorecard - Translating strategy into action, xi, 322*. Boston: Harvard Business School.

Knapp, E. (1998). Knowledge management. *Business & Economic Review, 44*(4).

KPMG Consulting. (2000). *Knowledge Management Research Report 2000*, 1-13. Available for download on the KPMG main web site as 2000 Knowledge Management Survey.

Lev, B. (2001). *Intangibles: Management, measurement and reporting.* Brookings Institution. Washington. Cited in FASB Special report April 2001: Business and Financial Reporting, Challenges from the New Economy.

Martinsons, M., Davison, R., & Tse, D. (1999). The balanced scorecard: A foundation for the strategic management of information systems. *Decision Support Systems, 25,* 71-88.

Mouritsen, J., Larsen, H. T., Bukh, P. N., & Johansen, M. R. (2001). Reading an intellectual capital statement: Describing and prescribing Knowledge Management strategies. *Proceedings of the 4th Intangibles Conference*, Stern School of Business, New York University.

Neilson, R. (2000). Interview with Dr. Robert E. Neilson, Chief Knowledge Officer and Professor at the Information Resources Management College (IRMC) of the National Defense University, CHIPS Magazine, (Spring). Available online at http://www.chips.navy.mil/interview_with_dr.htm

Pulic, A. (2000). *An accounting tool for IC management.* Available online at http://www.measuring-ip.at/Papers/ham99txt.htm

Roos, J. (1996). *Intellectual capital: What you can measure, you can manage*. IMD Perspectives for Managers, No. 10. Available online at http://alexandrie.imd.ch/gotorec0302&id=&lang=?rec=031029057920189&act=0/

Roos, J., Roos, G., Dragonetti, N. C., & Edvinsson, L. (1997). *Intellectual capital: Navigating in the new business landscape*. Macmillan, Houndsmills, Basingtoke.

Shand, D. (1999). Return on knowledge: Proving financial payoffs from Knowledge Management investments plagues experienced and novice practitioners. *Knowledge Management*, (April). Available online at http://www.destinationkm.com/articles/default.asp?ArticleID=725

Strassmann, P. (1999). *Measuring and managing knowledge capital*. Report on Knowledge, Technology and Performance. Available online at http://www.strassmann.com/pubs/measuring-kc/

Surmacz, J., & Santosus, M. (2001). The ABCs of Knowledge Management. *CIO*. Online edition, available at http://www.cio.com/research/knowledge/edit/kmabcs. html#what

Sveiby, K. E. (1997). *The new organizational wealth: Managing and measuring knowledge based assets*. San Francisco: Berrett Koehler. Chapter on measuring available online at http://203.147.220.66/IntangAss/MeasureIntangible Assets.html

Sveiby, K. E. (2001a). *Methods for measuring intangible assets*. Available online at http://www.sveiby.com.au/articles/IntangibleMethods.htm

Sveiby, K. E. (2001b). *What is knowledge management?* Available online at http://www.sveiby.com/articles/KnowledgeManagement.html

Svioka, J. (2001). Knowledge pays. *CIO Magazine*, (February 15). Available online at http://www.cio.com/archive/021501/new.html

Truch, E. (2001). Mapping advances KM journey. *Knowledge Management*, (April). Available online at http://www.kmmag.co.uk/APRIL01/FORUMapr.HTM

Van Grembergen, W. (2000). The balanced scorecard and IT governance. *Information Systems Control Journal (previously IS Audit & Control Journal), 2*, 40-43.

Van Grembergen, W., & Saull, R. (2000). Aligning business and Information Technology through the balanced scorecard at a major Canadian financial group: Its status measured with an IT BSC Maturity Model. *Proceedings of the Hawaii International Conference on System Sciences (HICSS)*, Maui.

Van Grembergen, W., & Timmerman, D. (1998). Monitoring the IT process through the balanced score card. *Proceedings of the 9th Information Resources Management (IRMA) International Conference*, Boston (pp. 105-116).

Van Grembergen, W., & Van Bruggen, R. (1997). Measuring and improving corporate information technology through the balanced scorecard technique. *Proceedings of the Fourth European Conference on the Evaluation of Information technology*, Delft (pp. 163-171).

Van Grembergen, W., & Vander Borght, D. (1997). *Audit guidelines for IT outsourcing*. EDP Auditing, Auerbach 72-30-35 (pp. 1-8).

Wiig, K. M. (1997). Roles of knowledge-based systems in support of Knowledge Management. In J. Liebowitz & L. C. Wilcox (Eds.), *Knowledge management and its integrative elements* (pp. 69-87). Boca Raton: CRC Press.

Willcocks, L. (1995). *Information management. The evaluation of information systems investments*. London: Chapman & Hall.

World Bank. (1999). *Knowledge Management metrics - A learning process*. Comments from a speech from Laurence Smith, Knowledge & Learning Consultant, World Bank. Available online at http://www.zigonperf.com/resources/pmnews/knowledge_metrics.html

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Chapter 7.14
Knowledge Transfer Between Academia and Industry

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INTRODUCTION

Many policy makers and researchers consider knowledge transfer between academia and industry as one of the most promising measures to strengthen economic development. The idea of linking academia and industry is not new. Back in 1910 research universities were established, which strongly emphasized industry-related research as part of their activities and were funded by enterprises in order to tap this knowledge (see Matkin, 1990, for the history of technology transfer at four U.S. research universities—MIT, U.C. Berkeley, Penn State, and Stanford). Knowledge transfer has increased considerably during the last few decades. Many universities have established offices aimed at improving relations with industry. The performance of these offices varies considerably. One example for a quantitative performance indicator is license revenues of U.S. universities (Artley, Dobrauz, Plasonig, & Strasser, 2003). Only a handful of examined universities actually draw profit from it. The majority pay more for legal advice and fees than they earn from license income. It is obvious that the performance variances depend on many factors like staff resources at the transfer offices, type of university research (basic vs. applied, technical vs. non-technical domains), the brand of the university as well as prior industrial relationships, to name just a few. Not all of these factors can be changed in the short run, but knowing them and streamlining actions towards their improvement can lead to sustainable changes, in the end positively influencing economic performance. Despite the long history and recent efforts to improve university-industry collaborations, the full potential does not yet seem to be exploited (Starbuck, 2001). Jankowski (1999) and Clough (2003) confirm the decrease of federal funding for universities and point to increasing collaborations between academia and industry, which in their view comprises the danger of leaving fundamental frontier research, vital for breakthrough innovations, behind. At the same time, industry increasingly relies on external knowledge sources to keep up with the pace of their competitors (Business-Higher Education Forum, 2001; Tornatzky, 2000). In many cases, these external sources are customers and suppliers (Adametz & Ploder, 2003; Dachs, Ebersberger, & Pyka, 2004). This may be due to similar rationales, profit, and already-existing customer-client relationships. However, industry more and more turns to universities when looking for support. According to Godin and Gingras (2000), universities are still one of the major producers of knowledge, despite an increase of other R&D institutions. Collaborations between academia and industry bring partners with different competencies together and cover the whole range of the R&D chain, from basic research to application. By fulfilling the needs of both partners, universities as well as enterprises, and building up trust, knowledge transfer leads to knowledge flows and production of new knowledge, and thus creates a fertile environment for innovation. The article at hand examines motives as well as barriers related to knowledge transfer out of a systemic as well as a process-related view and provides some general suggestions for further improvements.

BACKGROUND

The earlier focus of knowledge transfer between academia and industry was on technology, in the sense of technological processes and artifacts inhibiting technological knowledge without paying much attention to the soft facts important for the success or failure of the transfer. Nowadays, technology transfer often comprises more than technological knowledge, including data as well as technology-related organizational knowledge (Abramson, Encarnacao, Reid, & Schmolch, 1997). As Schumpeter (1912) explained, technology is not exclusively the base of innovations. Using the term knowledge transfer instead of technology transfer reinforces Schumpeter's view of innovation, which additionally includes, for example, social innovations like new organizational structures or incentive systems (see Hofer, Adametz, & Holzer, 2004, for an example of a knowledge transfer program implemented by a university of technology in collaboration with a classical university). Knowledge transfer schemes range from regional programs and initiatives to national and international ones. Besides the different geographical focus, also the target group, at which knowledge transfer measures are aimed, can differ (broad approach vs. focus on specific industrial sectors). All these characteristics influence knowledge transfer at the operative level and require diverse additional partners and processes. Knowledge transfer between academia and industry as understood herein refers to activities, aimed at enabling and facilitating industry to tap knowledge produced at universities. The article examines knowledge transfer in general without limiting it to certain geographic borders. Knowledge transfer does not only comprise large collaborative R&D projects, but also measures like informal consulting as well as diploma theses commissioned by enterprises. The primary objective of knowledge transfer is to strengthen the competitiveness of both partners, leading in succession to improved economic development.

MAIN FOCUS OF THE ARTICLE

The article addresses regional as well as national governments trying to provide the right framework for parties involved in knowledge transfer—universities' managers, who would like to establish closer links with industry, as well as representatives of industry, who plan to or already use external knowledge sources like universities. The first part of this article deals with motives at different organizational levels of the parties directly involved; the second part discusses barriers negatively influencing knowledge transfer. The article concludes with some suggestions for future actions in order to amplify motives and overcome barriers, thus increasing the performance of knowledge transfer initiatives and programs.

What are the Driving Forces in Knowledge Transfer?

In order to improve knowledge transfer between academia and industry, it is not sufficient to examine solely existing barriers; one must also examine possible motives, as the driving power must be identified and intensified. This is not only important at the agency but also the individual level, where knowledge transfer ultimately takes place (Lipscomb & McEwan, 2001). The following comments are based on the results of a literature study performed for a paper presented at the 2004 Exploiting Change in the 21st Century international conference (Hofer, 2004). Motives for universities to get involved in knowledge transfer are mainly financial as well as legal ones. At many universities, the share of industrial funding already makes up a substantial part of the total budget. Without the financial commitment of industry, these universities would have to cut their expenses dramatically. The trend of increasing industrial funding of universities is likely to grow even more in the future, with governments stabilizing or even cutting resources and increasingly interdisciplinary R&D projects demanding researchers from various professional areas. But universities are involved not only for financial reasons, but also because they are legally bound to perform knowledge transfer with industry. For example, the Austrian Universitaetsgesetz 2002 [University Law 2002] lists "support to practically use and apply universities' R&D results" as one of the primary tasks of Austrian universities. Etzkowitz (2003) calls this additional task the third mission of universities besides doing research and educating students. Despite all perils like stronger emphasis on applied research, universities at the agency level are committed to perform knowledge transfer with industry and thus offering their knowledge. The commitment at the individual level does not always reflect this opinion. This is comprehensible if one considers that legal claims at this level do not exist as part of contracts between universities and their employees. Usually, there are no financial benefits, which recompense researchers for efforts to perform knowledge transfer with industry, except for researchers, whose jobs directly depend on external funds. Knowledge transfer does not seem to be perceived as important as other tasks (Kremic, 2003). If the researcher's employment does not depend directly on industrial funding, that person is free to decide whether or not and to which degree to get involved in knowledge transfer. Therefore the issue of what motivates researchers at universities to invest some of their time budget in projects with industrial partners is of particular interest. The majority of literature referred to in the following regards individuals in public laboratories. It is assumed that governmental scientists and their universities' counterparts are motivated by similar factors because of the similar framework such as public funding and similar kinds of R&D. Differently from their colleagues, university researchers must also teach their students, thus having even more time constraints. Studies performed by Large, Belinko, and Kalligatsi (2000), Schartinger, Schibany, and Gassler (2001), and Spivey, Munson, and Flannery (1994) identified personal interest and satisfaction as the primary motives of researchers to deal with industry. They do not seem to be motivated by extrinsic factors like additional income. Frey and Osterloh (2000) describe researchers as people typically motivated by intrinsic motives, which additionally confirms the results of the various studies. The main objective of private industries is to make profits, to be profitable for their owners, and to be a better investment than other corporations (Kremic, 2003). Industry collaborates with universities because it promises to be profitable. However, large-scale enterprises (e.g., in the life science industry) in some cases are funding blue-sky research at universities; they do not do it for the sake of basic research, but because this gives them the right to be first to exploit possible inventions and to recruit high potentials before others get a hold of them. Challenges like fast and highly specialized knowledge production, shorter product lifecycle due to increasing share of data as part of products, and increased marketing of universities, which present themselves as R&D partners of industry, push enterprises to get involved in knowledge transfer activities.

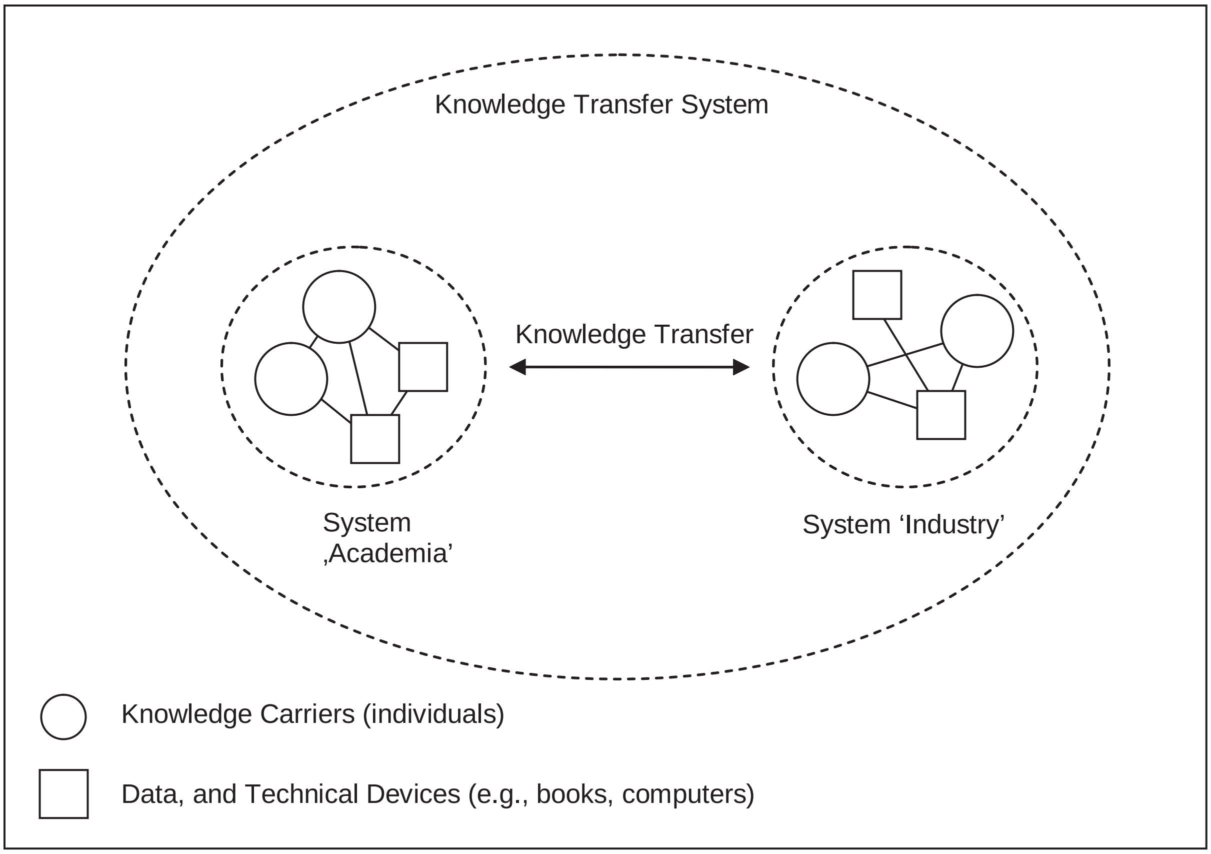
Large et al. (2000) identified various motives of individuals at enterprises for collaborating with public laboratories. The first three motives for enterprises' individuals are: (1) expected technical benefits for the end user, (2) expected proprietary knowledge for the manufacturer, and (3) expected financial benefits for the manufacturer. The comparison with the motives identified for scientists reveals a stronger profit-orientation on the part of the manufacturers. Kremic (2003), who points to the strong link between enterprises' performance and employment, also supports this view.

What are the Forces Hindering Involvement in Knowledge Transfer?

Motives are one side of the coin, but knowing what hinders industry and academia to transfer knowledge mutually is equally important in order to design holistic approaches. The following section will systematically examine barriers and suggest efforts to overcome them by providing suitable measures. The first part focuses on barriers deduced with the aid of system theory. The second part examines process-based barriers. The two directly involved parties here are universities and industry. As socio-technological systems, they consist of various elements: individuals as carriers of knowledge; data in the form of, for example, publications or entries in databases; and technical devices supporting information and documentation processes as well as data exchange. Links connect the elements of both systems, whereby these relations are not necessarily physical ones.

The knowledge transfer system displayed in Figure 1 shows the two primary parties: academia and industry. This form of knowledge transfer takes place directly between universities and industry. Reinhard (2001) lists four types of barriers, which apply to the systemic view and can equally apply to both parties: (1) not knowing each other, (2) not being allowed to work with each other, (3) not wanting to work with each other, and (4) not being able to work with each other. High search costs limit the possibilities on both sides to look for suitable partners (Beise & Spielkamp, 1996). The use of the Internet can actually help to limit such costs (Czarnitzki & Rammer, 2003), but especially for risky projects with insecure outcomes, it cannot replace prior hands-on experience. Additional barriers, which are part of the prior classification, are different organizational structures and objectives, prior or current projects of the university with enterprises' competitors, lack of motivation, or low qualification, which negatively influences the absorption capability (Reinhard, 2001). The fifth barrier identified from the systemic view stems from the characteristics of knowledge. Unlike products, which can be rather easily priced and tested, knowledge is characterized as an experience good (Watanabe, Yoneyama, Senoo, Fukushima, & Senoh, 2004). This makes it difficult for industry in an early stage to identify suitable knowledge sources. To some extent the identified barriers differ, taking

Figure 1. Knowledge transfer system—the system consists of two sub-systems, academia and industry, with various elements, which are linked with each other. Knowledge transfer takes place on an inter-organizational level between the two sub-systems.



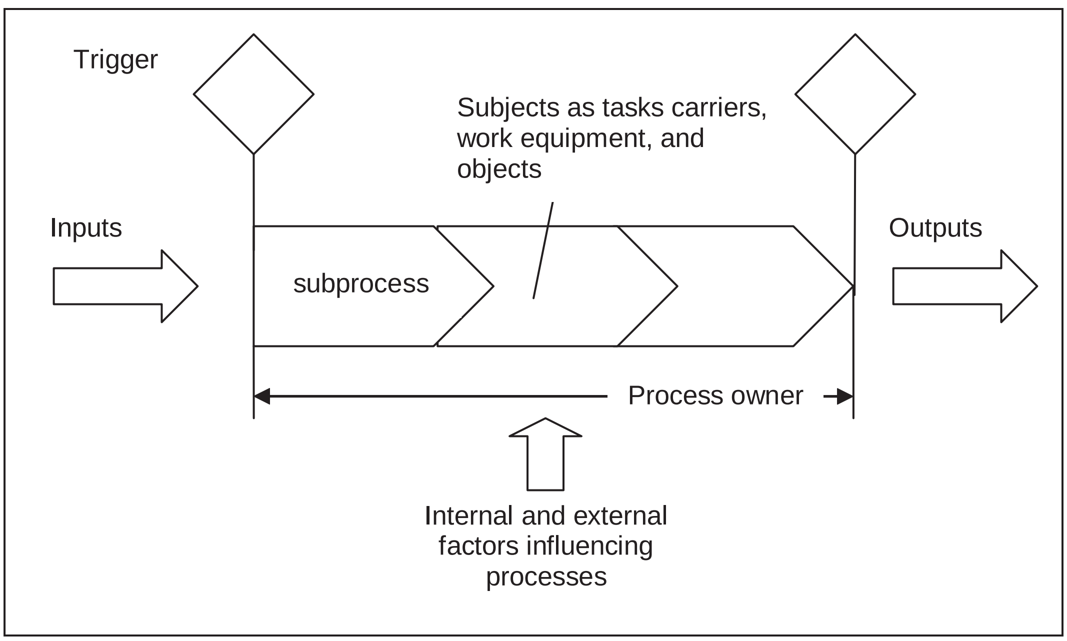
into account various geographic extensions. For example, the characteristics of knowledge will always remain the same, but enabling extensive face-to-face communication facilitates the decision on both sides whether collaboration could be fruitful or not. The following process-related view complements the systemic view and reveals additional barriers hindering the full exploitation of knowledge transfer. Although the whole range of knowledge transfer measures requires different processes (Pries & Guild, 2004), the following examination focuses on a general process definition, which should make it possible to apply the results to specific knowledge transfer processes. Processes are defined as a sum of various activities with a defined beginning and end which transform and/or transport objects (physical ones or data) following defined rules. They are logical, spatial, and chronological chains of activities (Remus & Schub, 2003; Schwickert & Fischer, 1996). The main reason to introduce process management is to overcome intra- and/or inter-organizational functional barriers, thus reducing 'frictional losses' and improving the quality of outcome.

Knowledge transfer processes can be divided into two major types: (1) looking for external knowledge, and (2) offering internal knowledge. If in need of external knowledge, sub-processes look like this: (a1) identifying missing knowledge, which at the same time demands the identification of the internal knowledge stock; (b1) identifying possible knowledge providers; and (c1) balancing knowledge needs and offers. Sub-processes for knowledge providers are: (a2) identifying the internal knowledge stock; (b2) identifying possible knowledge customers, which look for this kind of knowledge; and (c2) balancing knowledge needs and offers. The sub-processes at this level are the same, only the order is different. Hence, knowledge transfer processes have an intra- as well as inter-organizational dimension. Therefore, it is not sufficient to optimize processes solely at the interface of universities and industry. Additionally, internal processes like brokering of external enquiries and responsibilities for processes have to be taken into account. Some of the properties—like subjects, inputs, outputs, and internal and external factors influencing the process—are closely connected with the barriers identified above. Additional barriers identified with the help of the process-related view are associated to the trigger and process owner. Knowledge transfer processes between academia and industry can be triggered either by enquiries from industry or by universities (e.g., promoting proactive support services). Besides these physical triggers, other processes can also act as starting point; for example, successful R&D projects can automatically lead to defined knowledge transfer processes. In the past, industry often acted as a trigger and knocked at the ivory tower for support, but due to environmental changes like decreasing public funding, universities are more actively looking for contacts with industry. It is necessary for a holistic knowledge transfer approach to consider different forms of triggers and design the processes accordingly. Another important action to remove barriers is the unmistakable assignment of process owners. They are responsible for their processes, ranging from initial enquiries to the delivery of the outcome to the customer. This is especially important in the beginning of potential collaborations, in the idea or pre-project phase, where industry usually evaluates different collaboration partners. Due to the involvement of intermediaries, who are usually not the professionals (the ones actually performing the collaborative research project), handing over responsibility to the professionals at the right moment is critically important for further collaborations. If this happens too early, it could lead to unnecessary delays and misunderstandings. If it happens too late, both partners, academia and industry, perceive intermediaries as unnecessary bureaucratic entities slowing down the project advancement.

DIRECTIONS FOR FURTHER IMPROVEMENTS OF KNOWLEDGE TRANSFER ACTIVITIES

Simultaneously increasing motives and lowering barriers should help to further improve the accessibility of research institutions like universities to industry and thus promote economic development. The benefits for universities at the agency level are quite clear, but knowledge transfer ultimately depends on individuals. Especially, intrinsic motives like satisfaction and personal interest seem to play a major role for researchers (Frey & Osterloh, 2000; Large et al., 2000; Schartinger et al., 2001; Spivey et al., 1994). The motives for industry to use academic knowledge at the agency level are mainly profit driven, because of the close link between fulfilling the requirements of the employers and employment; this motive is likely to be valid also for individual employees in industry. Specifically, relations between universities' researchers and small and medium-sized enterprises seem to have potential for further improvements. Small and medium-sized enterprises typically lack strategic tools. Therefore, they usually concentrate on short-term projects and as a result on short-term profit. This limits the possibility to exploit knowledge transfer with academia, and in succession leads to a perceived low value of universities' research. The main barriers identified relate to: (1) not knowing each other, (2) not being allowed to work with each other, (3) not wanting to work with each other, (4) not being able to work with each other, (5) characteristics of knowledge, (6) not considering different forms of triggers, and (7) unclear assignment of process owners. Some of the barriers can be lowered or even eliminated by universities and industry on their own; others require additional support by, for example, intermediaries, governments, or funding agencies. The barriers given in the systemic view make it clear that a mix of different partners can greatly enhance knowledge transfer. The support by funding agencies as well as governments can play a vital role. The task of intermediaries is to bridge the gap between universities and industry. They can offer support services that are out of reach for research departments at universities because of time restraints. Funding agencies as well as funding programs introduced by governments can support the upgrading of industry's absorption capabilities, an important requirement for successful collaborations with external partners like universities. Setting up suitable processes, which consider barriers related to the different possible forms of triggers and clear assignments of process owners, are tasks of the involved institutions. The

Figure 2. Processes' properties—the process-related view enables the identification of further barriers using the properties that characterize processes.



more partners, the more complex are such tasks. However, as already mentioned earlier, only collaboration between complementary partners can provide the necessary critical mass to lower some of the barriers. Thus it is important to consider which institutions should be involved in knowledge transfer programs in order to facilitate such activities. Above all, changing external factors is a task that ultimately requires the support of local, regional, and national governments. The main results show the necessity of: (1) deciding at whom the knowledge transfer activities should be aimed, (2) the integration of additional partners besides universities and industry, and (3) arranging effective processes to eliminate barriers and increase motivation.

FUTURE TRENDS

Trends like growing global competition and rapidly changing environment put pressure on industry as well as academia. They have to establish and deepen their contacts with each other in order to keep up front. Therefore, knowledge transfer between academia and industry will increase in importance, and the winners will be the ones who fully understand how to utilize such activities. Traditional boundaries between institutions like universities, industry, and governments will be blurred further, thus following the idea of Etzkowitz and Leydesdorff (1995) which promotes close collaborations between universities, industry, and governments—the so-called triple-helix model.

CONCLUSION

Building on the framework provided here, the key for successful knowledge transfer activities lies in the following three key measures: (1) knowing the target group, (2) integrating all necessary parties, and (3) setting up the right processes. This requires the commitment and efforts of all involved parties. Despite global markets, regions still play important roles with respect to knowledge transfer, which includes amongst others tacit knowledge, learning, and innovation (Morgan, 2001). Therefore, establishing and enhancing regional initiatives and programs aimed at bringing academia and industry together could form the central part of regional economic development efforts and act as a springboard for national and international knowledge transfer measures. Through increasing intra-regional knowledge transfer, the collaboration capabilities of all involved parties will increase and thus make regions ready for other advanced measures.

REFERENCES

Abramson, H.N., Encarnacao, J., Reid, P.P., & Schmolch, U. (1997). *Technology transfer systems in the United States and Germany: Lessons and perspectives*. Washington, DC: National Academy Press.

Adametz, C., & Ploder, M. (2003). *Innovationsbericht Steiermark 2003* [Innovation survey styria 2003]. Graz: Forschungsgesellschaft JOANNEUM RESEARCH mbH.

Artley, R.J., Dobrauz, G., Plasonig, G.E., & Strasser, R.R. (2003). *Making money out of technology: Best practice in technology exploitation from academic sources*. Solothurn: ETeCH AG.

Beise, M., & Spielkamp, A. (1996). *Technologietransfer von Hochschulen: Ein Insider-outsider-effekt* [Technology transfer from higher education institutes: The insider-outsider effect]. Discussion Papers, 96-10.

Business-Higher Education Forum. (2001). *Working together, creating knowledge: The university-industry collaboration initiative*. Washington, DC: Business-Higher Education Forum.

Clough, G.W. (2003). National priorities for science and technology: A view from the academic sector. In A.H. Teich, S.D. Nelson, S.J. Lita, & A.E. Hunt (Eds.), *AAAS science and technology policy yearbook 2003* (pp. 23-31). Washington, DC: American Association for the Advancement of Science.

Czarnitzki, D., & Rammer, C. (2003). Technology transfer via the Internet: A way to link public science and enterprises. *Journal of Technology Transfer, 28*, 131-147.

Dachs, B., Ebersberger, B., & Pyka, A. (2004). *Why do firms co-operate for innovation? A comparison of Austrian and Finish CIS 3 results.* Volkswirtschaftliche Diskussionsreihe des Instituts für Volkswirtschaftslehre der Universitaet Augsburg [Discussion series of the Institute for Economics at the University of Augsburg], 255.

Etzkowitz, H. (2003). The European entrepreneurial university: An alternative to the U.S. model. *Industry & Higher Education, 17,* 325-335.

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix of university-industry-government relations: A laboratory for knowledge based economic development. *EASST Review, 14,* 11-19.

Frey, B.S., & Osterloh, M. (2000). *Managing motivation: Wie sie die Neue Motivationsforschung für ihr Unternehmen Nutzen Können* [Managing motivation: How you can use current motivation research for your enterprise]. Wiesbaden: Dr. Th. Gabler GmbH.

Godin, B., & Gingras, Y. (2000). The place of universities in the system of knowledge production. *Research Policy, 29*, 273-278.

Hofer, F. (2004, June). Understanding the motives to further improve knowledge transfer activities: A case of the Graz Region (Austria). *Proceedings of the TTI2004 Conference of Technology Transfer and Innovation Ltd.*, Edinburgh.

Hofer, F., Adametz, C., & Holzer, F. (2004). Technology and knowledge transfer scheme in the Graz region—10 years of experience. *Industry & Higher Education, 18,* 177-186.

Jankowski, J.E. (1999). Trends in academic research spending, alliances, and commercialization. *Journal of Technology Transfer, 24,* 55-68.

Kremic, T. (2003). Knowledge transfer: A contextual approach. *Journal of Technology Transfer, 28,* 149-158.

Large, D., Belinko, K., & Kalligatsi, K. (2000). Building successful knowledge commercialization teams: Pilot empirical support for the theory of cascading commitment. *Journal of Technology Transfer, 25,* 169-180.

Lipscomb, M., & McEwan, A.M. (2001). Technology transfer in SMEs: The TCS model at Kingston University. In H.H. Hvolby (Ed.), *Proceedings of the 4th SMESME International Conference: Stimulating Manufacturing Excellence in Small & Medium Enterprises* (pp. 406-413). Aalborg: Department of Production at Aalborg University.

Matkin, G.W. (1990). *Technology transfer and the university.* New York: Macmillan.

Morgan, K. (2001, September). The exaggerated death of geography: Localized learning, innovation, and uneven development. *Proceedings of the Conference of the Eindhoven Centre for Innovation Studies*, Eindhoven University of Technology.

Pries, F., & Guild, P. (2004). Analyzing the commercialization of university research: A proposed categorization scheme. In Y. Hosni, R. Smith, & T. Kahlil (Eds.), *Proceedings of IAMOT 2004—the 13th International Conference on Management of Technology* (Paper Identification Number: 652). Washington, DC: International Association for Management of Technology.

Reinhard, M. (2001). Absorptionskapazitaet und nutzung externen technologischen wissens in unternehmen [Absorption capability and the use of external technological knowledge in enterprises]. *ifo Schnelldienst*, *54*, 28-39.

Remus, U., & Schub, S. (2003). A blueprint for the implementation of process-oriented knowledge management. *Knowledge and Process Management, 10*, 237-253.

Schartinger, D., Schibany, A., & Gassler, H. (2001). Interactive relations between universities and firms: Empirical evidence for Austria. *Journal of Technology Transfer, 26*, 255-268.

Schumpeter, J.A. (1912). *Theorie der Wirtschaftlichen Entwicklung* [Theory of economic development]. Leipzig: Duncker & Humblot.

Schwickert, A.C., & Fischer, K. (1996). Der Geschaeftsprozess als Formaler Prozess—Definition, Eigenschaften, Arten [The business process as formal process—definition, characteristics, and types]. Arbeitspapiere WI des Lehrstuhls für Allgemeine Betriebswirtschaftslehre und Wirtschaftsinformatik der Universität Mainz [working papers WI of the Institute for Business Economics at the University of Mainz], 4.

Spivey, W.A., Munson, J.M., & Flannery, W.T. (1994). Understanding the environs that impact knowledge transfer and knowledge transition. *Journal of Technology Transfer, 19*, 63-73.

Starbuck, E. (2001). Optimizing university research collaborations. *Research Technology Management*, (January-February), 40-44.

Tornatzky, L.G. (2000). *Building state economies by promoting university-industry technology transfer*. Washington, DC: National Governor's Association.

Watanabe, T., Yoneyama, S., Senoo, D., Fukushima, M., & Senoh, K. (2004). Visualizing the invisible: A marketing approach of the technology licensing process. In Y. Hosni, R. Smith, & T. Kahlil (Eds.), *Proceedings of IAMOT 2004—the 13th International Conference on Management of Technology* (Paper Identification Number: 565). Washington, DC: International Association for Management of Technology.

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Chapter 7.15
Secure Knowledge Management

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INTRODUCTION

As the world is getting more and more technology savvy, the collection and distribution of information and knowledge need special attention. Progress has been made on the languages and tools needed for effective knowledge management and on the legal issues concerning the consumption and dissemination of critical knowledge. From a business perspective, a knowledge-management system (KMS) within a firm generally strives to maximize the human-capital utilization and profitability of the firm. However, security is becoming a major issue revolving around KMS; for instance, the KMS must incorporate adequate security features to prevent any unauthorized access or unauthorized dissemination of information. Acquiring the information that one needs to remain competitive while safeguarding the information one already has is a complicated task. Firms must balance the advantages of openness against its inevitable risks, and maximize the efficiency of electronic communication without making it a magnet for intruders. One must integrate offense and defense into a comprehensive strategy, and scholars have suggested that it is time to integrate intelligence and security imperatives with other knowledge-management strategies and processes (Barth, 2001).

Since the widely reported attacks on knowledge repositories in 2001 (e.g., Amazon was hit by denial-of-service attacks and the NIMDA virus hit financial markets), many organizations, especially the U.S. government, have increased their concern about KMSs. With the advent of intranets and Web access, it is even more crucial to protect critical corporate knowledge as numerous individuals now have access to the assets of a corporation. Therefore, we need effective mechanisms for securing data, information, and knowledge as well as the applications (Thuraisingham, 2003, 2004).

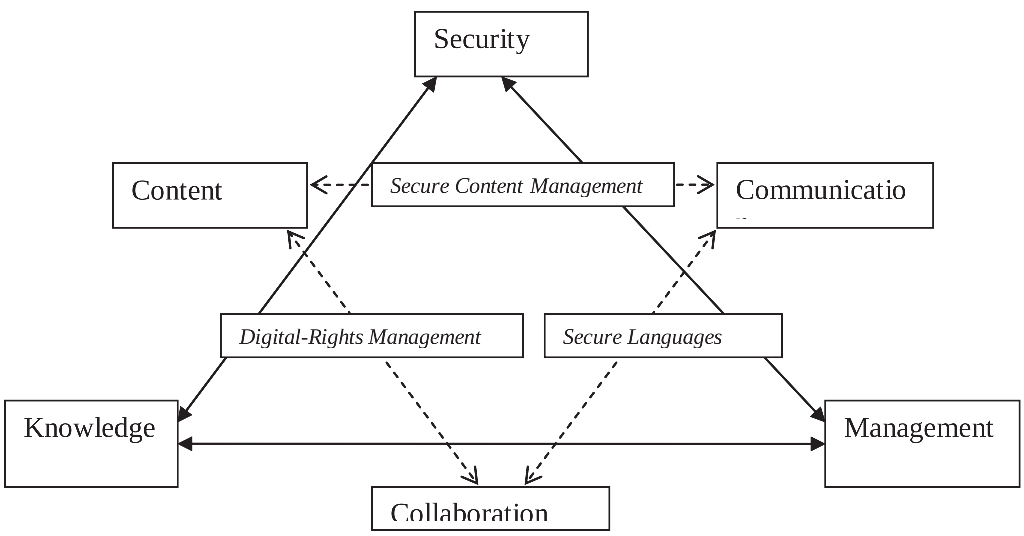
Security methods for knowledge-management systems may include authentication or passwords, cryptography programs, intrusion-detection systems, or access-control systems. Issues include insider threat (protecting from malicious insiders), infrastructure protection (securing against subversion attacks), and establishing correct policies, refinement, and enforcement. KMS content is much more sensitive than raw data stored in databases, and issues of privacy also become important (Thuraisingham, Chadwick, Olivier, Samarati, & Sharpston, 2002).

Asllani and Luthans (2003) surveyed over 300 knowledge managers about their job roles and found little or no evidence of security issues being considered in their jobs; their primary role was focused on communication within the organization. This article about secure knowledge management raises a number of issues in this critical area of research that need to be tackled by knowledge-management practitioners. The following sections focus on three important aspects of secure knowledge management: secure languages, digital-rights management (DRM), and secure content management (SCM).

BACKGROUND

A firm exists as a repository of knowledge over time (Zander & Kogut, 1995). Knowledge management is the methodology for systematically

Figure 1. A framework for secure knowledge-management systems



gathering, organizing, and disseminating information (Morey, Maybury, & Thuraisingham, 2003) in a firm. It essentially consists of processes and tools to effectively capture and share data, as well as use the knowledge of individuals within a firm. Knowledge management is about sharing information more freely such that firms derive benefit from such openness.

Secure knowledge-management (SKM) systems can be described in terms of the three Cs: communication, collaboration, and content. SKM systems act as a gateway to the repository of intellectual content that resides within an organization. SKM systems need to source and/or provide access to knowledge that resides in multiple machines across an organization or multiple organizations for collaborative efforts. Secure languages are utilized to transfer information safely. At the same time, digital-rights management becomes critical in cross-organizational transfers of knowledge, while access control and identity management play an important role in securing the knowledge-management system. A framework for secure knowledge management is shown in Figure 1 as two interlinked, triangular chains: The larger chain focuses on security, knowledge, and management, while the smaller triangular chain (with dotted links) focuses on content, communication, and collaboration. Different aspects within the smaller chain include secure content management, digital-rights management, and secure languages. This article focuses on the interarticulation of the different concepts in the triangles.

SECURE LANGUAGES

In order to communicate securely and collaborate with one another, organizations need to use secure languages. These languages can be implemented to enhance the security of knowledge-management systems. Some of these are detailed in the following sections.

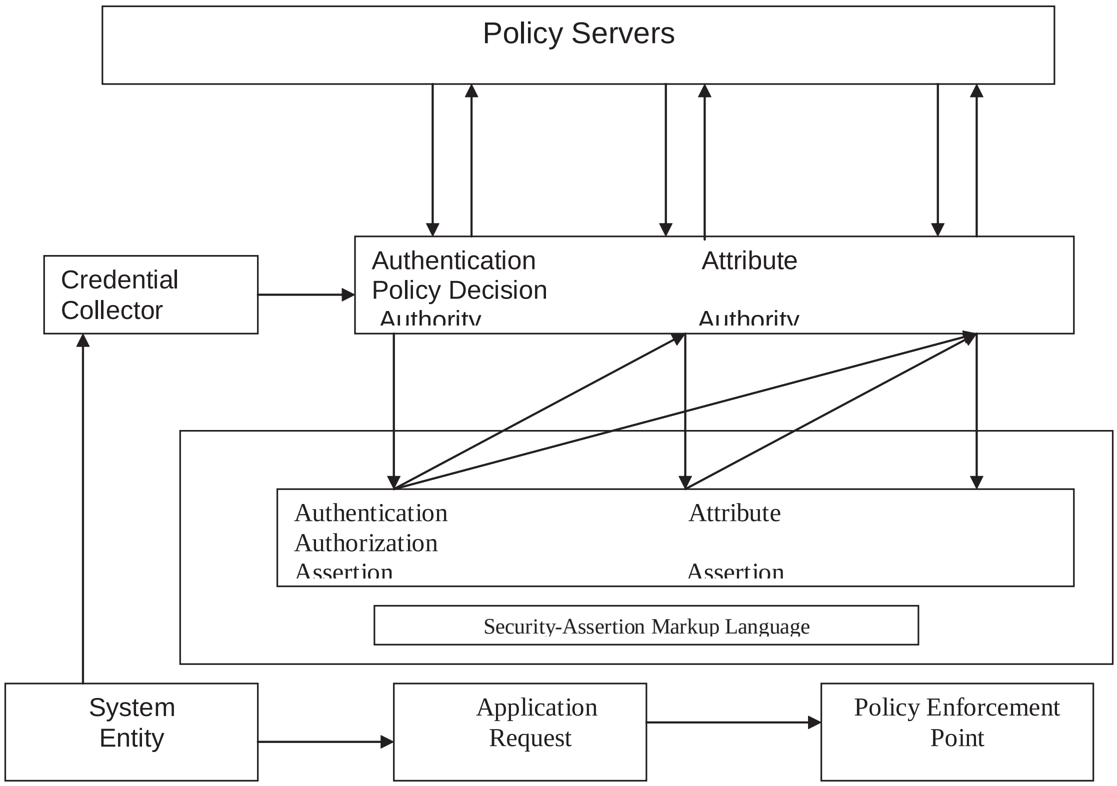
Security-Assertion Markup Language

The security-assertion markup language (SAML) can secure the KMS from insider or outsider threat by managing access control and identity. SAML is an extensible-markup-language- (XML) based framework (Cohen, 2003) for exchanging security information. In SAML, the expression of security is in the form of assertions about subjects. Most other security approaches use a central authority to authenticate the identity or the data. However, SAML does not use a central authority that authenticates the identity; it is up to the receiving application to accept if it trusts the assertion. The security-assertion markup domain model is depicted in Figure 2.

SAML shows how to represent users, identifies what data need to be transferred, and defines the process for sending and receiving authorization data (Cohen, 2003). SAML also has extensive applications in automated business-to-business (B2B) transactions that require secure transactions between the two parties. The increased collaboration among the various businesses has necessitated the need for such a technology (Patrizio, 2003). A case in point is that of Southwest Airlines (Wagner & Witty, 2003)—one of the first to use SAML-enabled identity management on a large scale to perform cross-domain trust. This implementation also marks an early step in the movement toward federated identity management.

SAML does not provide a complete security solution, but it does provide the identity-management functionality. In addition, it provides password management and access control, and a framework for implementing the "single sign-on" mechanism where authentication needs to be shared across multiple systems. Single sign-on becomes an absolute necessity when implementing complex KMSs that need to source or access data from multiple machines.

Figure 2. Security-assertion markup model



(Adapted from http://www.fawcette.com/xmlmag/2002_03/magazine/departments/marketscan/SAML/)

A number of commercial and open-source products provide SAML, including the following:

- Entegrity Solutions AssureAccess (http://www.entegrity.com/products/aa/aa.shtml)
- Internet2 OpenSAML (http://www.opensaml.org/)
- Netegrity SiteMinder (http://h71028.www7.hp.com/enterprise/cache/8258-0-0-225-121.aspx)
- RSA Security ClearTrust (http://www.rsasecurity.com/node.asp?id=1186)
- VeriSign Trust Integration Toolkit (http://www.xmltrustcenter.org/developer/verisign/tsik/download.htm)

Secure Knowledge-Query and Manipulation Language

KQML or the knowledge-query and -manipulation language is a language for exchanging information and knowledge. KQML focuses on an extensible set of performatives that defines the permissible operations that agents may attempt on each other's knowledge and goal stores. The performatives comprise a layer on which to develop higher level models of interagent interaction such as contract nets and negotiation. In addition, KQML provides a basic architecture for knowledge sharing through a special class of agents called communication facilitators, which coordinate the interactions of other agents. The ideas that underlie the evolving design of KQML are currently being explored through experimental prototype systems that are being used to support several test beds in such areas as concurrent engineering, intelligent design, and intelligent planning and scheduling (Lebrou, Finin, Sherman, & Rabi, 1997).

An extension of KQML is secure KQML, which is being developed to take into account security and privacy concerns that agents could encounter whenever they cross multiple administrative domains. Since traditional agent communication-language standards lack the necessary constructs that enable secure cooperation among software agents, SKQML enables KQML-speaking agents to authenticate one another, implement specific security policies based on authorization schemes, and, whenever needed, ensure the privacy of the messages exchanged. SKQML employs public-key cryptographic standards and it provides security mechanisms as an integral part of the communication language. In summary, SKQML incorporates a synthesis of public-key certificate standards and agent communication languages to achieve an infrastructure that meets the security needs of cooperating agents.

B2B Circles of Trust

As can be seen from the discussion above, while the secure languages do allow secure communication to an extent, they are not complete solutions. An alternate mechanism for enhancing secure communication and collaboration across organizations in the knowledge-management environment has been termed "circles of trust."

Circles of trust involve two or more organizations sharing supplier or customer authentication information among themselves via a common interface or single sign-on capability. XML provides the basis for operating circles of trust (Varney, 2003).

One of the premier organizations espousing the concept of circles of trust is the Liberty Alliance—a consortium of more than 150 organizations working worldwide to create open, technical specifications for federated network identity. The alliance outlines the specifications for simplified sign-on capabilities using federated network-identity architecture. Permission-based attribute sharing is utilized to enable organizations to provide users with choice and control over the use and disclosure of personal information. A commonly accepted platform and mechanism for building and managing identity-based Web services is based on open industry standards. The Liberty Alliance specification addresses privacy and security concerns, and enables the participating organization to build more secure, privacy–friendly identity-based services that can comply with local regulations and create a trusted relationship with customers and partners (Varney, 2003).

DIGITAL-RIGHTS MANAGEMENT

The confluence of content and collaboration across organizations has brought up the concept of digital-rights management. DRM has traditionally focused on security and encryption to alleviate copyright-infringement and unauthorized-use problems. In order to do so, DRM techniques have implemented a mechanism to lock content and limit distribution to subscribed customers. Current DRM solutions include the description, identification, trading, protection, monitoring, and tracking of all forms of rights usages over both tangible and intangible assets including the management of rights holders' relationships (Iannella, 2001).

DRM systems are supposed to serve markets in which the participants have conflicting goals and cannot be fully trusted, yet need to collaborate and share knowledge content with each other. This adversarial situation introduces interesting new twists on classical problems studied in cryptology and security research, such as key management and access control (Feigenbaum, Freedman, Sander, & Shostack, 2002). Furthermore, novel business models and applications often require novel security mechanisms. Recent research has also proposed new primitives for DRM that make it possible to identify content in an adversarial setting.

Functional Architecture

The overall DRM framework suited to building digital-rights-enabled systems is illustrated in Figure 3. The functional architecture stipulates the roles and behavior of a number of cooperating and interoperating modules under the three areas of intellectual property (IP): asset creation, management, and usage (Figure 3).

The concept of intellectual-property asset creation and capture refers to the key question of how to manage the creation of content so it can be easily traded. This includes asserting rights when content is first created (or reused and extended with appropriate rights to do so) by various content creators or providers. The IP asset-creation and -capture module supports (a) rights validation to ensure that content being created from existing content includes the rights to do so, (b) rights creation to allow rights to be assigned to new content, such as specifying the rights owners and allowable usage permissions, and (c) a rights workflow to allow for content to be processed through a series of work-flow steps for review and/or approval of rights (and content).

IP asset management involves the management and enabling of the trade of content. This includes accepting content from creators into an asset-management system. The trading systems need to manage the descriptive metadata and rights metadata (e.g., parties, usages, payments, etc.).

The IP asset-management module supports repository functions to enable the access or retrieval of content in potentially distributed databases and the access or retrieval of metadata. The metadata cover information regarding parties, rights, and descriptions of the work. The module also supports trading functions that enable the assignment of licenses to parties who have traded agreements for rights over content, including payments from licensees to rights holders (e.g., royalty payments). In some cases, the content may need to go through fulfillment operations to satisfy the license agreement. For example, the content may be encrypted, protected, or packaged for a particular type of desktop usage environment.

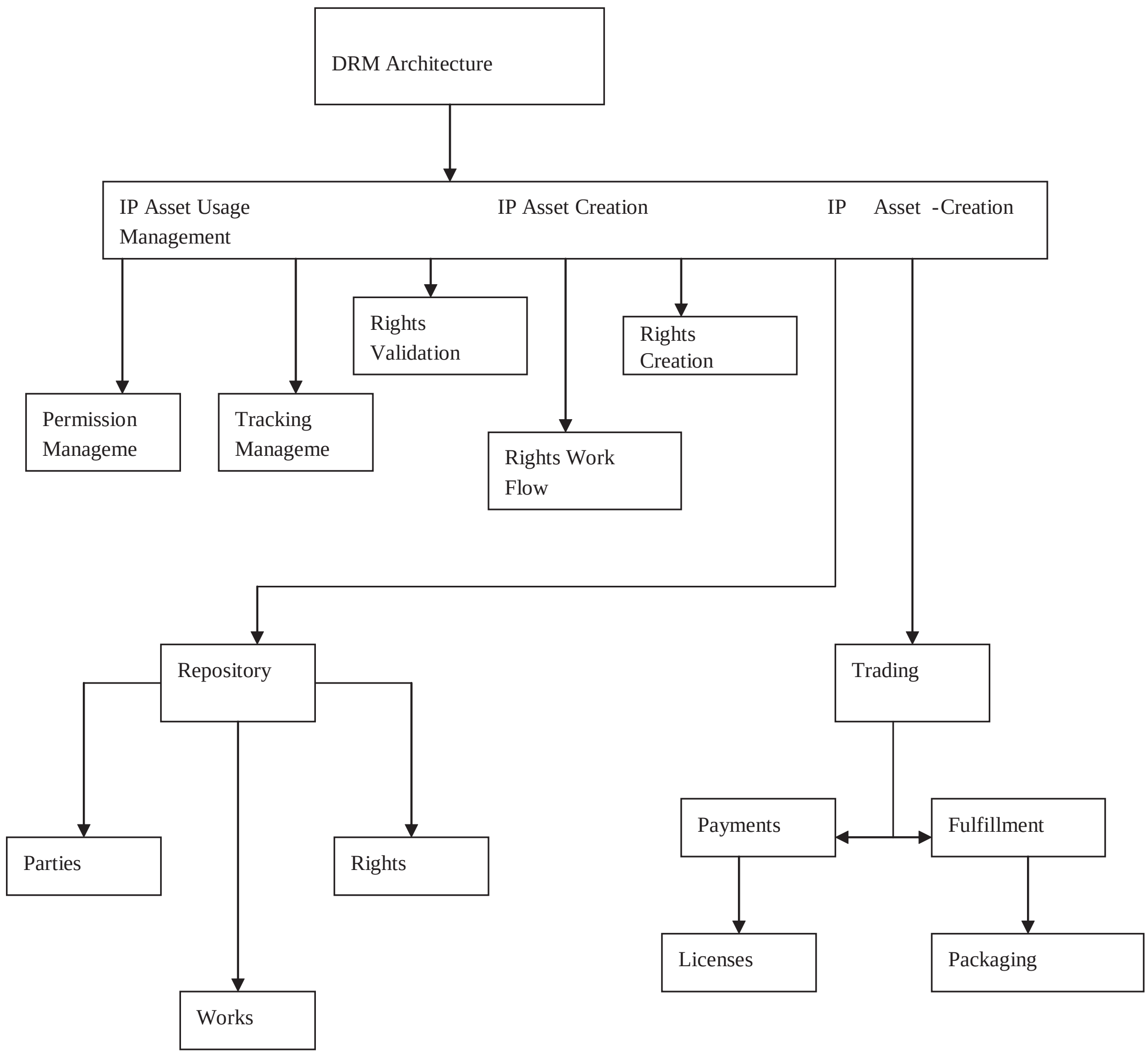
Once the IP asset has been traded, this module focuses on how to manage the usage of content. This includes supporting constraints over traded content in specific desktop systems or software.

The IP asset-usage module supports permissions management to enable the usage environment to honor the rights associated with the content. For example, if the user only has the right to view the document, then printing will not be allowed. It also allows tracking management to enable the monitoring of the usage of content where such tracking is part of the agreed-to license conditions (e.g., the user has a license to play a video 10 times; Iannella, 2001).

SECURE CONTENT MANAGEMENT

The final link in the secure knowledge-management chain is the one that links content and com-

Figure 3. Digital-rights-management architecture



munication, that is, secure content management. The Internet is a tremendous tool for enterprises to share intellectual property with customers, partners, and suppliers. It is an instant distribution network any corporation can use to improve communications while lowering operating costs (Ogren, 2003). The Yankee Group estimates that the market for secure content-delivery products and services amounted to $302 million in 2002 and will grow to $580 million by 2007. It is widely believed that more destructive and harder-to-detect threats, spam, legal liability, employee productivity, and compliance with privacy regulations will continue to fuel the growth of the secure content-management market over the next several years (http://www.csoonline.com/analyst/report1490.html).

The Internet, instant messaging, and the availability of Web content have transformed everyday business activities (Robb, 2003). As a result, CIOs (chief information officers) and IT management are increasingly looking for solutions to help enforce corporate policy, comply with privacy regulations, limit legal liability, increase employee productivity, and reduce network bandwidth consumption. All this is made possible by secure content-management solutions.

Secure content-management tools help to correctly label business-related content. The first generation of SCM products is now beginning to appear on the market. Generally, they consist of the following features: antivirus capabilities, proactive identification to block only malicious code, smart filtering of spam and URLs (uniform resource locators), keyword identification to safeguard against the transmission of proprietary and confidential information via e-mail, and centralized management of all facets to bring simplicity to the task of security administration (Robb, 2003).

Secure Content Delivery

With the advent of the Internet, content that enterprises once closely guarded in private databases is now being placed on the Internet to save distribution costs throughout the supply chain and to increase customer satisfaction. A Web initiative can take multiple forms: for example, an employee portal or Web-enabled self-service partner extranet. Each such initiative involves delivering business value. The Web has been instrumental in expanding communication channels and providing endless opportunities. Globalization has led to increased collaboration among trading partners that require the sharing of confidential information. The quest for cost-effective solutions for secure content delivery is intense since it must not only ensure the privacy of the electronic customers, but also reliably deliver important information only to designated recipients.

The trend has been to centralize identity management and documents in secure server repositories and portals accessed by browsers, and to avoid the complexities of client-side software installations. Content in transit has traditionally been protected by secure-sockets-layer (SSL) communications for browsers, and virtual private networks (VPNs) for application access, encrypted e-mail, and proprietary application solutions.

CONCLUSION

We are moving into a knowledge-based economy in the 21st century. Knowledge-based assets are gaining in importance, and it is becoming extremely important to protect these assets. In the area of national security, the knowledge that must be shared comes from many fields including homeland-defense activities, tactical intelligence missions, diplomatic channels, and direct military support. A range of KMS approaches and technologies and their security features need to be examined to enable critical intelligence gathering. Critical issues in secure knowledge management include content, communication, and collaboration. In this context, SAML, SKQML, circles of trust, DRM, secure content management, and secure content-delivery mechanisms would ensure the security and privacy of knowledge repositories.

REFERENCES

Barth, S. (2001). Open yet guarded: Protecting the knowledge enterprise. *Knowledge Management Magazine*.

Cohen, F. (2003). *Debunking SAML myths and misunderstandings.* IBM Developer Works.

Esllani, B., & Luthans, F. (2003). What knowledge managers really do: An empirical and comparative analysis. *Journal of Knowledge Management, 7*(3), 53-66.

Feigenbaum, J., Freedman, M., Sander, T., & Shostack, A. (2002). Privacy engineering in digital rights management systems. In Lecture notes in computer science: Vol. 2320. *Proceedings of the 2001 ACM Workshop on Security and Privacy in Digital Rights Management.* Berlin, Germany: Springer.

Iannella, R. (2001). Digital rights management (DRM) architectures. *D-Lib Magazine, 7*(6).

Labrou, Y., Finin, T., Sherman, A., & Rabi, M. (1997). *A proposal for a new KQML specification*. Baltimore, MD: Computer Science and Electrical Engineering Department, University of Maryland.

Morey, D., Maybury, M., & Thuraisingham, B. (2003). *Knowledge management: Classic and contemporary works.* MIT Press.

Ogren, E. (2003). *Secure content delivery protects shared, transmitted and post-delivery digital assets.* CSO.

Patrizio, A. (2003). *SAML advances single sign-on prospects.* Fawcette Technical Publications.

Robb, D. (2003). *The emergence of secure content management.* IT Management.

Thuraisingham, B. (2003). Data mining and cyber security. *Proceedings of the Third International Conference on Quality Software (QSIC'03).*

Thuraisingham, B. (2004). Cybertrust, data and applications security. *Proceedings of the Secure Knowledge Management Workshop,* Buffalo, NY.

Thuraisingham, B., Chadwick, D., Olivier, S. M., Samarati, P., & Sharpston, E. (2002). Privacy and civil liberties. In *IFIP Conference Proceedings* (256). Kluwer.

Varney, C. (Ed.). (2003). *Privacy and security best practices.* Liberty Alliance Project.

Wagner, R., & Witty, R. (2003). *Southwest Airlines shows SAML's promise.* Gartner Research.

Zander, U., & Kogut, B. (1995). Knowledge and the speed of the transfer and limitation of organizational capabilities: An empirical test. *Organization Science, 6.*

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Chapter 7.16
Secure Knowledge Discovery in Databases

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INTRODUCTION AND BACKGROUND

Knowledge management (KM) systems are quite diverse, but all provide increased access to organizational knowledge, which helps the enterprise to be more connected, agile, and effective. The dilemma faced when using a KM system is to balance the goal of being knowledge-enabled while being knowledge-secure (Cohen, 2003; Lee & Rosenbaum, 2003).

A recent survey of IT security professions found that over 50% of respondents indicated an increase in the security budgets of their organizations since September 11, 2001, and projected that 2004 IT security budgets would be larger than ever (Briney & Prince, 2003).

The need for increased security is driven by both monetary concerns and legal/regulatory requirements. The goal of any security architecture, and specifically for KM systems, is to reduce the potential loss caused by intrusion, system misuse, privilege abuse, tampering, and so forth. Protection must be provided against external threats and from internal abuse and must include components that address the requirements for preserving the confidentiality of data where appropriate.

A 2002 Jupiter Research Consumer Survey estimates that as much as $24.5 billion in online sales will be lost by 2006 due to consumers' lack of confidence in the privacy of online transactions (E-Compliance Advisor, 2002). While lack of trust is an opportunity cost, security breaches can causes real losses. One study found firms with publicly announced security breaches lose an average of 2% of market capitalization within two days of attack, for an average of $1.65 billion dollars per breach (Cavusoglu, Mishra, & Raghunathan, 2002). On the regulatory side, legislation like the Health Insurance Portability & Accountability Act (HIPAA) and the Gramm-Leach-Bliley Act (GLBA) have forced companies in health care and financial services fields to improve their security measures (Briney & Prince, 2003; Ingrian Networks, 2004). Table 1 summarizes some common security threats.

While most of the major news stories about security breaches involve hackers who steal or access confidential information, infect systems with viruses, and cause trouble with worms or spam, an equally important threat comes from inside organizations. A report from Ingrian Networks (2004) indicated that 50% of security breaches are perpetrated by internal staff (see Lee & Rosenbaum, 2004). Internal threats represent a bigger risk than those from outsiders due to the difficulty in quantifying and counteracting the attacks. But while the risk of insider intrusions

Table 1. Security threats

Information Source	Ingrian, 2004	Briney, 2000	Boren, 2003
General	Poor security policies, human error, dishonesty, abuse of privileges, introduction of unauthorized software	Viruses, malicious code, executables, electronic theft, disclosure of proprietary data, use of resources for illegal / illicit activities	Storage threats: theft of servers, desktops, hard drives, tape backups, information, malicious software installed on server
Identification / Authorization	Internal / external attackers posing as valid users / customers		
Reliability of Service	Natural disasters, equipment failures, denial of service	Denial of service, buffer overflows	
Privacy	Eavesdropping, unauthorized monitoring of sensitive data		
Integrity / Accuracy	Modification or damaging of information		
Access Control	Password cracking, backdoors, security holes	Protocol weakness, insecure passwords, attacks on bugs in servers	Authentication credentials stolen / not properly managed, users given access to unnecessary information

Table 2. Selected security measures

Information Source	Ingrian, 2004	Briney, 2000	Boren, 2003
Security Policies / Security Education Programs	X	X	X
Identification/ Classification of Sensitive Data	X		
Determination of acceptable threat level	X		X
Passwords	X	X	X
Firewalls	X	X	X
Encryption	X	X	X
Backup / Recovery	X		X

looms large, many IT security professionals still seem to be externally focused (Briney & Prince, 2003).

With the increased focus on security, both internally and externally, a method that seems to be gaining popularity is a layered security approach (e.g., Kolluru & Meredith, 2001; Clark, Croson, & Schiano, 2001). The layered approach proposes using multiple, overlapping forms of security measures. A representative list of such security measures is summarized in Table 2. The layered security approach is a good way to prevent breaches, because if one measure fails, it is possible that other measures employed can stop the attack.

While many network security texts discuss network related hardware and software that are relevant for protecting the IT and KM system infrastructure (e.g., Panko, 2004) from external threats, this article illustrates a complimentary approach. Data perturbation focuses on protecting confidential data primarily from unauthorized internal data snoopers. This approach can be used alone or in conjunction with other methods.

Data perturbation involves modifying confidential attributes using random noise, with the objective being to prevent disclosure while maximizing access to accurate information (Muralidhar, Parsa, & Sarathy, 1999). Thus, a KM system can maintain and allow access to masked representative confidential data while preventing exact data disclosure.

To illustrate the different ways that perturbation techniques can be utilized, consider an example scenario where two divisions of a company are sharing information, some of which is considered confidential, and the sharing of data is done electronically. A layered approach to security would be the use of both data perturbation and encryption to secure the data. Data perturbation can be done before the transfer to mask or hide confidential attributes. During the transfer of data, encryption can be used to prevent attackers from accessing the data. By using the layered approach, the sending division protects its confidential data, obtains security during the transfer, and gives the receiving division full access to the perturbed data on the back end.

Data perturbation also can be used as a stand-alone technique to prevent unauthorized access from snoopers and hackers. If the data that users have access to is masked, then the impact of either an internal or external security breach is minimized. All attributes that are confidential (and numerical) can be masked, so their true values are hidden. In this way, even if there is a breach of security, no confidential information will be exposed.

Of all the different hardware and software security measures that are well documented for use in all information systems, data perturbation techniques are uniquely equipped to be one of the most useful and specifically applicable security techniques for knowledge management systems due to their focus on the data (and, therefore, on knowledge contained in the data). Thus, understanding how such perturbation techniques work and the implications on knowledge workers in the organization is extraordinarily applicable and very important for today's knowledge worker. Since this area is relatively new, organizations that learn about perturbation could gain considerably from increased protection of confidential data. Thus, the article's focus on perturbation techniques, rather than a general discussion of all possible (well-documented) hardware and software techniques that "might" be applicable to KM, is definitely warranted.

SECURITY AND ACCURACY USING DATA PERTURBATION

Data Perturbation Techniques

Database, security, and KM administrators face a problematic balancing act regarding access to shared organizational data. Confidentiality might be a requirement for some data elements due to legal or competitive reasons, but using KM tools (such as data mining and knowledge discovery algorithms) to find patterns in data can lead to increased profits or improved processes for the organization. Thus, limiting access to data will hamper these important organizational efforts. Nonetheless, the need to protect individual confidential data elements in databases from improper disclosure is critical.

Data perturbation techniques are sophisticated, yet easily implemented, statistically based methods that protect confidential data by adding random noise to original data values. These approaches prevent exact disclosure of confidential data, add a degree of inferential security, and, most importantly from a KM perspective, allow complete data access and analysis flexibility. This flexibility provides significant benefits to the organization using the database in their KM activities. These techniques mask individual confidential data elements while maintaining underlying aggregate relationships of the database.

Note that these techniques are not encryption techniques, where the data is modified, transmitted, and then returned back to its original form. Once data is perturbed, it stays (and is accessed) in its perturbed form.

The Generalized Additive Perturbation Process (GADP) has emerged as the de facto standard in the data protection research area. Thus, we focus on it exclusively. Past studies have shown that today it is the best way to protect confidential data in this manner. No doubt, future research will find additional techniques that will improve upon GADP. But for now, it serves as the most appropriate example.

GADP possesses no statistical biases and preserves statistical relationships in a dataset (Sarathy & Muralidhar, 2002). The GADP process is briefly explained next, and Table 3 compliments the discussion by showing the differences between a dataset with confidential attributes and its perturbed compliment.

In a database, the confidential attributes that data administrators want hidden will be called set X, and all other non-confidential attributes set S. A database U has i instances with attributes

Table 3. GADP method details

Original Data Set				Perturbed Data Set		
Confidential Attributes	Non-Confidential Attributes	Class Variable		Confidential Attributes	Non-Confidential Attributes	Class Variable
Original values	Original values	Original values		Values are perturbed (masked) here	Same as original values	Same as original values

Mean (x)
COV (xx)

Mean (x)
COV (xx)

Statistical relationships unchanged

X+S. The GADP process creates a perturbed database P, based on U, also with i instances and attributes X+S.

For all attributes in S, the attribute value for instance i in database P will equal the corresponding value of that instance. Thus, GADP does not alter non-confidential attributes. However, for all X, the attribute values for instance i in database P will be perturbed, making it different from the value in the corresponding instance i in database U.

The perturbation process preserves the original statistical relationships of database U. These relationships include the mean values for attributes X, the measures of covariance between attribute sets X and S (i.e., a measure of how the two sets of attributes are related), and the canonical correlation between the attribute sets X and S, which is how well the actual values of attribute set X can be predicted by knowing the actual values of attribute set S.

Given these statistical properties of U, a multivariate normal distribution function is constructed for each instance i. Then, a multivariate random number generator generates the new X attribute values for the ith entry in the perturbed database P. This is repeated for all i instances.

Illustrating Data Perturbation

To illustrate the method and its analysis implications, a 50,000 record fictitious bank customer database was used. The data has five numerical attributes (Home Equity, Stock/Bonds, Liabilities, Savings/Checking, and CDs) and a sixth binary categorical class variable indicating whether a customer has been granted special service privileges or not (1 if yes, 0 if no). The means, standard deviations and correlation among these variables are shown in Table 4.

When the dataset was constructed, a decision tree format relating the five numeric attributes to the one class variable was used to assign the 50,000 records to the two classes equally (25,000 cases to each class). The choice of this format is arbitrary and just one of many structures that could represent the database's knowledge. The database was created with different degrees of

Table 4. Original database information

Descriptive Statistics	Home Equity	Stocks/Bonds	Liabilities	Savings/Checking	CDs	Class Variable
Mean	20.000	50.000	100.000	50.000	80.000	0.500
Standard Deviation	5.000	10.000	20.000	10.005	19.981	0.500
Correlation Matrix	Home Equity	Stocks/Bonds	Liabilities	Savings/Checking	CDs	Class Variable
Home Equity	1.000					
Stocks/Bonds	0.440	1.000				
Liabilities	0.501	0.218	1.000			
Savings/Checking	0.357	0.137	0.631	1.000		
CDs	0.237	0.112	0.756	0.723	1.000	
Class Variable	0.353	0.129	0.018	0.068	-0.161	1.000

"noise" in the assignment of class variables, representing different degrees of knowledge "crispness" (i.e., how well the five variables truly differentiate among the two classes of bank customers). We report the results for the 0% noise case, even though knowledge in practice would typically not be this easily defined. Nonetheless, the results will remain representative for the sake of our example.

Additionally, for example's sake, the variables representing Stock/Bonds, Liabilities, and Savings/Checking were deemed confidential, and the others, non-confidential. Thus, the perturbation process will mask the actual values of these three variables but will still preserve the linear relationships between the six variables.

Statistical Relationship Preservation

To check for the proper implementation of perturbation, the means, standard deviations, and variable correlations of the dataset before and after perturbation can be examined (see Tables 4 and 5). We see that the GADP process does preserve these important statistical relationships while masking or hiding the confidential data.

Thus, the knowledge worker can perform analyses on the protected database, and in terms of aggregate statistical measures, suffer no loss of accuracy. Given the confidential attributes have been masked, there is also no chance for the specific confidential data fields to be discovered by a data snooper or unauthorized user.

Table 5. Perturbed database information

Descriptive Statistics	Home Equity	Stocks/Bonds	Liabilities	Savings/Checking	CDs	Class Variable
Mean	20.000	49.906	100.011	49.966	80.000	0.500
Standard Deviation	5.000	9.995	20.046	10.031	19.981	0.500
Correlation Matrix	Home Equity	Stocks/Bonds	Liabilities	Savings/Checking	CDs	Class Variable
Home Equity	1.000					
Stocks/Bonds	0.435	1.000				
Liabilities	0.498	0.000	1.000			
Savings/Checking	0.355	0.132	0.633	1.000		
CDs	0.237	0.106	0.758	0.724	1.000	
Class Variable	0.353	0.124	0.018	0.067	-0.161	1.000

Knowledge Discovery Preservation

Using only simple statistical measures (means, variances, covariances, etc.) to measure the retained information and/or knowledge in a perturbed database is certainly a limited view of the usefulness of data. Knowledge discovery (KD) techniques (i.e., data mining) can identify underlying patterns in a database, which provide decision-makers deeper knowledge about that database, and, therefore, the organization. In this continuing example, we explore how perturbation impacts the ability for KM tools to discover the relationships (if any) between the five quantitative variables and the special services classification designation.

There are innumerable knowledge discovery tools. We choose two basic tools from two "common" families of knowledge discovery approaches. Multiple discriminant analysis (MDA) and logistic regression (LR) are the two traditional parametric approaches utilized, while an inductive learning approach—Classification and Regression Tree (CART)—and a feed-forward neural network (NN) approach were the two non-parametric tools utilized. All four approaches are readily available in software packages like SPSS, and our implementation was performed with SPSS using default values.

Classification accuracy of the knowledge discovery tools was measured to provide a measure of knowledge retention. Ten-fold cross-validation was used to ensure a robust measure of tool classification accuracy (Weiss & Kulikowski, 1991). An instance was labeled correctly classified when the tool classification matched the actual class value of the database instance. The correct number of classifications was assessed both for the training (development) and testing partitions. Because of the large size of the database, the accuracy of the tools for the training and testing sets were nearly identical. For simplicity, the results of only the testing sets are reported.

Table 6 shows the results of the analysis. Not surprisingly, CART, an inductive learning algorithm that discovers database knowledge in the format of a decision tree, correctly classified 100% of the cases in the original database. One would expect this approach to discover database knowledge in a precise manner because its structure matches the method in which the original knowledge was artificially created.

The level of performance of the other three approaches on the original data is also interesting. The NN performs almost as well as CART (98.6% accuracy), while the two parametric approaches, MDA and LR, perform quite poorly (72.55% and 72.85%, respectively). This suggests that the relative performance of knowledge discovery tools is a function of matching the underlying structure of the knowledge in the database. Unfortunately, this structure is not known until the data is analyzed.

Table 6. Classification accuracy

	Tool	Mean	Standard Deviation
Original Dataset	Decision Tree	100.000	0.000
	Artificial Neural Network	98.640	0.237
	Logistic Regression	72.850	0.836
	Multiple Discriminant Analysis	72.550	0.759
Perturbed Dataset	Decision Tree	90.240	0.470
	Artificial Neural Network	90.010	0.438
	Logistic Regression	71.800	0.978
	Multiple Discriminant Analysis	71.740	0.956

This example also indicates the potential utility of NN's as a general-purpose knowledge tool regardless of the knowledge structure.

When using our decision-making tools with the perturbed data, we can see a "loss" in classification accuracy for all tools used. CART and ANN correctly classify about 90% of the cases, a loss in accuracy of about 8 to 10%. The parametric tools had classification accuracy rates that were statistically similar between the original and perturbed data. This was due primarily to their relative inability to differentiate among the two customer classes in the original database.

This loss of accuracy stems from the perturbation process changing the values of the confidential data. While it preserves the statistical relationships, the masking of confidential data does destroy some of the crispness of the underlying knowledge.

Summarizing the results, the use of perturbation to mask confidential data in a KM-enabled database provides good inferential disclosure security and perfectly preserves aggregate statistical relationships, but appears to cause a loss in accuracy in discovering deeper relationships (knowledge) in the database.

Decision-Maker Implications

The results in the previous section have shown that using data perturbation as a means to secure confidential data shows promise. However, the GADP method could not perfectly preserve underlying knowledge in the database as it did the aggregate statistical relationships. A database administrator, or security policy maker, would need to assess whether a small reduction in predictive accuracy from a representative knowledge discovery tool is tolerable given the inferential disclosure security provided in the perturbation procedure.

There may be other measures of successful knowledge discovery beyond classification accuracy. Even with an 8 to 10% drop in accuracy, the rules discovered from the perturbed database might be the same or similar to the rules for the original data. If that were true, the accuracy loss would be irrelevant because the knowledge discovered would be equivalent.

Some practical implementation issues also are worthy of mentioning. The manner in which updates are made to the database is important. Most, if not all, organizational databases are dynamic (not static), and data would need to be perturbed on an ongoing basis. Certainly, coordination of this update would be an important implementation issue.

The costs to implement data perturbation techniques appear to be minimal, so from an economic standpoint, a database administrator would have no trouble justifying its use. In this article, for example, the authors used Microsoft Excel and a free spreadsheet add-in to accomplish the perturbation. For larger databases, similar libraries of code could be utilized to automatically update the databases appropriately. Since frequent updates to databases cause the need for ongoing perturbation, procedures would need to be put into place so that perturbation would occur on a regular (daily) basis and not interfere with employee use of the data. An automated routine can be written such that the perturbation process could occur nightly with little need for human supervision, so the only implementation costs would be in the form of computing time. It is our estimation that the additional cost that would accrue to an organization implementing this as part of their KM security process would be well worth the increase in confidential data protection.

As organizations continue to increase the degree of KM system sophistication, the difficult tradeoffs between data access, protection, and confidentiality must be considered. There are many security issues involved, and a layered, multi-faceted approach has obvious merit.

FUTURE TRENDS

This article has shown how data protection techniques can be used to help mask confidential attributes in an organization's database, which is a part of the overall KM system. The GADP method, a standard in the data protection literature, was used to illustrate the impact on the database attributes of the perturbation (very little) and the impact on the ability of knowledge discovery tools to accurately find important knowledge (somewhat impacted).

The findings indicated that GADP-protected databases have desirable characteristics but cannot perfectly maintain knowledge relationships to the same level as the statistical relationships are preserved. Therefore, some loss of knowledge accuracy is sacrificed when organizations employ this form of data protection technique. The benefits, though, are reduced disclosure risk and full access to data for analysis. These benefits are not found in any query reduction technique or other methods in which access to confidential data is restricted.

Future research will no doubt continue to look at techniques that go beyond GADP in their sophistication and ability to preserve additional relationships (such as knowledge) in databases. There also will be increased emphasis on sharing data between organizations in the future, and the promise of data perturbation will play a key role in dealing with the dilemma of protecting the unauthorized sharing of confidential data.

The focus of this article on one specific technique should not be viewed as myopic. Present research has shown that this technique cannot be matched. Of course, future modifications and variations will occur and these techniques will further mitigate "knowledge lost" that the example application in this article showed could occur. The future is promising for the use of perturbation as part of the layered security techniques in data-centric organizations.

CONCLUSION

The use of data perturbation techniques as a component of KM system security shows great promise, even as a stand-alone approach to protecting confidential data. Future research will continue to enhance our ability to simultaneously keep confidential data secure while making it available and useful to our KM systems. The continued importance of data and knowledge in business will spur further advances in this new innovative, effective, and economical area of data perturbation.

REFERENCES

Boren, S. (2003). *IT security cookbook*. Retrieved June 11, 2004, from http://boran.linuxsecurity.com/security/IT1x-2.html

Briney, A. (2000). *Security focused: industry survey 2000*. Retrieved June 11, 2004, from http://infosecuritymag.techtarget.com/articles/september00/pdfs/Survey1_9.00.pdf

Briney, A., & Prince, F. (2003). *Security survey: Disciplined security*. Retrieved June 11, 2004, from http://infosecuritymag.techtarget.com/ss/0,295796,sid6_iss143_art294,00.html

Cavusoglu, H., Mishra, B., & Raghunathan, S. (2002). *The effect of Internet security breach announcements on market value: Capital market reactions for breached firms and Internet security developers*. Retrieved June 11, 2004, from www.utdallas.edu/~huseyin/eventstudy.PDF

Cohen, A. (2003). *Security vs. accessibility: A fine balance*. Retrieved June 16, 2004, from http://zdnet.com.com/2100-1107_2-1018121.html

Clark, T.H., Croson, D.C., & Schiano, W.T. (2001). A hierarchical model of supply-chain integration: Information sharing and operational interdependence in the U.S. grocery channel. *Information Technology and Management, 2,* 261-288.

E-Compliance advisor: Use online privacy as a marketing initiative. (2002). Retrieved June 11, 2004, from http://crm-advisor.com/doc/09873

Ingrian Networks (2004). *Achieving data privacy in the enterprise.* Retrieved June 14, 2004, from www.itsecurity.com/papers/ingrian1.htm

Kolluru, R., & Meredith, P.H. (2001). Security and trust management in supply chains. *Information Management and Computer Security, 9*(5), 233-236.

Lee, J.B., & Rosenbaum, A.D. (2004). Knowledge management: Portal for corporate espionage? Part 2. *KM World, 13*(1), 10.

Lee, J.B., & Rosenbaum, A.D. (2003). Knowledge management: Portal for corporate espionage? Part 1. *KM World, 12*(10), 14.

Muralidhar, K., Parsa, R., & Sarathy, R. (1999). A general additive data perturbation method for database security. *Management Science, 45*(10), 1399-1415.

Panko, R. (2004). *Corporate computer and network security* (1st ed.). New York: Prentice Hall.

Sarathy, R., & Muralidhar, K. (2002). The security of confidential numerical data in databases. *Information Systems Research, 13*(4), 389-403.

Sarathy, R., Muralidhar, K., & Parsa, R. (2002). Perturbing non-confidential attributes: The copula approach. *Management Science, 48*(12), 1613-1627.

Shirley, R. (2000). *Internet Security Glossary.* Retrieved June 14, 2004, from www.ietf.org/rfc/rfc2828.txt

Weiss, S., & Kulikowski, C. (1991). *Computer systems that learn.* San Mateo, CA: Morgan Kauffman.

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Chapter 7.17
We've Got a Job to Do – Eventually:
A Study of Knowledge Management Fatigue Syndrome

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ABSTRACT

The implementation of knowledge management systems at universities can be tremendously costly in terms of both human and capital resources. One reason for this cost is the extended time period, generally measured in years, not months, over which they are implemented. This qualitative study presents data on the implementation of one such project at a Research I university in the southwestern United States. The analysis focuses on the concept of knowledge management fatigue syndrome and the increase of technological bloat and academic technocracy as a result of the project.

INTRODUCTION

Unforeseen costs and consequences of knowledge management projects at universities frequently are cited in the press. For example, the California State University system began a $400 million overhaul of its administrative information system in 1998. By 2003, there were many questions about the appropriateness and efficiency of the system, and it was clear that it has caused numerous unintended consequences to numerous administrative functions from accounting to student advising (Olsen, 2003). Similarly, an unforeseen problem with a management software upgrade at the University of Florida led to a delay in the processing of paychecks of more than 400 hundred graduate teaching assistants for nearly a month (Carnevale, 2004). These are just two examples of the problems universities face when implementing knowledge management systems. Given such problems, one wonders why a university would choose to implement these large-scale "enterprise" systems and what that process entails. This study illuminates one such implementation demonstrating knowledge management fatigue syndrome (Hakken, 2003). Further, the case study shows how knowledge management implementation can lead to technological bloat and academic technocracy (see Chapter IV).

This chapter is concerned with how such a long term project has affected the units of the university that have been directly involved in the first rounds of implementation, how users have responded to the system, and how the overall structure of units have changed. I will explore these questions by presenting data from e-mails, informal interviews and participant observation in one of the units that have been directly involved with the first round of the system's implementation. Before presenting data, I will discuss the conceptual framework that guided my inquiry.

CONCEPTUAL FRAMEWORK

Many organizations, including universities, in the 1990s chose to use knowledge management systems to improve the efficiency and service quality of their operations. As indicated in Chapter IV, these intended gains in efficiency and quality have remained elusive at best. Why, then, have organizations continued to pursue such goals? The concept of an academic technocracy presented is central to my analysis. In the previous chapter, my colleagues and I discuss three consequences of higher education institutions' efforts to respond to the pressures of academic capitalism and technocracy: the digital restructuring of academic labor, the unproven efficiency argument of academic technology, and the emergence of "technological bloat." Each of these phenomena may be giving rise to an "academic technocracy." In part, this chapter will present data that helps to support these hypotheses, but, more importantly, the chapter will incorporate Hakken's (2003) idea of "knowledge management fatigue syndrome" as an explanation of how an institution-wide knowledge management implementation project could continue for more than a decade.

More than 10 years ago a Research I university in the southwest (Southwest University) proclaimed in a strategic planning document for information technology that it would "leap forward utilizing information technology to fulfill the University's goal of becoming the best land grant institution in the country." Certainly, the goals of this project were grand. While it is not necessarily shocking to see a university desiring to improve its status in the U.S. higher education system, the study university does demonstrate a new dimension in how it intends to create this increased prestige. "Southwest University" intended that an information technology system would create the change needed to achieve the goal. Initially, the implementation process was intended to take only two years; today, after more than a decade, the project has yet to be fully realized. As discussed above, Southwest University envisioned a knowledge management system that would allow students and staff alike the ability to access essential data at any time, from any place. This access, of course, would be attainable because of the Internet and other advanced information technology. Hakken (2003) suggests that the early to mid 1990s was the prime time for such assertions because at that time knowledge management was the "killer application" that would justify the massive organizational investment in automated information technologies: "It [knowledge management] fed (and fed off) the media hype about the 'knowledge society'" (p. 55). In the early 1990s, it was reasonable to assume that a university attempting to improve its ranking would look to an all-encompassing, integrated knowledge management system to achieve its goals, as was the case for Southwest University. Hakken (2003) adds that as a result of the rhetoric of the information society, the New Economy, and globalization, "it was not difficult to convince the typical manager that highly touted information technology, as it got more complex, would provide an infrastructure for 'sharing the knowledge' among distributed staff" (p. 65).

Given the initial enthusiasm and high expectations that a new knowledge management system would solve all of the university's data access, manipulation, storage, and, particularly, integration problems, it is surprising that Southwest did not complete the project reasonably close to its initial two-year timeline. It can be argued, however, that the failure to complete the project in a timely manner was the result of knowledge management fatigue syndrome (Hakken, 2003). As conceptualized by Hakken, knowledge management fatigue syndrome results when enthusiasm for knowledge management solutions evaporates, projects are stalled, and discussion about them is stifled. Hakken offers five technical and conceptual explanations for the emergence of knowledge management fatigue syndrome in organizations: (a) the short shelf life of automated information technology slogans; (b) the overselling of products in a crowded marketplace; (c) continuing technical difficulties in using Web-based interfaces to merge complex information databases; (d) the inappropriateness of IT products designed for one purpose being sold for another; and, (e) the failure of many KM projects to take sufficient account for the social. Generally, technical explanations tend to be more apparent from outside an organization, while the conceptual explanation is more easily viewed from inside an organization.

Hakken's first technical explanation evokes Birnbaum's (2000) concept of management fads in higher education, where higher education institutions adopt popular management trends from the private sector before they have been proven effective. According to Birnbaum, by the time higher education organizations have adopted such practices, private businesses already have moved on to a new strategy because the initial one has lost its luster. In combining these two ideas, the first technical explanation for knowledge management fatigue syndrome would be understood as short-term information technology fads. Hakken (2003) explains that although knowledge itself still might be important to organizations, the term "knowledge management" can cease to have any importance and is, therefore, no longer "fashionable."

Over-competitiveness in a potentially lucrative market defines Hakken's (2003) technical explanation for knowledge management fatigue syndrome. That is, technology firms in their desire to capture market share with the appearance of "cutting edge" technology would simply repackage data and information networking products—without substantive modifications—as "knowledge management" products. Knowledge management in name only, these products were not designed to "address the problems of creating the trust, commitment, and community-life feel of teams/thick knowledge networking, on greater, more complex scales" (p. 65). Once again, this technical explanation for knowledge management fatigue syndrome is also related to Birnbaum's (2000) conception of higher education management fads. Too often higher education organizations seek easy answers in a new management style or system for what is a complex human issue. In the case of knowledge management, this second explanation illuminates the problem that information technology is unable to offer an easy solution to complex problems involving both data and human responses to it and to each other through it. Hakken (2003) suggests that too often inappropriate products were sold as knowledge management solutions.

The third technical explanation is mirrored in the dot com bust at the turn of the century. Initially, the Internet (and networking itself) was championed as the new, efficient model for all businesses and organizations. Unfortunately, that promise was found to be lacking in many instances. One such problem was the relative inability of Web-based products to always integrate large and complex sets of data; let alone doing it instantaneously from remote locations. Each of these three technical explanations, then, gives rise to the fourth. No technology—hardware or software—can be a panacea, the correct and efficient answer to all problems.

Hakken (2003) also offers one overarching conceptual explanation for knowledge management fatigue syndrome: "the failure of many KM projects to take sufficient account for the social" (p. 66). This conceptual explanation is closely related to the second technical explanation. Not only a means to integrating vast amounts of data into useful knowledge, knowledge management systems also need to integrate and coordinate various units in an organization, units which are often territorial about the data they control and the power and leverage such data grants them. To function properly, a knowledge management system must foster a real sense of cooperation and teamwork among units that may have no history of such interactions. This human function is much more complex than even the technical challenges facing knowledge management systems. Through both technical and conceptual frames, Hakken (2003) offers a means to examine the implementation of a fully integrated student information system at Southwestern University.

DATA AND METHODS

This study was a qualitative analysis of the experiences of one student services unit at a southwest university as it worked to implement a new student information software during the 2003/2004 school year. Data for the study included: informal interviews, participant observation, and most importantly for this chapter, analysis of two forms of documents—e-mail communications and historical documents concerning the development of the student information system—based on Hakken's (2003) explanations for knowledge management fatigue syndrome. Initially, I collected unit e-mails regarding the implementation process for a sixth month period, January 2004 – June 2004. After the data were collected, I coded them by Hakken's five explanations—technical and conceptual. I then analyzed the coded e-mail data to look for additional themes based on the challenges presented and discussed in the e-mails (Miles & Huberman, 1984). The informal interviews and my own observation during this period offered a means of triangulation for the e-mail data analysis. That is, the interviews and observations allowed a means of comparison to findings from the document analysis, which increases the validity and reliability of the findings (Creswell, 1994; Marshall & Rossman, 1989; Merriam, 1988) either by confirming patterns found in the document data or presenting contradictions to it.

ANALYSIS

Introduction

Before presenting findings from the study, I will briefly discuss the history of the implementation of the new student information system at "Southwest University." From its inception more than a decade ago, the student information system at Southwest University was intended to be Web-based and available to students, faculty, administration, and any other interested parties. This "anytime, anyplace" access was emphasized as one way that the university could improve its prestige. The new system would integrate data and reporting from all of the university's major academic and administrative units, including student financial aid, student billing, admissions and recruiting, curriculum and registration, and a student Web system.

The student information system project began in the spring of 1994 with the formation of a team to create an information planning study. This initial phase of the project moved quickly, with a report focused on strategic directions for the year 2000 completed by fall of the same year. That fall, a planning team was created to refine the recommendations made in the original strategic directions document. By March of 1996, the planning team had completed more intensive research into the technological needs and aspirations at Southwest. The result of this research phase was to support all of the major recommendations of the original strategic planning document and to suggest that the "initial reengineering" project begin immediately.

Based on evidence found in historical documents, it is unclear what happened with the project between 1996 and 1999. Whatever the cause, there was little action taken during this three-year period. During that period, a request for proposals (RFP) for the new student information software was issued. The RFP stipulated that the module for student prospecting and admissions should be in use by May 1999, with all system components implemented by December 2000. Other than this RFP and its suggested project timeline, there is little evidence of other activity during this period. What is clear is that this timeline was never close to being met.

The university had signed agreements with three corporate partners by March 2000, including a contract with the software company that had won the bid from the RFP. These partnerships were discussed in a March 2000 press release that also claimed that initial testing for the system would begin in July of that year, with complete implementation in three years (spring of 2003). A project newsletter from February 2001 indicated that the spring 2003 timeline was still on target while offering a revision of the project history by indicating that the project had achieved what had seemed impossible "two years ago." This accomplishment was simply completing the initial testing of the system which was still two years from scheduled implementation. The newsletter makes no reference to the RFP which called for full implementation by December of the previous year, let alone the original plan from 1994.

As of the summer of 2004, the project had finally implemented the first of its major modules, but it had not yet completed full implementation. While it may be reasonable to assume that full implementation should be achieved by 2005, that date would be two years after the spring of 2000 projection, five years after the RFP projection, and 11 years after the original strategic plan. The rest of this section seeks to illuminate how this process has taken so long.

Technical Explanations

In this study, I found ample evidence in both the historical documents about the project and in the e-mails concerned with its implementation of knowledge management fatigue syndrome (Hakken, 2003) and how it indicates increased technological bloat and academic technocracy.

The historical documents associated with the development of the student information system were of particular importance for finding evidence for Hakken's (2003) first technical explanation. In documents from 1994-2000 the need for students, faculty, and staff to access information "at any time and from any place" is repeated in all documents. This 24 hour-a-day, 365 day-a-year need for access to information was one of the mantras of 1990s technology enthusiasts. Certainly it would have been used as a major selling point and justification for any information technology project from the time. Beyond this any time, any place access for those associated with the university, the system was also frequently described as a means to share and capture data with "business partners, high schools, community colleges, the state, and the world." A concern with sharing and capturing data with business partners and, particularly, the world also echo the slogans of the New Economy. Finally, these early project documents also promised "information services [that] are automated, knowledge-based, and easily adapted to changing campus and external requirements." Again, the language of the need for constant adaptation of the New Economy is a central premise of the original project documents. From the beginning of the project, then, it is obvious information technology slogans (fads) were influential in the development of the new student information system project.

The historical documents also show a desire on the part of the university to foster partnerships with major technology corporations, including both hardware and software manufacturers. Specifically, the university created a hardware partnership with a major computer manufacturer and operation software corporation that made changing hardware and software platforms virtually impossible because of the nature of the agreements. It is important to note that neither of these companies was known in any way as leaders in the higher education administrative technology systems market; however, they did offer considerable in-kind donations to the university project, allowing the university to decrease its initial capital investment, while allowing the products of both companies to become entrenched in the system. The other major partnership was with the software company that would provide the actual information system software. While this company had worked with several major research universities, it was relatively small and from the beginning of the project it was clear that its software modules would need tremendous customization to fit the university's needs. All three of the partnerships were critical in the initial development of the student information system project at Southwestern University. But, as predicted by Hakken (2003), none of these partners actually had experience with meeting the exact needs of the university. By partnering with these firms, the university put itself in a position to be constrained by the technical limitations of the partners and to be left without viable alternatives when problems arose because of the nature of these exclusive partnerships.

While historical documents were important in establishing the relevance of the first two technical explanations, the experience of student services system analysts and staff members as documented by e-mail communications demonstrate the importance of the third technical explanation (Hakken, 2003). At the most basic level, the continuing technical difficulties in using Web-based interfaces to merge complex information bases is witnessed by the fact that since 2001 there have been three updates to the system minimum requirements for computer hardware and operation system software needed to use the student information system program. In other words, even at this basic level, the technical requirements for the program remain a moving target, demanding continual investments in technology infrastructure for the university. Related to these basic hardware and software changes, in July 2004 the student information system software, which had yet to go live in all units of the university, itself was upgraded. That is, the student information system, although it was not yet in campus-wide use, was already experiencing upgraded versions.

Beyond these continual changes in infrastructure, there were three general problems during the opening months of 2004 that demonstrate the challenges of using a complex Web-based system. Data has been lost, there have been problems with properly synchronizing data from units and central computing, and there was a potential data security problem. While there were only two instances mentioned in e-mails during the first half of 2004, student data was lost in the information system for unknown reasons. The second incidence left "no audit trail at all." Clearly, lost data, especially when there is no indication why it was lost, is a critical problem in such an information system. While not as critical as lost data, improperly synchronized data files were much more frequent than lost data. According to one e-mail, the system was "experiencing an inordinate number of file synchronization errors." With both data loss and data synchronization problems, data-entry and data-processing staff members were required to retrace steps taken with lost or improperly synchronized files and report to two different system analysts, one for the unit itself and one for the central information technology unit. It would take analysts from both units to correct these problems. Finally, because of the net-based nature of the system, users were instructed to "dump their browser cache (including offline content)" because of a "potential" security "issue." Each of these examples amply demonstrates the challenges of using a Web-based interface to manage complex data files among various organizational units and the labor intensive solutions required to remedy such problems.

The fourth technical explanation for knowledge management fatigue syndrome is closely related to the first three: it is particularly challenging for an organization to easily and successfully implement a new knowledge management system when the system was not originally designed for that purpose. The experience of Southwestern University clearly demonstrates this point. In the historical documents, the student information system was described as a product that already had been developed and implemented at several other higher education institutions and would only need to be customized to fit the university's needs. By the spring of 2004 the system was described in an e-mail from the student services director as "a software product that has not been used anywhere else in the world." So, what had been billed as an off-the-shelf product needing some minor modifications was later trumpeted as a unique system. In the same e-mail, the director also described the information system as having "a mind of its own."

Conceptual Explanation

The evidence from the section above provides a clear picture that each of Hakken's (2003) four technical explanations for knowledge management fatigue syndrome manifested themselves during the implementation of the student information system at Southwest University. Beyond these four explanations, there is evidence of a conceptual explanation at Southwest as well. The need for input and cooperation from all members of the university community was stressed throughout both the historic documents and unit e-mails. The planning stages of the project were highlighted by numerous university-wide committees that were intended to work cooperatively together to create a description of a single information system that would meet the needs of all units. These cooperative workgroups themselves would certainly be an example of Birnbaum's (2000) management fads, but more importantly they demonstrate how disparate and sometimes competitive units were expected to define and solve problems together throughout the entire process. The historical documents present technical reasons for why this needed to happen, but there was no suggestion as to how members from these units would be able to work together to accomplish the project's goals. The complex social interactions required of such a process are virtually ignored in the historical documents, leaving one to assume that it was a matter of faith that the promise of an advanced knowledge management system would unite all units of the university with a minimum of problems.

By the spring of 2004, one method of achieving unification became clear. In an e-mail, the director of the department in this study explained to all of its members that the systems personnel from the study's department along with their counterparts in both the financial aid and the curriculum and registration offices were "being merged into one Enrollment Management Information unit. In an effort to improve life for all of the systems people and to improve the service [the student information system] provides to the offices." So, what had originally been envisioned as a means to increased cooperation and information distribution between units finally had become a wholesale reorganization of student services departments at Southwestern University. While all data indicates that this was not an intended result of the new student information system, the system itself had caused the reorganization and redefinition of key student services units.

Ironically, the explanation given for the reorganization of the systems personnel emphasizes the centralized power of experts (as in a technocracy) over the independence and interconnectedness of individual units at the university. In the same e-mail, the unit director explains that "the new unit will expand the resources available to address any one problem in any of the units to a group of 20+ people instead of the limited personnel resources of each unit." Essentially, the use of technology and the information available to each unit would now be controlled by one central group whose individual members would have no direct connection or allegiance to any particular student services unit. It is possible to imagine that without personal ties to the needs of individual units, this new systems unit might be concerned with what it deems best from a technological standpoint without considering the human needs of the various student services units it is intended to serve—a serious sociological consequence of the implementation of the new student information system.

CONCLUSION

In this study, I was concerned with two central questions. First, can Hakken's (2003) concept of knowledge management fatigue syndrome be used to analyze and understand the implementation of the student information system at Southwest University? And, does the implementation of the system show evidence of technological bloat and academic technocracy? The data from this study clearly present evidence of each of Hakken's (2003) descriptions of knowledge management fatigue syndrome and those descriptions provide a means to interpret the long process of the student information system's implementation. Given this evidence one other question arises: Why continue with the project if there is knowledge management fatigue syndrome? The answer to this question is at once simple and complicated. The university is heavily invested in the technology infrastructure demanded by the project—there are tremendous sunk costs. They cannot simply ignore the project; they must forge ahead. At Southwest University, as at other higher education institutions, there may be fatigue, but such labor and capital intensive projects must be completed. Interestingly, there has been little fanfare about the project during the last two school years. A project that was heralded as a means to achieving prominence for the university is now quietly nearing completion. Although understated, the project's implementation has led to a complex reorganization of several student services units into a single enrollment management systems unit.

The new enrollment management systems unit shows evidence of technological bloat and academic technocracy. This new unit is centered on ever-changing advanced technology, and many of its positions which were originally defined as temporary for the project have become institutionalized—clearly a form of bloat. With this new unit, technocrats have assumed an increasingly important role in student services and administrative strategic planning. This increased prominence of "experts" will increase their influence at Southwest—a precursor of academic technocracy.

It is possible to view this technological bloat and academic technocracy as a consequence of knowledge management fatigue syndrome. Because the project has taken an inordinate amount of time to complete, the resulting fatigue has caused institutional stakeholders to be less concerned about efficiency and long-term consequences of decisions than they are about finding ways to complete the project—at 10 years and counting, it is easy to understand why.

REFERENCES

Birnbaum, R. (2000). *Management fads in higher education: Where they come from. What they do. Why they fail.* San Francisco: Jossey-Bass.

Carnevale, D. (2004). University of Florida's software upgrade delays payday for teaching assistants. *The Chronicle of Higher Education, October 1*, A35.

Creswell, J.W. (1994). *Research design: Qualitative and quantitative approaches.* Thousand Oaks, CA: Sage.

Hakken, D. (2003). "Knowledge management fatigue syndrome" and the practical importance of the cyberspace knowledge question. In D. Hakken (Ed.), *The knowledge landscapes of cyberspace* (pp. 55-69). New York: Routledge.

Marshall, C. & Rossman, G.B. (1989). *Designing qualitative research*. Newbury Park, CA: Sage.

Merriam, S.B. (1988). *Case study research in education: A qualitative approach.* San Francisco: Jossey-Bass.

Miles, M.B. & Huberman, A.M. (1984). *Qualitative data analysis: A sourcebook of new methods.* Beverly Hills, CA: Sage.

Olsen, F. (2003). Giant Cal State computing project leaves professors and students asking, why? *The Chronicle of Higher Education, January 17,* A27.

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Chapter 7.18
Knowledge Calibration

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INTRODUCTION

The purpose of this article is to describe the concept of knowledge calibration within the context of knowledge management. Knowledge calibration is a concept borrowed from the psychology of decision making. It refers to the correspondence between knowledge accuracy and the confidence with which knowledge is held. Calibration is a potentially important concept for knowledge management because it describes one of the subtle errors that can lead to poor decisions. Where the correspondence between the accuracy of one's knowledge and the confidence in that knowledge is high, decisions are described as well calibrated; but poor correspondence implies miscalibrated decisions. Since one concern of the field of knowledge management is the best use of knowledge for decision-making purposes, this topic is relevant.

BACKGROUND

A variety of scientists, including meteorologists, statisticians, and psychologists, have been interested in measuring and in explaining judgments of confidence and their relation to accuracy (e.g., Harvey, 1997; Yates, 1990). Most of these studies report that people are systematically overconfident about the accuracy of their knowledge and judgment. In fact, scholars have even considered overconfidence as a stylized fact of human cognition.

The construct "calibration of knowledge" refers to the correspondence between accuracy of knowledge and confidence in knowledge (see Figure 1). High accuracy and high confidence in knowledge promote high calibration; confidence in these decisions is justified. Low accuracy and low confidence also promote high calibration. In this case, decision makers are aware of their

Figure 1. Accuracy-confidence matrix

	Confidence	
Accuracy	High	Low
High	Good calibration	Miscalibration
Low	Miscalibration	Good calibration

ignorance and are unlikely to overreach. A lack of correspondence between accuracy and confidence means miscalibration. Miscalibrated individuals are either overconfident or underconfident—situations that can result in costly mistakes in decision making.

For example, a description of the difficulties Xerox had in successfully bringing their new inventions to market (Carayannis, Gonzalez, & Wetter, 2003) reveals that, among other problems, managers placed great faith in their knowledge of the market, technology, and future trends that was subsequently proved to be misplaced. One could argue that the Bush Administration's decision to go to war with Iraq in order to destroy weapons of mass destruction that did not exist, but were claimed to exist on the basis of high confidence in flimsy evidence, is also an example of miscalibration and its influence on decision making.

Although several approaches to improving knowledge calibration have been suggested, little effort has been made to integrate them into the field of knowledge management. A new dimension of the discourse on knowledge management can be added by examining the implications of the construct of knowledge calibration to knowledge management. In the subsequent paragraphs, we elaborate on how this can be achieved and why it is important.

MAIN FOCUS

Literature on knowledge management has focused on: (a) defining the constructs of knowledge and knowledge management; (b) describing processes associated with knowledge creation, storage and retrieval, transfer, and application; and (c) developing and implementing systems to facilitate these processes. Implicit in these tasks is the idea that knowledge is embedded in individuals, groups, as well as in physical structures (Alavi & Leidner, 2001; Brown & Duguid, 2000). These discussions implicitly assume that knowledge available in the organization will be used in decision making and that such use will enable users to make better decisions. As research has noted, however, knowledge, which as commonly used refers to accurate or correct knowledge, is not the sole factor affecting decision quality. Users have to access and wisely use the knowledge in decision making before KM systems can be said to improve management activity. One instance of this can be found in the "knowledge/use-reuse" situation where knowledge is developed and stored for reuse by its creators later on or by other subsequent users (Markus, 2001). If the knowledge is not well recorded, stored, or made easily retrievable, users will be few and their effectiveness compromised. A further problem is described by the impact of new technologies on marketing management, where Tapp and Hughes (2004, p. 293) argue that "…KM systems have increased the supply of knowledge 'objects' (explicit, recorded, packets of knowledge), but that usage of these 'objects' by other workers (the crucial added value) remains elusive." The skill with which users and re-users take advantage of knowledge depends on many factors, including capturing, packaging, and distribution of the knowledge (Markus, 2001). Moreover, the confidence with which the decision maker accepts that knowledge also affects the way he/she uses the knowledge to make decisions. In other words, knowledge calibration affects the quality of decision making.

Ideally, organizations are better served if all individuals have high calibration, arising from high accuracy and high confidence in the knowledge. This is not to deny that there could be cases where overconfidence can be justified as a functional adaptation to motivate the implementation of decisions (Russo & Schoemaker, 1992). Investigation of subtleties in the context of knowledge management can be the focus of later research. At this stage, the critical issues pertaining to knowledge calibration in the context of knowledge management are: (a) What factors contribute to miscalibration? (b) How can they be reduced or eliminated? and (c) What organizational practices can help promote calibration through knowledge management systems?

Factors Contributing to Miscalibration

Where does miscalibration come from? Although miscalibration is likely due to multiple causes and their interactions, two principal sources can be identified for our purposes: internal (personal) and external (structural). That is, miscalibration can arise from cognitive causes as well as from the quantity of information provided and how it is presented to the user.

Alba and Hutchinson (2000, pp. 139-142) summarize the main cognitive causes. These first include failures of memory due to distortion or incompleteness. Memory is often biased in the direction of a prior judgment, thus increasing overconfidence. Memory might be incomplete when decision-consistent facts are more easily recalled, better decision options fail to be considered, or where other aspects of the knowledge interfere with recall and consideration. Underconfidence can also arise when the consequences of decisions fail to be considered. The difficulty and frequency with which outcomes can be imagined reduces the perceived likelihood of an outcome. A second cognitive source of miscalibration comes from misweighting evidence, thereby not optimally incorporating decision inputs into the decision process. For example, decision makers often fail to use base rates in solving problems. They rely on available cues instead of valid ones. They overemphasize extreme instances, irrelevant data, and easy-to- understand information. Overconfidence can come from poor appraisal of the diagnosticity of information where diagnosticity varies with its ease of use. Motivational factors may induce decision makers to fail to consider hypothesis-disconfirming evidence, accept confirmation uncritically, or limit their search to supportive evidence only. Having some familiarity or expertise with the decision task might induce overconfidence where the decision tasks are inordinately difficult, as in turbulent environments where it is difficult for everybody to see the future. Finally, overconfidence arises where expertise is not helpful to the decision.

Alba and Hutchinson (2000, pp. 142-144) and others describe some of the ways in which information is presented (inappropriate decision inputs) that can also induce sub-optimal levels of confidence. Too much information, where the assumption is made that greater amounts of information yield better decisions, or non-diagnostic information can cause overconfidence. Misattribution of information, as when fragments of retrieved information are interpreted as having been recalled from prior knowledge so that inference is interpreted as recall, can induce miscalibration. The number of operations needed to get an answer, familiarity with judgments, and the ease with which information can be retrieved may play a role. Another example of misattribution can be found in the "sleeper effect," where the source of information is forgotten over time, but the information itself is remembered; confidence in even poor information may increase if its provenance is lost.

Empirical evidence from the literature on information systems suggests that the design of both the information dimensions (quantity, form, format, etc.) and the inquiring system play key roles in user calibration. Oskamp (1965) used clinical psychology case studies to discover that increasing the quantity of information provided to decision makers produced miscalibration because it increased their decision confidence, but did not improve their decision quality. More information caused the confidence to soar out of proportion to the actual correctness of their decisions. Chervany and Dickson (1974) studied the effects of information overload on decision confidence, quality, and time. They found that decision makers using statistically summarized data outperformed those using raw data, but took longer and were less confident in their decisions. Familiarity with the decision task can promote overconfidence, as can the illusion of control, where decision makers come to believe that they have more influence on decision outcomes than they really do.

Ways to Improve Calibration

In general, it can be stated that calibration can be improved by promoting (1) accuracy of knowledge and (2) optimal levels of confidence in the knowledge. While accuracy can be viewed in monotonic terms, in as much as more of it is better, the knowledge management system should strive to promote optimal levels of confidence. Overconfidence and underconfidence mean miscalibration, and research has recorded the widespread prevalence of the former (Einhorn & Hogarth, 1981; Tversky & Kahneman, 1974). Hence, there is a need to build checks into the knowledge management system to promote optimal levels of confidence.

Bell (1984) compared different forms of presenting information and found a convergence between decision confidence and decision quality. Decision confidence based on information presented as text was greater than that for information presented in numeric form, but subjects found it easier to identify inconsistencies when the information was presented in numeric form rather than in textual form.

Literature also suggests that that using decision support systems—and by extension, knowledge management systems—also affects calibration. McIntyre (1982) found that the calibration of subjects using a DSS was worse than that of their unaided counterparts. He speculated that the DSS might have contributed to miscalibration (in the form of underconfidence) because it led subjects to believe that much better decisions existed than those from which they had selected.

Design features of a knowledge management system can also influence user calibration. Studies have examined the effects of design features on user calibration in the context of decision support systems. Davis, Kottemann, and Remus (1991) and Davis and Kottemann (1994) hypothesized that the use of a "what-if" inquiry design creates an illusion of control, causing users to overestimate the effectiveness of the what-if DSS design. Their results supported this hypothesis. Despite performance effects to the contrary, and the availability of tools whose recommendations would have led to much better decisions, subjects continued their use of the what-if design feature. That is, subjects maintained their overconfidence in the efficacy of the what-if inquiry design feature despite negative feedback and the availability of better tools. Davis and his coauthors concluded that an illusion of control was created by using the what-if feature of the DSS and that this illusion overwhelmed any negative feedback, including poor performance, in formulating the subject's attitude about the efficacy of the what-if DSS design feature.

Aldag and Powers (1986) also have suggested the illusory benefits of using a DSS. In their study, subjects analyzed strategic management cases and, assuming the role of a consultant, made written recommendations. Although the recommendations of those who used the DSS were judged no better than their unaided counterparts, the DSS-aided subjects reported more confidence in their recommendations than did those that were unaided, again resulting in miscalibration (Kasper, 1996). These illusory benefits were also found when the aid is an expert system. Faust (1986) provides a series of rules or necessary conditions for improving calibration. In summary form, his rules are: (1) decrease information overload and misleading illusory data; (2) present evidence that disconfirms and refutes one's position; (3) distinguish between knowledge and speculation, between knowledge and metaknowledge; and (4) generate competing alternative hypotheses. Kasper (1996) reviews relevant literature on decision support systems and opines that the design of both the information (overload, misleading, disconfirming, speculative) and the inquiring system (generate competing alternative hypotheses) plays key roles in user calibration. Thus, basic research into reducing miscalibration suggests ways in which knowledge management systems can incorporate features to improve calibration.

Knowledge Management and Knowledge Calibration

How then can knowledge management systems be applied to improving knowledge calibration to enhance decision making? Knowledge is described as consisting in two forms. Tacit knowledge can be summarized as personal or subjective knowledge (mental models, know-how, skills), and explicit knowledge is "articulated, codified, and communicated in symbolic form and/or natural language" (Alavi & Leidner, 2001, p. 110). Miscalibration can arise from overconfidence in both tacit and explicit knowledge. Accounts of the sources of overconfidence that stress the role of expertise and familiarity (Alba & Hutchinson, 2000) imply that the interaction of tacit and explicit knowledge can result in overconfidence as well. While explicit knowledge can be identified more easily, and systems and procedures can be developed to deal with it, for example through feedback and training, dealing with tacit knowledge poses a greater challenge.

When managers access the (explicit) knowledge base prior to decision making, a feature could be added to the retrieval mechanism that explicitly asks them to rate their confidence in the information retrieved. However, for information surrounded by uncertainty, such as strategic decisions for future action, managers could be trained to use such a KM rating system to make them more cautious in their use of this information. Simulations, games, and case studies, where the use of a feedback mechanism can be incorporated to reduce overconfidence, can be developed. By requiring decision makers to explicitly state their level of confidence, this aspect of the decision can be analyzed and critiqued by others involved in the decision process, and the decision maker can gain insight into his/her style of information use. Information sources can also be evaluated by these rating systems, leading to their modification and to improvement.

Calibration of explicit knowledge involves an implicit calibration of tacit knowledge as well, but dealing with miscalibration arising from tacit knowledge requires additions to the existing systems. The system should be capable of tapping into the tacit knowledge base of the user, and in an interactive manner, gauge the level of miscalibration. Obviously, this presupposes a tacit knowledge base within the system, which might go against the very notion of tacit knowledge itself (as something that cannot be made explicit). Still, we feel that at least some dimensions of such knowledge will lend itself to assessment of calibration. For example, evaluating the outcomes of using tacit knowledge by comparing them with the performance people expect of themselves could improve some aspects of decision making (cf. Alba & Hutchinson, 2000, p. 133). Decision making simulations could be designed to deliberately confound experts so as to make them more cautious in their conclusions, training them to pay attention to their assumptions and consider alternative hypotheses.

In this regard, we bring to attention the concepts of transactive and mechanistic memory that have been discussed (Lynn & Reilly, 2002; Wegner, 1987). Transactive memory refers to the set of individual memory systems in combination with their intercommunications; transactive memory exists as a property of a group as group members share their memories through their interactions with each other and with external memory storage devices. Mechanistic memory refers to information accessed from mechanical systems. A part of transactive memory can be conceptualized as overlapping with tacit knowledge. Codifying such transactive memory and systematizing it will enable the creation of interactive procedures that could assess the level of miscalibration of users (cf. Markus, 2001). While this is an idea at an incipient stage, research can look into its possible developments.

With modern IT advances, an intelligent agent could be developed to serve as a sounding board to evaluate decisions under different confidence conditions. Such systems would have to be developed to realistically challenge managers while not promoting underconfidence as found by McIntyre (1982). Miscalibration is more likely in turbulent rather than stable environments and in emergent knowledge processes (new product development, strategy making) because there is high uncertainty, less time for feedback, and little direct experience (cf. Markus, Majchrzak, & Gasser, 2002). Such scenarios encourage the formation of more tacit and less explicit knowledge. IT could be used to present such scenarios to managers in training sessions to accustom them to their environment and alert them to the dangers of overconfidence as well as ways to reduce its harmful impact.

Some researchers have examined issues that address these questions. Kasper (1996) proposes a theory of decision support systems for user calibration. Kasper's theory utilizes the theory of symbolic representation in problem solving (Kaufmann, 1985) according to which the quality of mental acts (including calibration) depends upon matching the appropriate symbolic representation and reasoning to problem novelty. Hence, the DSS design theory for user calibration is based on the notion that user calibration depends upon designing a DSS so that it effectively supports the users' symbolic representation in problem solving, and it contends that DSS designs for user calibration depend upon problem novelty.

Following the guidelines suggested by Faust (1986) and building on Kasper (1996), it can be suggested that future research and development should be devoted to devising ways to adjust KM systems so that:

- They reduce information overload, perhaps screening information so that irrelevant and illusory data can be removed, and only the most crucial and relevant information delivered.
- They incorporate negative or disconfirming information in the retrieval system so that decision makers are exposed to counter-arguments.
- They rate information to distinguish degrees of speculation.
- They require/suggest competing hypotheses that can be analyzed and rejected or accepted side by side with the favored course of action.

FUTURE TRENDS

Possible avenues for research into knowledge calibration in knowledge management include learning more about how decision makers interact with IT systems if the latter include explicit mechanisms to reduce overconfidence. More should be learned about the best ways to integrate knowledge calibration into training in the use of DSS. Which methods work best in reducing overconfidence? Increasing attention is being devoted to novel IS contexts, such as emergent knowledge processes, organizational activity patterns that exhibit "an emergent process of deliberations with no best structure or sequence; requirements for knowledge that are complex (both general and situational), distributed across people, and evolving dynamically; and an actor set that is unpredictable in terms of job roles or prior knowledge" (Marcus et al., 2002, p. 179). A variety of causes seem to induce miscalibration. Future research could focus on delineating more precisely the relationships among these prospective influences. Do multiple causes lead to the same phenomenon, or are there different types of miscalibration, perhaps with different causes? Recent theories of information foraging (Pirolli & Card, 1999) offer new insights into how humans acquire information; integrating these theories with KC and KM is an exiting prospect.

The challenge is to integrate these ideas into the ongoing dialogue on knowledge management, and formulate a dynamic theory of knowledge management systems for user calibration. Given the rapid increase in the research efforts and output on knowledge management, such a theory is likely to evolve over the course of the next few years.

CONCLUSION

Miscalibration seems to be pervasive feature of decision-making environments. We argue that more study should be devoted to it in KM. "The processes of knowledge creation, storage/retrieval, and transfer do not necessarily lead to enhanced organizational performance; effective knowledge application does" (Alavi & Leidner, 2001, p. 129). This brief outline makes a case for the incorporation of knowledge calibration into knowledge management research and practice as one aspect of improving knowledge application. The stream of research on knowledge management can be enriched by integrating relevant thought streams that have the potential of adding a new dimension to our understanding of knowledge management. For instance, Meso, Troutt, and Rudnicka (2002) recently highlighted how naturalistic decision-making research can enhance knowledge management. In the same fashion we hope that the idea outlined above catalyzes the synthesis of thoughts on knowledge calibration into the body of knowledge management research.

REFERENCES

Alba, J.W., & Hutchinson, J.W. (2000). Knowledge calibration: What consumers know and what they think they know. *Journal of Consumer Research, 27*(2), 123-156.

Alavi, M., & Leidner, D.E. (2001). Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(January), 107-136.

Aldag, R.J., & Powers, D.J. (1986). An empirical assessment of computer-assisted decision analysis. *Decision Sciences, 17*(April), 572-588.

Bell, J. (1984). The effect of presentation form on judgment confidence in performance evaluation. *Journal of Business Finance and Accounting, 11*(March), 327-346.

Brown, J.S., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Press.

Carayannis, E., Gonzalez, E., & Wetter, J. (2003). The nature and dynamics of discontinuous and disruptive innovations from a learning and knowledge management perspective. In L.V. Shavinina (Ed.), *The international handbook on innovation* (pp. 115-138). Amsterdam: Elsevier Science.

Chervany, N.L., & Dickson, G.W. (1974). An experimental evaluation of information overload in a production environment. *Management Science, 20*(October), 1335-1344.

Davis, F.D., Kottemann, J.E., & Remus, W.E. (1991). What-if analysis and the illusion of control. *Proceedings of the 24th Annual Hawaii International Conference on System Sciences,* 3, (pp. 452-460).

Davis, F.D., & Kottemann, J.E. (1994). User perceptions of decision support effectiveness: Two production planning experiments. *Decision Sciences, 25*(January), 57-78.

Einhorn, H.J., & Hogarth, R.M. (1981). Confidence in judgment persistence of the illusion of validity. *Psychological Review, 85*(May), 395-416.

Faust, D. (1986). Learning and maintaining rules for decreasing judgment accuracy. *Journal of Personality Assessment, 50*(April), 585-600.

Goldman, A.I. (1999). *Knowledge in a social world*. Oxford: Clarendon Press.

Harvey, N. (1997). Confidence in judgment. *Trends in Cognitive Science, 1*, 78-82.

Kasper, G.M. (1996). A theory of decision support system design for user calibration. *Information Systems Research, 7*(February), 215-232.

Kaufmann, G. (1985). A theory of symbolic representation in problem solving. *Journal of Mental Imagery, 9*(February), 51-70.

Lynn, G.S., & Reilly, R.R. (2002). *Blockbusters.* New York: Harper Business.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18*(1), 57-93.

Markus, M.L., Majchrzak, A., & Gasser, L. (2002). A design theory for systems that support emergent knowledge processes. *MIS Quarterly, 26*(3), 179-212.

McIntyre, S. (1982). Experimental study of the impact of judgment-based marketing models. *Management Science, 28*(January), 17-33.

Meso, P., Troutt, M.D., & Rudnicka, J. (2002). A review of naturalistic decision making research with some implications for knowledge management. *Journal of Knowledge Management, 6*(January), 63-73.

Oskamp, S. (1965). Confidence in case-study judgments. *Journal of Consulting Psychology, 29*(March), 261-265.

Pirolli, P., & Card, S. (1999). Information foraging. *Psychological Review, 106*(4), 643-675.

Russo, J.E., & Schoemaker, P.J.H. (1992). Managing overconfidence. *Sloan Management Review,* (Winter), 7-17.

Tapp, A., & Hughes, T. (2004). New technology and the changing role of marketing. *Marketing Intelligence & Planning, 22*(3), 284-296.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*(September), 1124-1131.

Wegner, D.M. (1987). Transactive memory. In B. Mullen & G.R. Goethals (Eds.), *Theories of group behavior* (pp. 185-208). New York: Springer-Verlag.

Yates, J.F. (1990). *Judgment and decision making.* Englewood Cliffs, NJ: Prentice-Hall.

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Chapter 7.19
Aristotelian View of Knowledge Management

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INTRODUCTION

Defining and understanding knowledge is a rather broad and open-ended pursuit. We can narrow it considerably by stating that we are interested in defining and understanding knowledge as it pertains to knowledge management (KM) rather than tackling the entire realm of epistemology. This article takes the theory of knowledge espoused by Aristotle and views it through the lens of knowledge management.

The writings of Aristotle have proven to be fertile ground for uncovering the foundations of knowledge management. Snowden (2006) points to Aristotle's three types of rhetorical proof as a basis for incorporating narrative in knowledge management. Buchholz (2006) traces the roots of ontological philosophy forming the basis of current KM ontology efforts back to Aristotle's work. Butler (2006), in his antifoundational perspective on KM, following Dunne (1993), argues that Aristotle's phrónésis and téchné need to be at the core of knowledge-management efforts, and while they cannot be directly applied to IT applications, they must be among the elements upon which knowledge management is based.

It is instructive to seek theoretical foundations for our treatment of knowledge in organizational settings and knowledge-management systems. By doing so we increase the likelihood that our solutions are complete and that we have considered all relevant forms of knowledge that we may desire to manage. Rather than start with modern differentiators of knowledge such as tacit vs. explicit (Nonaka & Takeuchi, 1995), descriptive vs. procedural (Holsapple & Winston, 1996), local vs. global (Novins & Armstrong, 1997), and declarative vs. procedural (Minsky, 1975), we will take a step back to first principles.

Aristotle (n.d.), in his Nicomachean Ethics, presents five virtues of thought that can be mapped to levels of knowledge.

- Epistémé: Factual or scientific knowledge
- Téchné: Skills-based technical and action-oriented knowledge
- Phrónésis: Experiential self-knowledge or practical wisdom based on experience
- Noûs: Intuition
- Sophía: Theoretical knowledge of universal truths or first principles

Other learned traditions and cultures give us similar and related elements, such as the Talmudic philosophical tradition (Luzzatto, 1988; Maimonides, 1966) and Eastern religion and philosophy (Gier, 2004).

As a starting point, we are concerned with the processes shown in the first ring of Figure 1.

1. Knowledge that can be acquired in an organizational setting
   a. creation
   b. discovery
   c. gathering
   d. validation
2. Knowledge that can be organized, categorized, and stored
   a. modeling
   b. classification
   c. calibration
   d. integration
3. Knowledge that can be distributed to some point of action
   a. sharing
   b. reuse
   c. maintenance
   d. dissemination

Without the abilities to acquire, represent, store, retrieve, and apply knowledge in a way that positively affects the operation of our organizations, we are not engaging in knowledge management. Conversely, any form of knowledge to which the aforementioned cannot be applied, while of theoretical importance and interest, cannot be managed. True, as argued by Butler (2003, 2006), the knowledge foundations defined by Aristotle might not be transparently converted into IT-based systems, but that should not prevent us from designing our KM systems and processes to support those knowledge foundations to the greatest extent possible.

Consider the view presented in Figure 1 giving a holistic view of knowledge management and its foundations. The central core of philosophies (the middle) must inform our choice of practical knowledge-management processes (the first ring). These processes must be implemented and adapted to address managerial, social, and organizational needs (the second ring). Finally, the implementation of KM processes to meet our organizational needs must be supported by and implemented through a set of relevant information technologies (the outer ring).

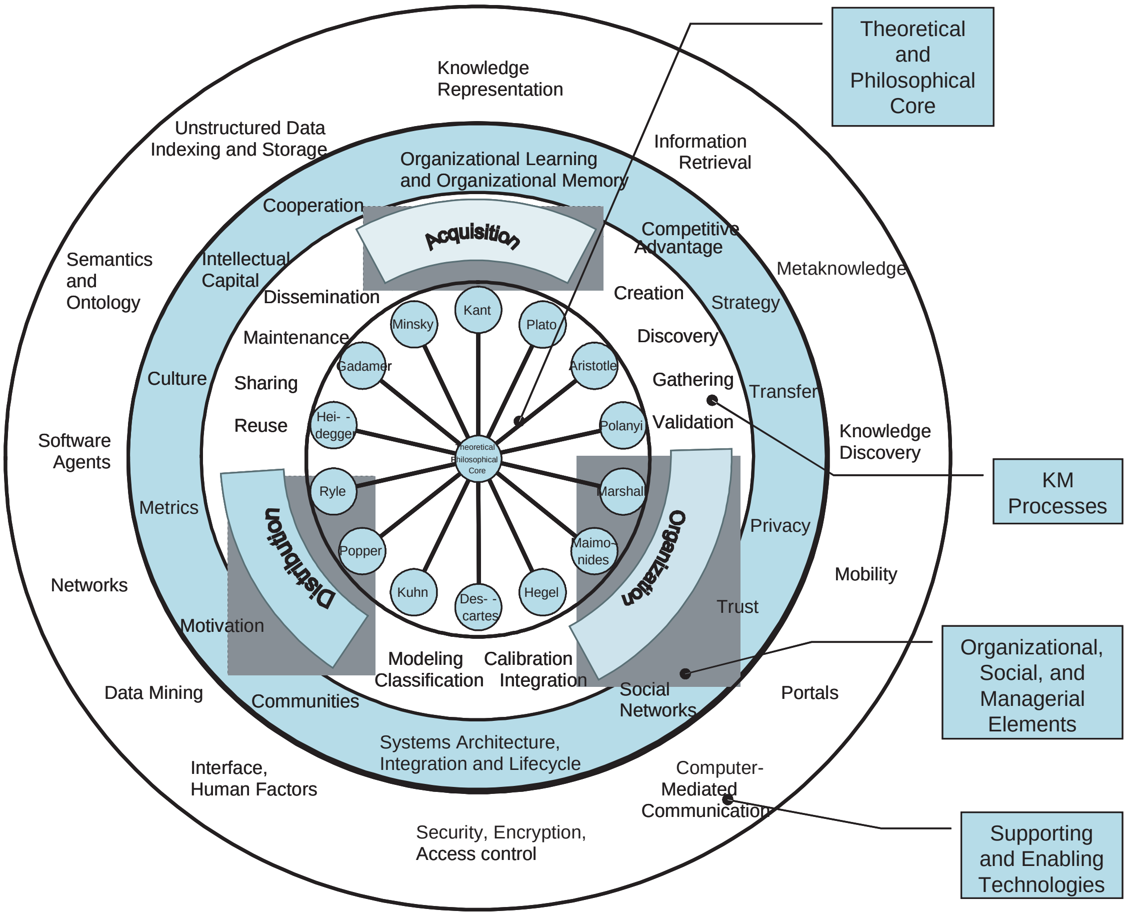
But how do we get from the central core to the first ring? In this article we will examine the definition and understanding of knowledge as a meeting between the Aristotelian classification and the requirements of practical knowledge-management processes.

BACKGROUND

The KM-process ring of Figure 1 shows the three bases of acquisition, organization, and distribution (Schwartz, Divitini, & Brasethvik, 2000), and it is but one of many viable characterizations of process-oriented knowledge management. It represents an emphasis on praxis, taking as a starting point the question, What do we need to do with knowledge in order to make it viable for an organization to use, reuse, and manage it as a tangible resource, and apply it toward specific actions?

By taking this perspective, we avoid to a certain extent the knowledge-information-data (KID) debate regarding the granularity of knowledge. We

Figure 1. Layer upon layer of knowledge management



argue that the distinction between data, information, and knowledge can be conveniently ignored: not treated as irrelevant for a philosophical debate, mind-body discussion, or a metalevel, object-level analysis, but not essential to the fundamental mission of knowledge management.

Arguing that information technologies process data and not information or knowledge, Galliers and Newell (2003) seek to refocus the KM-IT effort on the better management of data. They suggest that since an IT system cannot deal with the fundamental elements of truth and knowledge, it can be counterproductive to create IT-centric knowledge-management initiatives. Holsapple (2002) provides an excellent introduction to different aspects of knowledge and its attributes, including perspectives based on representational issues, knowledge states, production, and the KID debate as well.

Knowledge management, however, does not need to get bogged down in the KID debate. What it does need is to become knowledge centric. Becoming knowledge centric does not necessitate a resolution to the KID debate. Rather, it means that the field of knowledge management could benefit from taking cues from its philosophical lineage—the theories of knowledge—and not only from the praxis that has driven KM over the past two decades. The heavily practice-oriented roots of organizational knowledge management (Davenport & Prusak, 1998; Senge, 1990) have largely developed independent of any relationship to a theory of knowledge. The necessary KM processes have not evolved from any declared need to find an applied outlet for theories of knowledge. While that in no way invalidates KM processes or practice, it does leave open a very broad question as to how knowledge management relates to its epistemological roots.

Aydede's (1998) analysis of different possible interpretations of Aristotle's epistémé and noûs provides some intellectual breathing room to shape our own interpretation of those concepts in directions most amenable to knowledge management.

Hanley (1998) helps provide insights into the applicability of Aristotle to knowledge management by presenting the work of Heidegger, who takes the basic Aristotelian approach to knowledge and presents it from an applied pragmatic view. While Hanley's work does not explicitly consider the discipline of knowledge management, the perspectives drawn from Heidegger's interpretation of Aristotle will appear familiar to knowledge-management researchers.

Let us begin by examining each level of knowledge as envisioned by Aristotle, and see how each relates to certain elements of knowledge management.

AN ARISTOTELIAN VIEW OF MANAGING ORGANIZATIONAL KNOWLEDGE

The Aristotelian virtues are not hierarchical in nature. They are presented as discrete forms of knowledge intended to cover all possible acts of knowing.

Epistémé: Factual or Scientific Knowledge

Epistémé may be the most controversial element of knowledge for knowledge management. It is pure knowledge, such as that of mathematics or logic. Attempting to pin down epistémé is the essence of the knowledge-information-data debate that we discussed, and chose to dismiss, earlier. As scientific knowledge, epistémé is most relevant to our pursuit, and it encompasses knowledge of cause and effect, and deduction (Parry, 2003). A stated goal of information technology is to represent those facts and relationships known as epistémé in digital form, and leverage that representation in different applications as declarative knowledge. In addition, data-mining techniques seek to help identify epistémé that is buried within an organization and bring it to the surface. In parallel, IT seeks to do the same for procedural knowledge, which maps very well to Aristotle's téchné.

Téchné: Skills-Based Technical and Action-Oriented Knowledge

Téchné deals with things that change rather than the constant relationships found in epistémé. Harnessing téchné is at once one of the most challenging and most fruitful of knowledge-management pursuits. To begin with, an organization is the primary place where one would find the bearer of téchné relevant to that organization, and it is precisely that knowledge that we seek to encapsulate and reuse. Téchné reflects the dynamic nature of knowledge. Furthermore, and perhaps most difficult in practice, it is the téchné that artificial intelligence and decision-support systems seek to automate. So, from that perspective, Aristotle has given us a clearly defined and delimited type of knowledge that can be addressed by information technologies.

Phrónésis: Experiential Self-Knowledge or Practical Wisdom Based on Experience

Phrónésis is practical knowledge dealing with action and getting things done. In Aristotle's view, phrónésis is acquired through hands-on training and experiencing the actions being learned. From a learning-through-action perspective, phrónésis differs from téchné in terms of the way each type of knowledge can be shared. The Aristotelian view would be that téchné can be taught from practitioner to student, whereas phrónésis can only be shared through actual mutual experience. In terms of the value of knowledge, Sveiby's (1997) focus on the knowledge-action value chain can find relevant roots in phrónésis. In terms of knowledge management, phrónésis leads us in the direction of simulation, rich media, e-learning, and other forms of the experiential presentation of knowledge or immersion in a virtual environment in which the experience yielding phrónésis can be achieved.

Noûs: Intuition

Noûs is perhaps the least understood of all elements necessary for knowledge management. Noûs not only embodies the intuitive side of knowledge, it also subsumes a large part of what we have come to refer to as tacit knowledge (although clearly there can be tacit knowledge of téchné and phrónésis). Noûs is not restricted to knowledge of first principles, but is viewed by Aristotle as a manner in which one can become aware of first principles. Observing the relationship between noûs and tacit knowledge, we note that there are two fundamental approaches to dealing with tacit knowledge in knowledge management. The first approach is to attempt to externalize the tacit knowledge through interventions and representation methods in order to create explicit knowledge. This, in essence, is attempting to transform the noûs into the epistémé. The second approach is to recognize that the tacit will and should remain tacit, but that the goal of knowledge management is to enable the organization to identify and reach the owner of the tacit—the bearer of the noûs—in an efficient and effective manner. This leads us to employ information technologies to support organizational communications, forums, communities, relationship networks, and the abundance of Internet-enabled interactions that have developed over the past decade.

Another interpretation of noûs is that it emerges from our familiarity with phrónésis and téchné. In other words, by nurturing our support for phrónésis and téchné, we strengthen our ability to exhibit noûs. Butler (personal communication, 2005), based on Bruner's observation (1962, p. 18) that "the act that produces effective surprise…[is] the hallmark of the creative enterprise," suggests that noûs can come about as a result of the processes in which phrónésis and téchné are applied to repairing breakdowns (and to a certain extent epistémé as well). In other words, what we know and how we intuit noûs comes about in part from our reflections on téchné and phrónésis. Therefore, it would appear that support for the noûs within knowledge management may in fact be derived from our treatment of these two contributing types of knowledge.

Sophia: Theoretical Knowledge of Universal Truths or First Principles

We argue that sophía, representing the universal and necessary characteristics of knowledge, has little place in understanding knowledge specific to organizational knowledge management. While universal and necessary truths are surely important to any analysis and treatment of knowledge, they are firmly in the domain of the philosophical and theoretical. Scientific discovery (which we may wish to manage postdiscovery), argumentation, and proof of theorems are all in the realm of the sophía, but still not within the knowledge-management mandate.

Discussion

The first step in bridging the gap between Aristotle's theory of knowledge and knowledge management is to envision how each Aristotelian virtue can be addressed in each phase of knowledge management. Table 1 illustrates.

We can see that the acquisition, organization, and distribution process demands of knowledge management will differ for each of Aristotle's types of knowledge. By understanding this categorization of knowledge, we can achieve greater clarity of thought in our attempts to develop knowledge-management processes for application in organizational settings.

Finally, we can take the analysis one step further by considering which of the 12 specified processes of knowledge management can be reasonably performed on each type of knowledge, as shown in Table 2.

Consider the noûs, for example. We would argue that while noûs cannot be acquired by an IT-based KM system, it can in fact be discovered, modeled, and classified through the use of social network-mapping tools. True, from a philosophical purist perspective, the noûs itself

Table 1. Mapping Aristotle's knowledge virtues to knowledge management stages

	Acquisition	**Organization**	**Distribution**
Epistémé	By gathering facts and relationships known about the organizational knowledge domain and its human participants	Knowledge bases, databases, data warehouses, documents, and diagrams	Enabled and enhanced by information technologies and computer-mediated communications
Téchné	Through interaction, interviews, and discussions with practitioners who have exhibited acquired téchné	Extensive cross-referencing of skills and activities across the organization	Potentially replicated and implemented through information technologies, artificial intelligence, and decision-support systems.
Phrónésis	By recording lessons learned and case studies in the ongoing organizational experience	Case books, project retrospectives, and narratives	Stored, replicated, and delivered through rich media-based computer technologies
Noûs	By determining paths to those people who have exhibited relevant noûs within the organization By increasing support for phrónésis and téchné	Social networks guided by metaknowledge describing participants and their capabilities	The network through which noûs is uncovered is enabled by computer-mediated communications, forums, and online communities.
Sophía	Not a goal of knowledge management	Not a goal of knowledge management	Not a goal of knowledge management

Table 2. Mapping Aristotle's knowledge virtues to KM processes

Process	*Noûs*	*Epistémé*	*Téchné*	*Phrónésis*	*Sophía*
Acquisition					
creation	no	yes	no	no	n/a
discovery	yes	yes	yes	yes	n/a
gathering	no	yes	yes	yes	n/a
validation	no	yes	yes	yes	n/a
Organization					
modeling	yes	yes	yes	yes	n/a
classification	yes	yes	yes	yes	n/a
calibration	yes	yes	yes	yes	n/a
integration	yes	yes	yes	yes	n/a
Distribution					
sharing	yes	yes	yes	yes	n/a
reuse	no	yes	yes	yes	n/a
maintenance	no	yes	yes	yes	n/a
dissemination	yes	yes	yes	yes	n/a

will always remain within its bearer; however, the sharing and dissemination of knowledge within an organization considers both knowledge and metaknowledge. Having a digital representation of where noûs can be found and how it might be applied is as important for some aspects of knowledge management as building a lessons-learned database is for others. Thus, the values for noûs shown in Table 2 relate to a metalevel reference to the noûs.

Knowledge of the types téchné and phrónésis, while they cannot be created through KM processes, can indeed be discovered, gathered for storage by representational systems, organized, and distributed. While phrónésis and téchné may be the core constituents of practical knowledge (Butler & Murphy, 2006), we can enhance noûs within the organization by increasing accessibility to téchné and phrónésis, leveraging the relationship between these different types of knowledge discussed earlier. Here there would seem to be an important role to be played by metaknowledge describing the téchné and phrónésis within the organization to create some form of organizational noûs, which may effectuate to some degree Heidegger's hermeneutical circle (Sampaio, 1998) or Gadamer's (1975) circle of understanding.

With epistémé we can go a step further and utilize data mining, text mining, neural networks, information resource discovery, and other advanced pattern-recognition technologies to create new knowledge based on the patterns of data that exist within our extensive organizational information systems.

FUTURE DIRECTIONS

For knowledge management to advance, it must continue to explore different theories of knowledge and how those theories will affect both the representation and use of knowledge in organizations.

Viewing knowledge as something that we want to manage forces us to narrow down the realm of epistemology to something we can handle in an applied manner. The analysis shown in this article can also be fruitfully applied to other philosophies of knowledge that differ from the Aristotelian view.

The choice of processes presented in Table 2 is by no means definitive: There are many KM frameworks and models proposing equally attractive alternative sets of processes. However, we should seek the broadest possible matching or coverage between our proposed KM processes and the core knowledge virtues. Subjecting a model of KM processes to some form of "Aristotle test" can help us evaluate the completeness of that model.

CONCLUSION

Understanding and defining knowledge can lead us to an open-ended philosophical debate, or it can lead us to a pragmatic characterization aimed at enabling the organizational goals of knowledge management. By choosing the latter, we are able to focus on those elements of knowledge that truly make a difference in practice: in this case, a mapping of the Aristotelian view to managing knowledge in organizations.

Knowledge can be debated at an epistemological and theological level as seen from Aristotle down to Heidegger and beyond. It can be debated at an implementation and representational level as seen in the ongoing knowledge-information-data discussions. We need to understand and appreciate both debates if we are to engage in the management of knowledge, but we should not let the lack of resolution in either debate hinder our advancement. The pragmatic, process-oriented view of defining and understanding knowledge is what we need to embrace, while the insights from both knowledge debates will continue to inform our activities and enrich our understanding. Examining the philosophical bases of knowledge will enable us to move outward from the philosophical core of Figure 1, to relevant KM processes that can then be moderated by and applied to organizational settings.

Each type of knowledge has different applied value and different challenges in acquisition, organization, and distribution. Aristotle's five core intellectual virtues or types of knowledge can even today serve as a base from which we launch our knowledge-management initiatives, and understanding them will help guide us.

REFERENCES

Aristotle. (n.d.). *Nicomachean ethics: Book VI* (W. D. Ross, Trans.). Retrieved November 2004, from http://classics.mit.edu/Aristotle/nicomachaen.html

Aristotle. (1934). *Metaphysics* (H. Rackham, Trans.). Retrieved November 2004, from http://www.perseus. tufts.edu/

Aydede, M. (1998). Aristotle on Episteme and Nous: The posterior analytics. *Southern Journal of Philosophy, 36*(1).

Bruner, J. S. (1962). *On knowing: Essays for the left hand*. Cambridge, MA: Harvard University Press.

Buchholz, W. (2006). Ontology. In D. G. Schwartz (Ed.), *Encyclopedia of knowledge management* (pp. 694-702). Hershey, PA: Idea Group Reference.

Butler, T. (1998). Towards a hermeneutic method for interpretive research in information systems. *Journal of Information Technology, 13*(4), 285-300.

Butler, T. (2005). *Personal e-mail correspondence with the author.*

Butler, T. (2006). An antifoundational perspective on knowledge management. In D. G. Schwartz (Ed.), *Encyclopedia of knowledge management* (pp. 1-9). Hershey, PA: Idea Group Reference.

Butler, T., & Murphy, C. (2006). Work and knowledge. In D. G. Schwartz (Ed.), *Encyclopedia of knowledge management* (pp. 884-891). Hershey, PA: Idea Group Reference.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Dunne, J. (1993). *Back to the rough ground: "Phronesis" and "techne" in modern philosophy and in Aristotle*. Notre Dame, IN: University of Notre Dame Press.

Gadamer, H. G. (1975). *Truth and method*. New York: The Seabury Press.

Galliers & Newell. (2003). Back to the future: From knowledge management to the management of information and data. *Information Systems and E-Business Management, 1*(1).

Gier, N. F. (2004). The Buddha and Aristotle compared. In *The virtue of non-violence: From Gautama to Gandhi*. Albany: State University of New York Press.

Hanley, C. (1998). Theory and praxis in Aristotle and Heidegger. *Proceedings of the 20th World Congress of Philosophy,* Boston. Retrieved November 2004, from http://www.bu.edu/wcp/Papers/Acti/ActiHanl.htm

Holsapple, C. (2002). Knowledge and its attributes. In C. Holsapple (Ed.), *Handbook on knowledge management: Vol. 1. Knowledge matters.* Springer.

Holsapple, C., & Winston, A. (1996). *Decision support systems: A knowledge based approach*. West Publishing.

Luzzatto, M. H. (1988). *The ways of reason*. Feldheim Publishers.

Maimonides. (1966). *Maimonides' Arabic treatise on logic*. American Academy for Jewish Research.

Marvin, M. (1975). A framework for representing knowledge. In P. Winston (Ed.), *The psychology of computer vision*. McGraw-Hill.

Nonaka, I., & Takeuchi, T. (1995). *The knowledge creating company*. New York: Oxford University Press.

Novins, P., & Armstrong, R. (1997). Choosing your spots for knowledge management: A blueprint for change. *Perspectives on Business Innovation: Managing Organizational Knowledge, 1.*

Parry, R. (2003). Episteme and techne. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy* (summer 2003 ed.). Retrieved November 2004, from http://plato.stanford.edu/archives/sum2003/entries/episteme-techne/

Sampaio, R. (1998). The hermeneutic conception of culture. *Proceedings of the 20th World Congress of Philosophy*, Boston.

Schwartz, D. G. (2005). The emerging discipline of knowledge management. *International Journal of Knowledge Management, 1*(2), 1-11.

Schwartz, D. G., Divitini, M., & Brasethvik, T. (2000). *Internet-based organizational memory and knowledge management*. Hershey, PA: Idea Group Publishing.

Senge, P. M. (1990). *The fifth discipline: Five practices of the learning organization*. New York: Doubleday.

Snowden, D. (2006). Narrative. In D. G. Schwartz (Ed.), *Encyclopedia of knowledge management* (pp. 678-682). Hershey, PA: Idea Group Reference.

Sveiby, K. E. (1997). *The new organizational wealth: Managing & measuring knowledge based assets*. San Francisco: Berrett-Koehler Publishers.

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Chapter 7.20
Anti-Foundational Knowledge Management

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INTRODUCTION

Under the influence of Enlightenment epistemological thought, the social sciences have exhibited a distinct tendency to prefer deterministic1 explanations of social phenomena. In the sociology of knowledge, for example, "foundational" researchers seek to arrive at objective knowledge of social phenomena through the application of "social scientific methodolog[ies] based on the eternal truths of human nature, purged of historical and cultural prejudices" and which also ignore the subjective intrusions of social actors (Hekman, 1986, p. 5). This article argues that "foundationalist" perspectives heavily influence theory and praxis in knowledge management. "Foundationalist" thinking is particularly evident in the posited role of IT in creating, capturing, and diffusing knowledge in social and organisational contexts. In order to address what many would consider to be a deficiency in such thinking, a constructivist "antifoundationalist" perspective is presented that considers socially constructed knowledge as being simultaneously "situated" and "distributed" and which recognizes its role in shaping social action within "communities-of-practice." In ontological terms, the constructivist "antifoundational" paradigm posits that realities are constructed from multiple, intangible mental constructions that are socially and experientially based, local and specific in nature, and which are dependent on their form and content on the individual persons or groups holding the constructions (see Guba & Lincoln, 1994; Bruner, 1990). One of the central assumptions of this paradigm is that there exist multiple realities with differences among them that cannot be resolved through rational processes or increased data. Insights drawn from this short article are addressed to academics and practitioners in order to illustrate the considerable difficulties inherent in representing individual knowledge and of the viability of isolating, capturing, and managing knowledge in organisational contexts with or without the use of IT.

BACKGROUND: WHAT KNOWLEDGE IS AND WHAT IT IS NOT?

The point of departure for the present treatise on the concept of "knowledge" is a definition that is in good standing within the IS field and which is congruent with extant perspectives across the social sciences (e.g., Grant, 1996). In their book Working Knowledge, Davenport and Prusak (1998) posit that:

Knowledge is a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organisations, it often becomes embedded not only in documents and repositories but also in organisational routines, processes, practices, and norms. (p. 3)

While this definition is, on the surface, all-embracing and without contradiction it does, however, possess certain weaknesses that can only be illustrated by a consideration of taken-for-granted issues of ontology. This involves a description of the relationships that exist between the individual and his social world; that is between the knowing social actor and the social groupings and contexts in which he or she participates and exists, and in which knowledge is socially constructed. In terms of the present analysis, this task begins with a brief consideration of the constructivist, "antifoundational" philosophies of Martin Heidegger and Hans Georg Gadamer in order to sketch out the ontological basis of knowledge. This undertaking is particularly timely given the recent emphasis on knowledge management, which is described "[as] an integrated, systematic approach to identifying, managing, and sharing all of an enterprise's information assets, including databases, documents, policies, and procedures, as well as previously unarticulated expertise and experience held by individual workers."2 Whereas the ability of organisations to identify, manage, and share, databases, documents, and codified procedures using IT is not in question, identifying, managing, and sharing tacit knowledge using IT is questionable, as the following treatise on knowledge illustrates.

An Anti-Foundational Perspective on Knowledge

In response to the question "What is knowledge and what is it not?" we argue that knowledge cannot ever become "embedded…in documents and repositories [and] also in organisational routines, processes, practices, and norms." Why? Precisely because it is impossible to isolate and represent objectively "a fluid mix of framed experience, values, contextual information, and expert insight." Certainly, as Bruner (1990) points out, a social actor's knowledge resides not only in his head, but also in the notes, underlined book passages, manuals, and guides he consults, and in the computer-based data he has access to. This is, in many respects, a shorthand description by Bruner. Social actors use such sources because of their inability to recall every source of data they have interpreted and laid down in memory (see Goleman, 1996)—hence they are considered sources of personal information only for the actor who has painstakingly sought out, collated, and put into context the data contained in each personal artefact. Accordingly, contextual, temporally based data makes the transition to knowledge only when an actor interprets (or subsequently reinterprets) them in order to inform his or her understanding of some phenomenon or other. This is a fairly straightforward task for the individual who has, over time, constructed a personal database of the type described. However, others who access the personal "notes, underlined passages, manuals, etc." that constitute such databases may interpret their content differently and not come to the same understanding, as they may not have the same pre-existing ground of understanding and knowledge of the phenomenon in question as the original author3. All this is indicative of the "situated" and "distributed" and "temporal" nature of knowledge4 (hence the origins of Hermeneutics in biblical studies and philosophy): But how does it relate to the social context and ground of knowledge?

As part of the interpretive process that characterizes all understanding, meaning is attributed to data within the context of the actor's constantly evolving "lived experience" and under the sway of a "tradition" (Gadamer, 1975). Heidegger (1976) and Gadamer (1975) illustrate that the "lived experience" of social actors arises out of the web of encounters and dialogues that characterize individual existence or "Being-in-the-world." The concept of "lived experience" describes the relationship between social actors and other beings that populate the tradition or culture in which they are embedded (in a Heideggerian sense, the term "beings" refers not only to other humans but all social phenomena). In delineating the constitution of "lived experience," Heidegger (1976) points out that social actors are "thrown" into a "life-world" where their existence has, from the outset, been "tuned" or "situated" to be a specific existence with other beings, within a specific "tradition," and with a specific history. However, in order to cope with their "throwness" social actors come ready equipped with a "fore-knowledge" or, in Gadamerian terms, a "prejudice"-laden "effective-historical consciousness," that enables them to interpret, make sense of, and partake in their social world. "Fore-knowledge" is, in many ways, knowledge of the "ready-to-hand" (Zuhanden) that constitutes an actor's "life world." Thus, the "ready-to-hand" possess a degree of familiarity that effectively sees them dissolved into the unreflective background of the actor's daily existence. If, however, something happens that results in a "breakdown" in understanding, social phenomena become the object of "theoretical" reasoning and acquire the ontological status of being "present-at-hand" (i.e., a Vorhanden) until the "breakdown" has been repaired. As Gadamer illustrates, social actors must give recognition to the influence that "effective-historical consciousness" exerts if they are to work out their "prejudices."

The process of "working out" prejudices and of repairing breakdowns in understanding is governed by what Gadamer called the hermeneutic "circle of understanding." Here, the "whole" that constitutes a phenomenon is apprehended by the cyclical interpretation of its constituent "parts" as they relate to each other and to the "whole." In so doing, an actor interprets relevant data as "present-at-hand" using a form of question and answer called the dialectic (Socratic, Hegelian, and Analytic-Reductionist—see Butler, 1998). Thus, the actor's understanding of constituent "parts" will be consolidated, and in so doing the horizons or perspectives of interpreter and interpreted will gradually fuse. Thus, in repairing breakdowns, a "fusion of horizons" (of understanding) takes place between interpreter and interpreted.

The pivotal role of language in the interpretive process of understanding has been noted by Gadamer (1975). Accordingly, Bruner (1990) argues that institutional contexts are socially constructed through the narratives of constituent actors. Thus, over time and through highly complex and ill-defined social processes constituted by a polyphonic dialectic, there evolves a shared understanding that constitutes a culture and tradition. In addition, it is clear from Gadamer (1975) that the authoritative impulse to conform, as indicated by the existence of Heidegger's "das Man," is testimony to the resilience of a shared "world view" among actors in institutional contexts and the unwillingness to accept "new" knowledge (e.g., Leonard-Barton, 1995; Pfeffer & Sutton, 2000). This brief ontological view of knowledge has profound implications for those who examine the nature of knowledge and its diffusion in institutional contexts, as will be seen in the following subsection.

IT AND THE SOCIAL CONSTRUCTION OF KNOWLEDGE

If the key to understanding social action lies in explicating the influence of shared "weltanschauungen," "lived experience," and "tradition," as socially embedded institutional knowledge, then the representation of such knowledge must be the goal of all who propose to manage it. However, the impossibility of this task is underlined by Dreyfus (1998), who cites Husserl's exasperation at trying to give a detailed account of the experience of the everyday lives of social actors. Husserl (1960) termed social actors' representations of their experiential knowledge the noema. However, after devoting his life's work to its delineation, he concluded in the face of the noema's "huge concreteness" that the "tremendous complication" in its representation made it an impossible task (Husserl, 1969, p. 244 and p. 246). Significantly, Minsky (1981) commented on the enormity of attempting to represent commonsense experiential knowledge using computer-based systems. This point is underscored by Bruner (1990) who argues that:

Information processing cannot deal with anything beyond well-defined and arbitrary entries that can enter into specific relationships that are strictly governed by a program of elementary operations. (p. 5)

Thus, in Bruner's Acts of Meaning, the message is clear: The experiential knowledge and skills of social actors cannot readily, if ever, be embedded in IT (see Boland, 1987). However, this is not surprising as Dreyfus (1998) notes that philosophers from Socrates to Husserl have wrestled with the problem of knowledge representation without much success. Nevertheless, additional arguments are now adduced to convince the skeptical.

The socially constructed nature of knowledge is described by Berger and Luckmann (1967) who posit that:

The primary knowledge about institutional order is knowledge on the pretheoretical level. It is the sum total of 'what everyone knows' about a social world, an assemblage of maxims, morals, proverbial nuggets of wisdom, values and beliefs, myths, and so forth, the theoretical integration of which requires considerable intellectual fortitude in itself, as the long line of heroic integrators from Homer to the latest sociological system-builders testify. (p. 65)

This point is indicative of the nature of institutional and organisational reality. For example, it indicates why there exists a high degree of rigidity in and immutability of the social stock of knowledge, especially if beliefs are strongly held, or of a religious nature5. This is why "das Man" exerts such a strong influence in fostering resistance to the acceptance of new knowledge and understanding and why those who articulate it often receive the opprobrium of "true believers."

Berger and Luckmann's insights also are congruent with the perspectives of Heidegger and Gadamer articulated previously. Hence, pretheoretical knowledge, as the articulated (present-at-hand) and unarticulated (ready-to-hand) components of Aristotelian phronesis (experiential "self-knowledge") and techne ("skills-based" knowledge), plays a formative role in establishing canonical modes of behaviour (habitualised social action or organisational routines, if you will) and in the transmission of social behaviours among actor networks (Gadamer, 1975; Dunne, 1993). To underscore the points made here, Dreyfus (1998) turns to Heidegger to argue that "the everyday context which forms the background of communications is not a belief system or a set of rules or principles…but is rather a set of social skills, a kind of know-how, any aspect of which makes sense only on the rest of the shared social background" (p. 285). What then of the IS researchers and practitioners who assume that it is possible to describe and codify social contexts as objective facts and who therefore consider unproblematic the transfer of knowledge in organisations? Dreyfus (ibid.) again draws on Heidegger to reject the notion that "the shared world presupposed in communication could be represented as an explicit and formalized set of facts" (p. 283). All this implies that social knowledge cannot be objectified and exist outside the "heads" of knowers (or the social relationships in which knowledge is constructed and maintained); furthermore, it renders fruitless any attempt to codify it objectively. It also casts doubt on those who speak authoritatively about knowledge transfer mechanisms and who ignore the social contexts that gives rise to such knowledge.

The Aristotelian Perspective on Knowledge

In Book 6 of Nicomachean Ethics, Aristotle focuses on practical and technical reason—phronesis and techne. The importance and relevance of this work to any treatment of knowledge is underscored by Dunne (1993). Hence, an understanding of phronesis and techne is essential to the present project as it brings into sharp focus the situated nature of individual knowledge and, as Gadamer (1975) illustrates, adds to the ontological description already offered. To begin, it must be noted that in reading the Ethics in the context of the Metaphysics one is led to conclude that both phronesis and techne are, ultimately, forms of practical knowledge. However, in the Ethics Aristotle distinguishes between praxis and poiesis. The conduct of social affairs in a thoughtful and competent manner Aristotle refers to as praxis. This involves the application of phronesis, that is, a social actor's experientially based "self-knowledge." Poiesis, on the other hand, Aristotle involves the activities of "making" or "production." Here techne is the kind of knowledge possessed by the expert craftsmen and involves the understanding and application of the principles governing the production of social phenomena—both tangible and intangible. It is important to note that Dunne (1993) in his extensive treatment of the topic interprets phronesis as being practical knowledge and techne as being skills-based knowledge. However, he (ibid.) states, in regard to poiesis and praxis, that: "To these two specifically different modes of activity, techne and phronesis correspond, respectively, as two rational powers which give us two quite distinct modes of practical knowledge" (p. 244). Thus, a social actor's "self-knowledge" or "practical wisdom" (phronesis) is a synthesis of his temporal experience of social phenomena with an ability to perform practical actions in relation to such phenomena. According to Gadamer's (1975) interpretation of Aristotle's phronesis, experiential or "self-knowledge" cannot be learned or forgotten; it is ethical and moral in character and, as such, it is the supreme influence on an individual's actions. It is clear that skill-based knowledge (techne) and theoretical knowledge (as theoria, sophia, or episteme) are informed by the "self-knowledge" (phronesis) of relevant social actors. In so doing, self-knowledge embraces, as Gadamer indicates, both the means and ends of social action. Because of its unique constitution, self-knowledge does not often lend itself to linguistic expression. The same could be said of techne, which provides the expert or craftsman with an understanding of the why and the wherefore, the how, and with-what of the production process. Thus, techne, in providing a rational plan of action, also embraces both the means and ends of production activities.

FUTURE TRENDS: IMPLICATIONS OF PHRONESIS AND TECHNE FOR KNOWLEDGE MANAGEMENT

This article argues that an understanding of phronesis and techne as the two primordial components of individual practical knowledge is vital for researchers and practitioners who involved in creating knowledge management systems (KMS), yet studies on information systems development and the field of knowledge management pay scant attention to the ontological ground of knowledge. Consider the assertion by Checkland and Holwell (1998) that "the core concern of the IS field [is] the orderly provision of data and information within an organisational using IT" (p. 39)—clearly this involves the development of IS and their use.

So what of the posited role for IT in the management of knowledge? Can phronesis and techne be embedded in IT? And can such systems account for all contingencies in their application? As Orr (1990) illustrated in his study of photocopier repair technicians, the attempted codification of a fairly well defined techne proved a failure; here phronesis proved the more influential of the two types of individual knowledge. Why? Because of the contextual nature of the Heideggerian breakdowns encountered and the experiential knowledge of the repairmen, some of which was vicariously acquired through the Brunerian narratives they engaged in while constructing their "community of knowing." How then can IT capture adequately the experiential and interpretive nature of the phronesis required for this type of problem-solving? As Dreyfus (1998) concludes, the answer to this question is "It cannot."

Consider also the IT-enabled techne of processing a business transaction. It is evident that the experiential knowledge of the business person managing the transaction plays a major role in dictating the questions posed and details taken in efficiently executing a transaction, irrespective of the routines and activities embedded in an IT-based business information system. Why? Because information systems are "closed" in the sense that they cannot ever capture all aspects of a business problem domain. In different spheres of organizational activity, the data required to resolve a breakdown might be of a more comprehensive nature (e.g., a report or narrative aimed at informing task-based problem-solving) while targeting a problem-solving techne. In this scenario, the context-dependent experiential knowledge of both the author and the recipient(s) will be of special import and will depend on the actors' unarticulated, shared social background. If, for example, the author and recipient belong to a particular socially constructed "community-of-practice" (Brown & Duguid, 1991), then each will participate in a shared tradition with similar phronetic and technic backgrounds. However, even with this shared background, Boland and Tenkasi (1995) indicate that the support available from conventional systems will be limited to well-defined user needs. Echoing Boland and Tenkasi (1995), McDermott (1999) argues that the important "technical challenge is to design human and information systems that not only make information available, but help community members think together" (p. 116); However, McDermott (1999) cautions that "[t]he great trap in knowledge management is using information management tools and concepts to design knowledge management systems" (p. 104).

Given all that has been said here, it is doubtful that the futuristic "electronic communication forums" suggested by Boland and Tenkasi (1995) will be anymore successful than their data processing predecessors in supporting knowledge transfer and management within "communities of knowing," despite shared phronetic and technic backgrounds. Echoing Dunne (1993), practical knowledge (as phronesis and techne) is a fruit that can grow on the fertile soil of individual experience; however, experience of the world occurs within a web of social relationships, and individual knowledge develops within the historical context of a tradition under the influence of significant others. But what are the implications in this for the IS field?

Consider, for example, that extant perspectives on IT capabilities chiefly operate from resource-based view of the firm6, which, with certain exceptions, is chiefly positivist in its orientation and focuses on the outcomes of the application of capabilities rather than the process by which they come into being (Butler & Murphy, 1999; cf. Wade & Hulland, 2004). It is clear from the literature that the resultant applications of this theory of the firm are not sensitive to the type of ontological issues described herein and, accordingly, fail to capture the social and historical nature of knowledge in institutional contexts. On this point, future studies on the development and application of IT capabilities should, we believe, take an interpretive stance and focus on how phronesis and techne are developed and applied in institutional contexts and not just on outcomes of their application.

CONCLUSION

This article joins calls within the IS field for a reassessment of its position on the important topic of knowledge (see Galliers & Newell, 2001). True, the fundamental ideas presented herein are not new, but the manner of their presentation and argument is. In any event, given the recent feeding frenzy on the topic of knowledge and the unquestioning acceptance of the nostrums proposed by some of those championing the cause, a timely injection of commonsense is called for. To recap, this article's main argument is that knowledge of social phenomena, which is enmeshed in a web of social relationships and contexts, defies objectification and cannot be comprehensively and unambiguously represented due to the uncertainty that arises from interpretations that are informed by divergent "worldviews" and different "horizons of understanding." Institutional knowledge does not therefore exist as an objective phenomenon outside of the heads of the knowers and their "communities-of-practice," where it exists primarily in the intersubjective understandings of social actors.

Having illustrated why knowledge cannot be represented objectively, a question is raised as to the status of information. Following a constructivist logic, Introna (1997) points out that information is "hermeneutic understanding" and is acquired through an interpretive process by an "already-knowing" individual. Hence, if information also is abstract and ambiguous in its depiction, data is all that can be represented, stored, transferred, and manipulated by IT. It must be emphasized that the primary mode of informing is the narrative: Narratives serve to define the canonical, and help construct and maintain institutionalised patterns of behaviour. Nevertheless, narratives, written or oral, consist of data, not knowledge or information—hence, the need for dialogue and dialectic. Therefore, if information technology is to be utilized to give voice to organizational narratives, then it must be recognized that it will be a conduit for data only. And, because gaps in comprehension will always exist, no matter how sophisticated the technology and its power of representation, IT must enable a dialectic to take place between social actors and the phenomena they wish to understand. These points are reflected in the capabilities of the latest generation of Internet/Intranet-enabled knowledge management tools7. Although the vendors of such products argue that they are capturing the knowledge of customers, employees, and domain experts, the inputs to and outputs from such applications tend to be well-defined and constitute significant abstractions from the phronesis and techne of social actors (again in the form of data). Hence, considerable interpretation is required, and while knowledge base inference engines are limited in this respect (Butler, 2003), human beings are well adapted to this process, even though their interpretations of phenomena rarely concur with those of other actors, except in situations where the data in question is well delimited. That such systems are of limited value in helping social actors communicate and repair the breakdowns they encounter is not at issue; they do not, however, help social actors manage knowledge in organisations.

REFERENCES

Aristotle (1945). *Nicomachean ethics. Translated by H. Rackham*. Cambridge, MA: Harvard University Press.

Berger, P., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge*. Garden City, NY: Doubleday and Company, Inc.

Boland, R.J. (1987). The in-formation of information systems. In R.J. Boland and R.A. Hirschheim (Eds.), *Critical issues in information systems research* (pp. 362-379). Chichester, UK: John Wiley.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science, 6*(4), 350-372.

Brown, J.S., & Duguid, P. (1991). Organisational learning and communities of practice: Toward a unified view of working, learning and innovation. *Organisation Science, 2*, 40-57.

Bruner, J. (1990) *Acts of meaning.* Cambridge, MA: Harvard University Press.

Butler, T. (1998). Towards a Hermeneutic method for interpretive research in information systems. *Journal of Information Technology, 13*(4), 285-300.

Butler, T. (2003). From data to knowledge and back again: Understanding the limitations of KMS. *Knowledge and Process Management: The Journal of Corporate Transformation, 10*(4), 144-155.

Butler T., & Murphy, C. (1999, December 13-15). Shaping information and communication technologies infrastructures in the newspaper industry: Cases on the role of IT competencies. In Prabuddha De & J. I. DeGross (Eds.), *The Proceedings of the 20th International Conference on Information Systems* (pp. 364-377). Charlotte, NC.

Checkland, P., & Holwell S. (1998). *Information, systems and information systems: Making sense of the field.* Chichester, UK: John Wiley & Sons.

Conway, S., & Sligar, C. (2002). *Unlocking knowledge assets.* Redmond, WA: Microsoft Press.

Davenport, T.H., & Prusak, L. (1998). *Working knowledge: How organisations manage what they know.* Boston: Harvard Business School Press.

Dreyfus, H.L. (1998). Why we do not have to worry about speaking the language of the computer. *Information Technology and People, 11*(4), 281-289.

Dunne, J. (1993). *Back to the rough ground: 'Phronesis' and 'techne' in modern philosophy and in Aristotle.* Notre Dame, IN: University of Notre Dame Press.

Gadamer, H.G. (1975). *Truth and method.* New York: The Seabury Press.

Galliers, R.D., & Newell, S. (2001, June 27-29). Back to the future: From knowledge management to data management. In *Global Co-Operation in the New Millennium, The 9th European Conference on Information Systems* (pp. 609-615). Bled, Slovenia.

Goleman D.P. (1996). *Vital lies simple truths: The psychology of self-deception*. New York: Touchstone Books.

Grant, R.M. (1996). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17,* Winter Special Issue, 109-122.

Guba, E.G., & Lincoln, Y.S. (1994) Competing paradigms in qualitative research. In N. K. Denzin

& Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: Sage Publications Inc.

Hayek, F.A. (1945). The use of knowledge in society. *American Economic Review, 35,* 519-532.

Heidegger, M. (1976). Being and time. New York: Harper and Row.

Hekman, S. (1986). *Hermeneutics and the sociology of knowledge*. Cambridge, UK: Polity Press.

Husserl, E. (1960). *Cartesian meditations.* The Hague: M.Nijhoff.

Husserl, E. (1960). *Formal and transcendental logic.* The Hague: M.Nijhoff.

Husserl, E. (1969). *The crisis of European sciences.* Evanston, IL: Northwestern University Press.

Introna, L.D. (1997). *Management, information and power: A narrative for the involved manager.* London: MacMillan Press Ltd.

Leonard Barton, D. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Boston: Harvard Business School Press.

Minsky, M. (1981). A framework for representing knowledge. In J. Hagueland (Ed.), *Mind design*. Cambridge, MA: The MIT Press.

Orr, J.E. (1990). Sharing knowledge, celebrating identity: War stories and community memory in a service culture. In D. Middleton and D. Edwards (Eds.), *Collective remembering: Memory in society* (pp. 168-189). London: Sage Publications Ltd.

Pfeffer, J., & Sutton, R.I. (2000). *The knowing doing gap: How smart companies turn knowledge into action*. Boston: Harvard Business School Press.

Teece, D.J. (2001). Strategies for managing knowledge assets: The role of firm structure and industrial context. In I. Nonaka and D.J. Teece, (Eds.), *Managing industrial knowledge: Creation, transfer and utilization* (pp. 125-144). London: Sage Publications Ltd.

Wade, M., & Hulland, J. (2004). The resource-based view and information systems research: Review, extension and suggestions for future research. *MIS Quarterly, 28*(1), 107-142.

ENDNOTES

[1] The Enlightenment is generally characterized by Rationalism, Empiricism, Determinism, and an emphasis on logic (for a basic overview see http:/www.philosopher.org.uk/enl.htm). Tarnas (1991) highlights the influence of deterministic thinking and argues man's "belief in his own rational and volitional freedom" was attenuated by the "principles of determinism—Cartesian, Newtonian, Darwinian, Marxist, Freudian, behaviorist, genetic, neurophysiological, [and] sociobiological" (p. 332).

[2] Army Knowledge Online—An Intelligent Approach to Mission Success, U.S. Department of the Army, Washington, D.C., 1999.

[3] The author has some considerable experience in this area in his former capacity as a telecommunications engineer and member of a tightly knit "community-of-practice" in which knowledge sharing was critical to the community's organisational function.

[4] Antifoundationalists recognise that knowledge is socially constructed and therefore distributed among social actors in "communities-of-practice."

[5] Remember the neo-Platonic definition of knowledge as 'justified true belief' and Nonaka and Takeuchi's (1995) argument that

"knowledge, unlike information, is about beliefs and commitment" (p. 58).

6 The resource-based view considers knowledge as an intangible firm specific asset (see Teece, 2001; Conway & Sligar, 2002).

7 ServiceWare Inc.'s Enterprise, Microsoft's Sharepoint, PricewaterhouseCoopers' Knowledge Direct, and KnowledgeCurve tools and KM tools found in Siemens Learning Valley are examples of KM technologies.

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Chapter 7.21
Social Philosophy, Communities, and the Epistemic Shifts

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INTRODUCTION: DOMINANT AND PERIPHERICAL INFLUENCES

It is critical to distinguish between mainstream traditional management theory and the myriad of complementary approaches that have contributed to the development of alternative approaches to organisational and management theory. The dominant stream of management theory is still largely influenced by the command and control paradigm developed over a century ago by early theorists such as Weber, Taylor, and Fayol. Though the control paradigm today is closely connected to a technocratic and functionalistic perspective of management science, there is a growing awareness of the dangers of assuming a reductive and limited view of organisational complexity. In other words, it is important to recognise the role of bureaucratic, functional, and procedural-like aspects of organisational life, though it is critical to complement these perspectives with richer and more human-centred interpretations of organisational reality. This critical role is performed by, among others, communities of practice theory (Lave & Wenger, 1991; Wenger, 1999; Wenger, McDermott & Snyder, 2002; Brown & Duguid, 1991). In order to better understand the developments in terms of management thinking, it is relevant to revise the sequence of the different schools of thought that influenced the social sciences throughout the 20th century.

BACKGROUND

At the end of the 19th century, the spreading and dissemination of the use of electricity for industrial and domestic use implied profound changes in the way people lived and organised their lives. In parallel with this technologic development, there was a radical change in mentalities. The confident and self-assuring concept of human beings as rational, independent, and autonomous individuals had been the product of the Enlightenment movement of the 17th and 18th centuries, which followed from the 15th and 16th centuries' scientific revolution. Opposing the rationalist and utilitarist perspective, there emerged the idea that humans present different forms of rationality, some of which imply conflicting perspectives; that human beings are not that independent from the social structures in which they are immersed; and that there are hidden inner processes which undermine their apparent autonomy (Foucault, 1972). Following this process, holistic and systemic perspectives had to be incorporated and integrated into social sciences in order to acknowledge this complexity.

At the end of the 20th century, or rather throughout the whole century but more visible in the last quarter of the century, a similar move has occurred which has intensified the previous development. This development is still going through, and may go unnoticed if we fail to recognise the need for a change in perspective and of point of view. This change places its focus and its epicentre on the intrinsic and inherent nature of all human action and thought as socially embedded phenomenon. In order to grasp the importance of this change, it is critical to point out that this notion of social embeddeness has surpassed the traditional binary opposition between individual and social issues which still permeates current and mainstream management and organisational perspectives. Instead of opposing or separating psychological and sociological issues, it treats the individual and the collective, the internal and the external, the inner and the outer world as a unique single reality. In other words, it does not partition and divide, study each isolated part, and then take the result of this process for the whole. Rather, it takes the whole from the start.

Several contemporary organisational theories follow this pragmatist approach. Pragmatism was developed by Peirce who, at the end of the 19th century and together with Saussure, created the two large schools of semiotics that have been largely influential throughout the 20th century. Among these non-dualistic, post-cognitivist, and post-structuralist thinking approaches are Stacey's complex responsive processes (2001), Checkland's soft systems methodology (1984, 1999), Eijjnatten's chaordic systems thinking (2003), Alvesson and Skoldberg's reflexive methodology (2000), and Weick's organisational sense-making (1995, 2001).

MAIN FOCUS: THE EPISTEMIC SHIFTS

The importance of the concept of communities of practice at an organisational level is parallel to the growth in the interest of management approaches such as organisational learning and knowledge management. At a broader level, this development reflects the reactions from the management and organisational areas to the reality of the knowledge economy of the information age (Kearmally, 1999). This movement may be considered as the tip of an iceberg, as the culmination of a long process of development that is still going on.

Social philosophy is a valuable reading matrix for the interpretation of the current complexity of an organisation's environments. If we want to understand the work of Aristotle, we have first to grasp what issues and questions he was trying to answer—his context. In order to understand how to implement organisational practices such as collaborative work and learning, or knowledge creation and sharing, we first have to grasp the necessary conditions for them to work—that is, the relevant community of practice, of learning, or of interest. Communities refer to the form and context of human interaction, to the situated and embodied character of human action and thought. The community concept brings up the social, cultural, and historical underpinnings of individual embeddeness. The hidden part of the iceberg includes a myriad of threads which the philosophy of the social sciences may help to untangle.

Applying this line of reasoning to the field of communities of practice is equivalent to trying to unveil the hidden influences and underpinnings that condition its development, as well as its potential for action: the exploration of the full capacity of the communities of practice theory and practice within organisational settings, the thought-possibilities and action-possibilities of communities of practice as such.

The argument is that social sciences, as a whole, frame and condition the emergence of theories and concepts such as, for example, communities of practice theory. Foucault did a historical analysis of social sciences, or the "human sciences" as he called them (Foucault, 1970; Delanty, 2003; McHoul & Grace, 1993). He looked at the structure of knowledge of a time, at its way of establishing order. He starts long before the existence of the human sciences, and examines the development of the fields known in the seventeenth and eighteen centuries as general grammar, natural history, and the analysis of wealth. He considers the question of what marks the shift into the modern world and claims that before the 18th century, man did not exist. Of course human beings existed before that, and may even have looked at themselves as the centre of the universe. But they were central because God had made them that way. Man was then left with only himself at the centre, as the sole source of knowing, and thus turned to intense examination of what this knowing being was. The Human Sciences sprang up as old fields were re-examined, with a new notion of Man as both the object and the subject of study.

From empiricism and positivism, through rationalism, structuralism, interpretativism, pragmatism, post-structuralism, and post-modernism, the development of the philosophy of social sciences presents a broad array of trends and approaches. Though each one of them may still be present today through the influence it had in the development of specific knowledge areas, when taken as a whole it is possible to differentiate four epistemic shifts throughout the 20th century (Delanty & Strydom, 2003). The first and second shifts developed in the first part of the century, and the third and fourth on the second part. These divisions are not to be taken as once and for all changes, as each one of them still persists today. They mutually influenced and reacted against each other from the start.

The first is the logical turn, in early 1920s, originating in the work of the Vienna Circle, which reacted against 19th century's positivism and promoted logical positivism. Authors such as Schlick and Carnap are examples of this period. Wittgenstein travels at the time connected with Cambridge and Vienna thinkers.

The second shift is the linguistic turn, which developed out of the works of Saussure and Peirce at the turn of the century, and then it was further developed by Wittgenstein, Morris, and many others throughout the first half of the century. Levy-Strauss developed structuralism by applying Saussure's thought to culture in general. The interest in language included not only the syntax and semantic aspects, the structure and meaning, but also and above all the pragmatics of language use.

The third epistemic shift is the context turn, from post-war to the 1970s, and refers to an extension of the linguistic turn into a full historical-cultural revolution which radically contextualised science. Kuhn's work on the conflict of paradigms reflects this change. This development implied also a relativist turn. Further examples of this movement are the feminist standpoint epistemology, radical hermeneutics, constructivism, poststructuralism, and postmodernism, as well as the works of Foucault, Derrida, Rorty, and Bourdieu.

The fourth shift is the knowledge turn during the last quarter of the century; it is an attempt to deal with the problem of the inherent ambiguity and diffuseness of context. It is the turn towards knowledge in the discourses of the human and social sciences.

…knowledge recovers from the full implications of the historical-cultural turn…Knowledge is less about knowing reality than about emergent forms of the real and reflexive relation to the world in which reality is shaped…. (Delanty & Strydom, 2003, p. 10)

Apel, Habermas, and Fuller's work are examples of this shift. Delanty and Strydom call attention to the cognitive practices, structures, and processes that are constitutive of knowledge creation, that in turn occurs within research programs, traditions, and scientific communities. These authors refer that in parallel with the rise of cognitivism, and the interest in reflexivity, new controversies emerged such as the constructivist versus realism dilemma.

From this broad spectrum of approaches related to the historical development of social philosophy, we will situate the emergence of the communities of practice theory.

FUTURE TRENDS AND INFLUENCES

Marginally ignorant and indifferent to the logical, linguist, context, and knowledge epistemic turns of the social sciences, the vast majority of dominant theories and approaches within the fields of management science and organisational theory grew out of the influence, and still remain today largely influenced, by positivist, Cartesian, rationalist, mechanist, and utilitarian philosophical approaches, which developed out of the European Enlightenment. The sophistication of management theory and practice often remains secured within the broad positivist umbrella. This influence is usually subtle and pervasive so that more often than not it remains invisible, thus unquestioned and uncriticised.

Under this perspective, none of the epistemic turns directly and fundamentally influenced the core and functionalistic approach of mainstream management science, as it still remains constitutively determined by pure rationalist influences. Simultaneously to this core-functionalistic management centre, there is a minority and peripheral development which has long invested in non-orthodox and non-traditional management and organisational studies, ranging from cultural and sociological analysis, to the study of organisational development. It is critical to acknowledge these contributions, though still today, they are far from attracting the attention that they deserve. Even within the relatively recent fields of organisational learning and knowledge management, there are still prescriptive, linear, reductionist, and immediatist trends. The holistic, complex, and interpretative perspective of organisational reality is more an ideal than a widely disseminated reality.

These comments are not a dualistic, black-and-white analysis, but rather they aim at calling attention to the immense importance and the critical role of the communities of practice concept. By definition, this concept is intrinsically and inherently non-positivist. It is dynamic, flexible, and open, because it does not stand on rigid rules, clear-cut definitions, quantitative rationale, and universal laws. Its focus is on the particular and not on the general, on the local and not on the universal, on quality and not on quantity. This implies that the theory of the communities of practice potentially embodies every single contribution of all different epistemic turns which occurred in the social sciences during the 20th century.

A second aspect of analysis and directly related to this discussion is what Delanty and Strydom (2003) referred to as the fourth epistemic shift, the knowledge turn. Under their view, there is a radical importance given to cognitivism which becomes as if the new centre of the universe. However, cognitivism is still under a Cartesian and dualistic influence, focusing on the passive observer; on the rational, autonomous, and independent subject;, and on the mind as the centre and single focus of all rationalisation processes. Here, once again, the communities of practice theory implies a 180-degree shift as it calls attention to the intrinsic social nature of knowledge creation, and to the cultural, social, and historical embeddeness of every single human activity, from the external, visible interaction to the internal and invisible thought processes.

CONCLUSION

This somewhat harsh and direct discussion needs a devil's advocate comment. Both positivist and cognitivist approaches represent extremely valuable contributions to humankind and to science in general. The extraordinary development of science and technology, as well as the direct gains obtained from cognitivist research, are overwhelmingly important. At a different level, and within the management field, the functionalistic and mechanistic approaches are crucial in defining routines and procedures. No organisation could survive if it completely ignored its basic and repetitive tasks, and its rigid and bureaucratic structures. The issue that we have been referring to goes beyond these contributions and relates to the urgent and drastic need to pay as much attention to the visible, individual, immediate, repetitive, and standardised issues as to the invisible, collective, complex, subtle, and dynamic aspects of organisational life. Communities of practice theory corresponds to this effort which implies a hidden and subtle thought revolution. Referring again to the epistemic shifts, this thought revolution takes aspects of all previous contributions and integrates them within the fourth knowledge turn, which then becomes not solely restricted, reduced to, and limited by a cognitivist approach. And this is the greatest challenge and potential contribution that may be expected from communities of practice theory.

REFERENCES

Alvesson. M., & Sköldberg, K. (2000). *Reflexive methodology: New vistas for qualitative research*. London: Sage Publications.

Benton, T., & Craib, I. (2001). *Philosophy of social science*. London: Palgrave.

Brown, J., & Duguid, P. (2000). *The social life of information*. Boston: Harvard Business School Press.

Brown, J., & Duguid, P. (2001). Knowledge and organisation: A social-practice perspective. *Organisational Science, 12*(2), 198-213.

Checkland, P. (1984). *Systems thinking, systems practice*. West Sussex, UK: John Wiley & Sons.

Checkland, P. (1999). *Soft systems methodology: A 30-year perspective*. West Sussex, UK: John Wiley & Sons.

Delanty, G. (2003). Michel Foucault. In A. Elliot & L. Ray, L. (Eds.), *Key contemporary social theorists.* Oxford, UK: Blackwell.

Delanty, G., & Strydom, P. (2003). *Philosophies of social science*. Berkshire, UK: McGraw-Hill.

Eijjnatten, F. (2003). Chaordic systems thinking: Chaos and complexity to explain human performance management. *Proceedings of Business Excellence '03.*

Foucault, M. (1970). *The order of things: An archaeology of the human sciences.* London: Tavistock.

Foucault, M. (1972). *The archaeology of knowledge*. London: Tavistock.

Kearmally, S. (1999). *When economics means business*. London: Financial Times Management.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate and peripheral participation*. Cambridge, MA: Cambridge University Press.

McHoul, A., & Grace, W. (1993). *A Foucault primer—discourse, power and the subject.* New York: New York University Press.

Stacey, R. (2001). *Complex responsive processes in organisations: Learning and knowledge creation*. London: Routledge.

Weick, K. (1995). *Sense making in organisations.* Thousand Oaks, CA: Sage Publications.

Weick, K. (2001). *Making sense of the organisation*. Oxford, UK: Blackwell.

Wenger, E. (1999). *Communities of practice: Learning, meaning and identity.* Cambridge, MA: Cambridge University Press.

Wenger, E., McDermott, M., & Snyder, W. (2002). *Cultivating communities of practice*. Boston: Harvard Business School Press.

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Chapter 7.22
Phenomenon of Duality:
A Key to Facilitate the Transition From Knowledge Management to Wisdom for Inquiring Organizations

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ABSTRACT

"Wisdom is what you learn after you think you know it all" - unknown

In today's knowledge-based economy, sustainable strategic advantages are gained more from an organization's knowledge assets than from its more traditional types of assets, namely, land, labor, and capital. Knowledge, however, is a compound construct, exhibiting many manifestations of the phenomenon of duality such as subjectivity and objectivity as well as having tacit and explicit forms. Overlooking this phenomenon of duality in the knowledge construct has not only led many knowledge management initiatives to stumble but has also resulted in the discussion of the apparent contradictions associated with knowledge management in the IS literature as well as numerous discussions and debates regarding the "nonsense of knowledge management." It is the thesis of this chapter that a full appreciation of the phenomenon of duality is indeed necessary to enable inquiring organizations to reach the state of wisdom and enlightenment.

INTRODUCTION

Throughout the ages, the nature of knowledge has been central to many debates between philosophers, scientists, academics, and practitioners. In fact, it was the forbidden fruit from the Tree of Knowledge of Good and Evil that caused

Adam and Eve to be dismissed from the Garden of Eden; in addition, interestingly enough, the understanding of Good and Evil, a duality, was to lead Adam and Eve to wisdom. A key underlying and recurring theme in some shape or form with respect to knowledge in all these discussions is the phenomenon of duality as it relates to the knowledge construct and its management. Duality, or the principle of duality, refers to the existence of two irreducible aspects or perspectives that tend to complement each other, as in the example of Adam and Eve, the Tree had knowledge of good and evil. The key to the understanding of duality is that given the existence of duality, one must take a holistic perspective and realize that there is a harmonious balance between these duals. In contrast, taking a singular or one-dimensional perspective will lead to an incomplete understanding and consequently decisions and/or judgments based on such an incomplete view will then be suboptimal or less sound.

Webster's Dictionary defines wisdom as accumulated learning that provides knowledge, the ability to discern inner qualities and relationships, that is, insight and leads to sound judgment. Succinctly stated then, wisdom requires knowledge and is concerned with understanding principles and then being able to make sound decisions and/or judgments based on such an understanding. Knowledge is not a homogenous construct, rather it is a compound complex construct. One of the reasons knowledge is compound in nature is because it exhibits numerous duals at many levels. This chapter contends that by understanding the phenomenon of duality and how it relates to the knowledge construct, not only will inquiring organizations firstly be able to better understand the compound knowledge construct and its management, but also this will facilitate their moving from knowledge management to wisdom.

In this chapter, many specific manifestations of the duality phenomenon as it relates to knowledge and its management are highlighted, such as the subjective and objective perspectives, the consensus versus disensus perspective, the Lockean/Leibnizian aspects of knowledge versus the Hegelian/Kantian aspects, and the people versus technology dimensions. Throughout the chapter, no one perspective is singled out as correct or incorrect, rather the emphasis is on the fact that these respective duals not only underscore the duality phenomenon at different levels but are all useful, necessary, and important for an inquiring organization to fully appreciate the compound quality exhibited by the knowledge construct and thereby embrace superior knowledge management strategies, techniques, tools, and processes. In addition, a sound understanding of the duality phenomenon as it relates to knowledge will not only facilitate a better understanding of how to embrace knowledge management, an important strategy in today's knowledge economy (Drucker, 1993), but also address key needs such as identified by Nonaka that "few managers grasp the true nature of knowledge creating companies--let alone how to manage it" (Holsapple & Joshi, 2002, p. 47) and Ann Stuart that "[m]any managers would be hard pressed to explain precisely and concisely, what this evolving business trend (knowledge management) means" (Holsapple & Joshi, 2002, p. 47). The following then, serves to address this duality phenomenon with respect to the knowledge construct and thereby highlight that a true appreciation of this duality phenomenon with respect to knowledge and knowledge management, more specifically, should enable "the getting of wisdom" for inquiring organizations.

The chapter is structured as follows: first a background section which gives a brief description of key terms required for an inquiring organization to move from knowledge management to wisdom is presented as well as a brief synopsis of inquiring organizations and the integral role of knowledge and its management for these organizations. In addition, this section discusses the compound nature of knowledge and why knowledge as opposed to its related cousins, data, and information, exhibits this duality phenomenon. Then, a discussion of knowledge management, the knowledge construct as well as the major philosophical perspectives for understanding knowledge management is presented. This is followed by a discussion of the key perspectives of knowledge creation. Next, some specific dualities are highlighted and discussed in turn. Finally, conclusions are drawn and avenues for future research highlighted.

BACKGROUND

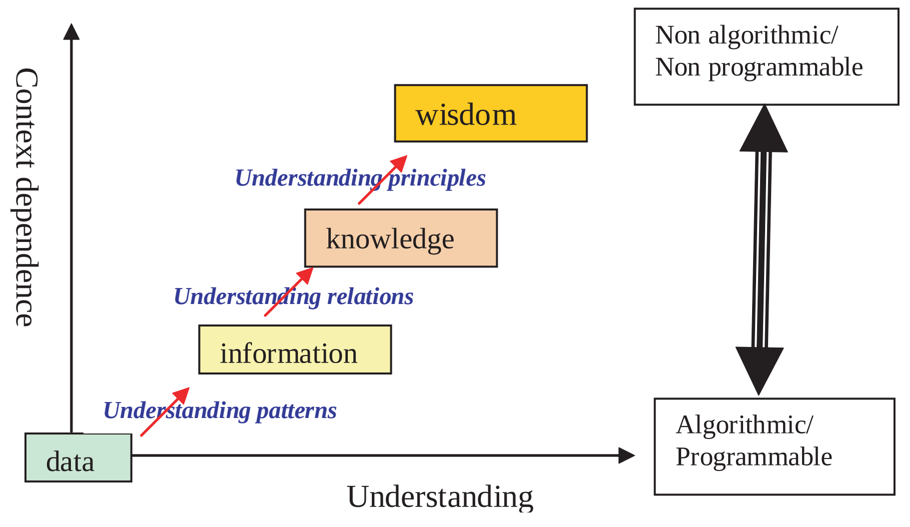
This sections serves to define knowledge and why it is a compound construct. In so doing, it also discusses other relevant terms, including data, information, wisdom, and understanding. The section will also summarize the integral nature of knowledge and knowledge management for inquiring organizations.

From Data to Wisdom

In today's knowledge economy, data can be viewed as an abundant, vital, and necessary resource. It is then possible to tap into this reservoir and by utilizing new ways to channel raw data into meaningful or processed data to form information. This information, in turn, can then become knowledge that ultimately with further understanding leads to wisdom (Alberthal, 1995). Thus data, information, knowledge, and ultimately wisdom are not just connected, but it is also possible to generate knowledge from data, thereby making data and information valuable raw materials in the knowledge economy.

Data can be defined as a series of discrete events, observations, measurements, or facts in the form of numbers, words, sounds, and/or images. In organizations, much of the useful data is in the form of transaction records, stored in data bases and generated through various business

Figure 1. Data to wisdom



processes and activities. Today organizations generate large amounts of various types of data. Given its discrete form, data is not very useful as it is and needs to be processed. When this data is processed and organized into a context, it becomes information. In transforming data into information, five important Cs have taken place as noted by Davenport and Prusak (1998), as follow:

1. Contextualized: the purpose surrounding the data collection/gathering is known.
2. Categorized: the key units of analysis and key factors relating to this data are known.
3. Calculated: mathematical and/or statistical analyses have been performed on this data.
4. Corrected: errors in this data have been corrected or accounted for.
5. Condensed: the data has been summarized and distilled.

There exist many plausible definitions of knowledge. For the purposes of this chapter, the definition of knowledge given by Davenport and Prusak (1998) will be used because it is not only broad and thus serves to capture the breadth of the construct but also and, perhaps more importantly for this discussion, it serves to underscore that knowledge is not a simple homogeneous construct, rather a compound construct:

"Knowledge is a fluid mix of framed experiences, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it is often embedded not only in documents or repositories but also in organizational routine, processes, practices and norms." (p. 5)

In transforming information to knowledge, the role of people is integral. Furthermore, such transformations take place with four key C activities identified by Davenport and Prusak (1998), including:

1. Comparison: information in one scenario is compared and contrasted with another.
2. Consequences: what implications does the information have for decision making?
3. Connections: how does this bit of information and/or knowledge relate to another?
4. Conversation: what do people think of this information?

What is important to note about these four C activities is that they require human cognitive processes to take place, which are all concerned, to a greater or lesser degree, to the understanding of relations and tend to be subjective in nature, unlike the five C activities associated with information which require more mechanistic or objective functions of understanding patterns. Herein lies the reason for why knowledge as opposed to its cousins of data and information can exhibit the phenomenon of duality, while the more simplistic constructs of data and information do not.

Understanding is an interpolative and probabilistic process where one can take knowledge and synthesize new knowledge from the previously held knowledge. The difference between understanding and knowledge is the difference between learning and memorizing (Wickramasinghe & Sharma, in press). Finally, wisdom is an extrapolative and nondeterministic, nonprobabilistic process (Wickramasinghe & Sharma, in press). It calls on all the previous levels of consciousness, and specifically on special types of human programming (moral, ethical codes, etc.). Given this explanation of wisdom coupled with Webster's definition of wisdom presented in the introduction, what becomes apparent is that to obtain wisdom in addition to knowledge, the understanding of principles is required, and a holistic rather than a singular inquiry system is necessary but not sufficient to the achievement of such a state. Furthermore, such a state of wisdom will lead to sound decision making and judgments.

From Figure 1, several aspects are important to note with respect to the progression from data to wisdom. First, as we move from left to right in the figure, or as we move from data to wisdom, we also move from constructs that are algorithmic and programmable to constructs that are nonalgorithmic and nonprogrammable. This means that while data is highly programmable and algorithmic, wisdom is almost nonprogrammable and nonalgorithmic. Further, we can see from Figure 1 that data is highly context independent while wisdom is highly context dependent. Therefore, the specific context becomes an integral component in the managing of wisdom, and while it is possible to generate a precise prescription for managing data, it is very difficult to generate a similar prescription for facilitating an organization to manage wisdom. The key then to achieving wisdom lies in the understanding and consequent application of principles, that is, making sound judgments and decisions based on a solid understanding of key underlying principles. One such principle is the principle of duality as it relates to the knowledge construct and knowledge management.

Synopsis of Knowledge and Its Management for Inquiring Organizations

In trying to understand knowledge, knowledge management, and related concepts, such as organizational learning and organizational memory, numerous researchers have employed the structure of an inquiring organization (Churchman, 1971; Courtney, 2001; Courtney, Croasdell & Paradice, 1998; Hall, Guo & Davis, 2003; Malhotra, 1997). By doing so, they are able to view knowledge creation and thereby examine knowledge, its management, as well as organizational learning and organizational memory through a systems lens. Since inquiring organizations employ inquiring systems consisting of interrelated processes, procedures, and other measures for producing knowledge on a problem or issues of significance (Courtney, Chae & Hall, 2000; Mitroff & Linstone, 1993), knowledge and its management then become integral to all major activities of inquiring organizations. To be successful today, the modern organization must be a learning organization (Senge, 1990). By viewing such a learning organization as an inquiring system and thus an inquiring organization, it is not only possible but useful to do so in order to identify knowledge creation, in particular, valid knowledge produced (Courtney et al., 1998; Courtney, 2001; Hall, Paradice, & Coutrney, 2003; Malhotra, 1997).

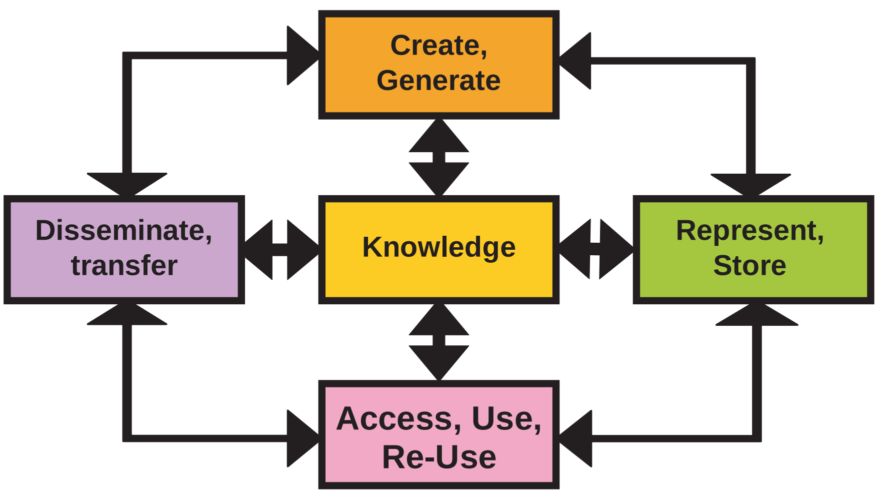
These inquiring organizations have typically been discussed as different types, corresponding to the different types of inquiring systems first identified by Churchman (Courtney et al., 2000) where Churchman's Leibnizian inquirer has led to the Leibnizian inquiring organization, his Lockean inquirer has led to the Lockean inquiring organization, his Hegelian inquirer has led to the Hegelian inquiring organization, his Kantian inquirer has led to the Kantian inquiring organization, and his Singerian inquirer has led to the Singerian inquiring organization, respectively. Such a singular perspective, however, appears limiting given the compound nature of knowledge itself. In this way, knowledge as a construct is set apart from related constructs of data or information because, unlike its distant cousins, it does in fact display instantiations of the phenomenon of duality. Hence, this chapter proposes an embracing of the phenomenon of duality into such inquiring systems and corresponding inquiring organizations as a necessary step to the acquiring of wisdom. Duality with respect to the knowledge construct and some of its manifestations will now be presented.

KNOWLEDGE MANAGEMENT

Knowledge management is a key approach currently being embraced by many organizations, irrespective of their industry to solve problems, such as competitiveness and the need to innovate, which are key challenges faced by businesses today. The premise for the need for knowledge management is based on a paradigm shift in the business environment where knowledge is central to organizational performance (Swan, Scarbrough & Preston, 1999). This macro-level paradigm shift also has significant implications on the micro-level processes of assimilation and implementation of knowledge management concepts and techniques (Wickramasinghe & Mills, 2001), that is, the Knowledge Management Systems (KMS) that are in place. In essence then, knowledge management not only involves the production of information but also the capture of data at the source, the transmission and analysis of this data as well as the communication of information based on or derived from the data to those who can act on it (Davenport & Prusak, 1998). Hence, knowledge management consists of four key steps (create/generate, represent/store, access/use/reuse, and disseminate/transfer) as depicted in Figure 2.

From Figure 2, it is important to notice that these steps are all interrelated, continuous, and impact each other and the knowledge itself throughout the organization. Furthermore, a full appreciation of the knowledge construct, the central component in Figure 2, has far reaching implications on the well functioning of all four steps and the sustainability of sound knowledge management practices. In order to better understand this knowledge construct, it is first important to identify the types of knowledge that exist. Given that the inquiring systems within inquiring organizations result in knowledge creation (Courtney et al., 1998), knowledge management becomes a necessity for inquiring organizations while a fuller understanding of the knowledge construct itself becomes a vital pursuit, and such a fuller understanding should incorporate an understanding of the various dualities that exist and the need

Figure 2. Four key steps of knowledge management



for achieving a harmonious balance of these duals in all their manifestations.

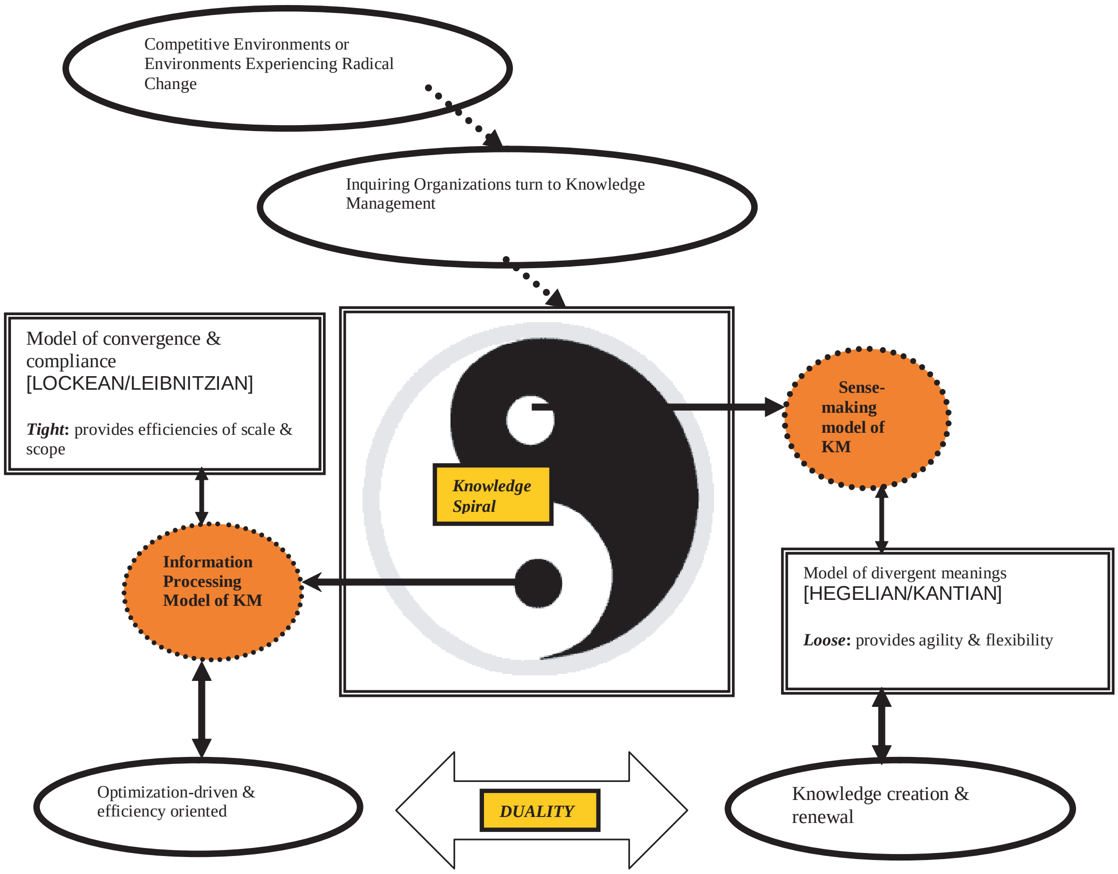
Types of Knowledge

In trying to understand the knowledge construct, it is necessary first to recognize the binary nature of knowledge, namely, its objective and subjective components (Wickramasinghe & Mills, 2001; Alavi & Leidner, 2001; Schultze & Leidner, 2002; WIckramasinghe & Lamb, 2002). Knowledge can exist as an object, in essentially two forms: explicit or factual knowledge and tacit or know-how (Haynes, 1999, 2000; Polyani, 1958, 1966). It is well established that while both types of knowledge are important, tacit knowledge is more difficult to identify and thus manage (Nonaka, 1994; Nonaka & Nishiguchi, 2001). Of equal importance, though perhaps less well defined, knowledge also has a subjective component and can be viewed as an ongoing phenomenon being shaped by social practices of communities (Boland & Tenkasi, 1995). The objective elements of knowledge can be thought of as primarily having an impact on process while the subjective elements typically impact innovation. Both effective and efficient processes as well as the functions of supporting and fostering innovation are key concerns of knowledge management. Thus, we have an interesting duality in knowledge management that some have called a contradiction (Schultze, 1998) and others describe as the loose-tight nature of knowledge management (Malhotra, 2000).

The loose-tight nature of knowledge management comes to being because of the need to recognize and draw upon some distinct philosophical perspectives, namely, the Lockean/Leibnizian stream and the Hegelian/Kantian stream. Models of convergence and compliance representing the tight side are grounded in a Lockean/Leibnizian tradition. These models are essential to provide the information processing aspects of knowledge management, most notably by enabling efficiencies of scale and scope and thus supporting the objective view of knowledge management. In contrast, the loose side provides agility and flexibility in the tradition of a Hegelian/Kantian perspective. Such models recognize the importance of divergence of meaning which is essential to support the sense-making subjective view of knowledge management. Figure 3 depicts the Yin-Yang model of knowledge management (Wickramasinghe & Mills, 2001). The principle of Yin-Yang is at the very roots of Chinese thinking and is centered around the notion of polarity or duality not to be confused with the ideas of opposition or conflict (Watts, 1992). By incorporating this Yin-Yang concept of duality and the need to have or recognize the existence of both components present, yet not necessarily in equal amounts, is appropriate for describing knowledge management from a holistic perspective. Further, by recognizing the manifestations of duality that exist with the knowledge construct as identified in Figure 3 and thereby taking such a holistic perspective, not only are both sides of these duals recognized (i.e., the loose and tight perspectives, subjective/objective, consensus/disensus, Lockean/Lebnizian vs. Hegelian/Kantian) but also, and more importantly, both are required (at least to some extent) in order for knowledge management to truly flourish.

Specifically, Figure 3 shows that given a radical change to an environment or given a highly competitive environment, an organization needs knowledge to survive; implicit in this model is the fact that the organizations that are being described are in fact inquiring organizations in today's competitive business environment. From the Yin-Yang depiction of knowledge management, we see that knowledge is required for the organization to be effective and efficient, but new knowledge and knowledge renewal is also necessary, thereby making both forms of knowledge (i.e., both sides of the duality) important for an organization to capture in order to truly benefit from knowledge

Figure 3. Yin-Yang model of knowledge management (adapted from Wickramasinghe & Mills, 2001)



management. The knowledge spiral represents the transformations that take place in knowledge creation (Nonaka, 1994; Nonaka & Nishiguchi, 2001) as well as a dynamic equilibrium between key dualities.

Such a holistic perspective then strongly suggests that focusing on only one component or having a singular perspective of an inquiring system without any regard for the other side of any given dual is limiting and likely to lead to a less complete picture of knowledge creation, hence, the need to recognize the duality phenomenon for inquiring organizations. The importance for inquiring organizations then, becomes twofold: (a) to recognize and understand this underlying principle of duality and (b) to utilize it by, in essence, finding the right mix of the duality or harmonious balance between these duals for the specific context, given the context-dependent nature of wisdom. Thus, the Lockean inquiring organization grounded in a Lockean inquiring system should not totally ignore aspects of a

Hegelian or Kantian inquiry system in order to create a fuller picture of valid knowledge. It is important to note here, however, that unlike the case with data, this right mix is neither programmable nor algorithmic and thus requires a deep understanding of the duality principle as well as the organization's specific context and what is key in that specific context; in this way, valid knowledge should be resultant and hence a state of wisdom achieved.

The Knowledge Spiral

Knowledge is not static; rather it changes and evolves during the life of an organization. What is more, it is possible to change the form of knowledge, that is, turn tacit knowledge into explicit and explicit knowledge into tacit or to turn the subjective form of knowledge into the objective form of knowledge (Wickramasinghe & Mills, 2001). This process of changing the form of knowledge is known as the knowledge spiral (Nonaka, 1994; Nonaka & Nishiguchi, 2001). Integral to this changing of knowledge through the knowledge spiral is that new knowledge is created (Nonaka, 1994), and this can bring many benefits to organizations. In the case of transferring tacit knowledge to explicit knowledge, for example, an organization is able to capture the expertise of particular individuals; hence, this adds not only to the organizational memory but also enables single-loop and double-loop organizational learning to take place (Huber, 1984). Implicit in this is the underlying dualities and a dynamic equilibrium or right mix between dualities that is determined by context. In the process of creating valid knowledge, inquiring organizations are in fact enacting these transformations and thus experiencing these dualities; however, it is unconscious and, to a great extent, much of the knowledge that potentially could be acquired is never captured by ignoring the underlying dualities and taking a singular focus, such as only a Lockean inquiring system as the lens to view knowledge creation.

Knowledge Creation

The processes of creating and capturing knowledge, irrespective of the specific philosophical orientation (i.e., Lockean/Leibnizian versus Hegelian/Kantian), has been approached from two major perspectives, namely, a people-oriented perspective and a technology-oriented perspective, another duality.

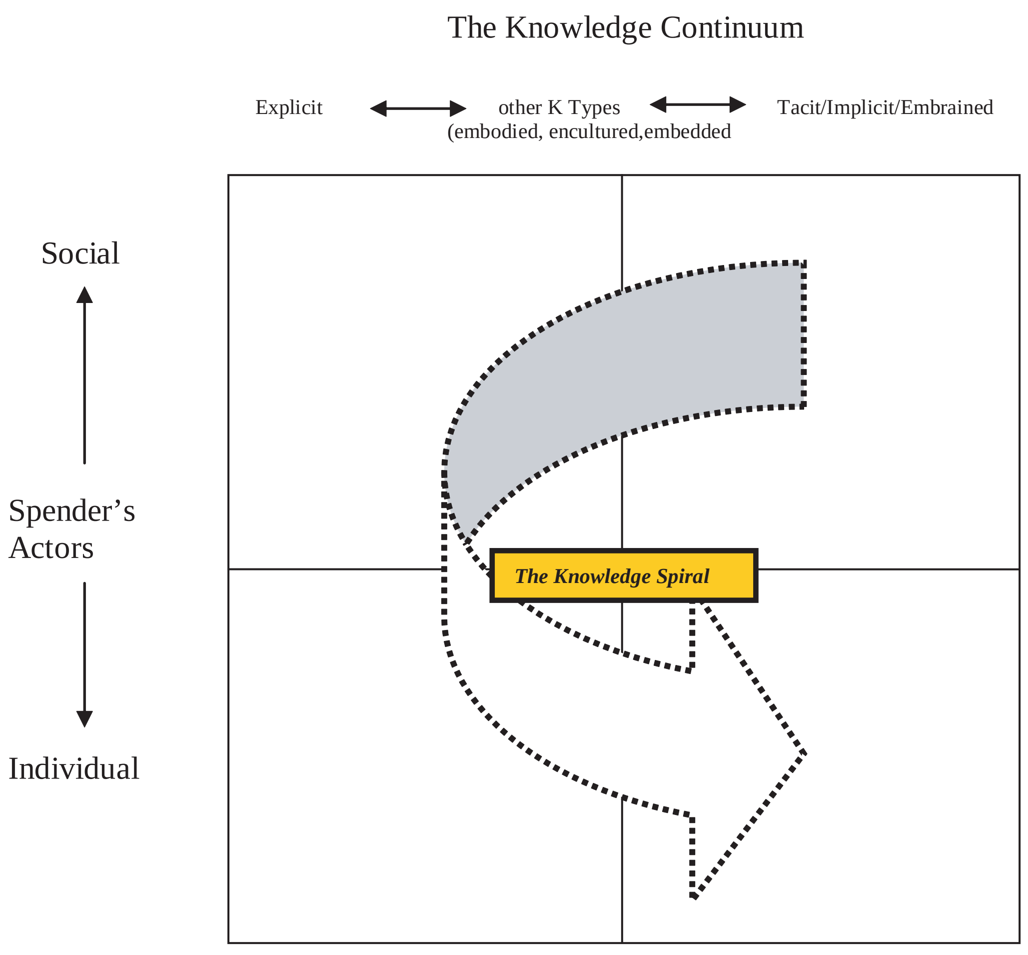
People-Oriented Perspective to Knowledge Creation

This section briefly describes three well known people-oriented knowledge creation frameworks: namely, Nonaka's Knowledge Spiral, Spender's and Blackler's respective frameworks.

According to Nonaka (1994): (1) Tacit to tacit knowledge transformation usually occurs through apprenticeship type relations where the teacher or master passes on the skill to the apprentice. (2) Explicit to explicit knowledge transformation usually occurs via formal learning of facts. (3) Tacit to explicit knowledge transformation usually occurs when there is an articulation of nuances; for example, as in healthcare if a renowned surgeon is questioned as to why he does a particular procedure in a certain manner, by his articulation of the steps, the tacit knowledge becomes explicit. (4) Explicit to tacit knowledge transformation usually occurs as new explicit knowledge is internalized; it can then be used to broaden, reframe, and extend one's tacit knowledge. These transformations are often referred to as the modes of socialization, combination, externalization, and internalization, respectively (Nonaka & Nishiguchi, 2001).

Spender draws a distinction between individual knowledge and social knowledge (yet another duality), each of which he claims can be implicit or explicit (Newell et al., 2002). From this framework, we can see that Spender's definition of implicit knowledge corresponds to Nonaka's tacit knowledge. However, unlike Spender, Nonaka doesn't differentiate between individual and social dimensions of knowledge; rather he just focuses on the nature and types of the knowledge itself. In contrast, Blackler (Newell et al., 2002) views knowledge creation from an organizational perspective, noting that knowledge can exist as encoded, embedded, embodied, encultured, and/or embrained. In addition, Blackler emphasized that for different organizational types, different types of knowledge predominate, and highlights the connection between knowledge and organizational processes (Newell et al., 2002). Blackler's types of knowledge can be thought of in terms of spanning a continuum of tacit (implicit) through to explicit with embrained being predominantly tacit (implicit) and encoded being predominantly explicit while embedded, embodied, and encultured types of knowledge exhibit varying degrees of a tacit (implicit)/explicit combination. Figure 4 depicts an integrated view of all the three frameworks.

Figure 4. Integrative framework of the main people-oriented perspectives

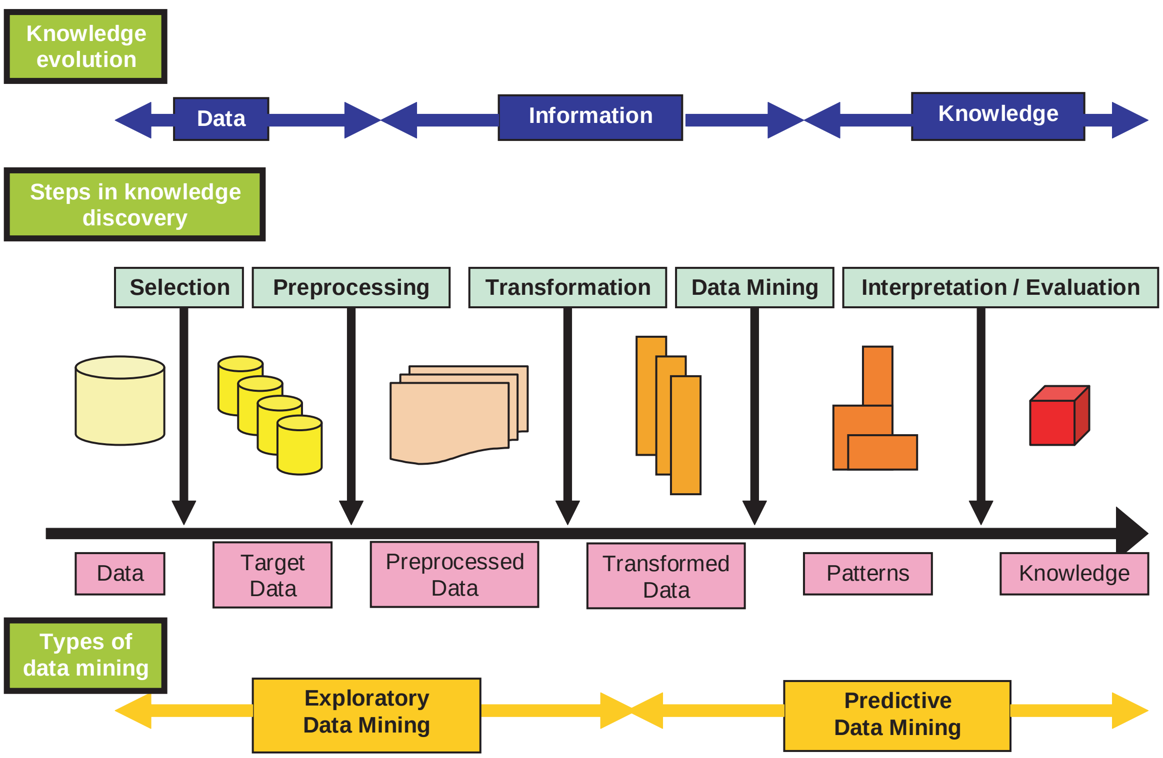


Specifically, from Figure 4 we can see that Spender's and Blackler's perspectives complement Nonaka's conceptualization of knowledge creation and, more importantly, do not contradict his thesis of the knowledge spiral wherein the extant knowledge base is continually being expanded to a new knowledge base, be it tacit/explicit (in Nonaka's terminology), implicit/explicit (in Spender's terminology), or embrained/encultured/embodied/embedded/encoded (in Blackler's terminology). What is important to underscore here is that these three frameworks take a primarily people-oriented perspective of knowledge creation. In particular, Nonaka's framework, the most general of the three frameworks, describes knowledge creation in terms of knowledge transformations as discussed above that are all initiated by human cognitive activities as well as the enacting of at least one of the four Cs relating to knowledge discussed earlier. Needless to say that both Spender and Blackler's respective frameworks also view knowledge creation through a primarily people-oriented perspective. Typically, Hegelian and Kantian inquiring systems would incorporate knowledge creation that is consistent with these people-oriented perspectives (Malhotra, 1997).

Technology-Oriented Perspective to Knowledge Creation

In contrast to the above primarily people-oriented perspectives pertaining to knowledge creation,

Figure 5. Integrative framework of the technology-oriented perspectives



knowledge discovery in databases (KDD) (and, more specifically, data mining), approaches knowledge creation from a primarily technology-oriented perspective. In particular, the KDD process focuses on how data is transformed into knowledge by identifying valid, novel, potentially useful, and ultimately understandable patterns in data (Fayyad, Piatetsky-Shapiro & Smyth, 1996). KDD is primarily used on data sets for creating knowledge through model building or by finding patterns and relationships in data. How to manage such newly discovered knowledge and other organizational knowledge is at the core of knowledge management. Figure 5 summarizes the key steps within the KDD process; while it is beyond the scope of this chapter to describe in detail all the steps which constitute the KDD process, an important duality to highlight here is that between exploratory and predictive data mining. Typically, Lockean and Leibnizian inquiring systems would subscribe to a technology-oriented perspective for knowledge creation (Malhotra, 1997).

The preceding discussions then have highlighted some key aspects of knowledge creation from both a people-oriented perspective as well as a technology-oriented perspective. Irrespective of which knowledge creation perspective the concept of duality is reflected in, the knowledge creation process both between the people-oriented and technology-oriented perspectives as well as within each respective perspective; for example, within the people-oriented perspective we have the dualities of social versus individual and tacit versus explicit, while in the technology-oriented perspective we have the duality of exploratory versus predictive data mining. Unlike the dualities identified in the Yin-Yang model of knowledge management though, these dualities represent instantiations of the duality principle at the micro-level. So it is possible then to have the manifestations of dualities with respect to the knowledge construct at both the macro- and micro-levels, yet another reason why the knowledge construct is compound in nature. The following section elaborates on these dualities at both the macro- and micro-levels with respect to the knowledge construct and the impact they have on knowledge management.

DUALITIES IN THE KNOWLEDGE CONSTRUCT

The previous section highlighted several dualities with respect to the knowledge construct and knowledge creation at both a macro- and micro-level. In so doing, we can see that in fact many dualities manifest themselves when we begin to understand the knowledge construct and its management. It would make sense then that our inquiring systems, which are creating knowledge through their activities, should also be viewed in such a light and embrace such a perspective. Before discussing the benefits of embracing such a perspective, it is first useful to summarize the key dualities discussed and their benefits to knowledge management. Table 1 highlights these key dualities and why each side of the duality has importance with respect to knowledge management.

As noted in the introduction, any duality represents the existence of two irreducible aspects or perspectives. By recognizing both sides of a specific dual then, be it tacit/explicit, individual/social, Lockean/Leibnizian versus Hegelian/Kantian, subjective/objective, consensus/disensus, loose/tight or people/technology, a more complete and richer picture of knowledge is created and hence the impact to knowledge management, be it in terms of sharing knowledge, creating knowledge or enhancing the knowledge context, in turn is superior. On the other hand, taking a one-dimensional view, which is more often than not what too many organizations tend to do with respect to their knowledge management initiatives, for example, only recognizing the technology side of knowledge creation (and not being cognizant

Table 1. Key knowledge management dualities

Duality	Impact on KM	Benefits of Recognizing the Dual
Tacit/Explicit	Knowledge creation	From Nonaka's knowledge spiral both tacit and explicit knowledge as well as the transformations of tacit to explicit and vice versa are important to KM. Only focusing on tacit (or only focusing on explicit) provides an incomplete picture with respect to knowledge creation.
Individual/Social	Knowledge sharing	Spender and Blacker, in particular, highlight the significance of both sides of this duality. Only focusing on individually constructed knowledge limits us to a much narrower domain of knowledge creation. Especially given the gregarious nature of humans socially constructed knowledge should also form an important part of the total knowledge created.
Lockean/Leibnitzian vs. Hegelian /Kantian	Knowledge context	These fundamental philosophical perspectives all highlight important facets of the knowledge context (a key dimension of wisdom) and thus when taken together facilitate the understanding of the full spectrum for knowledge management.
Subjective/Objective	Knowledge capture	The sides of this duality highlight both the complexities of knowledge capture relative to the knowledge type being captured as well as the importance of capturing all types of knowledge.
Consensus/Disensus	Knowledge sharing/dissemination	While the consensus side of this duality emphasizes convergence of thought the disensus side emphasizes the need for divergence; however both are reflections of group dynamics that are important for knowledge sharing/ dissemination.
Loose/Tight	Knowledge context	This duality also highlights the need for considering both internal and external organizational context in the framing of KM issues for supporting activities that lead to optimization as well as activities that lead to knowledge creation and renewal
People/Technology	**Knoweldge creation**	This duality underscores the need for a socio-technical approach to knowledge creation because it highlights that knowledge can be created by technologies and people as well as it also being embedded in processes.

of the people side of knowledge creation, i.e., the Lockean and/or Leibnizian inquiring organization) or disregarding the existence of explicit knowledge (and only recognizing the existence of tacit knowledge; i.e., the Hegelian and/or Kantian inquiring organization), in a knowledge creation will lead to a much narrower and limited resultant body of knowledge as well as an inferior and most likely less useful or appropriate knowledge management initiative. Hence, we should not be surprised by the many discussions prevalent in the literature regarding the "nonsense of knowledge management" (Wilson, 2002).

Two key characteristics of inquiring organizations are (1) accuracy of the system basis and (2) continual review of the stored knowledge for accuracy in changing environments (Hall et al., 2003). Surely, a partial picture of knowledge would never be able to provide a similar level of accuracy as a fuller richer picture, hence, the benefit to inquiring organizations of understanding the duality principle and incorporating the many manifestations of these duals both macro and micro with respect to the compound knowledge construct.

Understanding the duality principle necessitates an understanding of the right mix or dynamic equilibrium for the given context. Given this connection with the context and the nonprogrammable nature of the knowledge construct, such an understanding becomes a necessary albeit not sufficient step for transforming inquiring organizations from knowledge to wisdom.

CONCLUSION

This chapter has served to highlight several instances of the duality principle as it relates to knowledge and its management. These instances represented dualities at both the macro- and micro-levels. By so doing, the pervasive nature of the duality principle to knowledge as well as to knowledge management was emphasized. In presenting the duality principle as it relates to knowledge and its management, it is important to recognize its macro and micro aspects because these aspects are characteristics of any organizational setting. Furthermore, an appropriate mix of these dualities is determined by the specific organizational, environmental, technological, and situational context and is necessary but not sufficient in the formulation of an appropriate knowledge management strategy; while the understanding of the underlying principles is important for the achievement of wisdom.

Integral to inquiring organizations is the creation of knowledge; however, as discussed in this chapter, these inquiring systems have tended to focus on a singular line of inquiry, be it Lockean, Leibnizian, Hegelian, Kantian, or Singerian and thus do not recognize or explicitly capture the dualities as connected with knowledge and its management.

Underlying the Yin-Yang model of knowledge management is the recognition of the need to take a holistic view, and thus a fuller richer perspective to knowledge and its management is achieved by understanding the duality principle. Given the importance of knowledge and its management to inquiring organizations, such an understanding would then appear to be essential. Wisdom was defined as the understanding of principles which in turn lead to the making of sound decisions and judgments. Thus, the understanding of the duality principle, in its many manifestations as it relates to knowledge and its management, represents a transition to wisdom or, at the very least, a key step for inquiring organizations trying to attain a state of wisdom. This chapter has severed to create the awareness and appreciation of the existence of the duality principle with respect to knowledge and its management for inquiring organizations; future research will focus on identifying the right mix or equilibrium point for specific inquiring organizations to reach the harmonious balance with respect to these many duals.

REFERENCES

Alavi, M., & Leidner, D. (2001). Review: Knowledge management and knowledge management Systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alberthal, L. (1995, October 23). *Remarks to the Financial Executives Institute*. Dallas, TX.

Boland, R., & Tenkasi, R. (1995). Perspective making, perspective taking. *Organizational Science, 6*, 350-372.

Churchman, C. W. (1971). *The design of inquiring systems: Basic concepts of systems and organizations*. New York: Basic Books.

Courtney, J. F. (2001). Decision making and knowledge management in inquiring organizations: Toward a new decision-making paradigm for DSS. *Decision Support Systems, 31*(1), 17-38.

Courtney, J. F., Chae, B., & Hall, D. (2000). Developing inquiring organizations. *Knowledge and Innovation, 1*(1), 132-145.

Courtney, J. F., Croasdell, D. T., & Paradice, D. B. (1998). Inquiring organizations. *Australian Journal of Information Systems, 6*(1), 3-15.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Drucker, P. (1993). *Post-capitalist society*. New York: Harper Collins.

Fayyad, U. M., Piatetsky-Shapiro, G., Smyth, P., & Uthurusamy, R. (1996). From data mining to knowledge discovery: An overview. In U. M. Fayyad, G. Piatetsky-Shapiro, P. Smyth, & R. Uthurusamy (Eds.), *Advances in knowledge discovery and data mining* (pp. 249–271), Menlo Park, CA: AAAI Press/MIT Press.

Hall, D., Guo, Y., & Davis R. (2003, January 6-9). Developing a value-based decision-making model for inquiring organizations. *Proceedings of the 36th Hawaii International Conference on System Sciences.*

Hall, D. J., Paradice, D. B., & Courtney, J. F. (2003). Building a theoretical foundation for a learning-oriented knowledge management system. *Journal of Information Technology Theory and Application (JITTA), 5*(2), 63-89.

Haynes, J. D. (1999). Practical thinking and tacit knowing as a foundation for information systems. *Australian Journal of Information Systems, 6*(2), 57-64.

Haynes, J. D. (2000, August 9-12). Inquiring organizations and tacit knowing. *Proceedings of the AMCIS* (pp. 1544–1547), California.

Holsapple, C., & Joshi, K. (2002). Knowledge management: A threefold framework. *The Information Society, 18*, 47-64.

Huber, G. (1984). The nature and design of postindustrial organizations. *Management Science, 30*(8), 928-951.

Malhotra, Y. (1997, August 15-17). Knowledge management in inquiring organizations. *Proceedings of the 3rd Americas Conference on Information Systems (Philosophy of Information Systems Minitrack)*(pp. 293-295), Indianapolis, IN.

Malhotra, Y. (2000). Knowledge management and new organizational form. In Y. Malhotra (Ed.), *Knowledge management and virtual organizations* (pp. 000-000) Hershey, PA: Idea Group.

Mitroff, I., & Linstone, H. A. (1993). *The unbounded mind: Breaking the chains of traditional business thinking.* New York: Oxford University Press.

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2002). *Managing knowledge work*. Palgrave, New York.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organizational Science, 5*, 14-37.

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge emergence*. Oxford: Oxford University Press.

Polyani, M. (1958). *Personal knowledge: Towards a post-critical philosophy*. Chicago: University of Chicago Press.

Polyani, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Schultze, U. (1998). *Investigating the contradictions in knowledge management*. Presentation at IFIP Dec. Helsinki, Finland.

Schultze, U., & Leidner, D. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *MIS Quarterly*, *26*(3), 212-242.

Senge, P. M. (1992). *The fifth discipline: The art and practice of the learning organization*. New York: Doubleday.

Swan, J., Scarbrough, H., & Preston, J. (1999, June). Knowledge management: The next fad to forget people? *Proceedings of the 7th European Conference on Information Systems.*

Watts, A. (1992). *Tao the watercourse way*. London: Arkana.

Wickramasinghe, N., & Lamb, R. (2002). Enterprise-wide systems enabling physicians to manage care. *International Journal Healthcare Technology and Management, 4*(3/4), 288-302.

Wickramasinghe, N., & Mills, G. (2001). MARS: The electronic medical record system the core of the Kaiser Galaxy. *International Journal Healthcare Technology Management, 3*(5/6), 406-423

Wickramasinghe, N., & Sharma, S. (in press). *The fundamentals of knowledge-based organizations.* Upper Saddle River, NJ: Prentice Hall.

Wilson, T. (2002). The nonsense of knowledge management. *Information Systems Research, 8*(1), 1-41.

ENDNOTE

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Chapter 7.23
Postmortem Reviews

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INTRODUCTION

Postmortem reviews are collective learning activities which can be organized for projects either when they end a phase or are terminated. The main motivation is to reflect on what happened in the project in order to improve future practice—for the individuals that have participated in the project and for the organization as a whole. Projects are the typical way of working in most knowledge-intensive organizations, and postmortems provide a possibility to learn from the projects with little effort, which makes it ideal as an initial knowledge management activity in a company.

This type of process has also been referred to as "after action reviews," "project retrospectives," "postmortem analysis," "post-project review," "project analysis review," "quality improvement review," "autopsy review," "Santayana review," and "touch-down meetings."

Researchers in organizational learning sometimes use the term "reflective practice," which can be defined as "the practice of periodically stepping back to ponder on the meaning to self and others in one's immediate environment about what has recently transpired. It illuminates what has been experienced by both self and others, providing a basis for future action" (Raelin, 2001). This involves uncovering and making explicit results of planning, observation, and achieved practice. It can lead to understanding of experiences that have been overlooked in practice.

There are a number of methods to conduct postmortems which we will describe in more detail in the following. The methods rely on collecting information from project participants either through interviews, group processes, or a meeting (preferably where participants meet physically). The outcome of a meeting is a postmortem report.

BACKGROUND

In the knowledge creation model of Nonaka and Takeuchi (1995), postmortems are a combination of learning through socialization and through externalization. In listening to others you employ socialization, and in reflecting and sharing your own experience you externalize your tacit knowledge. Postmortems are also a method for leveraging knowledge from the individual level to the organizational level.

In a survey on essential practices in research and development-companies, "learning from post-project audits" are seen as one of the most promising practices that could yield competitive advantage (Menke, 1997).

A survey on post-project reviews in research and development companies show that only one out of five projects received a post-project review (Zedtwitz, 2002). Also, the reviews tend to focus on technical output and bureaucratic measurements. Process-related factors are rarely discussed.

As a knowledge management tool, postmortem reviews are simple to organize. The process focuses on dialogue and discussion, which is a central element in knowledge transfer. Von Krogh, Ichijo, and Nonaka (2000) write:

It is quite ironic that while executives and knowledge officers persist in focusing on expensive information-technology systems, quantifiable databases, and measurement tools, one of the best means for knowledge sharing and creating knowledge already exists within their companies. We cannot emphasize enough the important part conversations play.

An example of postmortem reviews are "after action reviews" conducted by the U.S. army since after the Vietnam war, focusing on a "professional discussion of an event" to provide insight, feedback, and details about the event (Townsend & Gebhart, 1999).

Conducting Postmortem Reviews

There are several ways to perform postmortem reviews. Apple has used a method (Collier, DeMarco, & Fearey, 1996) which includes designing a project survey, collecting objective project information, conducting a debriefing meeting and a "project history day," and finally publishing the results. At Microsoft they also put much effort into writing "postmortem reports." These contain discussion on "what worked well in the last project, what did not work well, and what the group should do to improve in the next project" (Cusomano & Selby, 1995). The size of the resulting document is quite large: "Groups generally take three to six months to put a postmortem document together. The documents have ranged from under 10 to more than 100 pages, and have tended to grow in length."

Kerth (2001) lists a total of 19 techniques to be used in postmortems, many focusing on creating an atmosphere for discussion in the project. Kerth recommends taking three days to discuss projects in detail. (For a more complete overview of methods and purpose of postmortem reviews, see Dingsøyr, 2005)

METHODS FOR CONDUCTING POSTMORTEM REVIEWS

Postmortems can differ in length from activities that takes weeks, to an activity that can be done as a half-day group process. In the following, we present two methods for conducting postmortems, and also present example results from one type of postmortem.

Two techniques are used in both types of postmortems: For a focused brainstorm on what happened in the project, a technique called the "KJ Method," named after Japanese Ethnologist Jiro Kawakita (Scupin, 1997), is used. For each of these sessions, the participants are given a set of Post-It notes and asked to write one "issue" on each note. Five notes are handed out to each person. After a few minutes, the participants are asked to attach one note to a whiteboard and say why this issue is important. Then the next person presents a note and so on until all the notes are on the whiteboard. The notes are then grouped, and each group is given a new name.

Root cause analysis, also called Ishikawa or fishbone-diagrams, are used to analyze the causes of important issues. A process leader draws an arrow on a whiteboard, indicating the issue being discussed, and attaches other arrows to this one like in a fishbone, with issues the participants think are causing the first issue. Sometimes, underlying reasons for some of the main causes are attached as well.

Postmortem Review as a Large-Scale Process

Collier et al. (1996) describe postmortem reviews through five activities:

1. Project Survey: Define a set of questions you would like project participants to answer, such as "Did schedule changes and related issues involve the right people?" and "Were the right tradeoffs between features, quality, resources, and schedule done for the product developed in the project?" Analyze the results of such a survey, and complement with gathering objective data.
2. Collect Objective Information: Objective information related to resources spent, products developed, and other objective information that is valuable for a project.
3. Debriefing Meeting: Give project participants the opportunity to give direct feedback about the project. Use survey results to guide the topics to be covered in the meeting. Organize a series of meetings if more than 30 people participated in the project. Use a facilitator for the meetings in order to ensure a balanced discussion.
4. Project History Day: Formulate a problem statement to focus activities based on findings from the previous steps. An example is: "What are the root causes that determined or affected resources, schedule, and quality?" Invite key project participants, use a facilitator to discuss the problem statement, and use techniques such as root-cause-analysis. Limit participation to six or eight people. Ask participants to read the information gathered from the project, discuss deviations from the project schedule, and perform root-cause analysis on major deviations. Take note of the top 20 "root causes," and categorize using the KJ process.
5. Publish the Results: The leadership summarizes its findings and publishes it in an "open letter to project teams," which should be readable for project management and participants in the organization. It consists of four parts: (1) a description of the project, (2) a summary of positive findings ("the good"), (3) a summary of negative findings ("the bad"), and (4) issues that need to be improved ("the ugly").

Postmortem Review as a Half-Day Group Process

Birk, Dingsøyr, and Stålhane have used postmortem reviews as a group process (Birk, Dingsøyr, & Stålhane, 2002; Dingsøyr, Moe, & Nytrø, 2001; Stålhane, Dingsøyr, Moe, & Hanssen, 2003), where most of the work is done in one meeting lasting half a day. They try to get as many of the persons working in the project as possible to participate, together with two process consultants—one in charge of the postmortem process, the other acting as a secretary. The goal of this meeting is to collect information from the participants, make them discuss the way the project was carried out, and also analyze causes for why things worked out well or did not work out.

The "requirements" for this process include that the project should not take much time for the project team to participate, and it should provide a forum for discussing and analyzing the most important experience from the project. The main findings are documented in a report.

The postmortem meeting has following steps:

1. Introduction: First, the consultants introduced the agenda of the day and the purpose of the postmortem review.
2. KJ Session 1: Consultants hand out Post-It notes and ask people to write down what went well in the project, hear presentations, group the issues on the whiteboard, and give them priorities.
3. KJ Session 2: Consultants hand out Post-It notes and ask people to write down problems that appeared in the project, hear presentations, group the issues on the whiteboard, and give them priorities.
4. Root Cause Analysis: The process consultant leading the meeting draws fishbone diagrams for the main issues, both from the things that went well and the things that were problematic.

Birk et al. use a Dictaphone during the presentations and transcribe everything that is said. The consultants write a postmortem report about the project; the report contains an introduction, a short description of the project analyzed, how the analysis was carried out, and the results of the analysis. The result is a prioritized list of problems and successes in the project. Statements from the meeting are used to present what was said about the issues with highest priority, together with a fishbone diagram to show their causes. In an appendix, everything that was written down on Post-It notes during the KJ session is included, as well as a transcription of the presentation of the issues that were used on the Post-It notes. Such reports are usually between 10 and 15 pages in length.

The day after the meeting, the consultants present the report to the people involved in the project to gather feedback and do minor corrections.

Example Results from a Postmortem

We now present results from one review. First, we present the company, then the project where the review was carried out, and finally extracts from the postmortem report (see Dingsøyr et al., 2001, for more information).

The company makes software and hardware for stations receiving data from meteorological and Earth observation satellites.

The postmortem was organized for a project which had developed a software system for a satellite that was recording environmental data. The project had developed a module that was to analyze data from this satellite from European Space Agency specifications. The project lasted for approximately one year, and employed six people full time and two people part-time—a total of eight man-years. Five people participated in the postmortem review including the project manager.

One result from the KJ session was two Post-It notes grouped together and named "changing requirements." They are shown in the upper left corner of (some of) the results from the KJ process in Figure 1.

Participants made the following statements about "changing requirements":

Another thing was changes of requirements during the project: from my point of view—who implemented things, it was difficult to decide: when are the requirements changed so much that things have to be made from scratch? Some wrong decisions were taken that reduced the quality of the software.

Unclear customer requirements—which made us use a lot of time in discussions and meetings with the customer to get things right, which made us spend a lot of time because the customer did not do good enough work.

Figure 1. Post-It notes showing some of the problems in a software development project

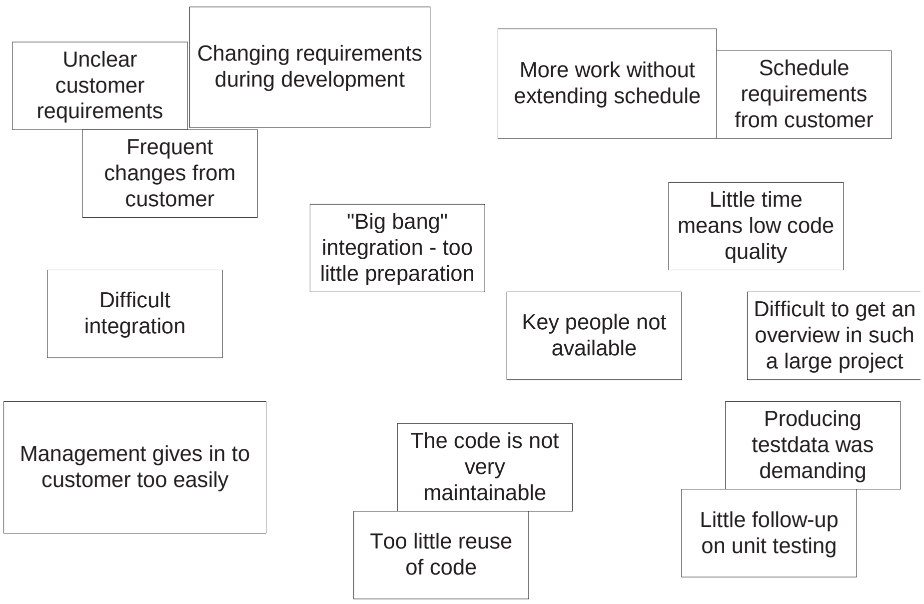
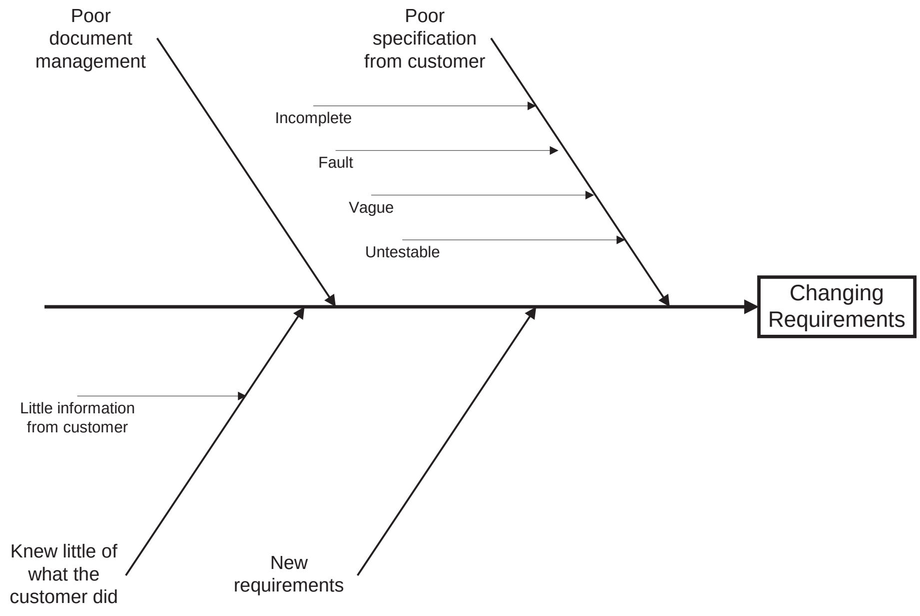


Figure 2. Ishikawa diagram for "changing requirements"



When we later brought this up again and tried to find some of the root causes for "changing requirements," we ended up with the fishbone diagram in Figure 2.

The root causes for the changing requirements, as the people participating in the analysis saw it, was that the requirements were poorly specified by the customer, there were "new requirements" during the project, and the company knew little of what the customer was doing. Another reason for this problem was that documents related to requirements were managed poorly within the company. In Figure 2, we have also listed some sub-causes.

The postmortem helped surface problems and successes that people were already aware of, but was not systematically presented in any way. It helped to focus on some important issues to improve and to sustain in future projects. The report was readable for people who were working on other projects in the company.

FUTURE TRENDS

In a study of 19 companies across Europe on project-based learning practices, Keegan and Turner (2001) found that "project team members frequently do not have the time for meetings, or for sessions to review lessons learned. Often, project team members are immediately reassigned to new projects before they have had time for lessons learned sessions or after action reviews." They did not find a single company where employees expressed satisfaction with the postmortem process.

We think there is a need for simple and practical descriptions of how to conduct postmortems, in order to stimulate knowledge-intensive companies to do it more often. The benefit of conducting postmortem reviews is mainly that it provides a learning forum where discussions are relevant to the project and to the company. It can also be a way for management to show that they listen to what the employees say, and are willing to discuss improvement efforts.

CONCLUSION

We have described postmortem reviews as a simple knowledge management technique, along with two particular methods to conduct postmortem reviews as a group process. We have also presented example results from a postmortem report.

REFERENCES

Birk, A., Dingsøyr, T., & Stålhane, T. (2002). Postmortem: Never leave a project without it. *IEEE Software, 3*(19), 43-45.

Collier, B. DeMarco, T., & Fearey, P. (1996). A defined process for project postmortem review. *IEEE Software*, *4*(13), 65-72.

Cusomano, M.A., & Selby, R.W. (1995). *Microsoft secrets—how the world's most powerful software company creates technology, shapes markets, and manages people*. New York: The Free Press.

Dingsøyr, T. (2005). Postmortem: Purpose and approaches in software engineering. *Information and Software Technology, 5*(47), 293-303.

Dingsøyr, T., Moe, N.B., & Nytrø, Ø. (2001). Augmenting experience reports with lightweight postmortem reviews. In F. Bomarius & S. Komi-Sirviö (Eds.), *Proceedings of the 3rd International Conference on Product Focused Software Process Improvement* (pp. 167-181). Kaiserslautern, Germany: Springer-Verlag (LNCS2188).

Keegan, A., & Turner, J.R. (2001). Quantity versus quality in project-based learning practices. *Management Learning, 1*(32), 77-98.

Kerth, N.L. (2001). *Project retrospectives: A handbook for team reviews.* Dorset House.

Menke, M.M. (1997). Managing R&D for competitive advantage. *Research Technology Management, 40*(6), 40-42.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company*. Oxford: Oxford University Press.

Raelin, J.A. (2001). Public reflection as the basis of learning. *Management Learning, 32*(1), 11-30.

Stålhane, T., Dingsøyr, T., Moe, N.B., & Hanssen, G.K. (2003). Postmortem—an assessment of two approaches. In R. Conradi & A.I. Wang (Eds.), *Empirical methods and studies in software engineering: Experiences from ESERNET* (pp. 129-141). Heidelberg: Springer-Verlag (LNCS 2765).

Scupin, R. (1997). The KJ method: A technique for analyzing data derived from Japanese ethnology. *Human Organization, 56*(2), 233-237.

Townsend, P.L., & Gebhart, J.E. (1999). *How organizations learn*. Crisp Publications.

Tiedeman, M.J. (1990). Postmortems—methodology and experiences. *IEEE Journal of on Selected Areas in Communications, 8*(2).

von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation*. New York: Oxford University Press.

Zedtwitz, M. (2002). Organizational learning through post-project reviews in R&D. *R&D Management*, *32*(3), 255-268.

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Section 8
Emerging Trends in Knowledge Management

This section highlights research potential within the field of knowledge management while exploring uncharted areas of study for the advancement of the discipline. Introducing this section is research that sets the stage for future research directions and topical suggestions for continued debate. Providing an alternative view of knowledge management are chapters that research the cultural dimension of knowledge management systems, particularly the relationship of learning and culture in knowledge management projects. The inevitable increase in complexity and quantity of the information that is available for students is also considered in this final section. Found in these 21 chapters concluding this exhaustive multi-volume set are areas of emerging trends and suggestions for future research within this rapidly expanding discipline.

Chapter 8.1
The Emerging Discipline of Knowledge Management

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ABSTRACT

This article presents some of the findings from the editorial process of creating an Encyclopedia of Knowledge Management. The global view of knowledge management (KM) research made available by this process provides interesting insights into the state of knowledge management research today and raises some questions regarding future directions for knowledge management as a discipline. The popularity and interaction between the different foundations of KM research is discussed, and specific attention is given to the discipline of social epistemology as a frame of reference for knowledge management research.

INTRODUCTION

After more than 40 years of information systems research, there remains great divergence and diversity in how to accurately define this important discipline. Banville and Landrey (1989), Backhouse, Liebenau, and Land (1991), Vessey, Ramesh, and Glass (2002), Adam and Fitzgerald (2000), Baskerville and Myers (2002), and Avison (2003) are but six of the many attempts to reach a broadly accepted definition. Fortunately, the lack of acceptance of any such definition has in no way hampered the development of the field. On the contrary, some, such as Frank (1998), question whether a common profile for information systems research is even desirable.

One is tempted to apply this same sort of qualification process to the endeavor of knowledge management (KM) and ask what constitutes the field of KM, what common profile can be ascribed to KM researchers, and if, in fact, knowledge management can be considered a discipline in its own right. Jennex and Croasdell (2003) have called for a determination that knowledge management be considered a discipline. As they discuss, meeting

Kuhn's (1996) criteria for the establishment of a discipline may be a necessary step—it is clearly not sufficient. The actual nature, characteristics, behavior, and interaction of those researchers identifying themselves as KM researchers will ultimately determine whether we emerge as a discipline or not. The analysis presented in this article moves us a step forward in that direction by taking a broad analytical view of KM research underway from both departmental and geographic standpoints.

This article will present some of the initial findings from the editorial process and draw insights regarding the global knowledge management community. We will present a number of findings based on the initial response to a Call for Papers (CFP) for the Encyclopedia of Knowledge Management that was issued in October 2003 (Schwartz, 2003, 2005). We will present some descriptive statistics that form what in essence is a profile of the self-described knowledge management community. Our discussion of these findings will address the question of whether KM should be considered a discipline and raise number of additional provocative questions.

Reviewing the extant KM-related literature, and examining the various research forums in which KM is addressed, one is inexorably drawn toward a conclusion that KM is an increasingly important subfield of information systems research. And, in fact, it was from that perspective that the creation of an Encyclopedia of Knowledge Management (EKM) was initiated. The early stages in the process of creating such a volume have shed light on how KM is viewed around the world.

In this article I will respectfully suggest that most of the IS community, myself included, has it backwards. KM is not an important area of IS research, rather IS research is an increasingly important part of the discipline of knowledge management. In doing so, I will proffer a holistic definition of the field of knowledge management, placing it within, or perhaps replacing it with, the discipline of applied social epistemology.

BACKGROUND AND MOTIVATION

If the field of knowledge management can be considered a meta-level pursuit in which we create and collect knowledge about organizational knowledge and how it can be created, captured, organized, and reused, then the creation of an Encyclopedia of Knowledge Management must be a meta-meta-level task.

Attempting to manage the knowledge of knowledge management means creating an overall map of research being conducted that impacts KM both directly and indirectly. It means reaching out to practitioners and academics in a wide range of disciplines to elicit their views on what makes KM the pursuit that it is (acquisition of knowledge management knowledge). And it means attempting to organize that knowledge in a meaningful way (organization of KM knowledge) so that it can be delivered to and made use of by KM researchers and practitioners in the future (delivery of KM knowledge). In essence the same Acquire-Organize-Distribute model (Schwartz, Divitini, & and Brasethvik, 2000) that can be used to manage the knowledge of a single enterprise is being modified and applied to a multi-organizational and multi-party knowledge management task.

In an attempt to provide as broad coverage as possible for KM, the call for papers including a detailed list of topics and subtopics (Figure 1), prepared in consultation with the international Editorial Advisory Board (faculty.biu.ac.il/~dgk/ekm/EAB.htm). It was through the interactions of the EAB that the CFP metamorphosed from what was originally a very IT-centric world view, to the knowledge- and organization-centric view of its final form. Further modifications (shown

Figure 1. Detailed major topics from the Encyclopedia of Knowledge Management CFP, each of which will have multiple sub-topic entries

Theoretical Aspects of Knowledge Management	**Legal Aspects of Knowledge Management**
Defining and Understanding Knowledge	Intellectual Property/Capital
Types of Knowledge	Privacy Issues
Philosophical underpinnings	Digital Rights Management
Ontologies of Knowledge Management	Liability and the Reliance upon KM Systems
Historical Underpinnings	*Ethics*
Organizations and the Inquiring Organization	**Technological Aspects of Knowledge Management**
The People Perspective	Knowledge Representation
Knowledge Management Models	Knowledge Organization and Indexing
Processes of Knowledge Management	Meta-knowledge and Metadata
Knowledge Creation	Storage and Retrieval
Knowledge Discovery	Presentation and Application Integration
Knowledge Acquisition	Artificial Intelligence in KM
Knowledge Classification	*Computational Experimentation*
Knowledge Verification and Validation	Data Mining in KM
Knowledge Codification	Other specific technologies impacting KM
Knowledge Calibration	**Application-specific Knowledge Management Issues**
Modeling Knowledge	Biomedical Knowledge Management
Knowledge Integration	Commercial and Financial KM
Knowledge Sharing	Industrial Knowledge Management
Knowledge Dissemination	Military Knowledge Management
Knowledge Maintenance	*Mobile Knowledge Management*
Organizational and Social Aspects of Knowledge Management	*Safety-Critical Systems*
Knowledge Transfer	*Customer Knowledge Management*
Corporate Culture	*Mathematical Knowledge Management*
Motivation	*KM in Counter-terrorism*
Organizational Memory	*Higher Education*
Organizational Learning	*Workflow Systems*
Cross-border knowledge	*Engineering Design*
Innovation Processes	*Legal Knowledge Management*
Social Capital	*Social Welfare Organizations*
Social Network Analysis	*Franchise KM*
Community-based knowledge	*Software Maintenance Knowledge*
Organizational Structure	**Noteworthy Knowledge Management Systems and Initiatives**
Managerial Aspects of Knowledge Management	
KM Strategies and Practices	
KM Systems Analysis and Design	
KM Systems Management and Lifecycle	
Human Resource Management	
Operational KM	
Managing the Knowledge Environment	
Metrics, Milestones, and Measurement	

in italics) were the result of feedback from potential contributors subsequent to the release of the CFP.

Soliciting Contributions

Proposals for contributions to the EKM were solicited through five main channels:

1. the ISWORLD mailing list,
2. the DBWORLD mailing list,
3. the Knowledge Acquisition/Modeling/Management (KAW) mailing list,
4. the publisher's (IGI) master mailing list, and
5. the editorial advisory board—each member of the Editorial Advisory Board was asked to distribute the CFP through his or her personal mailing list of relevant researchers.

RESPONSE TO THE CFP

The initial response to the Call for Papers resulted in more than 170 relevant proposals from 249 co-authors for articles in the encyclopedia. Many of the proposals needed to be divided (in editorial consultation with the authors) into multiple articles in order to maintain a reasonable level of granularity for each article (i.e., a situation in which an author proposed covering multiple related topics in a single article).

Departmental Affiliation

One place to start understanding the directions being taken in knowledge management research is the departmental affiliation of those authors working in an area that they themselves identify as relevant to knowledge management.

Authors affiliated with 29 distinct disciplines found it relevant to contribute article proposals. Table 1 shows the Main Departmental Affiliation of proposal authors from the preliminary round of submissions to the Encyclopedia of Knowledge Management. Where an author indicated multiple affiliations, the first affiliation listed was used.

The top four affiliations show an overwhelming concentration in the fields where knowledge management has been actively addressed over the past decade.

These top four affiliations reflect what may be expected from most of the knowledge management community. Of greater interest, perhaps, is the participation in KM research in what can be termed "non-traditional" KM affiliations.

A second point of interest from Table 1 is the wide range of departmental participation, lending strength to the interdisciplinary nature of KM, and providing an indication as to what types of courses a form program Knowledge Management Studies might need to include.

Also of note is the complete lack of any departmental affiliation specific to knowledge management. While a number of authors were associated with KM research labs or facilities, these were clearly research-oriented initiatives and not teaching initiatives or programs.

Geographic Distribution

A second area of interest is that of geographic distribution. Here we show concentrations of KM research by country and geographic region.

Table 3 presents the total number of authors by country in which they work (i.e., main university/employer affiliation).

BIASES

Obviously the venues in which the CFP was posted to solicit articles had a significant impact on the departmental affiliation of the contributors. This effect was mitigated to a certain degree by the efforts by each Editorial Board member to distribute the CFP to his/her own colleagues in multiple fields.

Table 1. Departmental affiliation of responding authors

Rank	Main Departmental Affiliation	*Count*	%
1	Information Systems	111	44.58%
2	Computer Science	39	15.66%
3	Information and Library Science	15	6.02%
4	Management	12	4.82%
5	Communications	6	2.41%
6	Economics	6	2.41%
7	Marketing	6	2.41%
8	Cognitive Science	5	2.01%
9	Management Science	5	2.01%
10	Philosophy	5	2.01%
11	Engineering Management	4	1.61%
12	Social Psychology	4	1.61%
13	Information Management	3	1.20%
14	Organizational Science	3	1.20%
15	Sociology	3	1.20%
16	Education	2	0.80%
17	Engineering	2	0.80%
18	Finance	2	0.80%
19	Human Resource Management	2	0.80%
20	Innovation Studies	2	0.80%
21	Mathematics	2	0.80%
22	Media Management	2	0.80%
23	Technology Management	2	0.80%
24	Banking	1	0.40%
25	Business Administration	1	0.40%
26	Cultural Studies	1	0.40%
27	Real Estate	1	0.40%
28	Science and Technology	1	0.40%
29	Statistics	1	0.40%
		249	100%

The absence of certain terminology from the CFP may also have had an effect on response—for example, including social epistemology as a topic may have elicited an increased response from with the philosophy or information science communities.

As an edited volume, the EKM will also include a number of invited articles based on the decisions of the Editorial Board to include topics that may not have been addressed by the response to the CFP. The scope and quantity of these ad-

Table 2. Division of respondents into traditional and non-traditional IS/management fields

"Traditional" Information and Management related fields		Non-traditional fields	
Information Systems	44.6%	Economics	2.4%
Computer Science	15.7%	Marketing	2.4%
Information Science	6.0%	Cognitive Science	2.0%
Management	4.8%	Philosophy	2.0%
Communications	2.4%	Social Psychology	1.6%
Management Science	2.0%	Sociology	1.2%
Engineering Management	1.6%	Education	0.8%
Information Management	1.2%	Engineering	0.8%
Organizational Science	1.2%	Finance	0.8%
Human Resource Management	0.8%	Innovation Studies	0.8%
Media Management	0.8%	Mathematics	0.8%
Technology Management	0.8%	Banking	0.4%
Business Administration	0.4%	Cultural Studies	0.4%
		Real Estate	0.4%
		Science and Technology	0.4%
		Statistics	0.4%
Total	82.3%	Total	17.7%

ditional contributions has not been considered in this article.

DISCUSSION

I believe that one of the more significant results of this exercise in managing the knowledge of knowledge management is to be found not in the top 10 departmental affiliations shown in Table 1, but rather in the middle 10. Starting from philosophy through to the study of innovation, passing social psychology, sociology, and other non-IS disciplines along the way.

As stated in the introduction, I began this process from an information systems perspective. It is the depth and breadth of non-IS contributions that I have found most enlightening. I fear that in this shortcoming I am not alone amongst knowledge management researchers—a fear reinforced by the overwhelming number of contributions (over 50%) that came from the two fields of information systems and computer science.

The appearance of information and library science in the third spot mitigates those fears somewhat. This field, though viewed by many as ancillary to information systems research, has provided one of the most powerful directions of research for the field of knowledge management, as we will soon discuss.

Episteme

Consider the following definition of knowledge management research:

"The theory or science that investigates the origins, nature, methods, and limits of knowledge in organizations."

Table 3. National affiliation of responding authors

Rank	Author Affiliation by country	Count	Percent
1	United States	76	30.52%
2	England	26	10.44%
3	Italy	17	6.83%
4	Germany	16	6.43%
5	Netherlands	16	6.43%
6	Israel	15	6.02%
7	Australia	13	5.22%
8	France	13	5.22%
9	Ireland	10	4.02%
10	Spain	10	4.02%
11	Canada	9	3.61%
12	Brazil	5	2.01%
13	Singapore	4	1.61%
14	Switzerland	4	1.61%
15	Denmark	2	0.80%
16	Hong Kong	2	0.80%
17	India	2	0.80%
18	Norway	2	0.80%
19	South Korea	2	0.80%
20	Austria	1	0.40%
21	Greece	1	0.40%
22	Japan	1	0.40%
23	Macau	1	0.40%
24	South Africa	1	0.40%
		249	100.00%

Table 4. Regional affiliation of responding authors

Geographic - by region	Count	Percentage
EMEA	98	39%
North America	85	34%
UK	36	14%
Asia Pacific	25	10%
South America	5	2%

- Origin—to cover issues related to knowledge acquisition and creation.
- Nature—to deal with types of knowledge, be it textual, visual, oral, tacit, or explicit.
- Methods—to understand and develop processes to enhance the management and use of such knowledge.
- Limits—to deal with metrics, ROI, accepted use, privacy, and cognitive limitations.

But we already have a field that deals with the theory or science that investigates the origins, nature, methods, and limits of knowledge in organizations. Well, we do if you drop the last two words "in organizations," for what you are left with is the precise definition of a word that appears in Webster's New Twentieth Century Dictionary (Webster, 1970, p. 614)—that word is epistemology.

Well, one might argue, classical epistemology deals with the individual attempting to ascribe knowledge or beliefs to an individual agent. Dealing with organizations requires much more than adding two words to the end of a definition—it requires an essentially different discipline. Even if one were to accept such an argument, one needs to look no further than to a major subfield of epistemology known as "social epistemology."

"Social epistemology is the study of the social dimensions of knowledge or information." (Goldman 2001)

While Goldman (2001) traces elements of social epistemology back to Plato, he brings a modern definition from Shera (1970), which appears to be finely tuned to today's field of knowledge management:

"Social epistemology is the study of knowledge in society…the focus of this discipline should be on the production, flow, integration, and consumption of all forms of communicated thought throughout the entire social fabric." (Shera, 1970, p. 86)

In identifying the "new" challenges in the management of knowledge, Shera (1961) states:

"We are here concerned with an epistemological discipline, a body of knowledge about knowledge itself. The manner in which knowledge has developed and has been augmented has long been a subject of study, but the ways in which knowledge is coordinated, integrated, and put to work is, as yet, an almost unrecognized field for investigation." (emphasis added)

Shera's stated goal (1961) for the proposed discipline of social epistemology is:

"From such a discipline should emerge a new body of knowledge about, and a new synthesis of, the interaction between knowledge and social activity."

Budd (2002) cites the first known reference to social epistemology as being by Egan and Shera (1952, p. 132) in which they state that it is "the study of those processes by which society as a whole seeks to achieve a perceptive or understanding relation to the total environment—physical, psychological, and intellectual."

Back to Information Systems

Let's return for a moment to our starting point—the IS perspective. From an information systems perspective, what is missing from the definitions of Goldman and Shera is the element that turns the study of knowledge into the management of knowledge. It is the element that turns science into engineering. It is the element of the applied (Banville & Landry, 1992) that has driven and differentiated information systems research since its inception.

Thagard (2000) attempts to apply epistemological techniques and standards to the Internet as a corpus of knowledge and foundation for scientific discovery. His analysis focuses primarily on how

Internet technologies (and not information systems and technologies in general) can contribute to scientific research. The relevance of Thagard's work (2000, 1997, 1993) is in its attempt to tie classic epistemology to current technological tools—not unlike our focus in IS-based knowledge management.

There are other attempts to more formally tie information systems and information science to philosophical underpinnings, most notable that of Floridi (2002; Herold, 2001). He proposes and develops a "Philosophy of Information" as "a normative branch of philosophy primarily concerned with the conceptual and foundational investigation into the nature of information, its dynamics, and utilization." A clear definition to be sure, but bearing no obvious advantage to that of Egan and Shera's social epistemology.

The bridge from social epistemology to knowledge management was most recently crossed by Fuller, who in Knowledge Management Foundations (2002) builds a solid basis for the discipline upon the foundations of social epistemology—which, it may come as no surprise, was the focus of his earlier books of the same title (1986, 2002).

Where is all this leading? Based on the above chain of research, and on the specific editorial experiences from the Encyclopedia of Knowledge Management, I suggest that knowledge management as we know it today is in fact applied social epistemology.

So what, you ask? What does it matter what we call it as long as we all know what we are talking about? A rose by any other name would smell as sweet, would it not? Well, it does matter. It matters because what we call it has a direct impact on our perspective and on the directions that we look for related and relevant research upon which to build.

Social epistemology—or social knowledge management—has much to offer our field of organizational knowledge management. At a minimum, the treatment of organizations as social entities opens a wealth of relevant literature.

In terms of a historical progression, it may be useful to consider the following:

Individual Epistemology → Social Epistemology → Applied Social Epistemology

Becoming a Discipline

Where does all this leave us in terms of an agenda for knowledge management research and teaching? First, it tells us that we need to look far beyond the castle walls of information systems in our pursuit of knowledge management. Second, it tells us that a discipline of knowledge management, or a formal academic program of knowledge management, needs to draw from at least 10, and perhaps as many as 20, contributing disciplines. Finally, a glance at Table 4 tells us that while 82% of the respondents to the CFP came from classic information and management-related departments, 18% did not. If the 80-20 rule is any indicator, one can be sure that the "other 18%" will prove to be as challenging, difficult, important, and elusive as the "core 82%."

CONCLUSION

Before having to fend off questions regarding the validity of the statistics reported in this article, let me preempt by pointing out that this was in no means meant to be a formal scientific study into the nature of the knowledge management community and KM research. That being said, in the course of editing the Encyclopedia of Knowledge Management, the sheer scope of interactions between myself and KM researchers has had a formative effect on my own view of the field. This article has been an attempt to share that experience with you and raise some introspective questions in your mind.

Has KM reached the point that it should be considered a discipline in its own right? Is it sufficiently distinct from those component research streams from which it has evolved, or is it in fact applied social epistemology? Should an interdisciplinary undergraduate degree program in knowledge management find its rightful place alongside degrees in information technology management?

I suggest that although we, in the information systems community, have become accustomed to seeing and participating in KM tracts at major IS conferences, by doing so we have reinforced the backward approach. What we should really be doing is attending IS tracts at major KM conferences—developing the true heritage of applied social epistemology, in which we take the science of the applied that information systems research excels at, and systematically apply it to the philosophical and sociological foundations of this exciting emerging discipline.

REFERENCES

Adam, F., & Fitzgerald, B. (2000). The status of the IS field: Historical perspective and practical orientation. *Information Research, 5*(4). Retrieved from http://informationr.net/ir/5-4/paper81.html

Backhouse, J., Liebenau, J., & Land, F. (1991). On the discipline of information systems. *Journal of Information Systems, 1*(1), 19-27.

Budd, J.M. (2002). Jesse Shera, social epistemology, and praxis. *Social Epistemology, 16*(1), 93-98.

Elliot, S., & Avison, D. Information systems as a discipline. *Proceedings of the IFIP TC 8 Supervisors Workshop.* The International Federation for Information Processing Technical Committee on Information Systems.

Floridi, L. (2002). On defining library and information science as applied philosophy of information. *Social Epistemology, 16*(1), 37-49.

Frank, U. (1998). *Reflections on the core of the information systems discipline.* Institute fur Wirtschaftsinformatik, University of Koblenz-Landau, Report Nr. 14.

Fuller, S. (1986, 2002). *Social epistemology* (2nd ed.). Indiana University Press.

Fuller, S. (2002). *Knowledge management foundations.* Butterworth-Heinemann.

Goldman, A. (2001). Social epistemology. In E.N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy.* Retrieved from http://plato.stanford.edu/archives/spr2001/entries/epistemology-social/

Herold, K.R. (2001). Librarianship and the philosophy of information. *Library Philosophy and Practice, 3*(2).

Jennex, M.E., & Croasdell, D. (2005). Is knowledge management a discipline? *International Journal of Knowledge Management, 1*(1).

Kuhn, T.S. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago: University of Chicago Press.

Schwartz, D.G. (2003). *Call for Papers: The Encyclopedia of Knowledge Management*. Retrieved October 1, 2003, from http://faculty.biu.ac.il/~dgs/ekm/EKM-CFP.pdf

Schwartz, D.G. (2005). *Encyclopedia of knowledge management.* Hershey, PA: Idea Group Reference.

Schwartz, D.G., Divitini, M., & Brasethvik, T. (2000). *Internet-based knowledge management and organizational memory.* Hershey, PA: Idea Group Publishing.

Shera, J. (1961). Social epistemology, general semantics, and librarianship. *Wilson Library Bulletin, 35,* 767-770.

Thagard, P. (1993). Societies of minds: Science as distributed computing, *Studies in History and Philosophy of Science, 24,* 49-67.

Thagard, P. (1997). Collaborative knowledge. *NOUS, 31*(2), 242-261.

Thagard, P. (2001). Internet epistemology: Contributions of new information technologies to scientific research. In K. Crowley, C.D. Schunn, & T. Okada (Eds.), *Designing for science: Implications from professional, instructional, and everyday science* (pp. 465-448). Mahwah, NJ: Erlbaum.

Vessey, I., Ramesh, V., & Glass, R.L. (2002). Research in information systems: An empirical study of diversity in the discipline and its journals. *Journal of Management Information Systems, 19*(2), 129-174.

Webster, N. (1968). *Webster's new twentieth century dictionary of the English language.* Cleveland, OH: The World Publishing Company.

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Chapter 8.2
Knowledge in Innovation Processes

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INTRODUCTION

The success of industrial and scientific research has always been dependent on new discoveries and innovations, but tighter budgets and increasing global competition push the pace with which innovation must happen nowadays. Bringing new products to the market before competitors do constitutes a crucial competitive advantage for many companies and organizations. Accelerating discovery and innovation is increasingly dependent on the use of advanced information and knowledge technology for building environments that support the innovation process systematically and efficiently (cf. Specht, Beckmann, & Amelingmeyer, 2002; Amidon, 2002). Such environments depend on a number of advanced knowledge management technologies and have to adapt to the wide variety of innovative practices, innovation cultures, organizational context, and application areas where innovation takes place. It is essential that the functionalities of such are aligned with the needs of innovators and their context.

Innovation starts with an adequate identification of goals including an appropriate problem description and ends with the successful exploitation of the problem solution. Therefore, innovation is understood as dealing with complex problem-solving processes in whose activities knowledge of different types is applied and created. Systematic support of innovation processes requires efficient management of knowledge with respect to activities like acquisition, creation, enrichment, retrieval, reuse, and combination of such knowledge.

When taking a closer look at innovation activities in different areas, a common core innovation process can be identified that consists of six overlapping but distinguishable phases. The specific characteristics of the innovation process imply an innovation-specific, multi-stage knowledge lifecycle and knowledge management support that reflects the dependency on the innovation environment and the characteristics of the innovation process.

BACKGROUND

Innovation is the successful exploitation of new ideas which can be products or processes. It happens in the scientific domain (development of new scientific approaches, theories, methodologies, etc.) and organizations (new products, processes, marketing campaigns, etc.). Innovation is used by many scientific disciplines in many different shades. Nevertheless the core understanding of innovation can be identified as mentioned above (cf. Specht et al., 2002; Rogers, 1998; OECD, 1997).

Independent of the domain, innovation is a knowledge-intensive process. This means that proper knowledge management is necessary to support the innovation process successfully. To achieve a basis for this, a knowledge lifecycle model can be applied as a means of supporting externalization and application of innovation process and resource knowledge while following the general baseline of all approaches of knowledge management that knowledge is more useful if it does not reside in the minds of individuals, but is applied and made available to others (c.f. Alavi & Leidner, 1999), and that this is even crucial for the creation of new knowledge (Borghoff & Pareschi, 1998; Spiegler, 2000). Revisiting KM theory, several models for knowledge flow and knowledge lifecycles have been proposed that capture the dynamics of knowledge, its transformation and relationship to the respective application context (e.g., Nonaka & Takeuchi, 1995; Borghoff & Pareschi, 1998; Fischer & Ostwald, 2001). In the case of this article, the specific application context in the focus of our work is innovation processes. Therefore, the knowledge lifecycle model discussed here focuses on the specific needs of innovators with regards to managing their innovation resources in an appropriate way. The research work in which this model was developed was almost entirely performed in the context of the European project INNOVANET (IST-2001-38422).

Innovations lead to problem solutions which can differ in the degree of novelty of the solution and the amount of change implied. The terminology of TRIZ (Theory of Inventive Problem Solving, an algorithmic approach for solving difficult technical and technological problems) suggests five levels of innovation (Shulyak, 1977). This ranges from small evolutionary changes implementing improvements of existing systems or products on the lowest level to revolutionary changes on the highest level that offer solutions outside the confines of contemporary scientific knowledge. As discussed later, the partition into an evolutionary and a revolutionary type of innovation has an important impact on the activities in the knowledge lifecycle and on adequate process support.

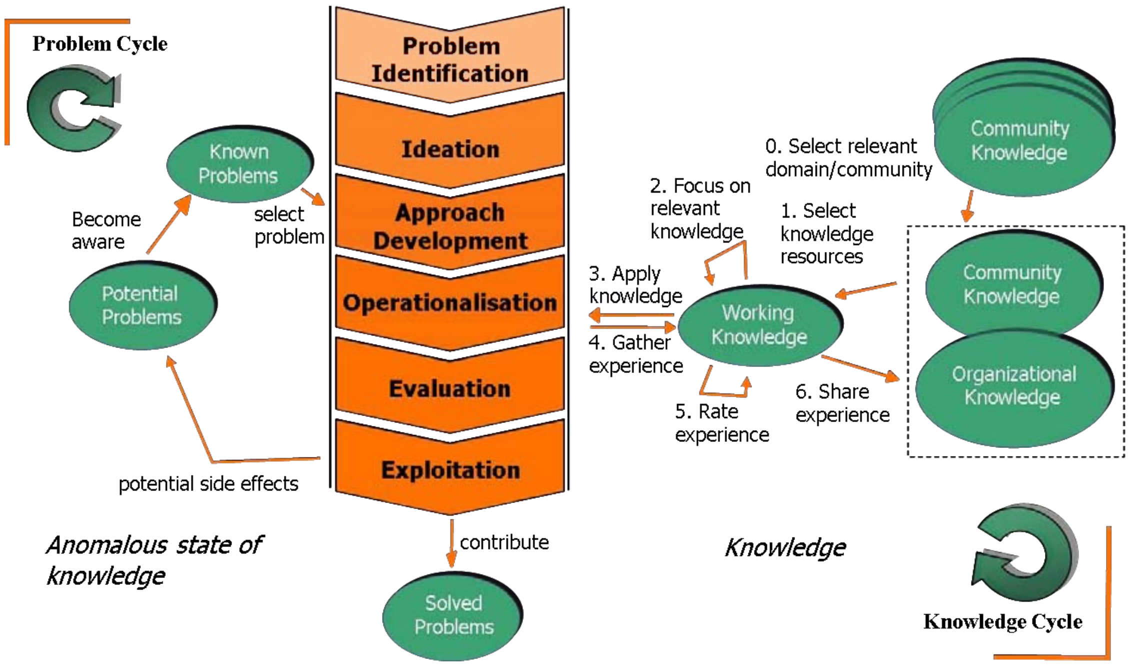
In the remainder of this article, the innovation knowledge lifecycle model is introduced and framed as a representation medium supporting a conceptual basis for externalization, management, and optimization of application of knowledge and knowledge resources in the context of innovation processes. The model is based on a thorough study of the state of the art in both innovation management and knowledge management theory. Within this article, an innovation-focused approach to represent and apply a knowledge management methodology is implemented. However, readers can also benefit from the general discussion around the proposed view of knowledge management activities and practices, while considering innovation as one contextual condition within which knowledge is applied. Finally, the IKLC model as introduced can also be considered as a valuable instrument that enables better understanding and better documentation of innovation processes during their preparation as well as during their execution. In turn, the model is the formal basis for achieving greater transparency, control, and efficiency within knowledge-intensive innovation processes.

MAIN FOCUS OF THE ARTICLE

The Innovation Knowledge Lifecycle (IKLC) is a domain-independent metamodel. It describes the phases of the innovation process in the Innovation Process Model, validated by Paukert, Niederée, Muscogiuri, Bouquet, and Hemmje (2003), and the knowledge flow in each of the innovation phases on an abstract level (Knowledge Lifecycle Model, mentioned above). The Knowledge Lifecycle itself includes a problem cycle and a knowledge cycle (see Figure 1).

The problem cycle (left side of Figure 1) is connected with the innovation process as a whole:

Figure 1. Innovation knowledge lifecycle (IKLC)



- Become aware: In a specific domain, there is a pool of actual and potential problems. By certain dynamics—changes in the environment, personal interests, and so forth—specific problems gain awareness and they receive the status of known problems.
- Select problem: The set of known problems is the starting point for innovation. Selecting a problem is a crucial step that is driven by various factors like market needs, innovation strategies, available resources, and so forth. The choice of the “right” problem is an essential precondition for successful innovation.
- Contribute: If the innovation process is successful, it provides a solution for the problem it was triggered by. The innovation process provides a contribution to the set of solved problems. When exploited, innovation also changes its environment, which in turn may lead to new challenges and problems, triggering further innovation (thus closing the cycle). The problem cycle complements the knowledge cycle and can be compared to the anomalous state of knowledge (a user’s inability to describe and articulate a problem), as discussed by Belkin, Oddy, and Brooks (1982) for the area of information retrieval.

The knowledge cycle (right side of Figure 1) models the knowledge flow in the innovation process, with a special focus on knowledge application. Especially, it follows the argument of Fischer and Ostwald (2001) that knowledge creation should be integrated into the work process and is not a separate activity. The knowledge cycle distinguishes three basic knowledge types: community knowledge; organizational knowledge, shared by a specific community or within an organization; and working knowledge, the knowledge at hand in a concrete working or task context. In the case of an individual activity, this is the personal knowledge of an individual, whereas in the case of a team effort, the working knowledge is the relevant joint knowledge of the members. The knowledge cycle indicates a linear process of seven steps—nevertheless, feedback loops in-between are possible:

- Step 0: Select Relevant Domain/Community: An innovation process is embedded into an application domain with an associated community, whose knowledge is applied. While this knowledge is sufficient for minor scale innovations, facing problems of a totally new kind requires radically new solutions and knowledge. For these revolutionary developments exploring knowledge of different domains/communities is needed. The identification of one or more relevant knowledge domains is an iterative process that requires the exploration of different knowledge domains, the development of an understanding of this knowledge, and assessment of the relevance for the current task.
- Step 1: Select Knowledge Resources: After identifying relevant domains/communities, adequate knowledge resources for the innovation task are selected. This can be a knowledge object, a collection of knowledge objects or an expert; selected and acquired knowledge becomes working knowledge. Identifying knowledge objects also includes internalization of the knowledge (Nonaka & Takeuchi, 1995).

  Selecting domains and focusing on knowledge resources is only necessary if the existing working knowledge is not sufficient. Typically, revolutionary innovations require more new knowledge and also knowledge from different domains. Thus, more effort will be put into these first two steps.
- Step 2: Focus on Relevant Knowledge: Only a small part of the knowledge is relevant for solving the problems in a specific situation.

The process of focusing on relevant knowledge objects may be a mental process if an individual has enough background knowledge to judge the knowledge resources. In case one individual does not have enough knowledge to focus on the relevant knowledge, negotiation and cooperation with others become necessary.

- Step 3: Apply Knowledge: The selected knowledge has to be applied in a specific task in the innovation process, for example, deciding on a certain evaluation method or choosing a specific representation language. Before the knowledge can be applied, it may require adaptation to the context of use. The effort to be spent depends on the match of the current task context and the context the knowledge was learned from.
- Step 4: Gather Experience: By applying knowledge to a task, experiences are made to what kind of result this application leads by observing the performance and the emerging results. For sharing the insights from this knowledge application, at least a minimum of externalization is necessary.
- Step 5: Rate Experience: The gathered experience is set into relationship with the goals of the innovation process or the current activity, and it is rated in this context. This rating provides the basis for the decision about further actions. The rating provides the basis for further applications of the same knowledge. Depending on the rating it may be considered more often or it may be neglected because it was not helpful. Cooperative activities require rating negotiation between team members.
- Step 6: Share Experience: Gathering and rating of experiences producing new knowledge. Ideally, the rated experience and the resulting knowledge are made explicit as knowledge objects, so they can be shared with others, thus closing the knowledge cycle. This requires extra effort, which has to be well motivated (Fischer & Ostwald, 2001). Even negative experiences represent knowledge that might become valuable at a later point in time (Ruggles & Little, 1997).

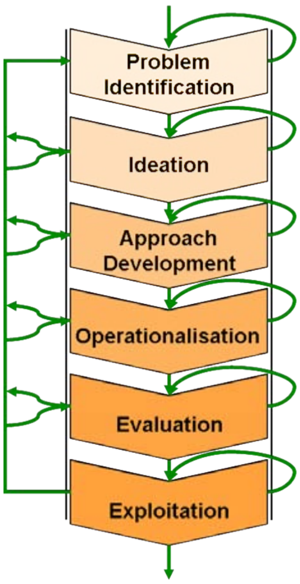
The model described above takes into account another fundamental dimension related to the IKLC, called the contextual dimension. Many studies from philosophy (e.g., Kuhn, 1962), organization science (e.g., Boland & Tenkasi, 1995), cognitive science (e.g., Fauconnier, 1985; Johnson-Laird, 1992), and knowledge representation (cf. Giunchiglia, 1993; McCarthy, 1993) stress the fact that knowledge cannot be viewed simply as a collection of "objective facts" about reality, as any "fact" presupposes a context which contributes to give it a definite meaning. Assuming that each community has its own shared context, which facilitates communication and knowledge sharing, it must be taken into account that communication and knowledge sharing across different communities presupposes a process of "perspective taking" (Boland & Tenkasi, 1993), which is qualitatively different from the process of "perspective making," which means building and using the shared perspective within a single community (Bouquet, Serafini, & Zanobini, 2003). This has an important impact on many of the described phases. For example, the way a community acquires another community's knowledge is not a simple step of incorporation, but may require a "translation" from one language to another, from a conceptual schema to another, and so forth. Analogously, the perception of how relevant a problem is depends also on a community's context, as many examples show that relevance is relative to what is implicitly assumed (cf. Paukert et al., 2003).

Model of the Innovation Process

As outlined earlier, the following model is based on a study of theories in the innovation domain as well as in the KM domain. It has been validated within an intensive evaluation procedure (Paukert et al., 2003). In the following, the model is presented without introducing its derivation to give priority to explaining the innovation domain as a KM application context. Understanding the properties of the introduced exemplar application domain is crucial for fully taking advantage of the IKLC model, even for transferring its generic properties into other KM application domains. Considering the wide variety of possible innovation forms and innovation application domains, generalizations are difficult. However, on an abstract level it is possible to identify six basic phases of an innovation process. They are described in the following innovation process model whose phases are common to most innovation processes (Paukert et al., 2003). The phases are depicted in Figure 2.

There is basically a sequential order between these phases. But there are also overlaps and loops between the phases, where, due to (intermediate) results or external events, revisiting earlier phases becomes necessary. This need for feedback is also stressed by Pérez-Bustamente (1999). In the following, the six phases are described in detail.

Figure 2. Innovation process model (IPM)



Problem Identification Phase

Each innovation is started by a problem that the innovative process is expected to solve. Systematically, two forms can be distinguished (Pérez-Bustamente, 1999):

- proactive forms, which include trend setting, recognition of market opportunity, need creation, and identification of research opportunity; and
- reactive forms, which include open problems in production or processes, changed requirements, and reaction to changed environments.

Regardless of how the innovation is started, the problem needs a proper description. The more people are involved, the more detailed and explicit the problem representation has to be. A first validation of the problem checks the adequacy of the description with respect to the targeted problem as well as the novelty of the problem. Further, a first estimation about the feasibility and the relevance of the problem has to be conducted to reduce the risk of investing resources into further steps. Clearly, these considerations are influenced by the innovation strategy of the involved organization.

Ideation Phase

In the Ideation phase, ideas are generated and collected which are thought to contribute to a possible solution to the described problem. These activities form the core of the innovation process since the subsequent phases are directly dependent on the decisions made at this point. There are several (systematic) ways to discover ideas for solving the problem such as analogy, data mining, paradigm shift, and luck. These all involve the exploration and selection of the current state of the art. The amount of needed knowledge in this phase increases, the more revolutionary the innovation is supposed to be since new domains may be required to find an appropriate solution to the problem.

For negotiating factors like adequacy for the problem, novelty, and feasibility, the ideas have to be formalized and described.

Approach Development Phase

Approach Development is the first step towards solidifying the idea towards an implemented solution. In this phase a conceptual model for the implementation is developed which describes its planned solution on a conceptual level. This phase takes the description, the problem, and the idea as input.

The first set of activities in this phase involves the identification of a useful approach for conceptually describing the implementation of the idea. This involves exploration, selection, application, and creation of related knowledge in terms of technologies, methodologies, and formalisms. The approach and the conceptual model have to be validated for adequacy, novelty, and feasibility of operationalization before they can be considered a valid input for the operationalization phase.

Operationalization Phase

In the Operationalization phase, the developed approach is actually implemented according to the developed model. The goal during operationalization is to achieve results which show that the selected approach adequately resolves the initial problem. This may require a number of iterative steps that are conducted to increase the quality of the solutions to achieve a maximum outcome. Operationalization can become quite resource consuming, making the validation in the preceding phase a crucial activity.

Validating the activities in this phase checks the adequacy of the operationalization with respect to the chosen approach. Also, it checks if it is possible to scale up the developed approach from, for example, a prototype production to a mass production process and with respect to exploitation.

Evaluation Phase

In addition to the validation activities which conclude each developmental cycle during operationalization, there is a separate Evaluation phase which tests the results produced during the innovation process. Negative evaluation results can lead to revision of individual decisions, or they can even lead to cancellation of the entire innovation process. The evaluation requires careful planning of the experimental design and analysis to ensure representative and valid results. The evaluation criteria and methods depend on the domain and intended application area. For revolutionary innovation activities, the evaluation phase is much more challenging than for evolutionary innovation, since revolutionary innovation often also invalidates the traditional best-practice methods of evaluation applied so far.

Exploitation Phase

In this integral part of innovation, the results of the prior phases are distributed in order to gain benefit from them and to meet the goals of the innovation request it was triggered by: a company takes the newly developed product and will try to market it as profitable as possible, or a new process is implemented and integrated into the operational workflow for its improvement and to obtain more cost-effective performance. In the scientific domain, innovations—new insights, methodologies, theories—are disseminated via publication into scientific communities of interest.

Depending on the type of innovation—evolutionary or revolutionary—the demands towards the knowledge lifecycle vary. In an evolutionary innovation scenario—like selling soft drinks in green bottles instead of brown plastic bottles—less knowledge is required than in a revolutionary innovation scenario—like opening new power resources.

An evolutionary innovation requires no knowledge from external domains; the domain knowledge is well known and so are the knowledge resources. Only small shifts of focus have to be made. Applying, gathering, rating, and sharing the knowledge are well-understood operations, although the motivation of systematic knowledge sharing is a challenge in many organizations.

A revolutionary innovation demands knowledge which is out of the main domain of the innovator. Domains will have to be identified which are thought to hold the necessary knowledge. Being unacquainted within these domains, innovators are missing the prerequisite knowledge to decide about the important knowledge resources at first. Also, the process of focusing on the relevant knowledge may take longer since the criteria for these activities are not familiar yet. Applying, gathering, and rating knowledge may require new methods and strategies, whereas sharing the acquired knowledge is less of a problem since this activity is domain-independent.

FUTURE TRENDS

Future steps will concentrate on developing a framework for systematic innovation support. Such innovation support and the knowledge management tools applied in innovation have to be flexible and adaptable in order to take into account that:

- the different phases of the innovation process have specific requirements;
- innovating organizations and teams have their own specific innovation practices, and innovation culture and requirements; and
- requirements and cultural characteristics of innovation culture can change over time (Paukert, Niederée, & Hemmje, in press).

For an Innovation Engineering Environment (IEE) for systematic innovation support by knowledge technology, the following four core technology areas were identified:

- Innovation Process Management: This component is necessary to support the general management of innovation processes. Even though innovation processes present peculiar aspects, an innovation process is first of all a process, and as such it must be managed. This component contains tools that allow innovation managers to plan, log, and monitor the phases and the related activities and resources.
- Generic Innovation Support Components: This core component's sub-components provide classes of functionalities which are intrinsic to knowledge management functionality of any innovation process, independently from domain and application. Examples include: adequate representation, intelligent matchmaking, discovery, and interaction support.
- Application-Specific Support Components: Effective innovation support also requires tools that are domain-specific. This is especially true for approach development and operationalization. Examples of such tools are design and simulation tools. In the design of the IEE, it is important to enable the flexible integration of existing and newly developing application-specific tools.
- Innovation Environment Configuration Support: This functionality has to be specialized for the different phases. This may include method and tool selection, tool configuration, and user interface design. IEE specialization results in a system architecture that provides specific support based on the

generic tools and functionalities suggested by the IKLC.

These four core technology areas have been identified and validated within the resulting research roadmap work (see www.innovanet.eu.com). Implementing solutions to these technology challenges within ongoing knowledge technology R&D will promote and support a more systematic approach to managing innovation. Following a meta design approach (Fisher, 2000), tools for the customization step can finally be part of the overall knowledge-based innovation management framework itself, increasing the flexibility of the approach and enabling involvement of the innovators themselves into the customization process. This allows the adaptation of the system to the requirements of individual organization sand teams, as well as the evolution of the system when the innovation factors change or the environment changes.

CONCLUSION

Although it is generally understood that innovation is a knowledge-intensive process with specific requirements, the work on systematic support of the innovation process by an Innovation Engineering Environment is still in an early state. This article lays a conceptual foundation for the further work in building tools and systems for more systematically supporting the innovation process by information and knowledge technology, with the final aim of contributing to the acceleration of innovation.

In designing and building IEEs that are applicable in different domains, the wide spectrum of existing innovation processes (mostly deviations from the presented innovation process model) is a large challenge and requires flexible and adaptable solutions. However, aiming for a common core of innovation support functionality reduces the overall effort, keeps the R&D activities in this area focused, and eases the adoption of successful innovation cultures and practices across the borders of individual organizations and domains.

Some of the current trends in information and knowledge technology promise to be supportive of the successful development of information technologies:

- the success of service-oriented architectures implemented by Web services can be exploited for building adaptive IEEs, where (Web) services in support of specific innovation activities can be easily and dynamically integrated;
- the Semantic Web activities resulted in widely accepted approaches and exchangeable formats for describing innovation resources and the process itself; and
- the currently increased activities in the area of ontology development and exploitation, which is triggered by the Semantic Web activities, will result in pragmatic and scalable approaches for intelligent decision making and for the interoperable mediation of innovation resources, especially also across the borders of domains as it is required for revolutionary innovation activities.

In spite of the large challenges of this task, it is expected that there will be considerable progress in more systematic and efficient innovation support in the near future.

REFERENCES

Alavi, M., & Leidner, D. (1999). Knowledge management systems: Issues, challenges, and benefits. *Communication of the AIS, 1*(February). Retrieved June 24, 2004, from http://cais.isworld.org/articles/1-7/article.htm

Amidon, D.M. (2002). *The innovation superhighway. Frontiers of entrepreneurship and innovation: Readings in Science Park policies and practices*. International Association of Science Parks.

Belkin, N.J., Oddy, R.N., & Brooks, H.M. (1982). ASK for information retrieval: Part II. Results of a design study. *Journal of Documentation, 38*, 145-164.

Boland, J.R., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organizational Science, 6,* 350-372.

Borghoff, U., & Pareschi, R. (1998). *Information technology for knowledge management.* Berlin, Heidelberg: Springer-Verlag.

Bouquet, P., Serafini, L., & Zanobini, S. (2003, October 23-25). Semantic coordination: A new approach and an application. *Proceedings of the 2nd International Semantic Web Conference (ISWC-03),* Sanibel Island, FL.

Fisher, G. (2000). Social creativity, symmetry of ignorance and meta-design. *Knowledge-Based Systems Journal, 13*, 527-537.

Fischer, G., & Ostwald, J. (2001). Knowledge management: Problems, promises, realities, and challenges. *IEEE Intelligent Systems, 16,* 60-72.

Fauconnier, G. (1985). *Mental space: Aspects of meaning construction in nature language.* Cambridge, MA: Bradford Books.

Giunchiglia, F. (1993). *Contextual reasoning. Epistemologia,* (Special Issue on I Linguaggi e le Macchine XVI), 345-364.

Johnson-Laird, P. (1992). *Mental models.* Cambridge: Cambridge University Press.

Kuhn, T.S. (1962). *The structure of scientific revolutions.* Chicago: The University of Chicago Press.

McCarthy, J. (1993). Notes on formalizing context. *Proceedings of the 13th International Joint Conference on Artificial Intelligence (IJCAI'93),* Chambery, France (pp. 555-560).

Nonaka, I., & Takeuchi, H. (1995). *The knowledge creating company.* Oxford: Oxford University Press.

OECD (Organization for Economic Cooperation and Development). (1997). *The Oslo manual: Proposed guidelines for collecting and interpreting technological innovation data.* Retrieved from http:// www.oecd.org/findDocument/0,2350,en_2649_34409_1 _119669_1_1_1, 00 .html

Paukert, M., Niederée, C., Muscogiuri, C., Bouquet, P., & Hemmje, M. (2003). Knowledge in the innovation process: An empirical study for validating the innovation knowledge lifecycle. *Proceedings of the 4th European Conference on Knowledge Management* (pp. 725-738). Oxford, UK.

Paukert, M., Niederée, C., & Hemmje, M. (in press). Adapting organizational knowledge management cultures to the knowledge lifecycle in innovation processes. In M. Rao (Ed.), *KM chronicles: Cultures of knowledge.*

Pérez-Bustamente, G. (1999). Knowledge management in agile innovative organizations. *Journal of Knowledge Management, 3,* 6-17.

Rogers, M. (1998). *The definition and measurement of innovation*. Melbourne Institute Working Paper Series No. 10/98.

Ruggles, R., & Little, R. (1997). *Knowledge management and innovation—an initial exploration.* White Paper, Ernst&Young LLP.

Shulyak, L. (1977). Introduction to TRIZ. In G. Altshuller (Ed.), *40 principles*. Worchester, MA: Technical Innovation Center.

Specht, G., Beckmann, C., & Amelingmeyer, J. (2002). *F&E management.* Stuttgart: Schäffer-Poeschel-Verlag.

Spiegler, I. (2000). Knowledge management: A new idea or a recycled concept. *Communication of the AIS, 3*(March). Retrieved April 22, 2004, from http://cais.isworld.org/articles/1-7/article.htm

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Chapter 8.3
Experiential Perspective on Knowledge Management

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INTRODUCTION

The last few decades have seen a growing proportion of organizational wealth being represented by intangible assets, i.e., assets with value that cannot be measured in terms of any physical attribute. Management thinking, conditioned over centuries to extract the greatest value out of physical assets, has had to bring within its ambit the leveraging of these intangible assets in building the capabilities required to deliver superior products and solutions. The discipline of knowledge management (KM) was born and came to encompass the gamut of organizational processes, responsibilities, and systems directed toward the assimilation, dissemination, harvest, and reuse of knowledge. In simpler terms, KM is the answer to the question, "How can the organization update and use its knowledge more effectively?" (Kochikar, 2000).

Some of the world's most successful organizations, be they corporate, academic, or government, invest considerably in KM. McKinsey & Co. spends at least 10% of revenues on managing knowledge. The World Bank's annual KM budget is $50 million. IBM has one of the oldest formal KM initiatives, dating back to 1994.

Substantial benefits have been reported across industries. Johnson & Johnson has implemented KM for speeding up the FDA application process and reported savings of $30 million on one product alone (Berkman, 2001). British Petroleum has estimated savings of $400 million a year, while Chevron has discovered operational cost savings of $2.5 billion over 8 years (Infosys, 2002). Tufts University's school of medicine has used KM to integrate its curricula and has been hailed as a national model for medical education (Genusa, 2001). KM is, however, not an unmixed blessing, as Storey and Barnett (2000) noted. Each organization must fashion a KM strategy that takes cognizance of its unique competencies, aspirations, and business context.

Infosys Technologies (NASDAQ: INFY) has conceived, developed, and deployed internally an elaborate architecture for KM that aims to empower every employee with the knowledge of every other employee. The company's success on the knowledge-sharing front has been affirmed by the fact that the company has been a Global MAKE (most admired knowledge enterprises) winner in 2003 (Chase, 2003) and Asia MAKE winner for 2002, 2003. Key elements of the KM architecture include the Knowledge Currency Unit scheme, a comprehensive mechanism for reward, recognition, and measurement of KM benefits; KShop, the corporate knowledge portal built in-house; and the knowledge hierarchy, a four-level taxonomy of 1800 subject areas that constitute knowledge in the Infosys context.

Along the KM journey, we also accumulated a sizeable body of thought on what organizations need to do in order to implement KM successfully, and it is the intention of this article to communicate some of that thought.

BACKGROUND—THE BUSINESS CASE FOR KM

In achieving its goal, KM needs to percolate into every corner of the organizational mind and create a culture of sharing within the organization. The following definitive statement of Lew Platt, Hewlett-Packard's former CEO, sums up the case for KM: "If HP knew what HP knows, we would be three times as profitable." A strong focus on KM has paid undeniable dividends to leading organizations wordwide. This year's Global MAKE winners have delivered a total return to shareholders of 19.6%, twice the Fortune 500 median of 9.1% (Chase, 2003). Similarly, these leading KM practitioners have shown a return on capital employed of 30.4% versus a Fortune 500 median of 18.5%. These winners also figure prominently in other honor lists, such as Fortune magazine's Most Admired Companies list (Hjelt, 2003) and Business Week magazine's list of the world's top brands (Business Week, 2003).

Chard (1997) and Bartlett (1998) have identified the following drivers for KM: the pace of change in a knowledge-driven age, which makes constant learning an imperative; globalization, which means acquiring knowledge about new environments and cultural and economic issues; the emergence of new technologies that offer new leverage if used well; the increase in virtual work, which needs much better knowledge sharing; rising expectations from all stakeholders, to meet the companies that need to be proactive and agile; and growth, which accentuates the challenge of leveraging the knowledge of individuals for corporate advantage.KM Review magazine's survey of 400 global corporations revealed that the following are key objectives of KM programs (KM Review, 2002):

1. Increasing organizational communication
2. Gaining competitive advantage
3. Increasing collaboration among employees
4. Improving customer relationships
5. Becoming more efficient
6. Innovating
7. Learning from previous mistakes and successes
8. Capturing and retaining tacit knowledge

Using the framework of Nahapiet and Ghoshal (1998), the above objectives can be classified as improving financial capital (2, 5); improving social capital (1, 3, 4), and improving intellectual capital (6, 7, 8). While KM activity, as enumerated below, focuses strongly on the social and intellectual capital aspects, the success of KM must necessarily be measured in terms of improving financial capital. As our extracts from Chase (2003) above demonstrate, successful KM adopters have found that this is the case.

BUILDING AN ORGANIZATIONAL KM ARCHITECTURE: CHALLENGES

An organizational architecture for KM must exhibit the following properties:

- Motivation: It must make people want to share knowledge.
- Facilitation: It must make it easier for them to do so.
- Awareness: It must make people aware of the KM architecture that has been created, and their roles in using it.

Figure 1 depicts conceptually the relative organization-wide effort required to be devoted to each of the above as the KM initiative evolves over time.

KM success hinges on an architecture that is designed specifically to suit each organization's business and cultural context. Such an architecture must address four key dimensions: people, process, content, and technology. Figure 2 outlines the key considerations to be addressed by a KM architecture along these four dimensions.

Enumerated below are a few key challenges on the people, process, content, and technology

Figure 1. Relative organization-wide effort devoted to motivation, facilitation, and awareness, as a KM initiative evolves over time

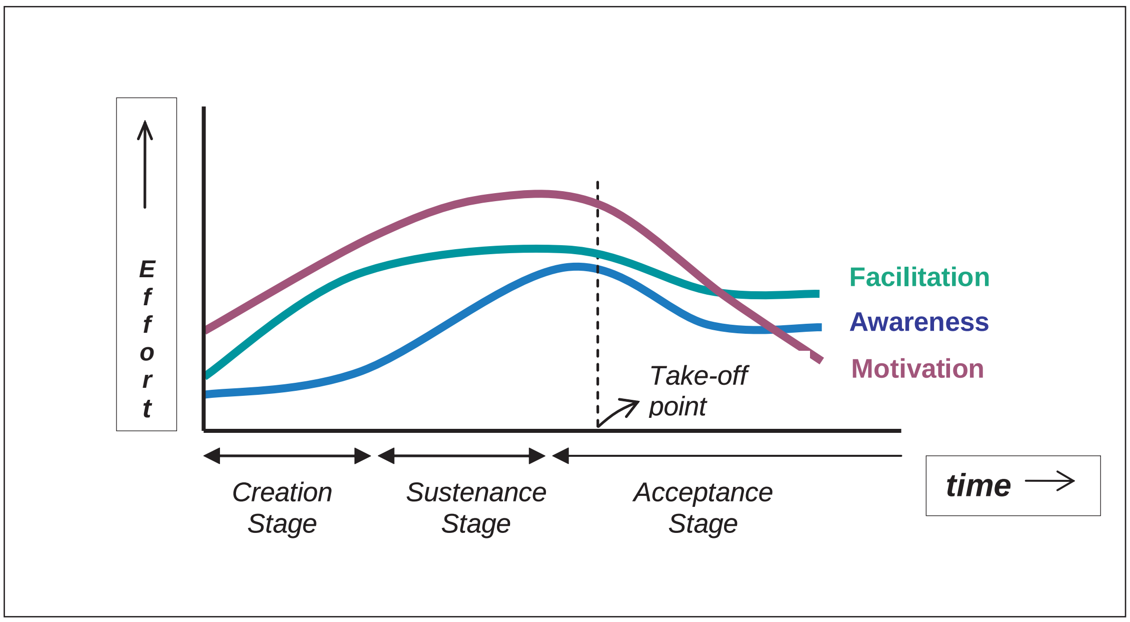
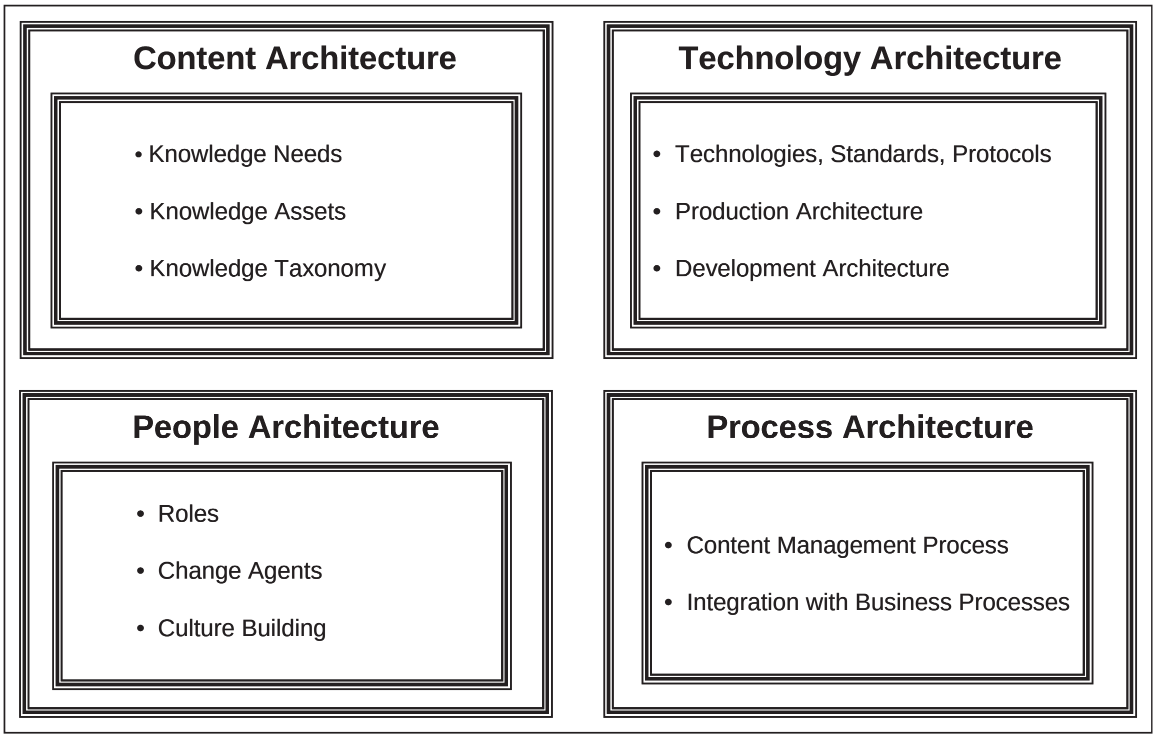


Figure 2. Sample people, process, content and technology considerations to be addressed by a KM architecture



dimensions that must be addressed when creating a KM architecture.

Deciding How Much Effort Should be Devoted to Technology

As its name implies, information technology (IT) is a mechanism for classifying, storing, and presenting information, as well as ensuring its speedy and effective flow across the organization. Because these capabilities are so critical for KM, it is difficult to conceive of any successful KM implementation that does not lay significant emphasis on the use of IT.

It is, however, necessary to guard against excessive reliance on IT—a tendency that has been liberally fostered by vendors of various hues. Clearly, the use of IT must be judicious, appropriate, preferably ROI-driven, and most importantly, backed by a clear strategy and ownership within the organization (Kochikar, 2000).

A popular yardstick is that not more than a third of the effort and investment of implementing KM should go into technology (Davenport & Prusak, 1998)—any excess makes it highly likely that the “softer” issues related to people, content, and process are being neglected. The extent of IT focus is governed by the target audience’s familiarity with, and willingness to use, IT tools.

Table 1. Typology of technologies for KM

Collaboration Technologies Stable Collaboration Technologies: Electronic mail Newsgroups/discussion forums/list servers Chat and instant messaging Expertise management systems Audio, video, and desktop conferencing E-learning technologies Mobile devices Emerging Collaboration Technologies: Whiteboarding and application sharing Virtual workspaces **Enabling Technologies for Collaboration** XML (extensible markup language) WAP (wireless application protocol) and WML (wireless markup language) WebDAV LDAP DSL (digital subscriber line) IP Telephony (VoIP) Streaming media
Enterprise Technologies Application servers Enterprise portals Business intelligence Emerging enterprise technologies Voice portals: Peer-to-peer (P2P) technology
Presentation Technologies Portlets Visualization technologies Personalization Dashboards and Web parts **Enabling Technologies for Presentation** Dynamic HTML (hypertext markup language): Applets Cookies *Source: Infosys Research*.

In the Infosys experience, because KShop has been built internally by the central KM group's technology team without the use of any special hardware or software products, the monetary investment in IT for KM has been extremely small. In terms of effort, the investment hovers around the one-third mark.

Table 1 provides a classification typology of technologies for KM and summarizes some of the key technologies.

Deciding the Degree of Centralization of Responsibility

A key question related to the people architecture for KM is, whose responsibility is it to make KM happen? Although every individual and group in the organization must work to make KM successful, there must clearly be an identified group of some form that will "own" KM in the organization. At the same time, this argument must not be taken to the absurd extreme of saying that this central group will have complete responsibility for all aspects of making KM happen. The question thus reduces to, what is the most appropriate position to occupy on the centralization–decentralization spectrum?

The answer to this question is, of course, dependent on issues deeply embedded in the organization's specific context. The extent of senior management's willingness to commit resources for KM is a key determinant. Expectations of KM in the organization also strongly determine the degree of centralization; in general, as more "guarantees" are expected, the more the onus shifts onto the central group.

In our experience, a "facilitated decentralized approach" works best: the technology architecture management for KM—development, deployment, and maintenance—is done by a central KM group. All stages of the content management process are anchored by the KM group; however, creation of internal content must happen in the field and is facilitated by the KM group. The conception and implementation of the KM strategy is also anchored by the central KM group.

This approach entails considerable investment in training and development of staff in the central KM group and in orienting all other roles in the organization to their knowledge-sharing aspect. One practice that we have found useful has been to "catch them young"—sensitize every fresh employee joining the organization to the mechanics of using the organizational KM infrastructure, within the first 2 weeks. In this manner, they learn the KM ropes at a time when their need to acquire knowledge about the organization is very high.

The "Buy versus Build" Decision

There is an abundance of packaged IT solutions for KM on the market. Some of these have been conceived by their vendors with the KM paradigm in mind, and thus support organizational KM requirements to a fair degree. Others are existing products repackaged with a "KM" label, and thus, they meet only a subset of an organization's requirements.

Organizations interested in reaping the full benefits of KM must, as said earlier, invest in designing a customized KM architecture that fits their context. For the technology dimension then, the "build" route becomes inevitable, as the technology solution must fit well into the people, process, and content dimensions of the KM architecture. Clearly, the economics of the buy versus build decision are also influenced in significant degree by relative costs.

In the Infosys experience, the decision to build was influenced largely by the fact that our proprietary knowledge hierarchy referred to earlier was a central mechanism for accessing content and expertise, and it needed to be supported by the technology system. Similarly, the unique knowledge currency unit (KCU) mechanism needed to be supported. The system was required to compute and use composite KCU ratings (a quality measure for documents) and provide interfaces for users of documents to award KCUs and manage their individual KCU accounts. Further, the system needed to exchange data with a number of existing corporate databases that store employee and project data in disparate schemas. A key requirement, the ability to control access based on organizational role, needed to be supported. Another strong need was for the technology architecture to evolve in response to changes in the other KM architectural elements, and an extraordinary degree of flexibility was a must.

Deciding the Degree of Centralization of Content

From a practical angle, the degree of distribution of content is another challenge to be surmounted. Does all content need to be centralized in one repository, or does it live and evolve in different pockets across the enterprise? The former choice appears attractive, because it offers features such as simplicity of architecture, administration, usage, change management, etc. However, the fact that specialized knowledge continues to develop in pockets—and that the responsibility (and pride) associated with ownership is the best driving force for its continued currency and relevance—indicates a distributed content architecture.

Using Synchronous versus Asynchronous Mechanisms for Knowledge Sharing

Another important aspect is the relative focus on direct, people-to-people collaborative sharing vis-à-vis sharing through codification of knowledge. Collaboration is characterized by its reliance on bringing people "in touch" for knowledge transfer through synchronous mechanisms. The latter approach (also called content management) is asynchronous, depends on repositories, and emphasizes defined ways of explicating knowledge. Conventional KM wisdom associates collaboration with the potential for tacit knowledge transfer and content management with explicit knowledge transfer. However, our experience suggests that technology, used innovatively, can help blur the boundaries between the two. For example, collaboration through technology systems is largely synchronous, and yet, as for example in the open source movement, is capable of creating exciting possibilities for knowledge transfer in virtual teams. The knowledge represented by the content can also be viewed as providing the live context for the exchange of implicit knowledge. It may, therefore, be said that the conversion of the implicit knowledge of the organization into content is a property of mature KM programs. Technology systems that sit atop the e-mail system, and content mining agents on collaborative forums, are further examples indicating the blurring distinctions between collaboration and content management.

Measuring the Benefits of KM

As KM implementations mature, it becomes imperative that mechanisms to evaluate the benefits must emerge. A complete treatment of KM metrics is beyond the scope of this article, and the interested reader may refer to Skyrme (2003).

In our experience, there are three forms of evidence that can be used in assessing the benefits of a KM program, in increasing order of reliability and difficulty: anecdotal, survey-based, and metrics-based (Kochikar & Suresh, 2003). Anecdotal evidence—"Thanks to using good KM, my project saved 12 weeks and saved 15% of cost to the customer"—although it may represent the viewpoint of a few opinion leaders, can be used to great effect. Surveys are generally more convincing, as they represent the view of a sample carefully chosen to represent the views of the entire target population. For example, an internal survey at Infosys found that more than 99% of the respondents believed KM is essential for the company, and 70% said good knowledge-sharing practices had helped in delivering tangible benefit to customers.

The metrics-based approach is the most powerful, and yet the most difficult to implement, demanding a high degree of maturity of the KM implementation. Our approach has been to measure in quantitative terms the impact of knowledge sharing on traditional indicators of project performance, using the KCU mechanism. Several projects have been able to quantify savings in dollar terms, and also report various other benefits, such as improved quality, faster turnaround times, etc.

FUTURE TRENDS

A heartening trend observed over the past few years is the increasing geographical uptake of KM. Of the 1998 MAKE winners, 73.3% were from North America, 17.7% from Europe, and 4.4% from Asia. In the 2003 MAKE study, North America's representation had dropped to 55%, Europe's had risen to 22.4%, while Asia's had surged to 20.4%. Clearly, Europe's and Asia's acceptance of KM has grown at the expense of North America, and this is likely to be a continuing trend.

Over the coming years, KM will continue to be imperative for organizational effectiveness. There is likely to be greater focus on tacit knowledge sharing, evolution of standards for KM solutions, and sharing through communities of practice. These developments will continue to be supported by evolving technologies: the integration of content management and collaboration products, development of agent technologies to provide proactive services, increased role for multimedia content, automated knowledge capture in collaboration products, automatic content classification, and enterprise-level support for mobile application access (reducing the reliance on speech and voice recognition systems).

CONCLUSION

Creating a culture of sharing is governed by principles that have much in common with Metcalfe's law—as more people grow convinced of the benefits of participating in the knowledge-sharing movement, it becomes easier to convince still more people to buy in. Thus, as long as steady progress is made on the road toward achieving greater sharing, the pace of adoption accelerates with time. Once a "critical mass" of users has been reached, the movement reaches a take-off stage (Figure 1), beyond which it becomes self-sustaining, without significant effort being devoted toward building up the motivation and awareness properties. Until this point is reached, it is crucial to understand and manage KM adoption as a process of organizational change.

REFERENCES

Bartlett, C. A. (1998). *McKinsey & Company: Managing knowledge and learning. Case,* Harvard Business School.

Berkman, E. (2001). When bad things happen to good ideas. *Darwin Magazine,* April. Received from www.darwinmag.com/read/040101/badthings_ content. html

Bontis, N., Crossan, M., & Hulland, J. (2002). Managing an organizational learning system by aligning stocks and flows. *Journal of Management Studies, 39*(4), 437–469.

Business Week (BW). (2003, August 4). The top 100 brands. *Business Week International*, pp. 72–76.

Chard, A. -M. (1997). *Knowledge management at Ernst & Young*. Case, Graduate School of Business, Stanford University.

Chase, R. (2003). *Global most admired knowledge enterprises (MAKE) report.* Teleos. Retrieved from http://knowledgebusiness.com

Concordia University. (2002). *Survey on knowledge leaders' critical issues.*

Davenport, T. H. (1996). *Hewlett-Packard promotes knowledge management initiatives*. Retrieved from www.webcom.com/quantera/HP.html

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Cambridge, MA: Harvard Business School Press.

Genusa. (2001). *Rx for learning.* Retrieved from http://www.cio.com/archive/020101/tufts.html

Gurteen. (2003). *The Gurteen Knowledge website.* Retrieved from http://www.gurteen.com/gurteen/gurteen. nsf/0/17B666B9EE45086B80256CD500474AF0/

Hjelt, P. (2003, March 3). The world's most admired companies. *Fortune,* pp. 24–33.

KM Review. (2002). KM Review Industry Survey 2002. Melcrum Publishing.

Kochikar, V. P. (2000, September). Learn once, use anywhere. *Knowledge Management Magazine, 4*(1).

Kochikar, V. P. (2002). Creating the KM infrastructure at Infosys: The technology challenge. *IIMB Management Review, 13*(4), 104–110.

Kochikar, V. P., & Raghavan, S. (2000). Managing knowledge in the e-organization: The IT perspective. In *Proceedings of ICEIS 2000, The International Conference on Enterprise Information Systems,* Stafford, UK. July 4–7, 2000.

Kochikar, V. P., & Suresh, J. K. (2003). The Infosys KM experience. In M. Rao (Ed.), *Leading with Knowledge*. New York: McGraw-Hill.

Metcalfe, R. (1996). *The Internet after the fad.* Retrieved from http://www.americanhistory.si.edu/csr/comphist/montic/metcalfe.htm

Nahapiet, J., & Ghoshal, S. (1998, April). Social capital, intellectual capital and the organizational advantage. *Academy of Management Review, 23*(2), 243.

Skyrme, D. J. (2003). *Measuring knowledge and intellectual capital.* Business Intelligence.

Storey, J., & Barnett, E. (2000). Knowledge management initiatives: Learning from failure. *Journal of Knowledge Management, 4*(2), 145-156.

Sveiby, K. -E. (1997). *The new organizational wealth: Managing and measuring knowledge-based assets.* San Francisco: Berret-Koehler.

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Chapter 8.4
Strategic Experimentation and Knowledge Management

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INTRODUCTION

Historically, the focus of IT infrastructure has been to capture the knowledge of experts in a centralized repository (Davenport & Prusak, 1998; Grover & Davenport, 2001). These centralized databases contained knowledge that was explicit and historical (e.g., competitor pricing, market share), and the IT infrastructure served to facilitate functional decision-making or to automate routine tasks (i.e., in re-engineering). The users of technology approached the repository to obtain data in a narrowly defined domain (Broadbent et al. 1999). Consequently, IT originally played a significant yet ultimately limited role in the strategy creation process. Management information systems (MIS) arguably generated information that was less applicable to strategy creation, as noted in early writings on the linkage between MIS and strategic planning (Holmes, 1985; Lientz & Chen, 1981; Shank et al., 1985).

The active management of knowledge was similarly underdeveloped. Despite the fact that strategic decision makers had always emphasized the role of tacit knowledge, the actual importance of knowledge was not explicitly recognized. Formalized knowledge management (KM) (Davenport & Prusak, 1998), with its associated terminology and tools, is a recent development and, as such, did not inform the strategic planning process.

However, the shifts that have taken place in IT infrastructures over the last decade and the recent developments in knowledge management have brought them closer to the creators of strategy. Indeed, both IT and knowledge management are increasingly enablers in the contemporary strategic management practice.

1. IT infrastructure is transitioning in its focus from the functional work unit to a process orientation. Whereas computer systems were once the focal point, the new infrastructure is network-centric, with an emphasis on business knowledge (Broadbent et al., 1999). For example, traditional search engines utilized rule-based reasoning to identify elements matching specific search criteria; the "state-of-the-art" knowledge management systems employ case-based search techniques to identify all relevant knowledge components meeting the user's request (Grover & Davenport, 2001).
2. IT now takes into account contexts that include cross-functional experts that are knowledgeable in a wide variety of potentially relevant issues. Additionally, there is a greater emphasis on the integration of infrastructure with organization, structure, culture (Gold et al., 2001), and organizational roles (Davenport & Prusak, 1998). In many ways, the newer IT infrastructures have enabled the garnering of explicit knowledge throughout the organization improving the speed of strategy creation.

The objective of this article is to outline how the developments in IT and KM are facilitating the evolution of strategic management to strategic experimentation in order to create quantum improvements in strategy creation and unprecedented developmental opportunities for the field of IT.

BACKGROUND

Information Technology (IT)

For the purposes of this chapter, IT is defined as physical equipment (hardware), software, and telecommunications technology, including data and image and voice networks employed to support business processes (Whitten & Bentley, 1998). The overarching plan for IT deployment within an organization is called the IT architecture. Technology infrastructure refers to the architecture as including the physical facilities, the services, and the management that support all computing resources in an organization (Turban et al., 1996).

Knowledge Management (KM)

As used in this chapter, data are objective, explicit pieces or units; information is data with meaning attached; and knowledge is information with an implied element of action.

Knowledge is the fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms (Davenport & Prusak, 1998, p. 5).

KM is "a set of business practices and technologies used to assist an organization to obtain maximum advantage from one of its most important assets—knowledge" (Duffy, 2000, p. 62). In other words, it is actively capturing, sharing, and making use of what is known, both tacitly, informally, and explicitly, within the organization. IT often facilitates knowledge management initiatives by integrating repositories (e.g., databases), indexing applications (e.g., search engines), and user interfaces. Davenport and Prusak (1998) note that KM also incorporates traditional management functions: building trust among individuals, allocating resources to KM, and monitoring progress.

Strategic Management

The concept of "strategy" explicated in strategic management is one of marketplace strategy (i.e., winning in the marketplace against competitors, entrenched or incipient). The underlying premise is that "to enjoy continued strategy success, a firm must commit itself to outwitting its rivals" (Fahey & Randall, 2001, p. 30). A large body of literature on strategic management has persuasively argued that effective strategy creation and execution are central to a firm's performance (Covin et al., 1994).

Strategy creation involves both goal formulation—defined in terms of external stakeholders rather than operational milestones—and crafting of the strategic means by which to accomplish these goals (Hofer & Schendel, 1978). The means typically include business scope, competitive posture, strategic intent, and the organizational mechanisms for implementation. In practice, the process of strategy creation has often taken the form of strategic planning. Comprehensive strategic planning (Gluck et al., 1978) has historically been practiced in large corporations. A celebrated example is the use of scenarios by Royal-Dutch Shell. Planning usually consisted of several sequential stages of decision-making involving diagnosis, alternative development, evaluation and choice, and implementation. In each step, the strategic planners emphasized deliberate juxtaposition of "objective data" and careful analysis with top management judgment, thus highlighting the role of tacit knowledge.

Strategic planning has evolved over the years. Writing in the 1970s, Gluck et al. (1978) identified four phases of evolution: budgeting, long-range planning, strategic planning, and strategic management. Each phase of evolution incorporated the lessons from the earlier phases, but also took into account the emerging realities faced by corporations. Gluck et al. (1978) noted that during the 1980s the "strategic management" phase would represent the cutting edge of practice in the world.

TOWARD STRATEGIC EXPERIMENTATION

The 1990s witnessed a revolution in organizational environments often characterized as "hypercompetition" (D'Aveni, 1994). These environments have created three major imperatives for organizations: time compression, globalization, and technology integration (Narayanan, 2001). The increased environmental dynamism also contributes to an increase in the degree of uncertainty confronted by strategic managers, calling into question traditional planning practices. Consequently, a new type of strategy creation process is evolving, which is termed "strategic experimentation." With this evolution, the relationship between strategy creation, knowledge management, and IT is undergoing a profound shift.

All four phases of strategic planning documented by Gluck et al. (1978) incorporated a sequential approach to strategy creation and execution, leading to the identification of one winning strategy that has the highest probability of success. Consequently, firms found it logical to commit the maximum available resources to the implementation of one wining strategy. The goal was to obtain a sustainable competitive advantage vis à vis the firm's rivals, and to reduce uncertainty ex ante using analytical forecasting techniques as well as market research. This approach to planning seems to have been effective during the 1980s when the environment was moderately dynamic.

In hypercompetitive environments, market participants frequently confront great uncertainty over technological possibilities, consumer preferences, and viable business models. This high level of ambiguity often results in a situation where (a) traditional methods of ex ante uncertainty reduction (e.g., market research) fail, and (b) the costs and risks of the traditional "big bet" strategic management approach outweigh the advantages in terms of focus, decisiveness, and concentrated resource commitment. It is in this situation that the emerging strategic experimentation approach holds significant promise.

Strategic experimentation (Brown & Eisenhardt, 1998; McGrath, 1998; McGrath & MacMillan, 2000) draws on real-options reasoning (McGrath, 1997), discussions of exploration vs. exploitation, and trial-and-error learning (Van de Ven & Polley, 1992).

1. Companies engaging in strategic experimentation continually start, select, pursue, and drop strategic initiatives before launching aggressively those initiatives whose values are finally revealed (McGrath & MacMillan, 2000).
2. Strategic initiatives serve as low-cost probes (Brown & Eisenhardt, 1998) that enable the discovery of product technology and market preferences. They also serve as a stepping stone option for future competitive activity in that particular product-market domain.
3. The role of the strategic manager is to administer a portfolio of strategic initiatives that represent an appropriate mix of high and low uncertainty projects, and to maximize the learning from these real options (McGrath & MacMillan, 2000).

Strategic experimentation represents a fundamentally different view of the practice of strategic planning and the path to competitive advantage. Movement is emphasized over position in this approach. Thus, competitive advantage is viewed as temporary at best, and hence, innovation and learning are considered crucial to success. Strategic experimentation is especially appropriate for high velocity environments such as emerging product markets with high uncertainty surrounding both technology and customer preferences (e.g., the early Personal Digital Assistant, Internet appliance, and satellite-based telephony markets). Here, low-cost probes can be very effective in gaining knowledge and reducing uncertainty while minimizing exposure to the results of faulty assumptions.

THE ROLE OF IT AND KNOWLEDGE MANAGEMENT IN THE ERA OF STRATEGIC EXPERIMENTATION

Since strategic experimentation represents the cutting edge of ideas in strategic management, we should expect significant advances in tool development and utilization in the next few years that will enable us to move the idea towards normal organizational practice.

Strategic experimentation necessitates several major functions that should be performed by an organization. KM is critical in strategic experimentation; therefore, it is not surprising that many of the tools currently moving into practice have emerged from KM. Following are the four major strategic experimentation functions and the associated KM tools.

Rapid Decision-Making

The ability to quickly garner tacit knowledge in all phases of decision-making is a central requirement in strategic experimentation. Current KM tools to support this include visualization and prototyping, group decision facilitation, and knowledge representation. Each method attempts to reduce the time needed for a group to progress from problem identification to solution implementation. These tools help to coordinate the use of data, systems, tools, and techniques to interpret relevant information in order to take action (Little, Mohan, & Hatoun, 1982).

Integration of Learning from Experiments

Organizational learning, another core concept in strategic experimentation, requires that appropriate learning be distilled from each experiment. This orientation combines decision-making and learning. Initiatives judged to be failures are not merely weeded out; they become occasions for discovery of root causes. Nor are successes simply alternatives to back financially; successes often generate potential best practices. Current KM tools in use for this purpose include learning histories (Roth & Kleiner, 1998), group brainstorming, and shared communication platforms.

Diffusion of Learning

Organizational learning has to be diffused throughout the organization. Since formal organizational channels may stifle transmission of tacit knowledge, diffusion may require interactions among "communities of practice" (Grover & Davenport, 2001; Davenport & Prusak, 1998). An organizational architecture incorporating relevant tools and IT infrastructure has to be designed to support theses interactions. KM tools such as knowledge maps identifying the experts in specific areas and repositories of case histories, are evolving to include dynamic updating of repositories and focused search tools to reduce information overload.

Managing a Portfolio of Strategic Experiments

Finally, unlike in previous eras, strategic experimentation requires maintenance and management of a portfolio of initiatives (Narayanan et al., 2001). This has three major implications. First, the knowledge base for decisions has to be broader and richer, simply due to the increase in the number of initiatives. Second, the knowledge base becomes much more complex, since the initiatives themselves differ in terms of the mix of tacit and explicit knowledge. Thus, newer initiatives are likely to be more dependent on tacit knowledge, whereas mature ones can be augmented by explicit knowledge. Finally, the sheer number of people involved in the process will be larger, given specialized pockets of tacit knowledge that would have grown up around specific strategic initiatives. DSS and other rich data applications, including cognitive mapping, can be used to capture the knowledge and feedback.

IT can accelerate the development of strategic experimentation by designing infrastructures that accommodate the new KM demands imposed by this new mode of planning. Consider how each of the following functions can be enhanced by IT infrastructure development.

1. Future developments can significantly reduce the time expended in solution development through real time displays, and expand opportunities for geographically dispersed collaboration. Also, advanced multimedia and communication capabilities increase the benefits of GSS and DSS tools.
2. Learning from experiments can be enriched by qualitative database construction, multimedia enhancements to communication applications, and open platforms to permit the sharing of knowledge over various communication channels, including wireless media.
3. Today, diffusion is hampered by information overload that has intensified competition for the user's attention (Hansen & Haas, 2001). To solve the problem, search tools should include separate parameters for content, rationale, and purpose of the query in order to isolate salient responses. Additionally, knowledge repositories must be maintained to ensure the contents are accurate and of high quality. Maintenance, currently pro-

vided by intermediaries (Markus, 2001), might be performed by faster automated systems.

4. Expert systems or neural networks may be developed to manage and track portfolios, promoting reuse of the knowledge captured.

The significant implication for IT infrastructure from our discussion is the need for technology integration (Narayanan, 2001) with both hard and soft technologies. IT infrastructure should exploit the potential for integration with other hard technologies such as telecommunications to enhance the organizational capacity for speed and the carrying capacity for tacit knowledge. Similarly, IT should seek to interface with decision sciences to embed AI-based processing tools, and with cognitive theorists to capture the tacit knowledge pervasive in organizations.

CONCLUSIONS AND IMPLICATIONS

We have argued that the technological changes of the 1990s have ushered in the need for strategic experimentation as the metaphor for planning practice. Strategic experimentation involves (a) maintaining a portfolio of strategic thrusts, (b) rapid decision-making so that successful experiments are backed and failures are weeded out quickly, (c) learning from both successes and failures, and (d) diffusion of both explicit and tacit knowledge throughout the relevant segments of an organization. This phase requires fundamental shifts in our view of knowledge management—its significance, use, and tools. Finally, we have argued that the shift to strategic experimentation requires fundamental shifts in the development of IT infrastructure. Instead of developing in relative isolation to other disciplines, IT should focus on technology integration by working in close collaboration with the telecommunication technologies, artificial intelligence community, and managerial cognition scholars.

REFERENCES

Broadbent, M., Weill, P., & St. Clair, D. (1999). The implications of information technology infrastructure for business process redesign. *MIS Quarterly, 23,* 159-182.

Brown, S.L., & Eisenhardt, K.M. (1998). *Competing on the edge: Strategy as structured chaos.* Boston, MA: Harvard Business School Press.

Covin, J.G., Slevin, D.P., & Schultz, R.L. (1994). Implementing strategic missions: Effective strategic, structural and tactical choices. *Journal of Management Studies, 31,* 481-505.

D'Aveni, R.A. (1994). *Hypercompetition: Managing the dynamics of strategic maneuvering.* New York: The Free Press.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston, MA: Harvard Business School Press.

Duffy, J. (2000). The KM technology infrastructure. *Information Management Journal, 34,* 62-66.

Fahey, L., & Randall, R. M. (2001). *The portable MBA in strategy* (2nd ed.). New York: Wiley.

Gluck, F.W., Kaufman, S.P., & Walleck, S. (1978, October). *The evolution of strategic management* [Paper]. In McKinsey Staff Paper.

Gold, A.H., Malhotra, A., & Segars. A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18,* 185-214.

Grover, V., & Davenport, T. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18,* 5-21.

Hofer, C.W., & Schendel, D. (1978). *Strategy formulation: Analytical concepts.* St. Paul, MN: West Publishing.

Holmes, F.W. (1985). The information infrastructure and how to win with it. *Information Management Review, 1*(2), 9-19.

Lientz, B.P., & Chen, M. (1981). Assessing the impact of new technology in information systems. *Long Range Planning, 14*(6), 44-50.

Little, J.D., Mohan, L., & Hatoun, A. (1982). Yanking knowledge from the numbers: How marketing decision support systems can work for you. *Industrial Marketing, 67,* 46-56.

March, J.G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2,* 71-87.

Markus, M.L. (2001). Toward a theory of knowledge reuse: Types of knowledge reuse situations and factors in reuse success. *Journal of Management Information Systems, 18,* 57-93.

McGrath, R.G. (1997). A real options logic for initiating technology positioning investments. *Academy of Management Review, 22,* 974-996.

McGrath, R.G. (1998). Discovering strategy: Competitive advantage from idiosyncratic experimentation. In G. Hamel, C. K. Prahalad, H. Thomas, & D. O'Neal (Eds.), *Strategic flexibility: managing in a turbulent environment* (pp. 351-370). Chichester: Wiley.

McGrath, R.G., & MacMillan, I. (2000). *The entrepreneurial mindset.* Boston: Harvard Business School Press.

Narayanan, V.K. (2001). *Managing technology and innovation for competitive advantage.* Prentice Hall College Division.

Narayanan, V.K., Buche, M. & Kemmerer, B. (2002). From strategic management to strategic experimentation: The convergence of IT, knowledge management, and strategy. In Luis Joia (Eds), *IT-based management: Challenges and solutions*. PA: Idea Group Publishing.

Roth, G., & Kleiner, A. (1998). Developing organizational memory through learning histories. *Organizational Dynamics, 27,* 43-60.

Shank, M.E., Boynton, A.C., & Zmud, R.W. (1985). Critical success factor analysis as a methodology for MIS planning. *MIS Quarterly, 9*, 121-129.

Turban, E., McLean, E., & Wetherbe, J. (1996). *Information technology for management.* New York: Wiley.

Van de Ven, A.H., & Polley, D. (1992). Learning while innovating. *Organization Science, 3*, 92-116.

Whitten J.L., & Bentley, L.D. (1998). *Systems analysis and design methods* (4th ed.). Boston: Irwin McGraw-Hill.

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Chapter 8.5
Competitive Intelligence Gathering

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INTRODUCTION

Knowledge management (KM) is the process through which organizational performance is improved through better management of corporate knowledge. Its goal is to improve the management of internal knowledge processes so that all information required for corporate decisions can be made available and efficiently used. Competitive intelligence (CI) is a process for gathering usable knowledge about the external business environment and turning it into the intelligence required for tactical or strategic decisions. The two are strongly connected because gathered CI has no long-term value unless an effective KM process is in place to turn the information into something usable. Although most information collected during a CI investigation is used in immediate decision making, it must be integrated into the internal knowledge systems to provide a long-term resource when companies attempt to detect trends or adapt to changes in their environments (Aware, 2004).

Both KM and CI systems are designed to enhance the information resources of an enterprise, but often target different information types and sources. While CI is concerned with gathering information from the external environment to enable the company to gain competitive advantage (Williams, 2002), most investigation into KM has focused on capturing the knowledge stored within the minds of individual employees (Nidumolu, Subramani, & Aldrich, 2001). Bagshaw (2000), Johnson (2000), Rubenfeld (2001), and Williams (2002) all focus on the use of KM for collecting, managing, and sharing internally generated knowledge.

Restricting the focus to internal data severely limits the potential of KM systems. The vast wealth of knowledge outside the traditional boundaries of the company may prove just as useful to organizations seeking a competitive advantage (Gold, Malhotra, & Segars, 2001). Fortunately, some studies indicate an awareness of the value of external information. Abramson (1999) notes that KM enables companies to create and systematically use the very best internal and external knowledge that they can obtain. Grzanka (1999) notes that KM provides a methodology to leverage and manage all knowledge, whether external or internal. Other researchers take it a step further and recognize the synergies between KM and CI. Johnson (1999) states that KM and CI are two parts of the same whole because both are designed to apply enterprise knowledge of the internal and external environment for long-term competitive advantage. KM and CI "have similar goals and are natural extensions of one another (e.g., manage information overload and timely/targeted information delivery, provide tools for data analysis, identify subject matter experts, enable collaboration)" (Meta Group, 1998). Davenport (1999) even goes so far as to take the stance that CI can be viewed as a branch or subset of KM.

A major difference between KM and CI is the much broader scope of KM compared to the more clearly focused CI: rather than applying knowledge to the entire firm and its complete set of objectives, CI focuses on defending the firm from competitive threats, while at the same time proactively working to acquire market share from competitors (Johnson, 1999). Further, while KM often falls under the purview of the information technology department, more often than not CI activities are found within strategic planning, marketing, or sales (Fuld, 1998).

While it is difficult to simplify the relationship between CI and KM (Johnson, 1999), it is important to note that the two approaches complement each other. The goal of both disciplines is to evaluate current business decisions, locate and deliver appropriate knowledge from the environment, and ultimately help to give it meaning so that decision makers better understand the options available to them (Johnson, 1999). The synergies between KM and CI indicate that greater convergence between the two approaches is inevitable.

BACKGROUND

Each organization has associated with it a particular context pertaining to such issues as customer attitudes, competitors' actions, regulatory patterns, and technological trends. Environmental scanning tools collect information from the environment to assist in developing strategies that help the organization formulate responses to that environment.

Environmental scanning was first defined by Aguilar (1967) as the process of gathering information about events and relationships in the organization's environment, the knowledge of which assists in planning future courses of action. It entails perceiving and interpreting both the internal and external environment with the objective of making appropriate operational, tactical, and strategic decisions that help insure the success of the firm (Elofson & Konsynski, 1991). Any organization that fails to monitor its environment in order to determine the conditions under which it must operate courts disaster (Mitroff, 1985). Identification of key economic, social, and technological issues that affect the organization, its lifecycle stages, and their relevance to each other helps managers allocate attention and resources to them (McCann & Gomez-Mejia, 1992). Scanning is a fundamental, early step in the chain of perceptions and actions that permit an organization to adapt to its environment (Hambrick, 1981).

Aguilar (1967) stresses the close relationship between strategic planning and scanning, noting that scanning is the acquisition of external strategic information that is useful for making decisions about company strategy and long-term plans. The objectives of environmental scanning vary with the business strategy employed by an organization (Jennings & Lumpkin, 1992). Differentiation strategy is associated with a systematic scanning activity to alert the organization to market opportunities as well as indications of innovations (Miller, 1989). Cost leadership strategy involves scanning for more efficient methods of production as well as innovations made by the competition (Miller, 1989). Reactive strategy is associated with scanning the external environment for problems (Ansoff, 1975), while low-cost strategy directs the scanning effort toward solving specific problems regarding product cost (Hrebiniak & Joyce, 1985). An organization's strategy determines whether environmental scanning is used to search for opportunities or to forewarn of threats (Snyder, 1981). The goals of an organization are continuously evolving, and as they are changing, so too are the pertinent threats and opportunities that must be monitored (Elofson & Konsynski, 1991). Environmental scanning systems are dependent on the identification of pertinent factors, both external and internal, to be scanned.

Many tools can be used to perform environmental scanning, including CI, business intelligence, knowledge acquisition, knowledge discovery, knowledge harvesting, enumerative description, knowledge engineering, information retrieval, document management, and enterprise information portals. This article focuses on the approach most widely used in business, CI.

MAIN FOCUS OF THE ARTICLE

Miller (2001) defines CI as the process of monitoring the competitive environment. This competitive environment includes but is not limited to competitors, customers, suppliers, technology, political and legal arenas, and social and cultural changes. Kahaner (1996) explains that CI is a systematic and ethical program for gathering, analyzing, and managing information about competitors' activities and general business trends that can affect a company's plans, decisions, and operations. Note the distinction of CI as an ethical process, unlike business espionage, which acquires information by illegal means like hacking (Malhotra, 1996). CI enables management to make informed decisions about a wide variety of tactical and strategic issues. Outcomes from a formal CI program should enable strategists to anticipate changes in the company's marketplace and actions of its competitors. CI should also uncover the existence of new competitors, new technologies, products, laws, or regulations that will have an effect on business. CI can help a business learn from the successes and failures of other enterprises, make better mergers and acquisitions, and enter new business arenas. From an internal viewpoint, CI can help a company assess its own business practices from a more open and objective perspective while helping implement new management tools (Kahaner, 1996).

The CI process is becoming even more important as the pace of business both at home and abroad continues to accelerate. CI also helps managers deal with the rapid change in the political, legal, and technical environments (Kahaner, 1996). A key goal of CI is to provide early warnings or timely alerts that allow decision makers to proactively position the company to maintain or gain a competitive advantage. Management must be able to detect changes in the market early enough to place the company in the most strategically advantageous position possible. A key feature of CI is the analysis process, which organizes and interprets raw data to uncover underlying patterns, trends, and interrelationships, thereby converting it into actionable intelligence. Data thus transformed can be applied to the analytical tasks and decision making that form the basis for strategic management (Miller, 2001).

Lackman, Saban, and Lanasa (2000) propose a model of the CI process that consists of several processes, including Identify Users, Assess Intelligence Needs, Identify Sources of Information, Gather Information, Interpret Information, and Communicate Intelligence. In the Interpret Information step, they propose an Intelligence Library that is closely related to KM since the Library serves as a repository for intelligence and secondary data with a user-friendly retrieval system designed to encourage its use. The inputs into the Library could come from CI departments and their activities or from more traditional KM activities designed to capture and disseminate tacit knowledge as explicit knowledge regardless of the organizational structure of the business. This model of CI thus incorporates features of KM.

The classic intelligence cycle has four stages—collection, processing, analysis/production, and dissemination—which is closely mirrored by knowledge management's four-step cycle of capture, transformation, communication, and utilization (Nauth, 1999). Kahaner (1996) describes a four-step CI cycle consisting of planning and direction, collection activities, analysis, and dissemination, while Miller (2001) adds feedback as a fifth step. Planning and direction requires working with decision makers to discover and hone their intelligence needs. Based on the vast array of directions that CI can take as illustrated above, this is one of the most difficult and ill-defined tasks, especially for managers not accustomed to using the CI process. Collection activities involve the legal and ethical gathering of intelligence from various public and private sources, both internal and external to the company. Two major approaches used in information collection are responding to ad hoc requests and continuously monitoring key intelligence areas. Proactive requests can be answered with available data, perhaps in a KM system, while reactive requests require a search process to uncover pertinent intelligence (Breeding, 2000). Several resources can be searched, including pay-for-use services such as Dow Jones, Hoover's Company Data Bank, Standards & Poor's, NewsEdge, as well as free information sources such as company Web sites, SEC's Edgar system, and corporateinformation.com (Breeding, 2000).

There are also specialized databases from third-party vendors (Dialog, Lexus/Nexus), press release and newsfeed collections (WavePhore's Newscast Access or NewsEdge's NewsObjects), product literature, competitor Web sites, archived design specifications, company profiles and financial statements, and numerous other sources that are databased, searchable, and categorized (Johnson, 1998). Monitoring key intelligence areas falls under the purview of environmental scanning. While many of the same information sources can be used, this approach allows critical intelligence to be pushed directly to the desktops of those decision makers who most need it without their having to do any searching through newspapers, Web sites, or other resources on their own, and it heightens awareness about the competition, making users aware of the competition in many of their day-to-day activities (Breeding, 2000). Analysis involves interpreting data and compiling recommended actions. The analysis, like the collection process, is driven by the planning stage to answer specific questions or concerns that managers are dealing with at the time. These questions or concerns will range from very tactical to very strategic in nature.

Dissemination involves presenting the findings to decision makers. This again is directed by the planning stage where the question of how to disseminate the findings is determined and agreed to prior to the start of the project. It is important to insure that decision makers get the types of reports that they want, rather than what the CI personnel find most interesting. That means that if the decision maker wants a simple, direct-to-the-point report rather than a long, involved presentation, then he/she should get it. Feedback involves soliciting responses from decision makers about the quality, timeliness, and accuracy of the intelligence and their needs for continued intelligence reports. Whether we are contemplating the classic intelligence cycle, the knowledge management cycle, or the competitive intelligence cycle, the cycle is a circular, iterative process. Note that unlike internal knowledge management, CI's focus is on both internal and external events and trends, with a strong focus on competitors' and others' activities and likely intentions.

While all phases of the CI cycle may be equally critical, planning and direction—and the needs identification process involved therein—are pivotal. No information-gathering approach can be successful unless it is provided with an adequate specification of the variables that need to be monitored. A great deal of research has been devoted to studying how to look for information, while overlooking the equally vital issue of what information to look for. A recent review of software marketed toward the online intelligence community clearly illustrates that the ability of most software to determine what information to gather is clearly deficient (Fuld, 2001).

Many tools for gathering intelligence are profile based, designed to sift information through a profile of intelligence needs (Berghel, 1997). These profiles are often made up of a set of topics that describe specific interests (Foltz & Dumais, 1992), and are developed early in the CI cycle and modified throughout the course of the intelligence operations. Each topic can be expressed in terms of a keyword or concept. The primary weakness of this type of approach is its reliance on the completeness and accuracy of a one-dimensional or single-class profile. If the profile is insufficient in any way, the effectiveness of the filtering process is seriously diminished. For example, if the profile is too narrow in scope or omits critical intelligence topics, the competitive intelligence process will overlook much of the pertinent available information, leaving managers unaware of vital facts. Thus, decision makers may consistently make crucial decisions based on faulty information. If, on the other hand, the profile is too broad or general, the intelligence gathering process may be capturing irrelevant information, overwhelming the decision makers and convincing them that the CI process is ineffective. In short, the profile of information needs is the pivotal element in determining how well the CI process performs.

Needs identification requires a structured approach that takes into account multiple dimensions, or classes. Such an approach helps to insure that the process of identifying an organization's intelligence needs considers each of the categories that make up those needs. Stadnyk and Kass (1992) propose the development of knowledge bases of description categories over which individual models of interests can be defined. Herring (1999) proposes the concept of Key Intelligence Topics (KITs) to help identify intelligence requirements by considering strategic decisions, early-warning topics, and key players. Based on Herring's prior work with both the government and Motorola, the KITs process helps management to identify and define critical intelligence needs. CI programs often operate under the direction of upper management, which generally delineates the objectives or needs that CI must attempt to meet.

However, CI activity should not be restricted to the upper management level because it can assist all organizational levels. Further, CI needs vary by company and by project. Therefore, an analysis of the information needs of an enterprise requires consideration of the types of information required by decision makers at all levels of management. Many management models, including Anthony's Managerial Pyramid (1965), represent organizations as having various levels of decision making—operational control, tactical control, and strategic planning—each of which has different information needs.

The multi-class interest profile (M-CLIP), first proposed in 2001 (Parker & Nitse, 2001), addresses these shortcomings. It provides a strategically aligned framework based on the various types of information needs in order to insure that key items within each critical intelligence area are accounted for. Thorough needs identification guided by a structured, multi-dimensional framework increases the likelihood of a successful CI effort. The classes that make up the M-CLIP were derived by taking into consideration such information-intensive activities as project management, strategic planning, competitive analysis, and environmental analysis, and then acknowledging the correlation between the information needs of those activities and the decision-making levels described in the Managerial Pyramid. The project class consists of interest areas intended to target the information necessary for the execution of current projects, including both long-term activities such as tracking the daily or weekly actions of an overseas competitor, as well as shorter-term specialized projects such as the investigation of a possible acquisition or alliance prospect. The enterprise class includes internal and external interest areas, such as technological factors, investment issues, corporate news, operating expenses, and so forth, that are necessary for tactical decision making. The industry class targets information needs that stem from the type of industry or organization performing the investigation and helps the CI process supply intelligence related to the general external environment of the company.

The M-CLIP spans all decision-making levels and provides a structured, expanded set of intelligence topics. The M-CLIP system also provides specialized templates to aid in the identification of critical intelligence needs, an expansion mechanism to help insure that no key concepts are overlooked, and an adaptive mechanism to handle the removal of unproductive topics automatically.

A complete set of intelligence topics encompasses a wide spectrum of corporate interests, thus providing the means to access a greater percentage of relevant online information. A more complete information set makes the analysis and dissemination efforts more likely to succeed, insuring that the CI process provides decision makers with a more complete set of information, enabling them to assess domestic and international issues in an efficient, accurate, and timely manner.

FUTURE TRENDS

As noted above, the KM and CI functions complement each other. There is a great deal of overlap between the two, and KM systems will become more robust as KM workers recognize the benefits of adjusting their focus to include not only internal, but also external sources of information. At the same time, CI efforts will benefit by making greater use of KM. One statistic indicates that as much as 80% of the competitive knowledge that a firm requires to compete successfully is already present somewhere within the company and can be gathered by probing internal sources (Johnson, 2001). Competitive intelligence should be an integral part of knowledge management, and vice versa. Knowledge management can be improved by actively gathering competitive intelligence, and competitive intelligence can be improved by accessing the internal information gathered by knowledge management. The convergence of these two disciplines can be realized only when strategic planners are able to define more completely the relationships between CI and KM, and their specific role in delivering decision support (Johnson, 1998).

CONCLUSION

Effective CI requires an effective KM process. Without KM, gathered CI information is useful for only a brief period. CI data is highly time sensitive and is often useless unless acted upon immediately (Johnson, 1998). However, if CI is integrated into the internal knowledge processes, it will begin to have some long-term value to a firm (Aware, 2004). This integration will enable companies to detect trends and markets in which competitors act, as well as to identify latent and parallel competitors. This intelligence can then be of long-term use to decision makers at all levels (Johnson, 1998).

One measure of organizational effectiveness is the creation and continuance of a measurable competitive advantage (Gupta & McDaniel, 2002). KM and CI share that common goal, and a convergence of these two approaches will enable organizations to use the synergies between the two to take advantage of changes in both the internal and external environment.

REFERENCES

Abramson, G. (1999). On the KM midway. *CIO Enterprise Magazine.* Retrieved March 2003, from http://www.cio.com/archive/enterprise/051599_cons.html

Aguilar, F.J. (1967). *Scanning the business environment.* New York: Macmillan.

Ansoff, H.I. (1975). Managing strategic surprise by response to weak signals. *California Management Review, 18*(2), 21-31.

Anthony, R. (1965). *Planning and control systems: A framework for analysis*. Boston: Harvard University Press.

Aware. (2004). *Knowledge management and competitive intelligence.* Retrieved September 21, 2004, from http://www.marketing-intelligence.co.uk/help/Q&A/ question21.htm

Bagshaw, M. (2000). Why knowledge management is here to stay. *Industrial and Commercial Training, 32*(5), 179-183.

Berghel, H. (1997). Cyberspace 2000: Dealing with information overload. *Communications of the ACM, 40*(2), 19-24.

Breeding, B. (2000). CI and KM convergence: A case study at Shell Services International. *Competitive Intelligence Review, 11*(4) 12-24.

Davenport, T.H. (1999). Knowledge management, round two. *CIO Magazine.* Retrieved May 2001 from http://www.cio.com/archive/ 110199_think_content.html

Elofson, G., & Konsynski, B. (1991). Delegation technologies: Environmental scanning with intelligent agents. *Journal of Management Information Systems, 8*(1), 37-62.

Foltz, P., & Dumais, S. (1992). Personalized information delivery: An analysis of information-filtering methods. *Communications of the ACM, 35*(12), 51-60.

Fuld, L. (1998). Ask the expert: Role of IT strategy and knowledge management in competitive intelligence. *CIO Magazine*. Retrieved May 2002, from http://www2.cio.com/ask/expert/1998/questions/question246.html?CATEGORY=18&NAME=Knowledge%20Management

Fuld, L. (2001). Intelligence software: Reality or still virtual reality? *Competitive Intelligence Magazine*, 22-27.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Grzanka, L. (1999). Competitive intelligence. *Knowledge Management, 2*(4), 42-50.

Gupta, A., & McDaniel, J. (2002). Creating competitive advantage by effectively managing knowledge: A framework for knowledge management. *Journal of Knowledge Management Practice, 3.*

Hambrick, D.C. (1981). Specialization of environmental scanning activities among upper level executives. *Journal of Management Studies, 18*(3), 299-320.

Herring, J.P. (1999). Key intelligence topics: A process to identify and define intelligence needs. *Competitive Intelligence Review, 10*(2), 4-14.

Hrebiniak, L.L., & Joyce, W.F. (1985). Organizational adaptation: Strategic choice and environmental determinism. *Administrative Science Quarterly, 30*(3), 336-349.

Jennings, D.F., & Lumpkin, J.R. (1992). Insights between environmental scanning activities and Porter's generic strategies: An empirical analysis. *Journal of Management, 18*(4), 791-803.

Johnson, A. (2001). *On predicting the future: Competitive intelligence as a knowledge management discipline.* Retrieved September 20, 2004, from http://www.aurorawdc.com/kmworld1.htm

Johnson, A.R. (1998). An introduction to knowledge management as a framework for competitive intelligence. *Proceedings of the International Knowledge Management Executive Summit*, San Diego, CA. Retrieved September 20, 2004, from http://www.aurorawdc.com/ekma.htm

Johnson, A.R. (1999). Your say: Competitive intelligence and knowledge management—two parts of the same whole. *Knowledge Management Magazine, 3*(3).

Johnson, A.R. (2000). Competitive intelligence and competitor analysis as knowledge management applications. In J.W. Cortada & J.A. Woods (Eds.), *The knowledge management yearbook 2000-2001* (pp. 85-97). Woburn, MA: Butterworth-Heinemann.

Kahaner, L. (1996). *Competitive intelligence: How to gather, analyze, and use information to move your business to the top.* New York: Simon & Schuster.

Lackman, C.L., Saban, K., & Lanasa, J.M. (2000). Organizing the competitive intelligence function: A benchmarking study. *Competitive Intelligence Review, 11*(1), 17-27.

Malhotra, Y. (1996). *Competitive intelligence programs: An overview.* Retrieved September 20, 2004, from http://www.kmbook.com/ciover.htm

McCann, J.E., & Gomez-Mejia, L. (1992). Going 'on line' in the environmental scanning process. *IEEE Transactions on Engineering Management, 39*(4), 394-399.

Meta Group, Inc. (1998). *Applying knowledge management to competitive intelligence.* Retrieved May 2001 from http://www2.metagroup.com/products/insights/ aims_6_res.htm

Miller, D. (1989). Matching strategies and strategy making: Process, content, and performance. *Human Relations, 42*(3), 241-260.

Miller, S.H. (2001). *Competitive intelligence: An overview.* Retrieved September 23, 2004, from http://www.scip.org/Library/overview.pdf

Mitroff, I.I. (1985). Two fables for those who believe in rationality. *Technological Forecasting and Social Change, 28*, 195-202.

Nauth, K.K. (1999). *In from the cold*. Retrieved September 23, 2004, from http://www.topsecretnet.com/knowmag.htm

Nidumolu, S.R., Subramani, M., & Aldrich, A. (2001). Situated learning and the situated knowledge web: Exploring the ground beneath knowledge management. *Journal of Management Information Systems, 18*(1), 115-150.

Parker, K.R., & Nitse, P.S. (2001). Improving competitive intelligence gathering for knowledge management systems. *Proceedings of the 2001 International Symposium on Information Systems and Engineering ISE'2001 Workshop: Knowledge Management Systems: Concepts, Technologies and Applications* (pp. 122-128), Las Vegas, NV.

Rubenfeld, J. (2001). Knowledge management for life: Make the world a better place. *Ubiquity, 2*(41).

Snyder, N.H. (1981). Environmental volatility, scanning intensity, and organizational performance. *Journal of Contemporary Business, 10*(2), 5-17.

Stadnyk, I., & Kass, R. (1992). Modeling users' interests in information filters. *Communications of the ACM, 35*(12), 49-50.

Williams, R. (2002). *Applying KM lessons to competitive intelligence: Creating a user-driven competitive intelligence culture.* Retrieved March 2003 from http://old.apqc.org/free/articles/dispArticle.cfm? ProductID=1493

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Chapter 8.6
An Integrative Knowledge Management System for Environmental-Conscious Construction

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ABSTRACT

This chapter introduces an integrative knowledge management prototype named E+ for environmental-conscious construction based on a comprehensive integration of current environmental management (EM) techniques and tools in construction. The overall objective is to apply the theory of knowledge management (KM) in EM in construction, and the authors will achieve it though developing the E+ model and its tools for dynamic EM in construction. The approaches applied in this chapter include system analysis and development, literature review, questionnaire survey and interview, and case study. The results from this chapter include the E+, a comprehensive review of EM tools adopted in construction, and a demonstration of the implementation of

the E+. Furthermore, the authors hope that the adoption and implementation of the E+ can effectively improve contractors' performance in EM and reduce adverse environmental impacts in construction.

LEARNING OBJECTIVES

Due to the purpose of the integrative methodology of KMS for EM in construction, this chapter mainly contributes to existing theory for EM in construction in the area of quantitative analytical approaches and their integrative implementation. According to the literature review and questionnaire survey for this research, the lack of effective, efficient, and economical (E3) quantitative analytical approach is one of obstacles to implementing EM in construction. Therefore, there are four points of contribution of this research to the existing theory or practice for EM in construction:

1. This research has developed an integrative methodology (E+) to implementing EMS and KM in construction, with a rigorous dynamic Environmental Impacts Assessment (EIA) model based on various functional-different approaches to EM in a construction cycle. The E+ prototype was originally created in both the theory and practice for EM in construction, and it is open to further integration of various functional-different approaches for EM in construction other than the three EM tools presented in this chapter. Because the E+ is both EMS oriented and process oriented in construction, it can thus help contractors to implement EM from a messy situation to a normalised system, and to effectively share EM knowledge and information internally and externally.
2. The CPI method integrated in the E+ model is a quantitative approach to predicting and levelling complex adverse environmental impacts potentially generated from construction and transportation due to the implementation of a construction plan. As a result, the CPI method has been integrated into E+ EM Toolkit A, one functional section of the E+ system, to carry out the task in environmental-conscious construction planning.
3. The IRP method is a quantitative approach to reducing the waste of construction materials on a construction site, and it is designed to effectively be implemented by using a barcode system. The IRP is then integrated in the E+ EM Toolkit B, another functional section of E+, as a basic component.
4. The Webfill method is an e-commerce model designed for the trip-ticket system to effectively reduce, reuse, and recycle C&D waste. Although there is a lack of data to prove the efficiency in reality, the computer simulation results and a questionnaire survey from another research (Chen, 2003) have proven that the Webfill system can effectively realise the design function. As a result, the Webfill is also integrated in the E+ model as an important component of the E+ EM Toolkit C.

Readers can obtain the socio-technical perspectives from the introduction of the E+ prototype and its toolkits, and know how E+ can work for a dynamic EIA process in construction with integrated supports from E3 quantitative analytical approaches in the toolkits.

INTRODUCTION

The adverse environmental impacts of construction—such as construction and demolition waste, noise and vibration, dust, hazards emissions and odours, soil and ground contamination, water pollution, wildlife and natural features demolition, and archaeological destruction —have been of concern since the early 1970s, and received more and more academic and professional attention in the construction industry especially after the ISO 14000 series of EM standards was enacted. In this regard, quantitative analytical approaches to EM in construction are currently not as available as qualitative approaches such as regulations and practical guides due to the difficulties in the transformation of practical data to abstraction data that are needed in the calculation for EM. However, it is hard to accept an environmental management system (EMS) without adequate support from EM tools and knowledge warehouse (KW), which is the essential component of an enterprise's knowledge management system (KMS) where knowledge is developed, stored, organised, processed, and disseminated (SAP INFO, 2004). From this point of view, the overall objective of this chapter is to put forward a methodology of an integrative KMS based on the developed holistic approach for environmental-conscious construction project management, which can facilitate knowledge management (KM) initiatives for improved competitiveness of construction enterprises in EM. This objective will be achieved step by step though four sub-objectives. They are: (1) to illustrate an integrative KM prototype to capture and reuse data, information, and knowledge for dynamic EM in construction project management; (2) to describe quantitative EM tools that can be integrated into the integrative KM model for dynamic environmental-conscious construction project management; (3) to describe the interaction among the quantitative EM tools within the integrative KM model and key information techniques to develop the integrative KMS for dynamic EM in construction project management; and (4) to demonstrate the implementation of the integrative KMS through a case study.

BACKGROUND

EM in construction has received more and more attention over the past 30 years. For example, studies on noise pollution (USEPA, 1971), air pollution (Jones, 1973), and solid waste pollution (Skoyles & Hussey, 1974; Spivey, 1974) from construction sites were all individually conducted in the early 1970s. Although the expression of EM in construction came out in the early 1970s, after the U.S. National Environmental Policy Act of 1969 was enacted (Warren, 1973), the concept of EM in construction was introduced later in the '70s, when the role of environmental inspector was defined in the design and construction phases of projects to provide advice to construction engineers on all matters in EM (Spivey, 1974; Henningson, 1978). However, there has been little enthusiasm for establishing an EMS in construction organisations until two main important standards, BS 7750 (released by the BSI Group in 1992) and the ISO 14000 series (released by the International Organisation for Standardisation (ISO) in 1996) were promulgated to guide the construction industry from passive CM on pollution reduction to active EMS for pollution prevention.

Implementation of EM

In the 1990s, the Construction Industry Research and Information Association (CIRIA) conducted a series of socio-technical reviews on environmental issues and have undertaken initiatives relevant to the construction industry after the introduction of BS 7750 (Shorrock et al., 1993; CIRIA, 1993-95; Guthrie & Mallett, 1995; Petts, 1996). Thereafter, research works on EM have also been led to the implementation of EMS and the registration of ISO 14001 EMS by authoritative institutions in the construction industry, such as the CIOB (Clough & Antonio, 1996), the FIDIC (1998), the Construction Policy Steering Committee (CPSC) (1998), and the CIRIA (Uren & Griffiths, 2000).

To assess the implementation of EMS in construction, several socio-technical investigations have been conducted independently by researchers in different countries since 1999. For example, Kein, Ofori, and Briffett (1999) conducted a field study in Singapore to assess the level of commitment of ISO-9000-certified construction enterprises to EM. They found that contractors in Singapore were aware of the merits of EM, but were not instituting systems towards achieving it. Ofori, Briffett, Gang, and Ranasinghe (2000) then conducted a survey to ascertain the perceptions of construction enterprises on the impact of the implementation of the ISO 14000 series on their operations. Major problems were identified, such as the shortage of qualified personnel, lack of knowledge of the ISO 14000 series, indistinct cost-benefit ratio, disruption and high expenses on changing traditional practices, and resistance from employees. The CIRIA (1999) led a self-completion questionnaire survey of the state of environmental initiatives within the construction industry and of sustainability indicators for the civil engineering industry in the United Kingdom.

Tse (2001) conducted an independent questionnaire survey in the Hong Kong construction industry to gain a further understanding of the difficulties in implementing the ISO 14000 series. Lo (2001), also in Hong Kong, made an effort to identify nine critical factors for the implementation of ISO 14001 EMS in the construction industry based on critical factors drawn from an investigation in another industry. The CPSC (2001) in Australia conducted a questionnaire survey of the New South Wales construction industry on EM with industry leaders. Chen, Li, and Wong (2000) conducted a questionnaire survey of main contractors in five main cities in mainland China and found that there are five classes of factors influencing the acceptability of the ISO 14000 series including governmental regulations, technology conditions, competitive pressures, cooperative attitude, and cost-benefit efficiency. In addition, Zeng, Tam, Deng, and Tam (2003) conducted a questionnaire survey of the mainland China construction industry to discover the conditions of implementation of the ISO 14000 series. All these questionnaire surveys clarified real situations in adoption and implementation of the ISO 14000 series in the local construction industries, and provided relative perspectives on how to conduct EM of the construction industry.

In addition to the questionnaire survey, case studies are further applied to investigate the acceptability of the ISO 14000 series in the construction industry. For example, Valdez and Chini (2002) conducted a literature review and case study of a construction contracting firm certified for the ISO 14001 EMS in the United States. They concluded that the positive aspects of certification outweigh the negative aspects, and recommended adding government support and the combined use of the ISO 14000 series with other EM and matrices.

Conflicts with EIA

The Environmental Impacts Assessment (EIA) is a process to identify, predict, evaluate, and mitigate the biophysical, social, and other relevant environmental effects of development proposals or projects prior to major decisions and commitments being made (IAIA, 1997). Although the EIA has been accepted by the construction industry in different countries under governmental regulations to evaluate environmental impacts of construction projects, the implementation rate of ISO 14001 EMS accreditation is normally much lower than the implementation rate of EIA in the construction industry. For example, a remarkable disagreement/deviation between the rate of ISO

14001 EMS accreditation and EIA implementation in some countries indicates that contractors there have not really implemented EM and accepted the ISO 14000 series (Chen, 2003). According to the Official Report on the State of the Environment in China 2001 (China EPB, 2002), the annual implementation rate of EIA for construction projects was 97% in 2001 in mainland China. In addition, a further investigation on the implementation rate of EIA in mainland China indicates that the average EIA rate from 1995 to 2001 is 88%, with an increasing rate of 23% (China EPB, 2002). By contrast, the percentage of the construction enterprises that have been awarded environmental certificates versus total governmental registered construction enterprises in mainland China is as low as 0.083%, and statistical figures also indicate that most construction enterprises have not yet adopted or accepted the ISO 14000 series in mainland China (Chen, 2003). Because of the disagreement between the implementation rates of EIA and EMS, there may be little coordination between the EIA process and EMS implementation in construction projects, and thus the EIA may not really serve as a tool to promote EM in the construction industry in those countries. For that reason, adverse environmental impacts such as noise, dust, waste, and hazardous emissions still occur frequently in construction projects in spite of their EIA approvals prior to construction. As a result, the failure to implement mitigation measures adequately or monitor environmental impacts following the approval of projects is often cited as a major shortcoming of the EIA process, and the contents and recommendations of EIA are often disregarded when EMS are implemented (Sánchez & Hacking, 2000).

KM Will

The growing consciousness, requirements, and initiatives of KM are existent in order to manage the intellectual capital and get benefits from previous construction processes and projects (Zyngier, 2002; & Zarli, Rezgui, & Kazi, 2003). For example, the C-Sand project (c-sand.org.uk) has been conducted in the United Kingdom to foster organisational practices that enable knowledge creation for subsequent sharing and reuse, and to promote sustainable construction (Khalfan, Bouchlaghem, Anumba, & Carrillo, 2003). As one of the largest contracting companies in the United States, Centex Construction Group (centex-construction.com) faces some knowledge-related business challenges that are not always associated with the construction industry. For instance, they have a technology infrastructure in place where all professionals in the company have computing power, that is, laptops and/or desktops. All offices and job sites are connected to a nationwide WAN via dial, ISDN, and Frame. Remote access is Web based and available from anywhere to lead some initiatives to increase knowledge sharing and provide better information access across the company's diverse landscape (Velker, 1999). Beyond the development of knowledge warehouse (KW) in the construction industry, socio-technical research also reflected that there was a majority of agreement to the statement that KM is an extension of IT (Zyngier, 2002). The progress of KM in construction also reflects the trend of construction enterprises away from traditional blue-collar operations towards a more knowledge-based CM.

According to the survey results, EMS implementation requires practical approaches for contractors to conduct EM. That is, although the governmental regulations have been identified as a major factor influencing the implementation of the EMS and the EIA in the construction industry, the construction industry is still a negative receiver if there are not enough technology conditions to support EMS implementation, especially the techniques or tools that can help contractors to conduct EM in construction projects where most of the negative environmental impacts are generated. Even the positive bodies in the construction industry have high willingness to implement EM; the E3 EM tools are essential to them (Chen, 2003). Based on this consideration, the authors of this chapter will integrate several EM tools and an EMS-based dynamic EIA process developed previously into an environment of KM, entitled E+, for E3 EM in construction project management.

THE E+

Methodology

The E+ is an integrative methodology for E3 EM in construction projects in which an EMS-based dynamic EIA process is applied within a knowledge support system for active knowledge capture and reuse about environmental-conscious CM during construction. The successful implementation of an EMS in a construction project requires far more than just the apparent prevention and reduction of adverse or negative environmental impacts in a new project and its construction process development cycles during pre-construction stage, continuous improvement of the EM function based on institutionalisation of change throughout an onsite organisation to reduce pollution during construction stage, or efficient synergisms of pollution prevention and reduction such as waste recycle and regeneration during construction and post-construction stages. It necessitates a complete transformation of the CM in an environmentally conscious enterprise, such as changes in management philosophy and leadership style, creation of an adaptive organisational structure, adoption of a more progressive organisational culture, revitalisation of the relationship between the organisation and its customers, rejuvenation of other organisational functions (i.e., human resources engineering, research and development, finance, and marketing) (Azani, 1999). In addition to the transformation for the EM in construction enterprises, the E+ for the E3 implementation of the EM in all phases of construction cycle—including the pre-construction stage, the construction stage, and the post-construction stage—is necessarily activated, together with other rejuvenated CM functions such as human resources, expert knowledge, and synergetic effect.

There are already some approaches to effectively implementing the EM onsite at different construction stages. For example, the CPI approach, which is a method to quantitatively measure the amount of pollution and hazards generated by a construction process and construction project during construction, can be utilised by indicating the potential level of accumulated pollution and hazards generated from a construction site at the pre-construction stage (Chen et al., 2000), and by reducing or mitigating pollution level during construction planning stage (Li, Chen, & Wong, 2002). In addition to the CPI approach, an analytic network process (ANP) approach to construction plan selection (Chen, Li, & Wong, 2003), a life-cycle assessment (LCA) approach to material selection (Lippiatt, 1999), and a decision programming language (DPL) approach to environmental liability estimation (Jeljeli & Russell, 1995) also provide quantitative methods for making decisions on EM at the pre-construction stage. For the construction stage, a crew-based incentive reward program (IRP) approach, which is realised by using a bar-code system, can be utilised as an onsite material management system to control and reduce construction waste (Chen et al., 2002a). For the post-construction stage, an online waste exchange (Webfill) approach, which is further developed into an e-commerce system based on the trip-ticket system for waste disposal in Hong Kong, can be utilised to reduce the final amount of construction and demolition (C&D) waste to be landfilled (Chen et al., 2002b). Although these approaches to EM in a construction project have been proven effectively, efficiently, and economically applicable in a corresponding construction stage, it has also been noticed that these EM tools can be further integrated for a total EM purpose in construction project based on the interrelationships among them. The integration can bring about not only a definite utilisation of current EM tools, but also an improved environment for contractors to maximise the advantages of utilizing current EM tools due to sharing EM-related data, information, and knowledge in construction project management.

As mentioned above, the EMS is not as acceptable as the EIA at present in some countries and areas such as mainland China partly due to the lack of E3 EM approaches in construction, besides the governmental regulations; the tendency of practical EM in construction is to adopt and implement the EMS when the EIA report/form of a construction project has been approved. As a result, the E+ for contractors to enhance their environmental performance, which integrates all necessary KW and EM tools, simply appropriates to the occasion.

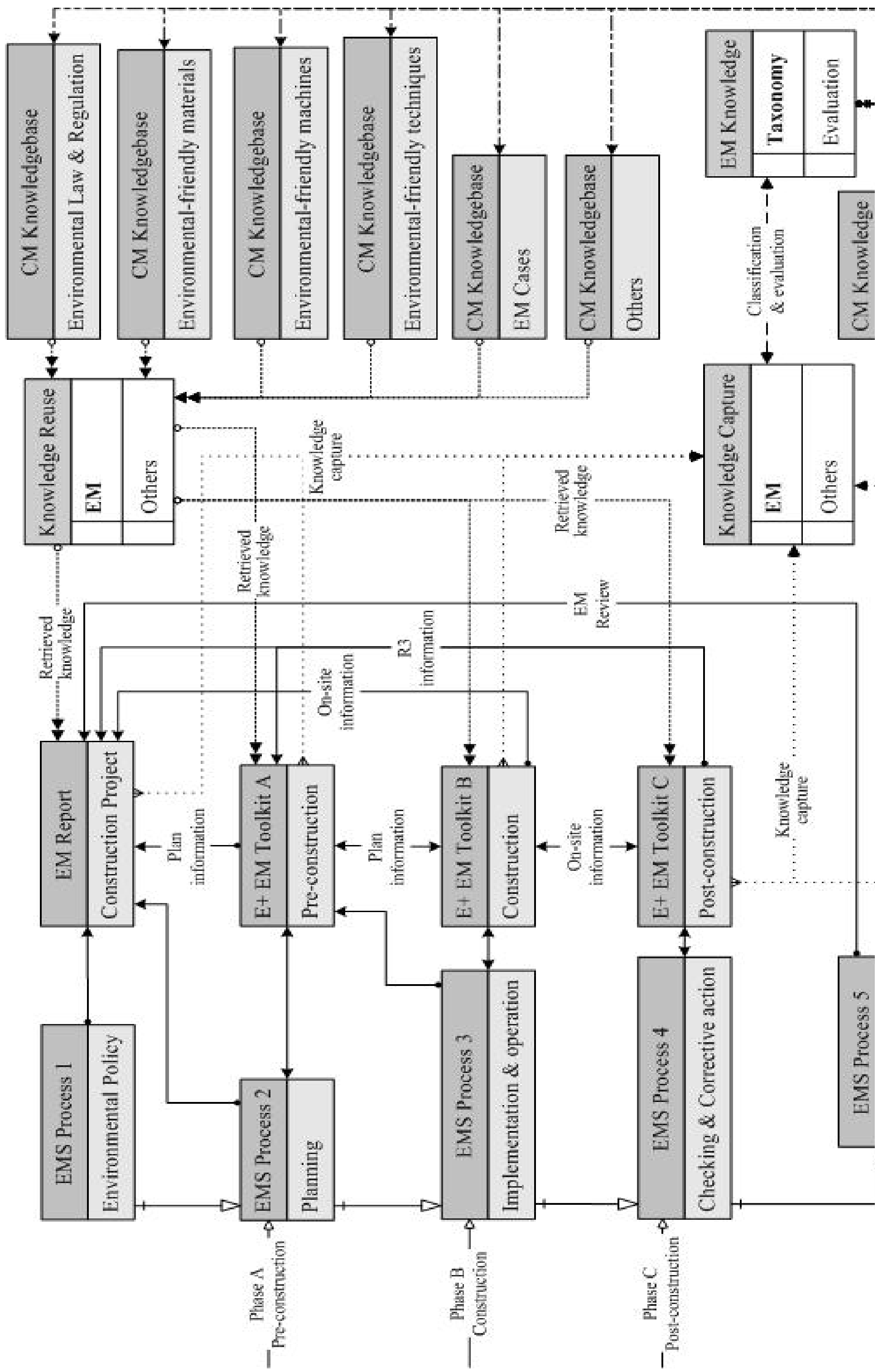
The proposed E+ aims to provide high levels of insight and understanding regarding the EM issues related to the project management in a construction cycle. In fact, current EIA process applied in construction projects is mainly conducted prior to the pre-construction stage when a contractor is required to submit an EIA report/form based on the size and significance of the project, and the EIA process for the construction stage is seldom conducted in normalised forms. Due to the strong alterability of the environmental impacts in the construction cycle, commonly encountered static EIA process prior to construction cannot accommodate the implementation of the EMS in project construction, and a dynamic EIA process is thus designed for the E+. In addition, several EM tools are to be combined with the ISO 14000 Model (ISO, 2002), which is a frame for implementation of the ISO 14000 series, according to their interrelationships with which various EM-related data, information, and knowledge in construction can be captured, organised, and reused (see Figure 1). Because the main task of the EM in the construction cycle is to reduce adverse environmental impacts, the dynamic data transference in the framework is the prime focus of the E+ methodology. Thus, a prototype of the E+ is put forward in Figure 1.

Operation

Operation of the E+ model needs an integrative software environment in which various EM tools can work together with the EMS process. There are three main steps to develop the E+ system (software environment) as follows:

1. Feasibility study. The feasibility study is conducted not only prior to the establishment of the E+ model, but also before the system analysis and realisation of the E+ software environment. First of all, it is important to analyse whether such an E+ system is necessary for the EMS-based dynamic EIA process in project construction, and this is to be done prior to the establishment of the E+ model. Next, if the E+ system is necessary, it is required to search for enough quantitative EM tools to support the E+ system, and this is to be done before the system analysis and development of the E+ system. The feasibility study is essential for both a practicable E+ model and an E3 E+ system.
2. System analysis and realisation. The system analysis and realisation is to be conducted after the E+ model has been established. The aim of this step is to realise the E+ system from a model to a software environment with computer programming. Being limited by the length of this chapter, no further discussion is presented here to illustrate the development of the E+ system.

Figure 1. The prototype of the E+



3. Application test. The application test is a trial process for the developed E+ system. There is also no further discussion related to this step due to the under-construction of the E+ system. However, an experimental case study is conducted to demonstrate the E3 EM function of the E+ system.

The following discussions focussed on several core EM tools adopted in the E+ model, and inter-relationships among these EM tools as to working for the EMS-based dynamic EIA process. The EM tools selected for the E+ model in this chapter include: the CIP approach for adverse environmental impacts indicated at the pre-construction stage, the IRP approach for material management onsite at construction stage, and Webfill approach for residual and waste material and equipment exchange at post-construction stage; no further EM tools will be discussed here.

EM TOOLS FOR THE E+

CPI

The Construction Pollution Index (CPI) (Chen et al., 2000) is an approach to quantitatively measure the amount of pollution and hazards generated by a construction project or a construction process during construction. Because the value of CPI reflects the accumulated amount of adverse environmental impacts generated by a construction project within its project duration, its utilisation in construction planning is easily realised though a CPI histogram, similar to the resource histogram in a Gantt chart used in construction scheduling. By integrating the concept of CPI into a commonly used tool for construction project management such as Microsoft Project, a system to neatly combine EM with project management is then formed, and project managers can use the CPI histogram to identify the periods in which the project will generate the highest amount of pollution and hazards, and reschedule the whole project to level extremely high CPI (Li et al., 2002).

In the E+ prototype, the CPI approach is set to the E+ EM Toolkit A for construction planning at the pre-construction stage (see Figure 1). The E+ EM Toolkit A captures data from three kinds of sources:

- Source one: EMS Process, including EMS Processes 2 and 3.
- Source two: E+ EM Toolkits, including Toolkits B and C.
- Source three: KW of EM, including knowledgebase of environmental law and regulation, environmental-friendly construction materials, environmental-friendly construction machines, environmental-friendly construction techniques, and EM cases.

Meanwhile, the E+ EM Toolkit A transfers data to these three kinds of data sources and the EM report, such as the EIA report of a construction project.

IRP

The Incentive Reward Program (IRP) approach (Chen et al., 2002b) is an approach to quantitatively measure the amount of material waste generated by a construction project or a process during construction.

In the E+ prototype, the IRP approach is set to the E+ EM Toolkit B for construction at the construction stage (see Figure 1). The E+ EM Toolkit B captures data from three kinds of sources:

- Source one: EMS Process 3.
- Source two: E+ EM Toolkits, including Toolkits A and C.
- Source three: KW of EM, including knowledgebase of environmental law and regulation, environmental-friendly construction

materials, environmental-friendly construction machines, environmental-friendly construction techniques, and EM cases.

Meanwhile, the E+ EM Toolkit B transfers data to these three kinds of data sources and the EM report, such as the EIA report of a construction project.

Webfill

The Webfill approach (Chen et al., 2002b) is an e-commerce method to increase the amount of construction and demolition waste exchanged for reuse and recycle among different construction sites and material regeneration manufacturers. As a matter of fact, disposal of C&D waste to landfills usually comes with a monetary charge in many countries (Chen, 2003). For example, to dispose of C&D waste in an orderly manner to disposal facilities by trucks, a trip-ticket system (TTS) was conducted of the Hong Kong construction industry in 1999, which requires contractors to pay for the disposal of their C&D waste in terms of waste disposal receipts issued to them. The Webfill approach sets a TTS-based e-commerce model conforming to the external requirement, and simulation results indicate that the Webfill-enhanced TTS can apparently reduce the total amount of the C&D waste through encouraging the increase of waste reuse and recycle.

In the E+ prototype, the Webfill approach is set to the E+ EM Toolkit C for post-construction work at the post-construction stage (see Figure 1). The E+ EM Toolkit C captures data from three kinds of sources:

- Source one: EMS Process 4.
- Source two: E+ EM Toolkit B.
- Source three: KW of EM, including knowledgebase of environmental law and regulation, environmental-friendly construction materials, environmental-friendly construction machines, environmental-friendly construction techniques, and EM cases.

Meanwhile, the E+ EM Toolkit C transfers data to these three kinds of data sources and the EM report, such as EIA report of a construction project.

Interrelationships

The interrelationships among the EMS process, the EIA process, the EM Toolkit, and the knowledge capture and knowledge reuse processes can be put up in agreement with EM-related data transfers. There are six kinds of EM-related data transfers in the E+ system. The first kind occurs between the EMS process and the EIA process; the second kind occurs among the EM toolkits and the EIA process; the third kind occurs among the various EM toolkits; the fourth kind occurs from the knowledge reuse entity to the EM toolkits and the EIA process; the fifth kind occurs from the EM toolkits, the EIA process, and the EMS process to the knowledge capture entity; and the sixth kind occurs from the knowledge capture entity to the knowledge reuse entity through several essential KWs such as knowledgebase of environmental law and regulation, environmental-friendly construction materials, machines, techniques, and EM cases. Because all these data are generated from different construction stages, integrative data transfer in the E+ system can thus provide up-to-date information to the EIA process, and the dynamic EIA process is realised accordingly. In order to completely clarify the interrelationship potentially existing in the E+ system, some of the EM-related data and their transfers are summarised in Table 1.

AN EXPERIMENTAL CASE STUDY

The experimental case study conducted here combines data such as wastage at different

Table 1. Interrelationship among EM-related data in the E+ system

Data Host	Data Name	Transfer to	Captured from	Usefulness
CPI Host (Toolkit A)	*CPI* and CPI_i	EIA Host and KW	-	Data update for EIA report
	CPI_i	EMS Process 1 and KW	-	Construction planning
	CPI_{waste}	IRP Host and KW	-	Quantity survey of waste
	h_i	KW	KW	Hazard magnitudes
	D_i	KW	KW	Construction duration
	$\Delta Q^i(j)$	-	IRP Host and KW	Wastage rate survey
	Q_{sold} and Q_{bought}	-	Webfill Host and KW	Wastage rate survey
	undefined	-	EMS Process 3&5	Pollution & hazard survey
IRP Host (Toolkit B)	$\Delta Q^i(j)$	CPI Host and KW	-	Wastage rate
	$\Delta Q^i(j)$ and $C^i(j)$	EMS Process 3 and KW	-	Reward
	$\Delta Q^i(j)$	Webfill Host and KW	-	Quantity survey of waste
	CPI_{waste}	-	CPI Host and KW	Wastage rate
	$Q^i_{de}(j)$ and $Q^i_{re}(j)$	-	EMS Process 3&4 and KW	Quantity survey of waste
	Q_{sold} and Q_{bought}	-	Webfill Host and KW	Quantity survey of waste
Webfill Host (Toolkit C)	Q_{sold} and Q_{bought}	IRP Host and KW	-	Quantity survey of waste
	Q_{sold}	EMS Process 4 and KW	-	Quantity survey of waste
	Q_{bought}	EMS Process 3 and KW	-	Deliver to crews
	Q_{sold} and Q_{bought}	CPI Host and KW	-	CPI_{waste}
	undefined	-	IRP Host and KW	Waste for exchange
	undefined	-	EMS Process 4 and KW	Price of waste
EIA Host	*CPI* and CPI_i	-	CPI Host and KW	Data update for EIA report
	$\Delta Q^i(j)$	-	IPR Host and KW	Data update for EIA report
	Q_{sold} and Q_{bought}	-	Webfill Host and KW	Data update for EIA report
	undefined	-	EMS Process 1 and KW	Data update for EIA report
	undefined	-	EMS Process 2 and KW	Data update for EIA report

Note:
1. CPI_{waste} represents the CPI_i that involves waste impact only;
2. Q_{sold} is the quantity of C&D waste a contractor sold; and
3. Q_{bought} is the quantity of regenerated materials or reusable material a contractor bought.

construction stages (Vaid & Tanna, 1997) from several separated cases (Chen et al., 2000, 2002) and authors' experiences with a virtual construction project because there are no data available at present to demonstrate the utilisation of the E+ system from only one construction project. In this case, the aim of this experimental case study focuses mainly on the utilisation of the E+ model. Data adopted are for reference only, although there is practical background to support them. Case studies for real construction projects can be further conducted in the future when the E+ software environment has been realised.

The experimental case study conducted in Table 2 demonstrates the process of the E+ model. The process of the EMS-based dynamic EIA in the experimental case study is divided into three stages corresponding with the construction cycle, including pre-construction stage, construction stage, and post-construction stage (see Table 2). The EM-related data for the EMS-based dynamic EIA provided by the E+ system are different from

Table 2. Case study of the E+ implementation for a dynamic EIA in a construction cycle

		EIA data at different construction stages								
		Pre-construction		Construction				Post-construction		
Construction Tasks	Duration (day)	Original CPI_{waste}	Q_{bought} (ton)	Relay CPI_{waste}	$\Delta Q^i(j)$ (ton)	Q_{sold} (ton)	Q_{bought} (ton)	Final CPI_{waste}	Total Q_{sold} (ton)	Total Q_{bought} (ton)
Caisson Pile	31	0.07	0.0	0.05	0.1	0.1	0.0	0.05	0.1	0.0
Braced Excavation	57	0.13	0.0	0.15	0.5	0.3	0.0	0.10	0.5	0.0
Transportation	435	0.00	0.0	0.05	0.0	0.0	0.0	0.05	0.0	0.0
Support System-Building	42	0.10	22.6	0.12	1.2	0.2	5.5	0.10	0.6	28.1
Support System-Demolition	28	0.60	0.0	0.50	0.0	2.1	10.0	0.45	20.5	10.0
Foundation Construction	43	0.10	0.1	0.20	3.3	3.2	1.1	0.18	5.6	1.2
Structural RC Work-Rebar	155	0.06	3.2	0.05	1.5	5.5	1.8	0.04	6.0	5.0
Structural Work-Form	155	0.36	5.7	0.30	1.2	0.2	1.1	0.28	0.5	6.8
Structural Work-Concrete	156	0.05	0.0	0.03	3.1	5.1	0.0	0.02	5.1	0.0
Mansion Work	176	0.20	0.5	0.10	5.6	3.3	2.3	0.09	3.5	2.8
Structural Steel	94	0.10	0.0	0.01	0.5	0.0	0.0	0.01	0.0	0.0
Finish Work-Wall	211	0.29	0.0	0.18	2.5	3.6	0.0	0.16	3.6	0.0
Finish Work-Ceiling	211	0.39	0.0	0.26	3.2	5.5	0.0	0.25	5.5	0.0
Finish Work-Floor	181	0.12	0.0	0.08	1.7	2.1	3.0	0.07	2.1	3.0
Total		2.57	32.1	2.08		31.2	24.8	1.85	53.6	56.9

stage to stage. At the pre-construction stage, there are two kinds of data for the EIA including the original set of CPIi and the Qbought requested by each crew; at the construction stage, there are four kinds of data for the EIA including the relay set of CPIi, the Qi(j), the Qsold, and the Qbought; and at the post-construction stage, there are three kinds of data for the EIA including a final set of CPIi, a total Qsold, and a total Qbought. Because the functions of current EM tools integrated in the E+ model are different, for example, the CPI approach deals with total adverse environmental impacts of construction processes, while the IRP approach and the Webfill approach deal with the C&D waste only; the CPIi in this case study is thus represented by a CPIwaste, which represents the CPIi that involves waste impact only (see Table 1).

Moreover, the case study puts forward and utilises the concepts of original CPIwaste, relay CPIwaste, and final CPIwaste to demonstrate the process of the EMS-based dynamic EIA, and looks at these three kinds of CPI as essential data in an EIA report. The original CPIwaste means the CPIwaste that is valued before a construction process, the relay CPIwaste means the CPIwaste that is devalued during a construction process, and the final CPIwaste means the CPIwaste that is finally valued after a construction process. Because the value of the CPIwaste is regarded as one important data in an EMS-based EIA process, the changing process of the three kinds of CPIwaste appropriately incarnates or reflects the process of a dynamic EIA. Thus an EMS-based dynamic EIA process is realised.

It is necessary to notice that in order to value each CPIwaste, expert experiences have to be used corresponding to changed amounts of Qsold and Qbought. The expert experiences required are stored in the knowledge reuse entity, which is distilled from crude data in KW including knowledgebase of environmental law and regulation, environmental-friendly construction materials, machines, techniques, and EM cases. Therefore the EM-related construction knowledge effectively supports the process of the EMS-based dynamic EIA.

The result of this experimental case study indicates that the implementation of the E+ system can finally reduce the adverse environmental impacts of project construction. For example, the total value of the original CPIwaste of all construction tasks in the experimental case study is 2.57, the total value of the relay CPIwaste of all construction tasks in the experimental case study is 2.08, and the total value of the final CPIwaste of all construction tasks in the experimental case study is 1.85. That is, the E+ system draws support from several EM tools such as the CPI approach, the IRP approach, and the Webfill approach, and realises an EMS-based dynamic EIA process, while the benefits of various EM tools can be shared within the E+ environment through EM-related data transfer and integrative data, information, and knowledge utilisation.

FUTURE TRENDS

Recommendations on the integrative KMS for environmental-conscious construction come from the usefulness, efficiency, and benefit of the E+ prototype and EM tools, which have been demonstrated in this chapter. However, due to the limitations of current research, it is thus recommended that further research be conducted on both the development of the E+ software environment and the development of more E3 EM tools for the E+ system.

First of all, the E+ model can be further developed to Web-based environmental information and KMS for a contractor to implement EM in construction project management. According to the essential theory and practice of EM in construction, the environmental information is required in construction planning, construction material management, and C&D waste exchange, whilst the EM knowledge in construction is essential to support decision making by using various EM tools. Because both environmental information and EM knowledge are needed in the E+ system, and the Internet is particularly suitable to implement effective and flexible CM by mobile site management units, the key issues of the development of such an E+ system are: how to establish a Web-based software system and enable managers in different construction sites to use and share environmental information and knowledge on the same platform of E+; and how to capture, transfer, and reuse necessary data between the E+ system and current CM system. Moreover, additional functional components such as E+ EIA—besides the E+ toolkits—are also under consideration.

Besides the development of the E+ system, further research is also needed in the development of fully user-oriented EM tools and their integration in the E+ system. The fully user-oriented EM tools can enable a contractor or construction manager to use the EM toolkits easily, without the help of the tool developers. For example, the fully user-oriented tool of CPI can enable them to define the CPI of each construction process in a construction plan and then level the extremely high CPI, whilst the fully user-oriented tool of EnvironalPlanning (Chen, 2003) can enable them to transfer necessary data from construction plan alternatives to an ANP environment and thus select the most environmental-friendly construction plan. In addition to the development of the fully user-oriented EM tools, improvements in the functional-different approaches for EM in construction are also necessary, focusing on the innovation of these approaches. For example, the CPI of a construction process is currently defined by experts' experience, and this treatment is definitely practicable; however, in order to receive a wide recognition and minimise the arbitrary decision or subjective error on the definition of the CPI of each construction process, we suggest development of an objective calculation method to define the CPI of each possible construction process a contractor may use in construction planning. So both the development of the fully user-oriented EM tools and the consummation of current functional-different approaches for EM in construction are required in further research.

Beyond the consummation of the E+ system and its components, additional functional-different approaches for EM in construction are also necessarily to be developed in order to improve the performance of the E+ system. Currently, the potential functional-different approaches to implementation of EM in construction include the life cycle analytical (LCA) approach and risk analytical approach for E+ EM Toolkit A, and the EIA template for the new E+ EIA Toolkit.

Although this research project has been accomplished with satisfying results, there are some limitations not only within the research but also in the duplicate implementation of the EM tools developed in the research. The limitations of the research exist in the following areas:

- This research has not accomplished an E+ software environment to further demonstrate its usefulness, efficiency, and benefit for EM in construction.
- The CPI method has not been developed into a fully user-oriented tool to help contractors deal with any CPI problem in construction planning.

As a conclusion, it is recommended that further research and development for the E+ system focus on the development of a Web-based E+ system, the consummation and innovation of current EM tools in construction, and the development of new EM approaches for the E+ system.

CONCLUSION

This chapter presents an integrative prototype to knowledge-based dynamic EM in construction, which integrates various EM approaches and knowledge bases with a general EMS process throughout all construction stages in a construction project. The EM approaches integrated in the E+ are divided into three categories, including EM Toolkit A for pre-construction, EM Toolkit B for construction, and EM Toolkit C for post-construction. These EM toolkits are further integrated with an ISO 14001 EMS and EM knowledge capture and reuse entities for an integrative KMS for environmental-conscious construction. In addition to the proposed E+ prototype, an experimental case study has also been conducted to demonstrate the usefulness, efficiency, and benefit of the E+ system. The E+ is expected to effectively, efficiently, and economically assist contractors in enhancing both their EM techniques and environmental performances in construction project management, and to overcome the weakness of static EIA formally applied in the construction industry in some countries by the dynamic EIA process where the necessary data for an EIA report can be updated in the construction cycle.

PRACTICAL TIPS AND LESSONS LEARNED

For the efficient management of environment-related knowledge, it is essential to integrate data and information from various dispersed tools and applications. In order to promote the implementation of the E+ model, further research is needed to transfer the E+ model to a computer software environment, improve current EM tools, and develop more EM approaches as subsidiary components of the E+ system to deal with all adverse environmental impacts of construction on the purpose of total EM in construction project management. Although the software environment of the E+ has not been presented in this chapter, the demonstration of the E+ model in the experimental case study enabled a closer understanding of how the E+ system can be effectively applied for EM in construction, and it also unveiled that the E+ methodology is flexible in the integrative implementation of functional-different quantitative approaches to EM in construction.

REFERENCES

Azani, C.H. (1999). An integrative methodology for the strategic management of advanced integrated manufacturing systems. In J. Sarkis & H.R. Parsaei (Eds.), *Advanced manufacturing systems: Strategic management and implementation* (pp. 21-41). Australia: Gordon and Breach Science.

Chen, Z. (2003). *An integrated analytical approach to environmental management in construction.* PhD Thesis, Department of Building and Real Estate, Hong Kong Polytechnic University.

Chen, Z., & Li, H. (2003). An analytic network process model for demolition planning. *Proceedings of the CIB Student Chapters International Symposium on Innovation in Construction and Real Estate*, Hong Kong Polytechnic University, September.

Chen, Z., Li, H., & Wong, C.T.C. (2000). Environmental management of urban construction projects in China. *ASCE Journal of Construction Engineering and Management, 126*(4), 320-324.

Chen, Z., Li, H., & Wong, C.T.C. (2002a). An application of bar-code system for reducing construction wastes. *Automation in Construction, 11*(5), 521-533.

Chen, Z., Li, H., Shen, G.Q.P., & Xu, W. (2002c). An empirical model for decision-making on ISO 14000. *Construction Management and Economics, 22*(1), 55-75.

Chen, Z., Li, H., & Wong, C.T.C. (2002d). Webfill before landfill: An e-commerce model for waste exchange in Hong Kong. *Journal of Construction Innovation, 3*(1), 27-43.

Chen, Z., Li, H., & Wong, C.T.C. (2002e). EnvironalPlanning: An analytic network process model for environmentally conscious construction planning. Accepted for publication in the *ASCE Journal of Construction Engineering and Management.*

Chen, Z., Li, H., & Wong, C.T.C. (2003a). An integrative analytical system for environmental management in construction projects. *Automation in Construction, 13*(5), 621-628.

Chen, Z., Li, H., & Wong, C.T.C. (2003b). E+: An integrative methodology for dynamic EIA in construction. *Proceedings of the 3rd International Post-Graduate Research Conference*, Salford University, Lisbon, Portugal, April.

Chen, Z., Li, H., & Wong, C.T.C. (2003c). Environmental priority evaluation for construction planning. *Proceedings of the 2nd International Conference on Innovation in Architecture, Engineering and Construction (AEC),* Loughborough University, UK, June.

Chen, Z., Li, H., & Wong, C.T.C. (2003d). An integrative methodology for dynamic EM in construction. *Proceedings of the ARCOM Doctoral Workshop*, Glasgow Caledonian University, Glasgow, UK, 18 June.

Chen, Z., Li, H., Wong, C.T.C., & Love, P.E.D. (2002b). Integrating construction pollution control with construction schedule: An experimental approach. *Environmental Management and Health, 13*(2), 142-151.

China EPB (Environmental Protection Bureau). (2002). *Official report on the state of the environment in China.* Retrieved 26 December from www.zhb.gov.cn/bulletin/country_intro.php3.

CIRIA. (1993). *Environmental issues in construction—a review of issues and initiatives relevant to the building, construction and relevant industries. Volume 2—technical review.* Publication Code: SP94. London: Thomas Telford.

CIRIA. (1994). *Environmental assessment.* Publication SP96. London: Thomas Telford.

CIRIA. (1994). *Environmental handbook for building and civil engineering projects: Checklists, obligations, good practice and sources of information.* Publication Code: SP97&98. London: Thomas Telford.

CIRIA. (1995). *A client's guide to greener construction: A guide to help clients address the environmental issues to be faced on building and civil engineering projects.* Publication Code: 120. London: Thomas Telford.

CIRIA. (1999). *Environmental issues in construction—research campaign. Executive summary.* Publication Code: PR74. London: Thomas Telford.

Clough, R.H., & Antonio, N. (1996). *Environmental management in construction: Model forms to assist implementation*. UK: The Chartered Institute of Building (CIOB).

CPSC. (1998). *Environmental management systems—guidelines.* Construction Policy Steering Committee, NSW Government, Australia. Retrieved 26 March from www.cpsc.nsw.gov.au/environment/.

CPSC. (2001). *Construction industry CEO survey: NSW construction industry survey of industry leaders*. Retrieved 26 March from www.cpsc.nsw.gov.au/docs/strategic-info/CEO-Survey-Fax-2001.pdf.

FIDIC. (1998). *Guide to ISO 14001 certification/registration* (test edition). Switzerland: International Federation of Consulting Engineers.

Guthrie, P., & Mallett, H. (1995). *Waste minimisation and recycling in construction: A review.* Publication Code: 122. London: CIRIA.

Henningson, J.C. (1978). Environmental management during construction. *ASCE Journal of the Construction Division, 104*(4), 479-485.

IAIA (International Association for Impact Assessment). (1997). *Principles of environmental impact assessment best practice.* Retrieved 26 March from www.iaia.org/principles/.

Jeljeli, M.N., & Russell, J.S. (1995). Coping with uncertainty in environmental construction: Decision-analysis approach. *ASCE Journal of Construction Engineering and Management, 121*(4), 370-380.

Jones, K.H. (1973). Synthesis approach to determining research needs in civil engineering; air pollution a test case. *ASCE Journal of the Environmental Engineering Division, 99*(4), 461-467.

Kein, A.T.T., Ofori, G., & Briffett, C. (1999). ISO 14000 series: Its relevance to the construction industry of Singapore and its potential as the next industry milestone. *Construction Management and Economics, 17*(4), 449-461.

Khalfan, M.M.A., Bouchlaghem, N.M., Anumba, C.J., & Carrillo, P.M. (2003). Knowledge management for sustainable construction: The C-SanD project. In K.R. Molenaar & P.S. Chinowsky (Eds.), *Winds of change: Integration and innovation in construction. Proceedings of the 2003 Construction Research Congress,* Honolulu, Hawaii, 19-21 March. Reston, VA: American Society of Civil Engineers.

Li, H., Chen, Z., & Wong, C.T.C. (2001). Application of barcode technology for an incentive reward program to reduce construction wastes in Hong Kong. *Computer-Aided Civil and Infrastructure Engineering, 18*, 313-324.

Li, H., Chen, Z., Wong, C.T.C., & Love, P.E.D. (2002). A quantitative approach to construction pollution control based on resource leveling. *International Journal of Construction Innovation, 2*(2), 71-81.

Lippiatt, B.C. (1999). Selecting cost-effective green building products: BEES approach. *ASCE Journal of Construction Engineering and Management, 125*(6), 448-455.

Lo, C.H. (2001). *Critical factors for the implementation of ISO 14001 environmental management system in Hong Kong construction industry.* MSc Thesis, Hong Kong Polytechnic University.

McMullan, R. (1998). *Environmental science in building* (4th edition). Basingstoke, England: Palgrave Macmillan.

Ofori, G., Briffett, C., Gang, G., & Ranasinghe, M. (2000). Impact of ISO 14000 series on construction enterprises in Singapore. *Construction Management and Economics, 18*(8), 935-947.

Petts, J. (1996). *Environmental assessment: Good practice. Proceedings of the Construction Industry Environmental Forum Conference on Good Practice in Environmental Assessment.* Publication Code: SP126. London: CIRIA.

SAP INFO. (2004). *SAP INFO glossary.* Retrieved on 22 July from www.sap.info/public/en/glossary.php4/displayglossarystart.

Shorrock, L. et al. (1993). *Environmental issues in construction—a review of issues and initiatives relevant to the building, construction and related industries. Volume 1—overview including executive and technical summaries.* Publication SP93. London: CIRIA.

Skoyles, E.R., & Hussey, H.J. (1974). Wastage of materials. *Building,* (February), 95-100.

Spivey, D.A. (1974). Construction solid waste. *ASCE Journal of the Construction Division, 100*(4), 501-506.

Tse, R. (2001). The implementation of EMS in construction firms: Case study in Hong Kong. *Journal of Environmental Assessment Policy and Management (JEAPM), 3*(2), 177-194.

Uren, S., & Griffiths, E. (2000). *Environmental management in construction.* Publication Code: C533. London: CIRIA.

USEPA. (1971). *Noise from construction equipment and operations, building equipment, and home appliances.* Washington, DC: Environmental Protection Agency.

Vaid, K.N., & Tanna, A. (1997). *Wastage control of building materials in construction of mass housing projects* (pp. 19-35). Mumbai, India: NICMAR (National Institute of Construction Management and Research).

Valdez, H.E., & Chini, A.R. (2002). ISO 14000 standards and the US construction industry. *Environmental Practice, 4*(4), 210-219.

Velker, L. (1999) Caution: KM under construction—challenges and solutions from a geographically diverse contractor. *KMWorld Magazine, 8*(5).

Warren, F.H. (1973). Environmental impact on project schedules. *ASCE Journal of Professional Activities, 99*(3), 299-306.

Zarli, A., Rezgui, Y., & Kazi, A.S. (2003). Present and future of European research on information technologies in construction. In K.R. Molenaar & P.S. Chinowsky (Eds.), *Winds of change: Integration and innovation in construction. Proceedings of the 2003 Construction Research Congress,* Honolulu, Hawaii, 19-21 March. Reston, VA: American Society of Civil Engineers.

Zeng, S.X., Tam, C.M., Deng, Z.M., & Tam, V.W.Y. (2003). ISO 14000 and the construction industry: Survey in China. *ASCE Journal of Management in Engineering, 19*(3), 107-115.

Zyngier, S.M. (2002). *Knowledge management strategies in Australia: Preliminary results of the survey of the knowledge management uptake in Australian companies.* School of Information Management and Systems, Monash University, Caulfield East, Victoria, Australia.

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Chapter 8.7
MNE Knowledge Management Across Borders and ICT

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INTRODUCTION

Firms are consumers, producers, managers, and distributors of information (Egelhoff, 1991; Casson, 1996) and as such a repository of productive knowledge (Winter, 1988). Consequently the ability to generate, access, and utilize relevant knowledge is an essential organizational activity in order both to reduce uncertainty about the firm's external environment and improve the efficiency of its internal operations.

Particularly for multinational enterprises (MNEs), efficient implementation of knowledge management processes is of competitive importance. In contrast to their set of indigenous competitors, MNEs face liabilities of foreignness (Zaheer, 1995) and a more complex organizational structure that transcends cultures and countries.

Advances in location insensitive information and communication technology (ICT), in particular the Internet's marketspace (Rayport & Sviokla, 1994), could significantly facilitate MNEs' knowledge management efforts. Ease of information gathering, communication, and knowledge management is no longer a strict function of geographical proximity. As a result of the Internet, the location specificity of knowledge (von Hayek, 1945) is becoming less location dependent, and thus less costly. Despite this, the role of the Internet in knowledge management has its limits due to its inherent media characteristics and the aforementioned liabilities particular to the operations of MNEs.

This article explores the possibilities and limitations of the Internet in supporting knowledge management in the specific context of MNEs. It is structured as follows. First we will provide a background to the article by discussing and defining the specifics of MNEs, MNEs' knowledge management challenges, and the specifics of the Internet. Subsequently the article will analyze and explore the potential impact of the Internet on MNEs' knowledge management processes. A discussion of future trends and an overall conclusion close the article.

BACKGROUND

Global trade has grown 16-fold since the 1950s, by far outstripping the growth in GDP (Economist, 1998). A key driving force behind this trend is foreign direct investment (FDI), whereas FDI is defined as an acquisition of an asset in a foreign country (host country) made by an investor in another country (home country) with the intention to manage this asset (WTO, 1996). MNEs are the main driver behind FDI. Although definitions vary, an MNE can be defined as a firm that is engaged in FDI in several countries outside its home country (for a more detailed discussion the reader might refer to, e.g., Vahlne & Nordström, 1993; Rugman & Verbeke, 2004).

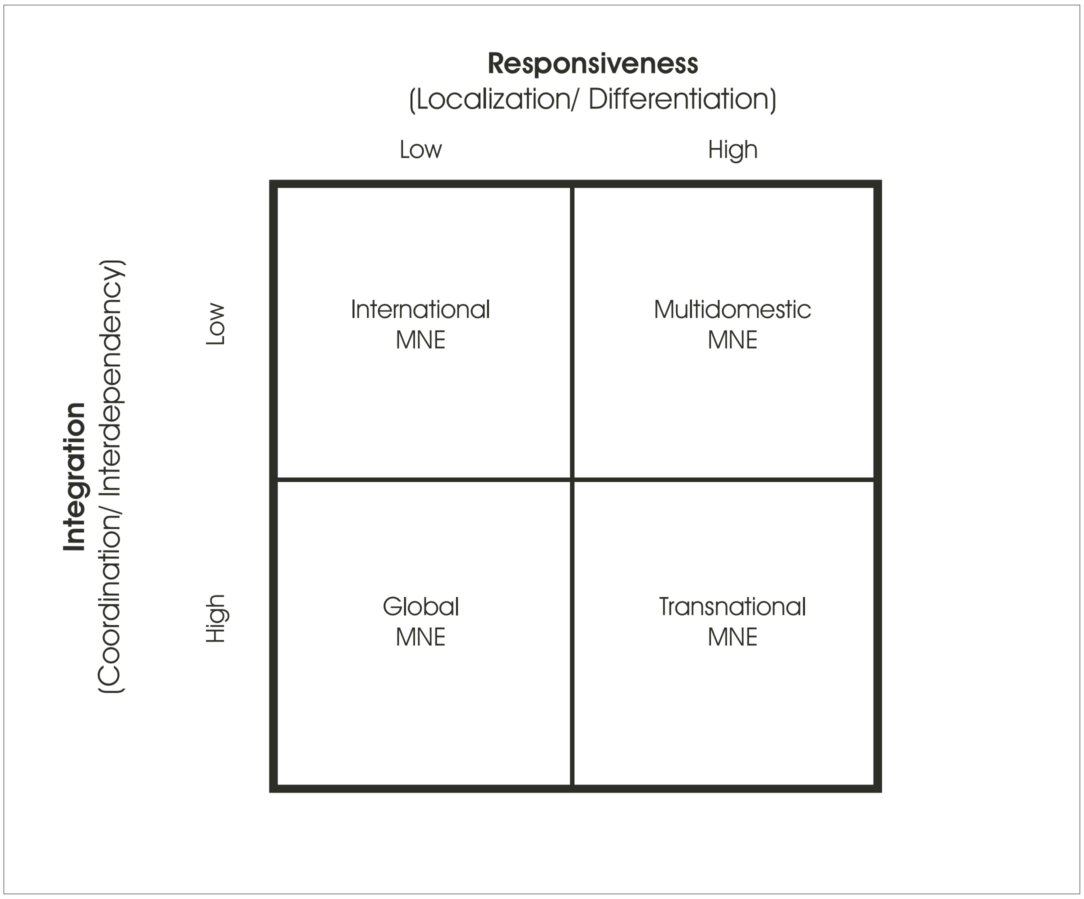
Before discussing the specific knowledge management challenges of MNEs and the role of the Internet therein, it is vital to understand why MNEs exist at all. International business theory has addressed this. The core idea of international trade theory—the idea of market imperfections—was utilized by international business researchers to explain international activities at the firm level by projecting these imperfections into the firm. This helped to explain the emergence and existence of MNEs, as opposed to firms only trading with each other by means of importing and exporting. In 1960 (published in 1976), Hymer's market imperfections theory in essence postulated that firm specific advantages like technology and management skills are the core source enabling firms to successfully operate abroad, offsetting cost and information advantages enjoyed by indigenous firms. Hymer's idea was then further refined and developed by Buckley and Casson (1976) to become internalization theory. Buckley and Casson conceptualized the MNE as a firm that responds to pre-product or intermediate-product market imperfections by internalizing these markets (like components, semi processed goods, knowledge, skills, and technology) across national boundaries (via FDI). Internalization means that a firm makes use of its organizational hierarchy and in-house resources to manage a specific business transaction as opposed to buying it on the market. By internalizing the transfer of a firm's assets and capabilities, firms mitigate transfer problems and at the same time exploit their internal advantage(s) internationally.

At the heart of internalization is the management of knowledge-related imperfections (Kogut & Zander, 1993), which makes effective knowledge management a central task for MNEs. Knowledge management within MNEs is about two interrelated tasks:

1. Knowledge management within the MNE (intra-MNE) which focuses on continuous knowledge creation, transmission, use, and retention between and within headquarters and subsidiaries.
2. Interface knowledge management (extra-MNE) which is about the continuous identification of the MNEs' external knowledge environment, its scanning, the collection of relevant external knowledge, and synthesis with existing intra-MNE knowledge.

This categorization can be related to types of MNEs (see Figure 1). Intra-MNE knowledge management mainly relates to the integration di-

Figure 1. Types of MNEs



Source: Derived from Harzing's MNE typology synthesis (Harzing, 1997)

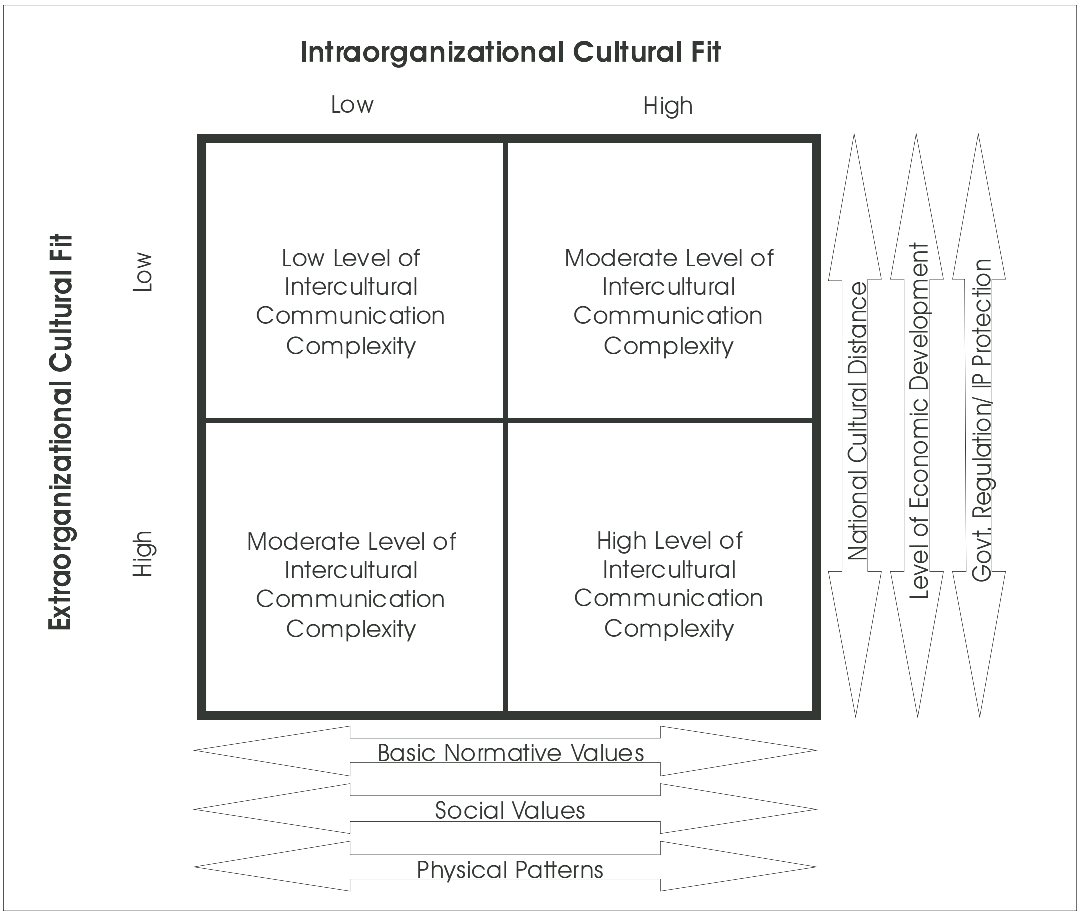
mension, and extra-MNE knowledge management mainly relates to the responsiveness dimension. Obviously, as an MNE moves from low to high on both dimensions, knowledge management (intra- and extra-MNE) requirements increase.

This article will focus on the first knowledge management task (intra-MNE knowledge; integration), because it is unique to MNEs.

The key challenge for intra-MNE knowledge management is knowledge transmission (Kogut & Zander, 1993). Transmitting knowledge is costly (Teece, 1977). The more tacit—or personal (Polanyi, 1958)—and complex the information, the more difficult and expensive it will be to transmit it. This is so because the codification and teaching costs in the transmission process increase as tacitness and complexity increases. Transmitting knowledge across different cultures and countries further increases the costs due to different norms, habits, languages, and interpersonal processes that can inhibit communication flows (Johanson & Vahlne, 1977). These differences operate at two levels, the intra-organizational level and the extra-organizational level, both defining the communication complexity in the knowledge transmission process (see Figure 2). While the former refers to differences between the different organizational cultures within MNEs (mainly headquarters to subsidiary/-ies), the latter refers to differences at the national level (home country to host country/-ies). However, the intra-MNE transfer of knowledge can be eased by the development of a common understanding and of capabilities—combinative capabilities according to Kogut and Zander (1993)—how to manage this transmission. Such development emerges—via repeated interactions—over time in the form of organizational routines.

Before analyzing how the Internet's marketspace could impact the intra-MNE knowledge management process, an evaluation of the marketspace is required.

Figure 2. Intercultural MNE communication matrix



Source: Derived from Harvey and Griffith (2002)

Whereas the marketplace represents the physical world of resources, the marketspace represents the virtual world of digitized information (Rayport & Sviokla, 1994). The most evident and widely known manifestation of the marketspace is the Internet. Following key elements of December's (1996) definition, the Internet can be defined as:

- Computer-mediated communication, including
- information dissemination and
- information retrieval that
- involves data (bits) exchanges taking place on the
- global collection of computer networks using
- the TCP/IP protocol suite for data transfer.

The information content can involve a broad range of data types (text, graphics, images, sound, video), and various forms of open and closed (in the case of intranets and extranets) information processes (one-to-one, one to many; asynchronous, synchronous) are possible. The Internet can thus be used by organizations such as MNEs to process, distribute, and retrieve codified knowledge, and it can be used to interact (communicate) with others. To express this, the terms "information pull," "information push," and "interaction" are introduced. Information pull refers to organizational activities related to synchronously or asynchronously pulling information from the Internet (or intranet, extranet). Information pull can be active or passive, with, for example, searching the Web referring to the former and subscribing to mailing lists referring to the latter. Subscribing to corporate mailing lists is a passive, non-specific information pull activity, because the subscriber does not know exactly what specific kind of information he or she receives prior to subscribing.

On the other hand, information push refers to organizational activities related to pushing information onto the Internet (or intranet, extranet). Active information push refers to organizations actively marketing their information push activities. In contrast, passive information push refers to organizations setting up Web sites without any internal or external promotions.

Interaction is the Internet's third potential use for organizations. The main difference between information push/pull and interaction is that interaction involves non anonymous, asynchronous or synchronous personal exchange of information between known communication parties. Both information pull and information push is at least partially anonymous. Interaction as understood here means mediated personal interaction between known users or parties. When an organization pushes corporate information onto the Internet, it does not know ex ante who might actually retrieve and read its content. The same applies for posting non personalized messages to newsgroups or mailing lists, because the sender does not know in advance who will read his message and who will not. In addition, the sender does not know the identity of all the receivers, unless he is the initiator and owner of the mailing list requiring subscribers to reveal their identity during the subscription process. The same applies in the case of information pull. Although users accessing a Web page or Internet-based databases leave "digital fingerprints" (Drèze & Zufryden, 1997) and Web sites can send so-called "cookies" to users accessing a Web page, users pulling information from the Internet can remain anonymous if they wish to by refusing cookies or by using anonymizer software. In contrast, interaction as defined here involves the one-to-one or one to many exchange of information between pre-specified and known parties. The defining element of interaction is value exchange between known parties.

All of the aforementioned three use categories are interrelated, with information pull activities potentially being influenced by and leading to information push activities and interaction activities, and vice versa. Also, the three uses relate to similarly interrelated activities taking place in the non mediated marketplace.

MAIN FOCUS OF THE ARTICLE

Although the role of ICT in organizations in general has been the focus of studies since the 1970s (e.g., Pfeffer & Leblebici, 1977), little is known about the specific role of ICT in cross-cultural contexts (e.g., St.Amant, 2002; Weisinger & Trauth, 2002) and MNE operations (e.g., Petersen & Welch, 2003). With the background provided in the previous section, it is possible to explore possible effects of the Internet's marketspace on intra-MNE knowledge management.

Knowledge management scholars have identified four dynamically interacting processes how organizational knowledge is created and transmitted (Nonaka, 1991). The first process—termed "socialization"—is about tacit-to-tacit knowledge transfers. The traditional German apprenticeship system is an example of such a transfer. An apprentice learns via observation, imitation, and practice. In this process he or she "imports" the tacit knowledge base of the master which becomes his or her own tacit knowledge. The second knowledge transfer process is "articulation," whereby explicit or codified knowledge is directly transferred to become explicit knowledge elsewhere. An example of such a process would be an individual recombining a set of coded knowledge such as a financial report into a different document. The third and fourth processes are about transformative transfers, whereby explicit knowledge in turned into tacit knowledge or vice versa. The tacit-to-explicit transfer is called "combination." Combination takes place when an individual articulates his or her tacit knowledge base, thereby converting it into explicit knowledge that can be shared with others. Finally, "internalization"—a technical term in the knowledge management literature that has a different meaning to the one in the international business context—is the explicit-to-tacit process of knowledge transfer. This process takes place when employees use the explicit organizational knowledge available, for example in the form of a database, to extend their own tacit knowledge.

How could the Internet support or enhance these four processes in the case of intra-MNE knowledge management?

On the one hand, the answer lies in an understanding of the differences between mediated and unmediated communication. On the other, an appreciation of cultural differences in communication is required. With regards to the former, rational media choice theories, such as social presence theory (Short, Williams, & Christie, 1976) and media richness theory (Daft & Lengel, 1986) postulate that an individual determines his or her choice of media by rationally assessing the requirements of a communication task and selecting an appropriate medium matching these requirements. Media is categorized along a continuum based on the channel's information richness, which depends on the medium's ability for immediate feedback, the number of carried cues, the number of channels utilized, its language variety, and its level of personalization capable of reducing equivocality. This set of theories postulates that the higher the perceived need for social cues and equivocality reduction in a communication situation, the higher the likelihood of face-to-face communication, the richest mode of information exchange with the highest degree of social presence. This would, for example, be the case in tacit-to-tacit knowledge transfers ("socialization"). In contrast, the Internet is considered less information rich. It follows that the reduction in channel capacity on the Internet compared to face to face communications makes knowledge transfers more difficult despite its cost-reducing properties in general.

Mixed empirical findings regarding the predictive validity of the rational media choice theories (e.g., Markus, 1994; Walther, 1996; Ngwenyama & Lee, 1997) have led to the development of social influence models of communication technology use (e.g., Ngwenyama & Lee, 1997). The social influence models of communication technology use all regard information richness or leanness in communications not as attributable to the properties of the communication medium alone, but as emerging from the interaction between people and contexts. According to this school of thought, media choice is influenced by the attitudes and behaviors of others, as well as norms that have developed within a group, within organizations, or across organizations. Hence, media perception is not fixed, but it varies across people, organizations, situations, tasks, time, and user experience with the medium. Because these models make no a priori assumption about any direct relationships between communication richness and the quantity of social cues (Ngwenyama & Lee, 1997), they in essence detach the message from the medium. Any message can be rich (or lean) relatively independent of the medium, more dependent upon the users' experience with the medium, their experience with the communication topic, and their experience with the communication partner or the communication context (Carlson & Zmud, 1999). Communication richness is therefore an outcome of social behavior, not solely an outcome of the nominal, rationally determined media richness of the communication channel. All this implies that although the amount of social information per communication act via the Internet is lower compared to face to face communication, it is more the rate of social information exchange than the amount of social cues exchanged that constitutes the key difference between the two forms of communication (Walther, 1996). Compared to non mediated communication, the exchange of social cues is "just" temporally retarded. Hence, informal, interpersonal communication can take place over computer-mediated communication channels, as user experience with the medium, the topic, the communication partner, and the communication context accumulates and increases. This phenomenon has been termed the "channel expansion effect" (Carlson & Zmud, 1999). But when first exposed to new media such as the Internet, it is likely that people's need for unmediated, face-to-face interactions increases (Nohria & Eccles, 1992).

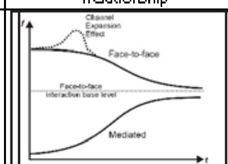
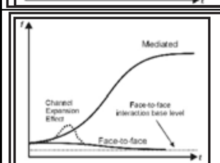
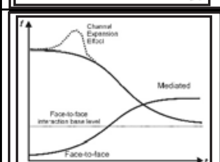
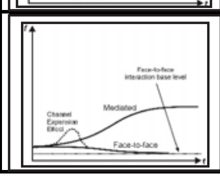
A similar, albeit media-independent expansion effect can be observed within the organizational context of the MNE. As described by Kogut and Zander (1993), the personnel of the MNE must share a similar background and organizational culture in order to be able to encode and decode messages—in any of the four processes described above—correctly, otherwise misunderstandings will arise. Such capability, constituting the MNEs' transactional ownership-advantage (Dunning & Rugman, 1985), is MNE specific and only emerges over time through repeated interactions.

Considering communication differences across cultures is the second aspect that requires attention to understand how the Internet could support or enhance the four processes of intra-MNE knowledge management (see Figure 2). Hall's work on intercultural communication (Hall, 1976, 1983) provides a suitable framework that has been applied widely in similar research contexts, especially its contextual dimension (e.g., St.Aman, 2002; Zakaria, Stanton, & Sarker-Barney, 2003; Matveev & Nelson, 2004). The contextual dimension in Hall's framework represents the ways in which information is perceived, exchanged, and used by people from different cultures. Hall categorized cultures on a high- to low-context continuum. Low-context cultures such as those in the United States, Germany, and Scandinavian countries tend to present and exchange information in an explicit and direct manner. The implicit assumption is that little or no contextual overlap with the receiver is required, because all necessary information is vested in the explicit code (i.e., words) used. In contrast, high-context cultures such as those in Japan, China, Russia, and Latin America tend to rely less on coded, explicit communication. In such cultures most of the actual information content resides within the physical and situational context, as well as inside the communication parties. Less explicit information exchange is the natural consequence. Research has shown that such cultural differences also impact the way people go about their information pull, push, and interaction tasks, whether ICT mediated or unmediated (e.g., Straub, Keil, & Brenner, 1997; Pook & Füstös, 1999; Kersten et al., 2003; Pauleen, 2003; Zakaria et al., 2003).

Considering these different aspects, it becomes evident that it is likely that the relative role of Internet versus face-to-face-based knowledge management processes depends on the type of knowledge transfer process; the MNEs employees' experience with the Internet and its three generic uses; the employees' experience in transferring, absorbing, and using intra-MNE knowledge; and the intercultural communication complexity. Table 1 provides an overview.

For tacit-to-tacit transfers, the role of the Internet is the most limited, and only one of the three generic uses apply. Unmediated face-to-face interactions will play the dominant role with the highest base level, particularly in complex communication situations that require very personal communication strategies (Harvey & Griffith, 2002). Only over time, as the previously mentioned expansion effects occur and the emergence of an organizational communication culture reduces communication complexity, will the interac-

*Table 1. Knowledge management aspects, culture, ICT, and MNEs**

Process	Culture		Role of the Internet#			Face-to-face#	Relevance for MNE Type				Hypothesized, Stylized Relationship
			Pull#	Push#	Interaction #		International	Multidomestic	Global	Transnational	
Tacit-to-Tacit ("socialization")	Intercultural Communication Complexity	High	–	–	Low	High	Low	Low – Medium	Medium – High	High	
		Low	–	–	Low → Medium	High → Medium					
Explicit-to-Explicit ("articulation")	Intercultural Communication Complexity	High	Medium	Medium	Medium	Medium	Low	Low – Medium	Medium – High	High	
		Low	Medium → High	Medium → High	Medium → High	Low → Low					
Tacit-to-Explicit ("combination")	Intercultural Communication Complexity	High	–	Low	Low	High	Low	Low – Medium	Medium – High	High	
		Low	–	Low → Medium	Low → Medium	High → Medium					
Explicit-to-Tacit ("internalization")	Intercultural Communication Complexity	High	Low	–	Low	Low	Low	Low – Medium	Medium – High	High	
		Low	Low → Medium	–	Low → Medium	Low → Low					

tion use of the Internet increase and the role of unmediated interactions decrease. An exception to this trajectory is a surmised initial increase in face-to-face interaction (Nohria & Eccles, 1992). The overall shift over time will be of a complementary rather than fully substitutive nature (Kraut, Steinfield, Chan, Butler, & Hoag, 1998), especially in high-context cultures (Zakaria et al., 2003). A video conference over the Internet with an instructor practically demonstrating procedural knowledge is an example of a tacit-to-tacit knowledge transfer.

Explicit-to-explicit transfers are the stronghold of the Internet. All three generic uses apply, the frequency of use is the highest, and the face-to-face base level is the lowest. Codified organizational knowledge such as a blueprint stored in an Internet-enabled database is an example. Here, the need for unmediated communication is rather low, with the exception of complex intercultural communication situations. In addition, the need for unmediated communication might increase initially to achieve source credibility and trust.

For tacit-to-explicit transfers, only the push and interaction use of the Internet applies and its relative role lies somewhere between the two processes previously discussed. Turning uncodified, personal knowledge into codified knowledge requires richer, unmediated communication, particularly initially and in culturally dissimilar contexts. However, similar to tacit-to-tacit transfers, expansion effects might reduce the relative importance of unmediated interactions over time. As previously mentioned, an initial increase in face-to-face interactions (Nohria & Eccles, 1992) might be an exception to this. An example of such a transfer over the Internet would be an employee who publishes (pushes) an installation guide that incorporates his experience in installing the described piece of machinery on an MNE's best practice intranet site.

In the case of explicit-to-tacit transfers, both media play a limited role, with the influence of the Internet's pull and interaction use likely to increase over time as users gain expertise in pulling the right set of information from the medium and in interacting with colleagues from different countries. Here the relative role of the Internet for the MNE is similar to its role in the tacit-to-explicit transfer. The two differences are that the pull use of the Internet applies while the push use does not and that the overall use frequency of both media is lower. Internalization is more of a media-independent internal human learning process where mainly the source—face-to-face or mediated—matters. An example would be an employee in a subsidiary who downloads a new manual containing work rules that he or she will subsequently use in the daily work. Over time the explicit, codified knowledge is absorbed and becomes part of the employee's personal, tacit knowledge base.

As indicated in Table 1, the importance of these effects depends on the MNE type and the associated importance of intra-MNE knowledge management (see Figure 1 and Table 1). If integration is low, the relevance and role of the Internet is limited. If integration is high, the Internet can facilitate intra-MNE knowledge management as described above. In addition, the MNE's overall strategic intent regarding knowledge management matters. If a personalization strategy rather than a codification strategy is followed (Hansen, Nohria, & Tierney, 1999), the role of the Internet will be more limited.

FUTURE TRENDS

The importance of knowledge management in MNEs will increase in the future. As economies' value add shifts to services and knowledge becomes the key asset for firms, productive use of organizational knowledge becomes the main challenge (Drucker, 1999). Moreover, as the international integration of economies increases, cross-cultural communication competence becomes an increasingly important aspect in knowledge management. Research has demonstrated its positive impact on performance (Matveev & Nelson, 2004). What is less clear is how the role of the Internet will change in the future and how this relates to knowledge management within MNEs. Even its present role in knowledge management processes is not well understood. The Internet is a very dynamic and innovative medium, and its capabilities have significantly improved over time, including faster network connections. Therefore one could speculate that the role of the Internet will expand further. As mobile access to the Internet improves, individuals' and organization's skills in using it improve, and its bandwidth further expands richer information can be transmitted. This will reduce—albeit not completely substituting—the need for unmediated communication in the knowledge transmission process. Real time, virtual reality conferencing between headquarters and subsidiaries is but one example. Additionally, as global Internet diffusion further increases, cultural differences might matter less and lead to the emergence of a meta-culture that transcends location-bound aspects of culture in communication.

Yet it is important to understand that the Internet is "only" an infrastructure technology available to every MNE. In other words, it is a competitive necessity, not a source of competitive advantage per se. Only if the MNE integrates the Internet seamlessly into its culturally sensitive knowledge management processes, leveraging its resource-related and transaction-related advantages, will the Internet enable MNEs to sustain their competitive advantage. An understanding of the Internet's limitations and strengths as discussed above will help.

CONCLUSION

This article explored the possibilities and limitations of the Internet in supporting intra-MNE knowledge management. As was shown theoretically, the Internet can support such management tasks, assuming that personal relationships among employees and a joint understanding of the organizational context and culture have developed. Over time, as experience with the medium, the exchange partner, and the exchange context increases, this role becomes more prominent. Despite this, unmediated communication remains of importance. Especially in complex intercultural communication situations, in the early phases of knowledge transmission processes, and in cases where tacit knowledge is dominant, the Internet's current role is more limited. In addition, the nature of the MNE matters. Especially for MNEs that manage a highly interdependent network of subsidiaries with a high level of integration, efficient use of the Internet is imperative to stay competitive. With this in mind, a more differentiated role of the Internet in intra-MNE knowledge management processes emerges. Neither will it completely obsolete distance and the location-dependency of knowledge, nor will it play no role in knowledge management (for the latter argument see, for example, McDermott, 1999).

Although this middle-of-the-road position might be logically appealing, future research should test these conclusions. Thus far, empirical evidence in this area is scant and mainly anecdotal. Can the hypothesized relationship be found in MNEs? What are the antecedents and consequences of face-to-face versus Internet-mediated knowledge management processes? Does intercultural complexity moderate or mediate antecedents and consequences of media use in knowledge management processes? What overall organizational impact could be expected? Will it lead to—or be the result of—smaller MNEs and/or more decentralized MNEs and/or more integrated MNEs (for such findings in general, see Brynjolfsson, Malone, Gurbaxani, & Kambil, 1994; Dewan, Michael, & Min, 1998)? So far, these questions have not been answered.

REFERENCES

Brynjolfsson, E., Malone, T.W., Gurbaxani, V., & Kambil, A. (1994). Does information technology lead to smaller firms? *Management Science, 40*(12), 1628-1644.

Buckley, P.J., & Casson, M.C. (1976). *The future of the multinational enterprise.* New York: Holmes & Meier.

Carlson, J.R., & Zmud, R.W. (1994). *Channel expansion theory: A dynamic view of media and information richness perceptions.* Academy of Management, Best Papers (pp. 280-284).

Casson, M.C. (1996). The nature of the firm reconsidered: Information synthesis and entrepreneurial organization. *Management International Review, 36*(Special Issue I), 55-94.

Daft, R.L., & Lengel, R.H. (1986). Organizational information requirement, media richness and structural design. *Management Science, 32*(5), 554-571.

December, J. (1996). Units of analysis for Internet communication. *Journal of Communication, 46*(1), 14-38.

Dewan, S., Michael, S.C., & Min, C.-K. (1998). Firm characteristics and investments in information technology: Scale and scope effects. *Information Systems Research, 9*(3), 219-232.

Drèze, X., & Zufryden, F. (1997). Testing Web site design and promotional content. *Journal of Advertising Research, 37*(2), 77-91.

Drucker, P.F. (1999). Knowledge-worker productivity: The biggest challenge. *California Management Review, 41*(2), 79-94.

Dunning, J.H., & Rugman, A.M. (1985). The influence of Hymer's dissertation on the theory of foreign direct investment. *American Economic Review, 75*(2), 228-236.

Economist. (1998). Survey world trade—time for another round. *The Economist,* (October 3).

Egelhoff, W.G. (1991). Information processing theory and the multinational enterprise. *Journal of International Business Studies, 22*(3), 341-368.

Hall, E.T. (1976). *Beyond culture*. Garden City, NY: Anchor.

Hall, E.T. (1983). *The dance of life: The other dimension of time.* Garden City, NY: Anchor.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review,* (March-April), 106-116.

Harvey, M.G., & Griffith, D.A. (2002). Developing effective intercultural relationships: The importance of communication strategies. *Thunderbird International Business Review, 44*(4), 455-476.

Harzing, A.-W. (1997). An empirical analysis and extension of the Bartlett and Ghoshal typology of multinational companies. *Journal of International Business Studies, 31*(1), 101-120.

Hymer, S.H. (1960). *The international operations of national firms: A study of direct investment*. PhD thesis, Massachusetts Institute of Technology, USA.

Johanson, J., & Vahlne, J.-E. (1977). The internationalization process of the firm—a model of knowledge development and increasing foreign market commitments. *Journal of International Business Studies, 8*(1), 23-32.

Kersten, G.E., Koeszegi, S.T., Vetschera, R. (2003). The effects of culture in computer-mediated negotiations. *Journal of Information Technology Theory and Applications, 5*(2), 1-28.

Kogut, B., & Zander, U. (1993). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies, 24*(4), 625-645.

Kraut, R., Steinfield, C., Chan, A., Butler, B., & Hoag, A. (1998). Coordination and virtualization: The role of electronic networks and personal relationships. *Journal of Computer-Mediated Communication, 3*(4). Retrieved August 5, 2000, from http://jcmc.huiji.ac.il/vol3/issue4/kraut.html

Markus, M.L. (1994). Electronic mail as the medium of managerial choice. *Organization Science, 5*(4), 502-527.

Matveev, A.V., & Nelson, P.E. (2004). Cross cultural communication competence and multicultural team performance—perceptions of American and Russian managers. *International Journal of Cross Cultural Management, 4*(2), 253-270.

McDermott, R. (1999). Why information technology inspired but cannot deliver knowledge management. *California Management Review, 41*(4), 103-118.

Ngwenyama, O.K., & Lee, A.S. (1997). Communication richness in electronic mail: Critical social theory and the contextuality of meaning. *MIS Quarterly, 21*(2), 145-167.

Nohria, N., & Eccles, R.G. (1992). Face-to-face: Making network organizations work. In N. Nohria & R.G. Eccles (Eds.), *Networks and organizations: Structure, form, and action* (pp. 288-308). Boston: Harvard Business School Press.

Nonaka, I. (1991). The knowledge creating company. *Harvard Business Review,* (November-December), 96-104.

Pauleen, D.J. (2003). Lessons learned crossing boundaries in an ICT-supported distributed team. *Journal of Global Information Management, 11*(4), 1-19.

Pook, L., & Füstös, J. (1999). Information sharing by management: Some cross-cultural results. *Human Systems Management, 18,* 9-22.

Petersen, B., & Welch, L.S. (2003). International business development and the Internet, post-hype. *Management International Review, 43*(Special Issue I), 7-29.

Pfeffer, J., & Leblebici, H. (1977). Information technology and organizational structure. *Pacific Sociological Review, 20*(2), 241-261.

Polanyi, M. (1958). *Personal knowledge: Towards a post critical philosophy.* Chicago: Chicago University Press.

Rayport, J.F., & Sviokla, J.J. (1994). Managing in the marketspace. *Harvard Business Review,* (November-December), 141-150.

Rugman, A.M., & Verbeke, A. (2004). A perspective on regional and global strategies of multinational enterprises. *Journal of International Business Studies, 35*(1), 3-18.

Short, J., Williams, E., & Christie, B. (1976). *The social psychology of telecommunication.* London: John Wiley & Sons.

St.Amant, K. (2002). When cultures and computers collide—rethinking computer-mediated communication according to international and intercultural communication expectations. *Journal of Business & Technical Communication, 16*(2), 196-214.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. *Information and Management, 33*, 1-11.

Teece, D.J. (1977). Technology transfer by multinational firms: The resource cost of transferring technological know-how. *Economic Journal, 87,* 242-261.

Vahlne, J.-E., & Nordström, K.A. (1993). The internationalization process: Impact of competition and experience. *The International Trade Journal, 7*(5), 529-548.

Walther, J.B. (1996). Computer-mediated communication: Impersonal, interpersonal, and hyper-personal interaction. *Communication Research, 23*(1), 3-43.

Weisinger, J.Y., & Trauth, E.M. (2002). Situating culture in the global information sector. *Information Technology & People, 15*(4), 306-320.

Winter, S.G. (1988). On Coase, competence, and the corporation. *Journal of Law, Economics and Organization, 4*(1), 163-180.

WTO. (1996, October 16). *Trade and foreign direct investment.* Report by the WTO Secretariat.

von Hayek, F.A. (1945). The use of knowledge in society. *American Economic Review, 35*(4), 519-530.

Zaheer, S. (1995). Overcoming the liabilities of foreignness. *Academy of Management Journal, 38*(2), 341-363.

Zakaria, N., Stanton, J.M., & Sarker-Barney, S.T.M. (2003). Designing and implementing culturally sensitive IT applications: The interaction of culture values and privacy issues in the Middle East. *Information Technology & People, 16*(1), 306-320.

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Chapter 8.8
Knowledge Management in Tourism

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INTRODUCTION

Management greatly depends on knowledge, and its detection, creation, transmission, and number of intangibles play a fundamental role in success.

In tourism, information systems must work on immaterial concepts and take steps to satisfy the expectations of multiple potential customers. These systems require complex models of reality and suitable conceptual tools to work out strategies.

This article expounds the use of different mathematical and management techniques that can be applied to the modeling, application, and control of strategic and operative management.

BACKGROUND

Data, Information, and Knowledge

These three concepts, which are frequently used as synonyms, are different representation stages of reality and its apprehension enables us in different ways.

Data, as simple representations, do not tell us much about themselves unless they are related to other data. It is from this relation that we get information.

Information is useful because of the possibility of intervention (e.g., cause–effect relationships), which is provided by knowledge.

What is knowledge? Knowledge can be understood as representation, production or estate

(Marakas,1999). In relation to this definition, any of the aforementioned concepts are, generically, knowledge. The definition of knowledge will depend on the usage and application of the term.

If we consider knowledge as "behavior support" (Lopez, 1999)—sharing perceptions in a socioeconomic system by means of the knowledge of goals, means, and evaluation of accomplishments—it will be easier to accomplish it effectively and efficiently.

If we consider knowledge taxonomically, we could derive, by means of appropriate processes, a linguistic and assimilative level of conceptualization and shared understanding from a primary level (descriptive, procedural, and rational). Hence, the possibilities of organization management success will be improved. Concepts such as "mission" are hard to explain, as its vagueness facilitates a certain mission to be attractive to many people who, at the same time, give their own meaning to it that does not always coincide with that of the others. The same happens with the comprehension of different functions, qualities, or behaviors, which must be shared by numerous actors.

The information systems meant to communicate knowledge vary according to what we want to transmit. However, it is always necessary to reduce ambiguity and unify concepts.

The following four types of formal systems can be distinguished (Simon, 1995):

a. of beliefs
b. of limit setting
c. of diagnosis control
d. of interactive control

In any of these, knowledge can be represented, generated, or established in different states, according to its usage, relationship, and application. For example, a certain number of guests in a hotel may be rather meaningless, but if we add the capacity, the date, and the category of the hotel to the number of people, it will have different meanings for the owner, the competitor or a new guest. These meanings will be influenced by, among other factors, the vision, the knowledge, and the expectations of the people involved. In this way, we will build up representation models, whose complexity will favor or damage our decisions according to our ability to deal with them.

Knowledge as Representation: The Indicators

If we take the concept "intellectual capital" to mean useful knowledge, which we develop "increasing the human capital" (Olve, Roy, & Wetter, 2000), it is obvious that people's knowledge varies from individual to individual. It is necessary to "translate the vision and the strategy into goals and indicators, through a well-balanced set of perspectives" (Kaplan & Norton,1999). The indicators will give the necessary homogeneity to the perceptions of those who have to make decisions in relation to the reality given by the indicator as well as its interpretation (i.e., people's subjective judgment).

Knowledge as Production

The occurrence of events, their measuring by means of indicators, and their processing provide elements of judgments, references, parameters, and interpretation of the reality on which decisions are made. In the dynamic of measuring and evaluating reality, we will "produce" new knowledge that will modify the evaluation as well as our behavior. A clear example is to study the environmental impact produced by tourist activity through intensity measures, and its extension and importance over the socioeconomical system (Coccossis & Parpairis, 1992).

Knowledge as State

According to its relevance, knowledge can be perceived in different ways: data, information, structured information, perceptions, judgments, and decisions (van Louizen, 1996). We are constantly changing the knowledge from one level to another until we get to the culmination of the knowledge, the decision. It is in this process that the precision and meaning of the information increases

At the same time, in the same process, we must reconcile material factors and goals with cultural and subjective factors (e.g., information, computing projects planning, information management with system of thoughts, learning systems, activity systems; Espinoza & Molina, 1999).

KNOWLEDGE MANAGEMENT IN TOURISM

Considering knowledge management as the process of managing immaterial assets explicitly, we immediately come to know that management in tourism (either private or public) is an especially fertile field. The aims of the service are mostly experiences, individual or group acquired knowledge, emotions, and personal transformations (Gunn, 1994). Likewise, the possibility of offering the service properly depends on the physical infrastructure and its usage as well as on the ability of interpreting expectations and needs, evaluating subjectivities and, getting ahead of them, understanding customs, likes and dislikes, preferences, and cultural and social guidelines (Tissen, Andriesen, & Lekanne, 2000) and from the offer of services and hiring until arrival time, staying, leaving, and even the memories and the will to come back (Organización Mundial de Turismo, 1997).

The challenge is to make the tourist destination offer the guests the desired utility, getting as a reward a successful operation of the system. To achieve this, the prodigal nature or the large investments are not enough. There are other elements that should be considered, such as proper management concepts directed towards constant learning and innovation, service processes, orientation to the customers, and the proper application of the economic–financial resources (Inskeep, 1991; Wisniewski & Dickson, 2001).

Service Profit Chain

Among the diverse approaches and strategies to increase the quality of the provision facilities, the customers' satisfaction, and, as a consequence, the increase in the incomes and the final profitability, it is useful to mention the "utility chain in services" (Heskett, Sasser, & Schlesinger, 1998).

The utility chain links different concepts that have an effect on the improvement of services, related to the ability of the ones whose mission is to carry them out. Almost all of them are related to knowledge, individual and shared knowledge of

a. structures
b. processes
c. needs
d. motivations for choice
e. service complementarity
f. demand complementarity
g. development of special packages for different segments
h. customers satisfaction
i. vision
j. personnel loyalty and satisfaction
k. investments in relevant aspects

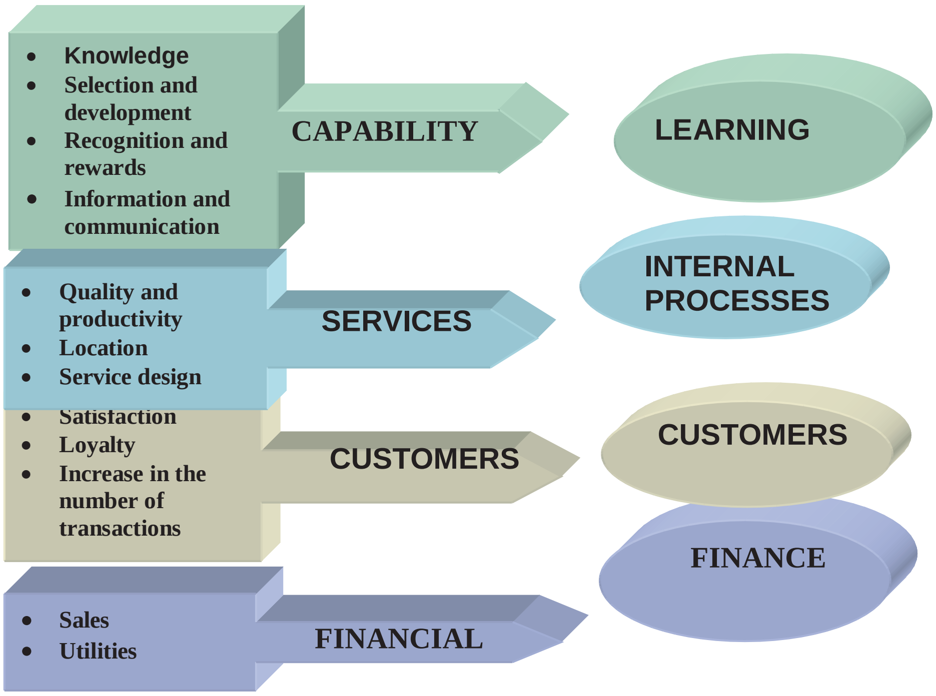
These concepts can be appreciated in the "value equation" (see equation below).

$$\textit{Value equation} = \frac{\textit{Results} + \textit{Process quality}}{\textit{Price} + \textit{Cost of access to a service}}$$

The keys for its application would be in

a. understanding the client needs
b. responding or covering needs
c. investing in key aspects, such as clients' restrain
d. developing value packages for different markets

Figure 1. Service profit chain and balanced scorecard



e. developing value conscience (Heskett et al.,1998; Ho & McKay,2002)

The service profit chain and its correspondence to the balanced scorecard is shown in Figure 1.

The service profit chain (Heskett et al., 1998) shows the relationship between different fundamental factors of tertiary activities such as tourism. This shows that the successful results in a certain administration come out as a result of the employees' capability, loyalty, satisfaction and productivity; generating high value services due to quality and low costs. Hence, not only do clients' satisfaction and loyalty rise, but so do growth and utilities.

Higher value is bounded to major commitment and people's training (growing perspectives). As a result, there will be better performed processes (internal process perspective) with more effective results (customer perspective), and thus better financial results (financial perspective). There is an important correspondence between the utility chain and the balanced scorecard perspectives.

Balanced Scorecard as a Tool of Knowledge Management

We can focus on knowledge in relation to two principal theories: information or people management (Probst, Raub, & Romhardt, 2000).

In information management, all the information is included at its different levels and support systems. In people management, its equivalence in the complex dynamic of human behavior takes particular significance. Both concepts should be considered within the frame of the structure in which they are developed or used. Therefore, we have three different elements at our disposal: information, people, and structure.

It is at this stage when the balanced scorecard functions as a knowledge management tool: the choice, diffusion, and application of the chosen strategy in the selected reference system. The data the BSC put together are useful to those people who are responsible for the application and control of the strategy. For example, the hotel reservation rate is useful to foresee the ticket sales to a certain tourist destination. In addition, the rate will be the result of the advertising and service strategies chosen and it will allow service providers to measure its efficiency (Miyake, 2002).

Need for Knowledge in Tourism

The basic knowledge in the sector are based on

a. physical assets
b. knowledge processes in tourist services (intangible assets)
c. strategies:
   - choice
   - diffusion
   - application

This knowledge is detected, elaborated, and transmitted through ratios, outcome measures and performance drivers whose substantial value is to reflect the cause–effect relationship of the items they are linking (Baud-Bovy, 1998; McIntyre,1992).

Balanced Scorecard as a Means for Managing Knowledge

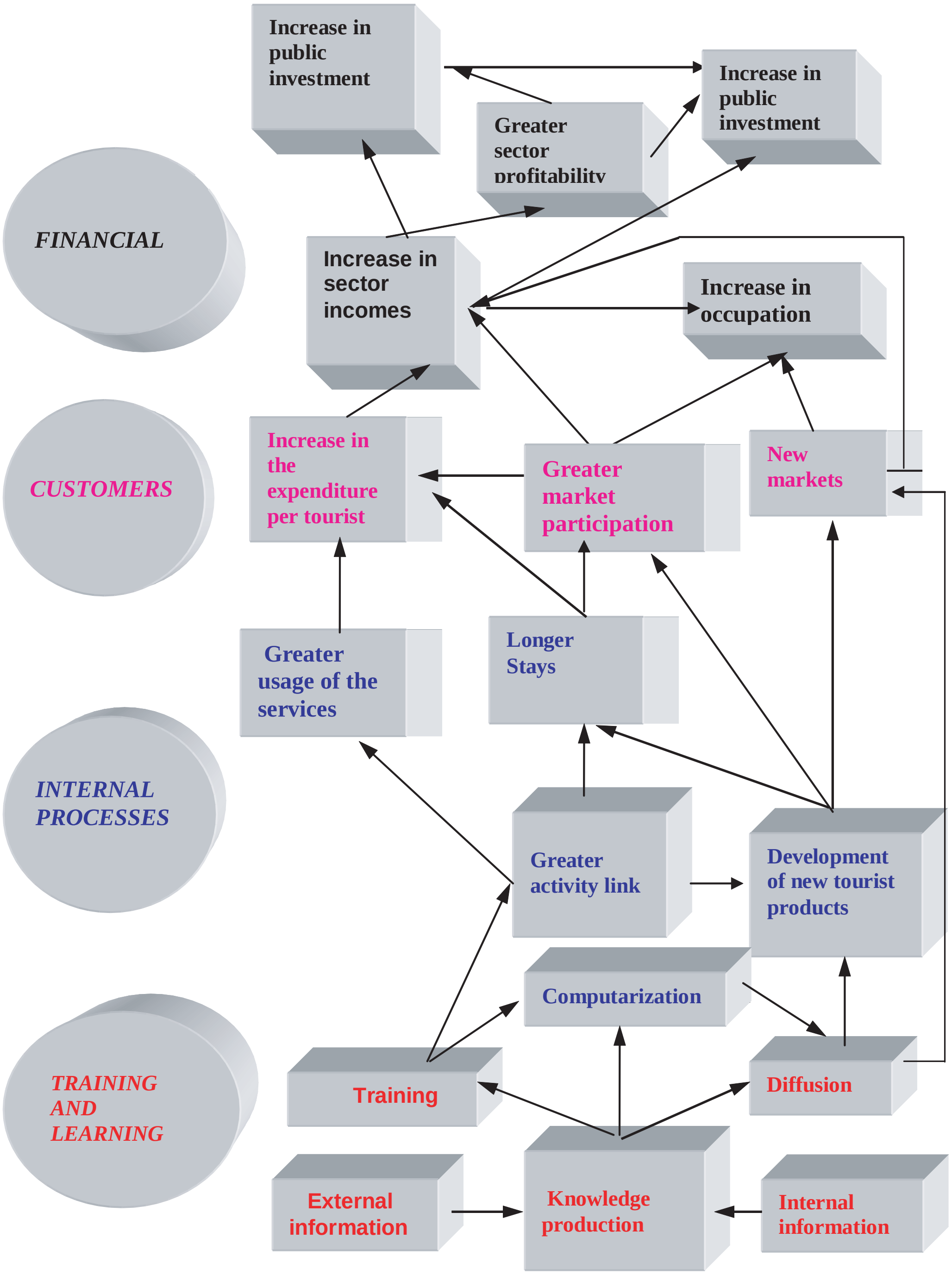
The balanced scorecard studies different aspects in the knowledge management of an organization and combines cultural, structural, and strategic aspects by causality relationships through

a. mission and vision
b. strategies
c. responsibilities
d. application
   - modeling of tasks
   - modeling of performance
e. transformation

Balanced Scorecard Advantages with Regard to Knowledge Management

a. it considers intangible assets
b. it makes use of linked outcome measures and future performance drivers
c. it makes the mission and the strategy more comprehensive by means of action
d. it is a cyclical process
e. it considers intellectual factors: creativity, innovation
f. its main utility is communication
g. it is multidimensional
h. it allows selecting indicators and inductors
i. it transfers the strategic outcome to quantitative measures
j. it transforms the strategy into action
k. it quantifies qualitative variants
l. it links cause–effect relationships to strategic activities
m. it is prospective
n. it allows measuring, simulating and evaluating alternatives

Figure 2. Some cause–effect relationships in tourism



o. it can be quickly modified (Kaplan & Norton, 2001; Malina & Selto, 2001; Neidorf, 2002)

The balanced scorecard (see Figure 2) outlines the tourist activity showing diverse cause–effect relationships.

Indicators

Outcome measures and performance drivers. The detection and selection of the indicators and inductors must be taken into account as diverse aspects to materialize the balanced scorecard.

a. cause–effect relationships
b. the possibility of obtaining, storing, and updating information
c. feasible control and processing
d. facility for diffusion and interpretation

FUTURE TRENDS

Informatic Applications in Tourist Knowledge Management

Data Warehouse, Data Mining, and Online Analytical Processing (OLAP) Applications and Use

Applications of these techniques (Fayyad, 1996, 1997) include

a. detection
b. selection of detection tools
c. integration of tools
d. application–organization
e. computerization and oversight

Data Warehouse as an Organization Process of the BSC

Data warehouse is a collection of data aimed at the matter—integrated, not volatile, thematic, and historical—organized to support a decision-making helping process. (Inmonn, 1996).

Useful Data Warehouse Characteristics for a BS

- Integrated: The data stored in the data warehouse are integrated in a structure; therefore, any existent inconsistency among the diverse operational systems must be eliminated. The information is often arranged into different detail levels for its adjustment to the users' needs.
- Thematic: Only the data essential for the knowledge generation process is integrated from the operational environment. The data is organized by topics to facilitate their access and understanding to the final users. For example, customers' data can be compiled in a unique data warehouse board. Consequently, the requests of information about customers will be easier to answer.
- Historical: Time is an implicit part of the information compiled in a data warehouse. In operational systems, data usually show the state of business activity at present. The information stored in a data warehouse can be used, among other purposes, to do trend analysis.
- Nonvolatile: The data of a data warehouse are meant to be read, no to be modified. Therefore, the information is permanent. Updating the data warehouse is the incorporation of the latest values the different variables it contains have taken without taking any kind of action on what already existed (Inmonn, Glassey, & Welch, 1997).

OLAP Tools for a Balanced Scorecard Information Analysis

We shall add the multidimensional information analysis by means of OLAP tools and consider OLAP systems as parts of the executive information systems (EIS), which are used to provide the strategic level with the necessary information for decision making (Codd, Codd, & Salley, 1993).

In an OLAP data model, the information is perceived as cubes that consist of descriptive categories (dimensions) and quantitative values (measures). The multidimensional data model makes it easier for the users to formulate complex queries, correct the mistakes in a report, change summed-up data for detailed data, and "filter" the data in meaningful subsets.

Applying Data Mining Tools in a Balanced Scorecard

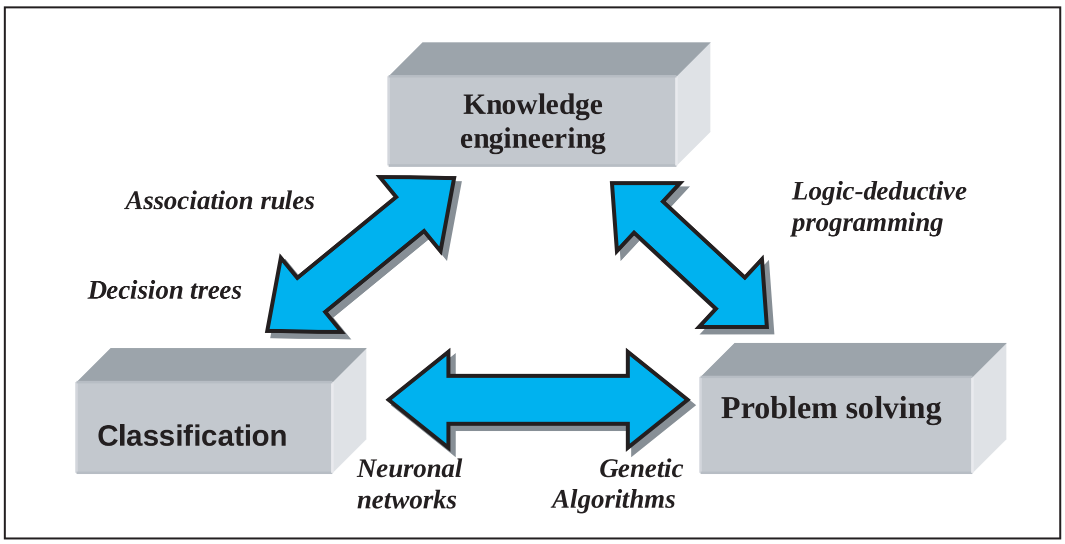
Data Mining Definition

Data mining is an analytical process that has been designed to explore large quantities of data and to search for consistent models and the systematic relationships among variables so as to validate the results of applying the discovered models to the new data subsets.

The process consists of three steps: exploration, construction or definition of the model, and validation/verification.

If the nature of the available data allows, we repeat it interactively until we identify a "strong" model. However, in business practice, the pos-

Figure 3. Learning algorithms



sibilities to validate the model in the analysis phase are usually limited. Consequently, the initial results often have the heuristic condition which might influence in the decision-making process.

There are three main working areas: knowledge engineering, classification, and problem solving. Each learning technique places itself in this three-dimensional space. No learning or pattern recognition technique is considered the best. An environment of knowledge databases discovery must bare these different types of techniques (hybrid environment, Indurkhya & Weiss, 1998).

Different Learning Algorithms Compared to Different Types of Tasks in the Application Inside a BSC

Any of the three techniques (i.e., knowledge engineering, classification, and problem solving) can be applied in a balanced scorecard to analyze and predict indicators or to take part in the indicators' building process (see Figure 3).

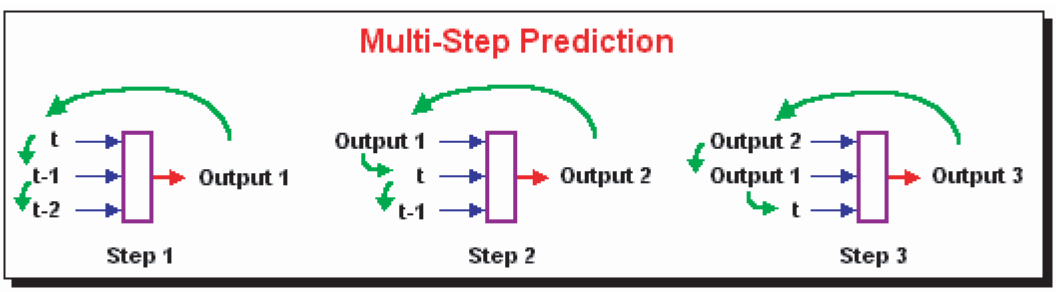
Structure and Application to the Proposed Indicators

Neuronal Networks Application in the Prediction of an Indicator. If we take a resulting indicator as the increase in the percentage of the average stay, we will get, in addition to this current indicator and its historical trajectory (i.e., applying temporal series), an indicator of the potential average stay for the following 6 months. The source of information of this indicator can be build up from (a) hotel and outing databases, and (b) sample interviews considering hotels and outings.

A temporal series represents the evolution of a magnitude in time. The factor of highest interest will be the correlation between different events along time. If such a correlation exists and can be modeled, predictions of the future behavior of the temporal series can be made.

The temporal series are build-up on a feed-forward architecture, such as multilayer perception (MLP) or radial basis functions (RBF). Alternatives include feed-forward networks, with a fixed-entry window and recurrent networks with unique entries.

Figure 4. Sequence of steps in the prediction



There are two types of models that can be applied to predict the next value in a temporal series:

a. single-step prediction, in which the inputs to the model are always known values taken from the temporal series, and
b. multi-step prediction, in which the result of the first prediction is fed back as a new entry in the network (see Figure 4).

Studying Techniques

There are two ways of studying temporal series:

a. finding out patterns to explain the past behavior of the temporal series, and
b. evaluating the effect of a fact that intervenes and changes the behavior of the temporal series.

Cycle Development: Preproject → Data Gathering → Data Preparation → Design → Training and Testing → Implementation and Maintenance

Between the design, and training and testing stages there is an interactive stage that corresponds to optimization.

Preparation of Data

The data employed in the application consisted of the following five fields registered (or calculated) in the T instant:

a. An increase in the percentage of the average stay (result indicator)
b. Quantity of necessary consultancies to define the trip
c. Increase in the number of options of tourist packages
d. Quantity of innovations in the Web site
e. Information availability in service centers

The last four items are guiding indicators.

Design

Selection of neuronal processing tools, model structure, and initial conditions.

a. Data input tool
b. Time series window
c. Time series plot

Data Input Tool

The data input tool allows the specifying of the variables to be included in the input window and also the ones that will go in the target window (prediction).

Time Series Windows

Time series windows allow the making of two kinds of predictions: single-step prediction and multi-step prediction.

Time Series Plot

Time series plot shows the results of an application as a two-dimensional graphic as a function of time. It shows the temporal comparison between the actual and predicted outputs and the actual outputs with inputs.

INDICATORS GROUPING TO GENERATE ANOTHER GUIDING INDICATOR

An example of this is taking into account the customers' level and Kohonen network.

The generated guiding indicator is "type of customer," with the following characteristics:

a. A varied passengers' origin
b. Percentage of reiteration of visits
c. Percentage of provenances
d. Segments diversity
e. Number of visitors
f. Total expenditure per tourist

Kohonen Auto-Organized Maps

These are based on evidences found at brain level. They associate entry vectors with output patterns and are able to make cluster analysis (i.e., to project a high-dimensioned space onto a smaller one).

The learning process is nonsupervised competitive. The neurons compete with each other to carry out a given task. When there is just one input, only one neuron activates (i.e., the winning neuron).

- Goal: "Cluster" the data introduced to the network.

SOFM Architecture: Connections

Each entry memory i is connected to each of the output neurons of j by means of weight (Wij). Each output neuron has a weight vector associated to it (Wij) as a reference vector, which represents the average vector of this category. Among the neurons of the output layer there are implicit lateral connections of excitement or inhibition (del Brío, 1997; see Figure 5).

Learning Stage

This stage aims to establish, by means of the presentation of a training pattern set, the different categories that will be employed during the working stage to classify new input patterns. A set of patterns is presented repeatedly in the network, until the different reference vectors are tuned to one or more input patterns. If the input space is divided into groups, each neuron will specialize in one of them, and the essential operation of the network will be interpreted as a "cluster analysis" (see Figure 6).

Figure 5. SOFM architecture

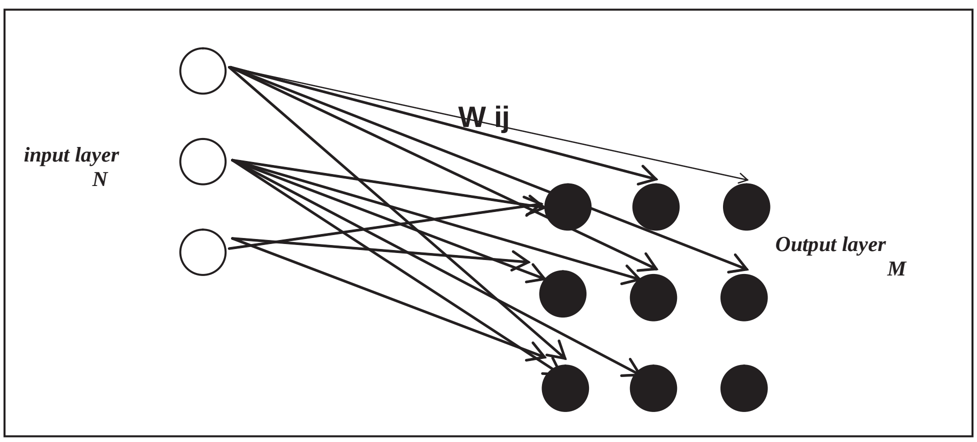
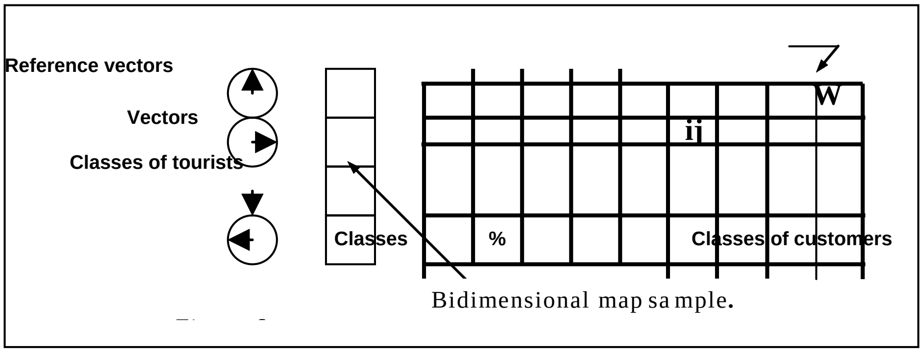


Figure 6. Bidimensional map sample



Working Stage

In the output layer, each neuron estimates the similarity between the input vector (Xp) and its own weight vector (Wij). Simulating a competitive process, the winning neuron will be the one whose weight vector resembles the input vector. The activated output neuron represents the class the input belongs to. When the input is a similar pattern, the same neuron, or a neighbor neuron, is activated.

Application of the Fuzzy Decision Theory as a Financial Indicator of the Future Investment in the Area

Fuzzy logic deals with imprecise information (such as the acceptance of a tourist package, the proper customers' attention, or an uncomfortable means of transport to the city) in terms of fuzzy sets (Lazzari, Machado, & Pérez, 1998). These fuzzy sets are turned into rules to define actions, such as "if the quality of a service is not good, the amount of tourists will decrease 50% in the following 6 months."

Control systems based on fuzzy logic combine input variables (which are defined in terms of fuzzy sets) by means of rules that produce one or several output values (Kasabov,1996). The fuzzy set theory comes from the classic set theory and adds a belonging function to the set, which is defined as a real number between 0 and 1.

The concept of fuzzy sets or subsets is introduced in association with a determined linguistic value, defined by a word, adjective, or linguistic label A.

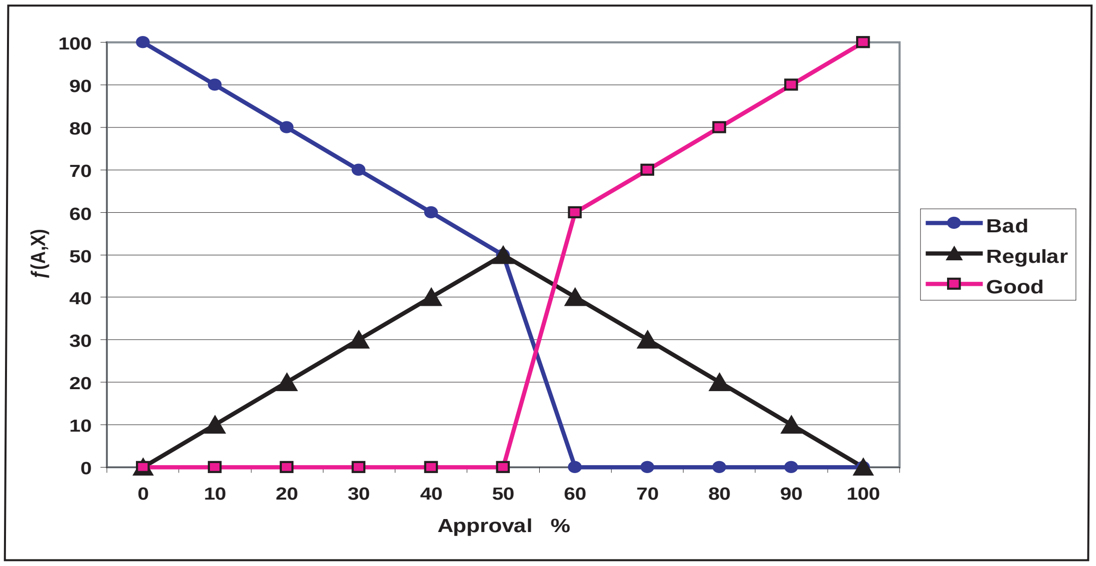
For each fuzzy set or subset there is a belonging or inclusive function ƒa(t) that indicates the degree in which the t variable is included in the concept that label A represents (Hilera & Martínez, 1995). For example, the linguistic value customers' attention may represent the acceptation degree in percentage to the attention of a specific tourist place expressed through interviews. Then, we can define three fuzzy sets, each one identified with a label (Bad, Regular, or Good) and with a belonging or inclusive function.

{ƒBad (t), ƒRegular (t),ƒ Good (t)}.

The outcome would be a distribution, as shown in Figure 7.

An economic–financial indicator to apply to the scorecard may be the amount of acquired packages for a specific tourist program. We will apply the fuzzy decision theory mechanisms to deduce different decisions about the acquisition of those packages and the future profits linked to

Figure 7. Fuzzy sets



each option (e.g., for each travel agent), according to the ways of searching information, the attitudes towards risk, the decision criteria, the total uncertainty, or others.

For these purposes, the concept of fuzzy logic may be applied, estimating the number of package tours to be sold, who will make decisions about the amount of reservations periodically booked in a specific excursion program. These decisions will have an initial capital investment intended to establish booking cost for each package to estimate the profitability.

CONCLUSION

Management has powerful formal tools at its disposal to optimize decisions. The computational decision systems (e.g., management information systems, decision support systems, executive information systems) are samples of the growing trend to eliminate empiricism, to go deeply into the analysis, to release from duty those who decide on routines, thus allowing them to adopt approaches of greater conceptual amplitude. Among these approaches are the ideals of understanding, vision, and quality, whose scope broadens the deterministic and quantitative approaches. Within this frame, the methods of proximal reasoning (in which we tend to include as an essential element the typical uncertainty that the social sciences constitute), together with computational algorithms, is a promising path in search of knowledge, which is a human concern for all people at all times.

REFERENCES

Baud-Bovy, M. (1998). *Tourism and recreation: Handbook of planning and design.* Oxford, UK: Architectural Press.

Bonsón, E. (1999). *Tecnologías inteligentes para la gestión empresaria.* Madrid, Spain: RA-MA Editorial.

Coccossis, H., & Parpairis, A. (1992). *Tourism and the environment. Some observations on the concept of carrying capacity.* Dordrecht, The Netherlands: Kluwer Academic Press.

Codd, F., Codd, B., & Salley, C. (1993). *Providing OLAP to user-analysts.* Codd.

del Brío, M. S. A. (1997). *Redes neuronales y sistemas borrosos, introducción teórica y práctica.* Madrid, Spain: RA-MA Editorial.

Espinoza E. M., & Molina S. C. (1999). Cambio organizacional: Sistemas de información y emociones. *Gestión y Estrategia, 15.*

Fayyad, U., & Simoudis, E. (1997). *Data mining and knowledge discovery in data bases.* Cambridge, MA: MIT Press.

Fayyad, U. M., & Piatetsky-Shapiro, G. (Eds.). (1996). *Advances in knowledge and data mining.* Cambridge, MA: MIT Press.

Grunewald, L. (Ed.). (2001). *Plan de desarrollo integral de la actividad turística y recreativa del municipio de tandil.* Buenos Aires, Argentina: Universidad del Salvador.

Gunn, C. (1994). *Tourism planning.* London: Taylor & Francis.

Heskett, J., Sasser, E., & Schlesinger, L. (1998). *The service profit chain.* Buesos Aires, Argentina: Gestion.

Hilera, J. R., & Martínez, V. J. (1995). *Redes neuronales artificiales, fundamentos, modelos y aplicaciones.* Madrid, Spain: RA-MA Editorial.

Ho, S.-J., & McKay, R. (2002). Balanced scorecard: Two perspectives. *The CPA Journal, 72*(3), 21-25.

Indurkhya, N., & Weiss, S. (1998). *Predictive data mining: A practical guide.* San Francisco: Morgan Kaufmann.

Inmon, W. H. (1996). *Building the data warehouse.* New York: Wiley.

Inmonn, W. H., Glassey, K. L., & Welch, D. (1997). *Managing the data warehouse.* New York: Wiley.

Inskeep, E. (1991). *Tourism planning: An integral and sustainable development approach.* New York: Van Nostrand Reinhold.

Kaplan, R., & Norton, D. (1999). *The balanced scorecard: Translating strategy into action.* Cambridge, MA: Harvard Business School Press.

Kaplan, R., & Norton, P. (2001). Transforming the balanced scorecard from performance measurements to strategic management. *Accounting Horizons, 15*(1), 87.

Kasabov, N. K. (1996). *Foundations of neural networks, fuzzy systems and knowledge engineering.* Cambridge, MA: MIT Press.

Lazzari, L. L., Machado, E. A. M., & Pérez, R. H. (1998). *Teoría de la decisión fuzzy.* Buenos Aires, Argentina: Ediciones Macchi.

Lopez, G. M. (1999). El cambio y la cultura organizacional en el diseño de un sistema de información de Gestión. *Gestión y Estrategia, 15.*

Malina, M. A., & Selto, F. (2001). Communicating and controlling strategy: An empirical study of the effectiveness of the balanced scorecard. *Journal of Management Accounting Research, 44,* 47.

Marakas, G. (1999). *Decision support systems.* Upper Saddle River, NJ: Prentice Hall.

McIntyre, G. (1992). *Desarrollo turístico sostenible. Guía para los planificadores locales.* Madrid, Spain: Organización Mundial de Turismo.

Miyake, D. (2002). Beyond the numbers: After years of evolution, balanced scorecard applications now integrate strategy and management for competitive advantage. *Intelligent Enterprise, 15*(12), 24-27.

Neidorf, R. (2002, September/October). Knowledge management: Changing cultures changing attitudes. *Online, 26*(5), 60-63.

Olvé, N., Roy, J., & Wetter, M. (1999). *Performance drivers: A practical guide to using the balanced scorecard.* New York: Wiley.

Organización Mundial de Turismo. (1997). *Guía práctica para el desarrollo y uso de indicadores de turismo sostenible.* Madrid, Spain: Author.

Probst, G., Raub, S., & Romhardt, K. (2000). *Managing knowledge.* Chichester, UK: Wiley

Simon, R. (1995, September/October). Los sistemas de control como instrumento de la renovación estratégica. *Harvard Deusto Business Review.*

Tissen, R., Andriesen, D., & Lekanne Deprez, F. (2000). *The knowledge dividend.* New York: Prentice Hall.

Van Lohuizen, C. W. W. (1996). Knowledge: Creation, diffusion, utilization. *Knowledge Management and Policy Making, 8*(1).

Wisniewski, M., & Dickson, A. (2001). Measuring performance in Dumfries and Galloway constabulary with the balanced scorecard. *Journal of the Operation Research Society, 52*(10), 1057.

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Chapter 8.9
Multidisciplinary Project Teams

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INTRODUCTION

Knowledge in designing a product or rendering a service does not form a complete and coherent body of knowledge that can be precisely documented or even articulated by a single individual. Rather, it is a form of knowing that exists only through the interaction among various collective actors (Gherardi & Nicolini, 2000). Existing literature (Kanter, 1988; Nonaka, 1994; Spender, 1998; Starbuck, 1992) has highlighted a need for the development of a diverse workforce if knowledge creation is to be promoted and sustained within organisations. This literature suggests that a diverse set of resources (experts with different backgrounds and abilities) provides a broad knowledge base at the individual level, offering greater potential for knowledge creation.

Conceptually, a team can be viewed as a socially constructed phenomenon or linking mechanism that integrates individuals and organisations (Horvath, Callahan, Croswell, & Mukri, 1996). A multidisciplinary team is defined by Nonaka and Takeuchi (1995, p. 85) as "a self-managed, self-organised team in which members from various functional departments, and/or areas of expertise work together to accomplish a common goal." The primary goal of the multidisciplinary composition is to marry diverse bodies of knowledge in a way that produces a synergistic knowledge outcome that is innovative, contextualised, and, as such, has strategic value. For the most part, project team tasks are nonrepetitive in nature and involve considerable application of knowledge, judgement, and expertise.

The advantage of adopting multidisciplinary project teams is that they are quicker in integrating the expert knowledge of different functions, for example, design, construction, marketing, maintenance, and accounting. Cross-functional project teams with mutual accountability and collective work products have been found to decrease development time and increase product quality (Ancona & Caldwell, 1992; Dougherty, 1992; Van de Ven, 1986; Wheelwright & Clark, 1992). Multidisciplinary project teams create a "task culture," facilitating the necessary close linkages and direct personal contacts between different functions (Cohen & Levinthal, 1990). These close connections are necessary, as new product development by its very nature includes uncertainty about potential market response and about new technology (Henke, Krachenberg, & Lyons, 1993). This transformation process is a team-level phenomenon. It emerges through "heedful interrelationships" (Weick & Roberts, 1993) and interdependencies between team members, their actions and interactions, and the enmeshment of their individual knowledge paradigms. If creating new collective knowledge is indeed a team-level phenomenon, then the multidisciplinary team is considered the greenhouse where such a phenomenon can be best cultivated.

This article views the multidisciplinary project team as an unusual team arrangement, primarily because it is composed of professionals from various disciplines who take pride in their fields of expertise. They are committed to the basic assumptions of their paradigms and they perceive their roles in the team as representing their knowledge bases in the best possible way. In addition, a project on which a multidisciplinary team works can metaphorically be seen as an experiment, a vehicle for knowledge creation, with knowledge being created through the process of executing the project.

Examining knowledge creation from a microscopic view, it can be further subdivided into knowledge development and knowledge acquisition. The former develops knowledge that is made available through internal resources, whereas the latter acquires required knowledge by external means. Knowledge development involves the development of knowledge through internal effort after identifying the difference between required and available knowledge. Developing knowledge internally can be achieved via personnel in-house, or through research and development efforts, education and training, creativity techniques like brainstorming, or customer satisfaction surveys. Knowledge acquisition entails the acquisition of knowledge from external sources if developing knowledge internally is not possible. This is done through employing specifically qualified personnel, by merging or acquiring firms, by purchasing e-learning training, by forming joint-venture companies, or by employing an external company to conduct market research.

The relationship between knowledge creation and knowledge management is like the metaphor of the chicken and the egg, that is, it is hard to say which one should come first. If we imagine just managing existing knowledge without creating new knowledge, we can foresee what kind of world we would be living in—probably just a highly effective society without much technological advancement or improvement in living standards. Alternatively, if we kept on creating new knowledge or innovating without properly managing our existing knowledge, we would end up going round and round in circles and repeating the same mistakes time after time. In order for a society to flourish or a new product to be successful when it is launched, knowledge should not simply be managed: The creation of new knowledge also should be possible. In essence, knowledge creation should go hand in hand with knowledge management, as without one or the other, our knowledge journey will be futile.

BACKGROUND

The issue of knowledge has been debated for several centuries. Knowledge has only recently been viewed as a collective phenomenon in organisational contexts. Two conflicting theoretical perspectives about knowledge emerge. The first, as highlighted by Prahalad and Hamel (1990) and Wernerfelt (1984), focuses on the resource-based view where knowledge is considered to be a set of strategically important commodities that exist independent of their creators and are context-independent (i.e., the firm's primary role is as knowledge applicator). The second perspective, from Berger and Luckmann (1966) and Nonaka and Takeuchi (1995), perceives knowledge as a set of shared beliefs that are constructed through social interactions and embedded within the social contexts in which knowledge is created (i.e., the firm's primary role is as knowledge creator). This view of knowledge embodies the social construction perspective held by this article of trying to understand knowledge creation processes in multidisciplinary project teams.

The present framework for examining the knowledge creation processes within multidisciplinary project teams is based on Nonaka and Takeuchi's (1995) organisational knowledge creation theory. Nonaka and Takeuchi's theory is utilised because it is one of the few knowledge creation theories available that examines the interrelationships between explicit and tacit knowledge. Further, Nonaka and Takeuchi's (1995) theory was inductively developed using case studies of product development projects, so the focus on technical knowledge creation is appropriate for this study. However, Nonaka and Takeuchi's (1995) knowledge creation model has some limitations that lessen the model's suitability for the study of knowledge creation in multidisciplinary project teams. Their primary distinction between tacit and explicit knowledge is problematic as tacit or unarticulated knowledge is always a precondition for explicit knowledge (Engeström, 1999). Tuomi (1999) also criticises the model for taking culture and language for granted. The difficulty of discussing the role of language as a "repository of culturally shared meaning" (Tuomi, 1999, p. 340), critical for any knowledge creation theory, may make its use difficult for multidisciplinary project teams. It also is not clear what happens when the knowledge-creating spiral expands outside a team: Is knowledge still created in the same way (Tuomi, 1999)? As pointed out by Tuomi (1999, p. 328), "There is no model of social activity within the [knowledge creation] model□the motives for knowledge creation, and their relations to individual or organisational needs, remain obscure. Why some knowledge is created, and why some knowledge is not, remains an open question." Furthermore, Tuomi (1999) finds that though Nonaka and Takeuchi (1995) stress that the process of knowledge creation is "social", their underlying focus is on individual and intrapersonal knowledge. He adds that "as their concept of knowledge is intrapersonal, truth becomes a necessary aspect of knowledge, grounding intrapersonal knowledge into interpersonal reality" (Tuomi, 1999, p. 333).

In order to overcome some of the shortcomings in Nonaka and Takeuchi's knowledge creation model, if one accepts the social construction perspective of knowledge as a set of shared beliefs constructed through social interaction amidst certain social circumstances, then both individual and social levels require acknowledgement and integration.

Two multidisciplinary project teams, working on two different construction projects at the design stage, were selected for study. In this article, a construction project also can be treated as a product because at the end of construction a facility will exist, with consumers using it to fulfill their needs. The selection of a residential development project recognises the large reservoir of idiosyncratic knowledge developed by the owner company over the years. It also recognises the crucial innovating dynamics behind the need to compete on the market with other residential developments. The infrastructure project presented alternative opportunities for knowledge creation and learning, unique in several respects. First, it was a complex operation, distinguished by an extraordinary multiplicity of consultants employed. Second, it is rare to find such a project, usually managed by government, in private hands. Finally, the technical challenges presented in this project made it an interesting arena for knowledge creation and absorption within the team.

MAIN FOCUS OF THE ARTICLE

Beyond modifying Nonaka and Takeuchi's (1995) model of knowledge conversion processes, a major and significant finding is that the collaborative nature of multidisciplinary project teams is essential in creating new knowledge. With a traditional focus on professional specialisation, many new development projects may be managed with tasks being executed in parallel or in sequence, or by certain project team members in isolation. This is often counterproductive when projects are so designed that the success of creating new knowledge among diverse disciplines may suffer, with optimal value possibly not being achieved.

The first process in knowledge creation involves boundary crossing, with two types of boundaries identified as affecting the progress and success of multidisciplinary knowledge creation. The importance of boundary crossing is reflected in solving the "boundary paradox" (Quintas, Lefrere, & Jones, 1997), where team members are able to exchange and combine knowledge (Nahapiet & Ghoshal, 1998). The interactions across these boundaries can either foster or hinder knowledge creation. The first boundary identified was between team members of different disciplines. The second existed between different stakeholders. The expertise boundaries could be crossed, not only through knowledge redundancy among team members, but also through boundary objects. The most prominent project boundary objects were drawings and personal conversations among team members. The second hierarchical boundaries could be crossed through team members consciously breaking down any barriers by valuing the expertise of others. It must be stressed that crossing boundaries does not necessarily guarantee the creation of knowledge. It is seen, however, as a prerequisite for the four remaining processes to occur.

The second process relates to knowledge sharing, with project team members of differing knowledge domains more likely to discuss their uniquely distinct information and knowledge than those who possess information in common. It seemed to be an advantage to have a diverse pool of knowledge for team members to access and share in discussion. Despite the existence of little competition among team members, external competition could act as a double-edged sword in the knowledge sharing process. Sharing important market or design knowledge could lead to imitation by competitors, possibly even resulting in project poaching. In addition, the type of communication appeared more influential in the transfer of tacit rather than explicit knowledge. For tacit knowledge to be effectively transmitted, interpersonal communication seemed of the utmost importance.

The third process to be considered is that of knowledge generation, in which teams create knowledge by generating new or "emergent" knowledge through interaction and communication. New or emergent knowledge, not possessed before discussion, can develop through group discussion and interaction (Kogut & Zander, 1992). The development of emergent knowledge is vital for creativity and innovation. It is generated through various means, including those of social networks, printed sources, and customer and competitor feedback.

Social networks were identified as the most important vehicle for information and knowledge exchange, with team members heavily reliant upon colleagues, friends, and ex-colleagues as rich resources for generating design knowledge. The use of printed data in the design process appeared to be limited: It was viewed as time-consuming and used mainly to cross-check the solutions offered. Social networks tended to recommend published materials, helping to reduce research time and enhance usability. Comprehension of customer needs, insight into competitor products, and an inspection of completed facilities all seemed to stimulate knowledge generation. Time and motivation were identified as two very significant influences, and it is interesting to note that both of these impacted on the sharing of knowledge, as well as the generation of new knowledge.

Fourth is knowledge integration, realised by marrying the differing perspectives and knowledge of various disciplines in the design decision-making process. This enables different stakeholder views to be incorporated so that they can be considered and integrated. New product design requires multidisciplinary skills and knowledge input. Various team members brought different sets of assumptions about optimal ways to proceed, prioritising different values and perspectives to ultimately best meet stakeholder requirements as well as arrive at satisfactory design solutions. Project documentation as well as various design objects were used as tools to integrate the range of knowledge input from project participants.

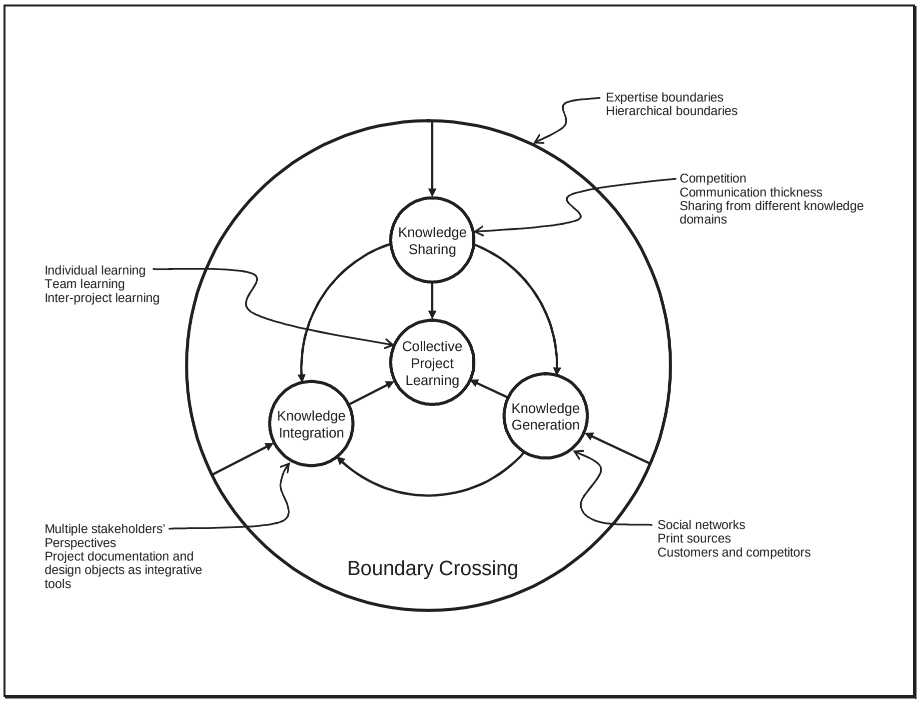
The fifth process involves collective project learning, in which professionals with extensive experience in self-directed learning learn from the projects they are engaged in. Project team members had to constantly absorb new technology and techniques in order to remain competitive. Experts in self-directed learning, they created an environment maximising opportunities for individual inquiry and learning. Problem-solving being central to their work, they also recognised that failure was an opportunity for learning and understanding. Understanding failure is a primary mechanism in learning how new technology and systems operate, optimally avoiding repetitive mistakes. Therefore, considerable effort should be made to support an individual's critical problem-solving and reflection processes. Individuals then develop personal strategies based on their own thinking and learning preferences.

The project teams themselves encouraged team learning activities, independent of any directives. Small sub-teams typically pooled their resources for learning, acquiring the necessary skills and knowledge to solve problems in an open and permissive environment. Individuals shared their information seeking strategies so that the sub-team might learn in as many different ways as possible. The larger project teams followed more formal processes and procedures for sharing and interacting. The smaller teams contributed directly to the work of the larger project teams, but they were not formally recognised in the organisational structure of the projects. They spontaneously grouped and regrouped, navigated by the team members themselves. Most formations were temporary, lasting only until the immediate goals were accomplished.

Inter-project learning can be seen as gaining knowledge from a project and transferring it directly or indirectly to other subsequent or concurrent projects. Interproject learning can happen both concurrently or sequentially. In concurrent transfer, a new project begins to transfer knowledge from a base project before it has completed its task. Sequential transfer happens when knowledge and experience are transferred from an initial project to a new one upon the original's completion. A central prerequisite for interproject learning is a certain degree of repetitiveness between projects, with the similarity of aspects enabling construction and refinement of procedures, whereas the total uniqueness of a project can slow learning, possibly hindering immediate progress. The most widely observed strategy in interproject learning involved personalisation rather than codification.

Through studying two multidisciplinary project teams working on two facilities projects during their design phase, this article has arrived at a new model of knowledge creation within multidisciplinary project teams, differing from the organisational knowledge creation theory developed by Nonaka and Takeuchi (1995). The new model of knowledge creation within multidisciplinary project teams is proposed and illustrated in Figure 1, with the interrelationships among different processes highlighted. It is emphasised that these processes are not linear in nature but intertwined with one another.

Figure 1. The interrelationships between multidisciplinary knowledge creation processes



FUTURE TRENDS

As more organisations employ multidisciplinary teams to sustain or improve their competitive advantage through innovative products or services, more attention should be directed to highlighting their unique features and understanding how to turn such teams into an effective knowledge creation force.

Though project teams with diverse workforces can be seen as essential units in promoting and sustaining knowledge creation within organisations (Kanter, 1988; Nonaka, 1994; Spender, 1998; Starbuck, 1992), the diversity of team members can be problematic, placing demands on the team to manage divergent thinking paradigms and basic assumptions, as well as the "professional egos" of team members (Dougherty, 1992). This would suggest a need for proper management before the benefits of knowledge creation can be harvested. This would require the joint effort of teams and their management. Four key lessons for multidisciplinary project teams and management are suggested here:

- The support of intra- and interorganisational social networks
- The enhancement of cooperative teamwork
- Mechanisms for easing tension among project team members

- Concentration on project value maximisation

Although this article has made some theoretical and practical contributions, it has limitations that call for further research. Several research agendas emanating from this model are:

First, only a specific type of team was included in the research data. The research site provided an excellent opportunity to explore the processes, interrelationships, and contributory factors to knowledge creation within a multidisciplinary setting. However, the experience of these teams cannot be extrapolated to all teams. It is suggested that future research could attempt to conduct similar studies in more diverse settings. Since different team structures and cultures could influence the knowledge creation processes in different ways, future research could contribute to the development of a pluralistic, rather than normative, view of team knowledge-creation capability. This might include comparative studies of information-intensive teams vs. production-oriented teams, and research- vs. product-oriented teams. Future studies could examine teams in more complex interdisciplinary circumstances (e.g., biotechnology, genomics, etc.) where teams are brought together, even from quite different fields and industries. These teams might work on complex problems, pooling their diverse backgrounds and training, possibly to solve a complex business problem, design a new system, product or service, or to reorganise a company.

Second, the research on knowledge creation extends across multiple theoretical boundaries. However, this study emphasised primarily the areas of knowledge creation and team processes. Though other related literature has been discussed, their review was not the main thrust. The ample information management and information systems literature, devoted to knowledge management or organisational knowledge, was not incorporated into the study. This limitation can be explained by the study's focus on the processes of knowledge creation within multidisciplinary project teams, rather than the effects of information systems on these processes. Such a limitation represents a major research opportunity through exploring the impact of information systems on knowledge creation.

Finally, the study did not measure the effectiveness or quality of the knowledge created by the multidisciplinary project teams. Such a measurement could facilitate a clearer understanding of any organisational competitive advantage that might result from knowledge creation. Clearly, future research aiming to tackle these issues might enable project teams and management to better understand and evaluate the potential impact of multidisciplinary project teams on knowledge creation.

CONCLUSION

This article has arrived at a new model of knowledge creation within multidisciplinary project teams, differing from the organisational knowledge creation theory developed by Nonaka and Takeuchi (1995). It places primary emphasis on the processes rather than the outcomes of multidisciplinary knowledge creation as put forward by previous researchers.

The underlying processes of knowledge creation in multidisciplinary project teams are different to those proposed in the organisational knowledge creation theories. A new model of knowledge creation within multidisciplinary project teams is proposed. In the model, the five processes of knowledge creation are identified, including the processes of boundary crossing, knowledge sharing, knowledge generation, knowledge integration, and collective project learning. The interrelationships of these five processes are elaborated to enable their thorough understanding. It must be stressed that that these knowledge creation processes within multidisciplinary teams are not linear. Instead they are interwoven, occurring throughout the projects. In addition, there is a need for proper management of multidisciplinary project teams before the benefits of knowledge creation can be harvested and recognised.

REFERENCES

Ancona, D.G., & Caldwell, D.F. (1992). Demography and design: Predictors of new product team performance. *Organization Science, 3*(3), 321-341.

Berger, P.L., & Luckmann, T. (1966). *The social construction of reality: A treatise in the sociology of knowledge.* Garden City, NY: Doubleday.

Cohen, W.M., & Levinthal, D.A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*(1), 128-152.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization Science, 3*(2), 179-202.

Engeström, Y. (1999). Innovative learning in work teams: Analyzing cycles of knowledge creation in practice. In Y. Engeström, R. Miettinen, & R.-L. Punamäki-Gitai (Eds.), *Perspectives on activity theory* (pp. 377-404). Cambridge: Cambridge University Press.

Gherardi, S., & Nicolini, D. (2000). The organizational learning of safety in communities of practice. *Journal of Management Inquiry, 9*(1), 7-18.

Henke, J., Krachenberg, R., & Lyons, T. (1993). Perspective: Cross-functional teams: Good concept, poor implementation! *Journal of Product Innovation Management, 10*(3), 216-229.

Horvath, L., Callahan, J.L., Croswell, C., & Mukri, G. (1996, February 29-March 3). Team sensemaking: An imperative for individual and organizational learning. In E.F. Holton (Ed.), *Proceedings of the Academy of Human Resource Development,* Minneapolis, MN (pp. 415-421).

Kanter, R.M. (1988). When a thousand flowers bloom: Structural, collective, and conditions for innovation in organizations. In B. Staw & L.L. Cummings (Eds.)*, Research in organizational behavior* (pp. 169-212). Greenwich, CT: JAI Press.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5*(1), 14-37.

Prahalad, C.K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review, 68*(3), 79-91.

Quintas, P., Lefrere, P., & Jones, G. (1997). Knowledge management: A strategic agenda. *Long Range Planning, 30*(3), 385-391.

Spender, J.C. (1998). Pluralist epistemology and the knowledge-based theory of the firm. *Organization, 5*(2), 233-256.

Starbuck, W.H. (1992). Learning by knowledge intensive firms. *Journal of Management Studies, 29*(6), 713-740.

Tuomi, I. (1999). *Corporate knowledge: Theory and practice of intelligent organizations.* Helsinki: Metaxis.

Van de Ven, A.H. (1986). Central problems in the management of innovation. *Management Science, 32*(5), 590-607.

Weick, K.E., & Roberts, K.H. (1993). Collective mind in organizations: Heedful interrelating on flight decks. *Administrative Science Quarterly, 38,* 357-381.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal, 5*(2), 171-180.

Wheelwright, S.C., & Clark, K.B. (1992). *Revolutionizing product development: Quantum leaps in speed, efficiency, and quality.* New York: Free Press.

Chapter 8.10
Boundaries in Communities

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INTRODUCTION AND BACKGROUND

This article suggests a way of complementing the notion of boundary objects from communities of practice to enable learning: That of extending the notion of boundary objects to account also for boundary people. There are some people whose participation in a community could provide benefits for them and the community. Although it has been suggested that in a community of practice there are different types of membership, little is mentioned about how learning could be fostered by developing inclusive membership. This could be a way of bringing relevant experience to the attention of a community.

BOUNDARIES AND MEMBERSHIP

In a community of practice, there are two main elements that constitute learning: experience and competence (Wenger, 1998). A community can be seen as a recurrent encounter between people who share interests with this permanency generating their competence, participation, and own identity. The community feeds itself from the experience of its members, including newcomers.

According to Wenger, McDermott, and Snyder (2002), cultivation of communities of practice requires establishing first a domain of competence, something that members care about. Nurturing this requires organizing activities of a community and roles for participants. It also requires establishing ways of dealing with contingencies (i.e., conflict). The result of this will be generating knowledge, which can be explicit (i.e., documents).

Although in the theory of communities of practice, it is acknowledged that communities have boundaries that define who is in and who is not part of it, there is very little guidance on how communities can deal with the resulting exclusion of individuals. It is assumed that members share interests that lead them to become part of a community and to define their engagement. Individual motivation is a condition for the formation of communities of practice, and the theory's main thrust is to provide guidance for the adequate development (or nurturing) of communities. An issue that remains unexplored is how to facilitate inclusion of those whose interest is (or might not be) developed to belong to a community, but who could greatly benefit from participating in it as well as benefiting the community.

CRITIQUE ON BOUNDARIES: BRINGING PEOPLE TO A COMMUNITY

The notion of what constitutes a boundary has been explored in management science, more particularly, in the literature of critical systems thinking (Midgley, 2000; Ulrich, 1983). A boundary is a social construction by which knowledge and people to be considered relevant in a situation are defined (Churchman, 1968). This notion presents a similarity with that of a boundary object of the theory of communities of practice (mentioned elsewhere in this encyclopedia). A boundary object helps people from a community to communicate with the rest of the world and to coordinate activities (Wenger, 1998).

This concept of an object could be extended to account for people who may be excluded from participation in a community of practice. Therefore, the idea of boundary people can be put forward. Midgley (1992) suggests that in any situation, reflection on people and issues which become marginalized from any decision could help those deciding to foster inclusion and participation. In a community, this type of reflection could also help members define their identity by acknowledging who they are and what they do, or who they could become. Often, Wenger (1998) argues, defining what and who constitutes a community helps individuals to define their own identity.

Non-participation and marginality are two issues that are accounted for in the theory of communities of practice. The first refers to a non-intensive engagement (i.e., when people are new to a community). The second refers to situations where there are barriers for people to become full members of a community. This situation may be problematic for the development of a community. In this aspect, reflection on boundaries and marginalization of both objects and people could help potential participants and community members identify issues that need to be addressed to facilitate inclusion and learning.

Midgley (1992) suggests that the definition of a boundary brings value judgments about what and who is to be included and marginalized from decisions. These value judgments could be subject to debate to enable a community to debate on possibilities of including some peripheral and marginalized members and their experience as a core element of their practice. The following questions could help a community to reflect on issues of inclusion and marginalization:

- Who is to be included within this community?
- What can constitute knowledge within the community?
- What and whose value judgments are supporting the above definitions?
- What and who is to be marginalized from activities? Why?
- From the above questions, what barriers for inclusion and learning could be identified?

CONCLUSION

In this article, a perspective to facilitate inclusion in a community of practice has been developed. This perspective takes the notion of a boundary object and extends it to account for the possible existence of people in the margins of boundaries whose participation in a community of practice could bring benefits for learning. In the dynamics of a community, it is inevitable some people and their knowledge could be marginalized. Reflecting on the implications of maintaining their marginality or avoiding it by including them into community's activities could be seen positively as a way of fostering learning and competency.

REFERENCES

Churchman, C. W. (1968). *The systems approach*. New York: Delacorte Press.

Midgley, G. (1992). The sacred and profane in critical systems thinking. *Systems Practice, 5,* 5-16.

Midgley, G. (2000). *Systemic intervention: Philosophy, methodology and practice.* New York: Kluwer Academic/Plenum.

Ulrich, W. (1983). *Critical heuristics of social planning: A new approach to practical philosophy*. Berne: Haupt.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). *A guide to managing knowledge: Cultivating communities of practice.* Boston: Harvard Business School Press.

Chapter 8.11
Representation Languages for Narrative Documents

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INTRODUCTION

A big amount of important, "economically relevant" information, is buried into unstructured "narrative" information resources: This is true, for example, for most of the corporate knowledge documents (memos, policy statements, reports, minutes, etc.), for the news stories, the normative and legal texts, the medical records, many intelligence messages as well as for a huge fraction of the information stored on the Web. In these "narrative documents," or "narratives," the main part of the information content consists in the description of "events" that relate the real or intended behavior of some "actors" (characters, personages, etc.)—the term "event" is taken here in its more general meaning, also covering strictly related notions like fact, action, state, and situation. These actors try to attain a specific result, experience particular situations, manipulate some (concrete or abstract) materials, send or receive messages, buy, sell, deliver, and so forth. Note that in these narratives, the actors or personages are not necessarily human beings; we can have narrative documents concerning, for example, the vicissitudes in the journey of a nuclear submarine (the "actor," "subject," or "personage") or the various avatars in the life of a commercial product. Note also that even if a large amount of narrative documents concerns natural language (NL) texts, this is not necessarily true. A photo representing a situation that verbalized could be expressed as "Three nice girls are lying on the beach" is not of course an NL text, yet it is still a narrative document.

Because of the ubiquity of these "narrative" resources, being able to represent in a general, accurate, and effective way their semantic content—that is, their key "meaning"—is then both conceptually relevant and economically important: Narratives form, in fact, a huge underutilized component of organizational knowledge. This type of explicit yet unstructured knowledge can be, of course, indexed and searched in a variety of ways, but it requires, however, an approach for formal analysis and effective utilization that is neatly different from the "traditional" ones.

BACKGROUND

Usual ontologies—both in their "traditional" and "Semantic Web" versions (see the "Knowledge Representation" and "RDF and OWL" articles in this Encyclopedia)—are not very suitable for dealing with narratives. Basically, ontologies organize the "concepts"—that we can identify here with the important notions to be represented in a given application domain – into a hierarchical structure, able to supply an elementary form of definition of these concepts through their mutual generic/specific relationships ("IsA" links). A more detailed definition of the concepts is obtained by associating them with a set of binary relationships of the "property/value" type (e.g., a "frame"). The combination of these two representational principles is largely sufficient to provide a static, a priori definition of the concepts and of their properties.

Unfortunately, this is no more true when we consider the dynamic behavior of the concepts, that is, we want to describe their mutual relationships when they take part in some concrete action or situation ("events"). First of all, representing an event implies that the notion of "role" must be added to the traditional generic/specific and property/value representational principles. If we want to represent adequately a narrative fragment like "NMTV (an European media company) … will develop a lap top computer system…," besides asserting that NMTV_ is an instance of the concept company_ and that we also must introduce an instance of a concept like lap_top_pc, we have to create a sort of "threefold" relationship; this relationship includes a "predicate" (like DEVELOP or PRODUCE), the two instances, and a third fundamental component, the "roles" (like SUBJECT or AGENT for NMTV_ and OBJECT or PATIENT for the new lap top system) used to specify the exact function of these two instances within the formal description of the event. Moreover, in an event context, we also must deal with those "connectivity phenomena" like causality, goal, indirect speech, co-ordination, and subordination that link together the basic "elementary events." It is very likely, in fact, that dealing with the sale of a company, the global information to represent is something like: "Company X has sold its subsidiary Y to Z because the profits of Y have fallen dangerously these last years due to a lack of investments," or, returning to our previous example, that "NMTV will develop a lap top computer system to put controlled circulation magazines out of business," or, that dealing with the relationships between companies in the biotechnology domain, "X made a milestone payment to Y because they decided to pursue an in vivo evaluation of the candidate compound identified by X." In computational linguistics terms, we are here in the domain of the "Discourse Analysis" which deals, in short, with the two following problems: (1) determining the nature of the information that in a sequence of statements goes beyond the simple addition of the information conveyed by a single statement; (2) determining the influence of the context in which a statement is used on the meaning of this individual statement or part of it.

It is now easy to imagine the awkward proliferation of binary relationships that sticking to the traditional ontological paradigm it would be necessary to introduce to approximate high-level notions like those of "role" and "connectivity phenomena."

Solutions for representing narratives in computer-usable ways that could move beyond a strict "binary" framework have, therefore, already been proposed in the past. In the context of his work—between the mid 1950s and mid 1960s—on the set up of a mechanical translation process based on the simulation of the thought processes of the translator, Silvio Ceccato (Ceccato, 1961, 1967), proposed a representation of narrative-like sentences as a network of triadic structures ("correlations") organized around specific "correlators" (a sort of roles). The correlators (100 or 200 in all, according to the different natural languages) included conjunctions and prepositions, punctuation marks, and syntactic/semantic relationships like subject-predicate, substance-accident, apposition, development-modality, comparison, and so forth. Ceccato also is credited to be one of the pioneers of the semantic network studies, even if the "official" beginning of this discipline is traditionally associated with the first publication, in 1966, of the Ross Quillian's thesis on "Semantic Memories" (Quillian, 1968). Basically, semantic networks are directed graphs (digraphs) where the nodes represent concepts, and the arcs represent different kinds of associative links, not only the "classical" IsA and property-value links, but also "ternary" relationships derived from Case Grammar in Linguistics (see Fillmore, 1966), and labeled as Actor, Object, Recipient, Instrument, and so forth. A panorama of the different conceptual solutions proposed in a semantic network context can be found in Lehmann (1992). In the 1970s, a sort of particularly popular semantic network approach was represented by the Conceptual Dependency theory of Roger Schank (1972). In this theory, the underlying meaning ("conceptualization") of narrative-like utterances is expressed as combinations of "semantic predicates" chosen from a set of 12 "primitive actions" (like INGEST, MOVE, ATRANS, the transfer of an abstract relationship like possession, ownership and control, PTRANS, physical transfer, etc.) plus states and changes of states, and seven role relationships ("conceptual case") in the Case Grammar style. Conceptual Graphs (CGs) is the representation system developed by Sowa (1984, 1999) and derived from Schank's work and other early work in the Semantic Networks domain. CGs make use of a graph-based notation for representing "concept-types" (organized into a type-hierarchy), "concepts" (which are instantiations of concept types) and "conceptual relations" that relate one concept to another. CGs can be used to represent narratives in a formal way, like "A pretty lady is dancing gracefully," and more complex, second-order constructions like contexts, wishes, and beliefs. CYC (see Lenat, Guha, Pittman, Pratt, & Shepherd, 1990) concerns one of the most controversial endeavors in the history of artificial intelligence. Started in the early 1980s as a MCC (Microelectronics and Computer Technology Corporation, TX) project, it ended about 15 years later with the set up of an enormous knowledge base containing about a million of hand-entered "logical assertions" including both simple statements of facts and rules about what conclusion can be inferred if certain statements of facts are satisfied. The "upper level" of the ontology that structures the CYC knowledge base is now freely accessible on the Web (www.cyc.com/cyc/opencyc). A detailed analysis of the origins, developments and motivations of CYC can be found in Bertino, Catania, and Zarri (2001, pp. 275-316).

NARRATIVE KNOWLEDGE REPRESENTATION LANGUAGE (NKRL)

With the exception of CYC and (very partially) of the Conceptual Graphs, the greater part of the solutions evoked in the last section concern mainly pure academic work, implying very sketchy forms of implementation. Narrative Knowledge Representation Language (NKRL) (Zarri, 1997, 2003) represents an up-to-date, fully implemented, and relatively complete solution to the problem of representing narratives without a too important loss of the original "meaning." NKRL innovates with respect to the usual ontology paradigm by associating with the traditional ontologies of concepts an "ontology of events," that is, a new sort of hierarchical organization where the nodes correspond to N-ary structures called "templates."

Instead of using the traditional object (class, concept)—attribute—value organization, templates are generated from the combination of quadruples connecting together the symbolic name of the template, a predicate, and the arguments of the predicate introduced by named relations, the roles. The quadruples have in common the "name" and "predicate" components. If we denote then with Li the generic symbolic label identifying a given template, with Pj the predicate used in the template, with Rk the generic role and with ak the corresponding argument, the NKRL core data structure for templates has the following general format:

(Li (Pj (R1 a1) (R2 a2) … (Rn an))) (1)

See the example in Table 1. Predicates pertain to the set {BEHAVE, EXIST, EXPERIENCE, MOVE, OWN, PRODUCE, RECEIVE}, and roles pertain to the set {SUBJ(ect), OBJ(ect), SOURCE, BEN(e)F(iciary), MODAL(ity), TOPIC, CONTEXT}. An argument of the predicate can consist of a simple "concept" (according to the traditional, "ontological" meaning of this word) or of a structured association ("expansion") of several concepts.

In turn, templates are included in an inheritance hierarchy, HTemp(lates), which implements

Table 1. Deriving a predicative occurrence from a template

```
name: Move:TransferOfService
father: Move:TransferToSomeone
position: 4.24
NL description: "Transfer or Supply a Service to Someone"

MOVE    SUBJ          var1: [var2]
        OBJ           var3
        [SOURCE       var4: [var5]]
        BENF          var6: [var7]
        [MODAL        var8]
        [TOPIC        var9]
        [CONTEXT      var10]
        {[modulators]}

 var1  =     <human_being_or_social_body>
 var3  =     <service_>
 var4  =     <human_being_or_social_body>
 var6  =     <human_being_or_social_body>
 var8  =     <process_> | <sector_specific_activity>
 var9  =     <sortal_concept>
 var10 =     <situation_>
 var2, var5, var7 = <geographical_location>

c1)     MOVE  SUBJ   british_telecom
        OBJ    payg_internet_service
        BENF   (SPECIF customer_ british_telecom)
        date-1: after-1-september-1998
        date-2:
```

the new "ontology of events," (see Figure 1); they represent then formally generic classes of elementary events like "move a physical object," "be present in a place," "produce a service," "send/receive a message," and "build up an Internet site." When a particular event pertaining to one of these general classes must be represented, the corresponding template is "instantiated" to produce what, in the NKRL's jargon, is called a "predicative occurrence."

To represent then a simple narrative like "British Telecom will offer its customers a pay-as-you-go (payg) Internet service in autumn 1998," we must first select in the HTemp hierarchy the template corresponding to "supply a service to someone," represented in the upper part of Table 1.

This template is a specialization (see the "father" code) of the particular MOVE template of HTemp corresponding to "transfer of resources to someone" (see Figure 1). In a template, the arguments of the predicate (the ak terms in (1)) are represented by variables with associated constraints—which are expressed as concepts or combinations of concepts, that is, using the terms of the NKRL standard "ontology of concepts" (HClass, "hierarchy of classes"). The constituents (as SOURCE in Table 1) included in square brackets are optional. When deriving a predicative occurrence (an instance of a template) like c1 in Table 1, the role fillers in this occurrence must conform to the constraints of the father-template. For example, in occurrence c1, british_telecom is an individual instance of the concept company_: this last is, in turn, a specialization of human_being_or_social_body. payg_internet_service is a specialization of service, a specific term of social_activity, and so forth.

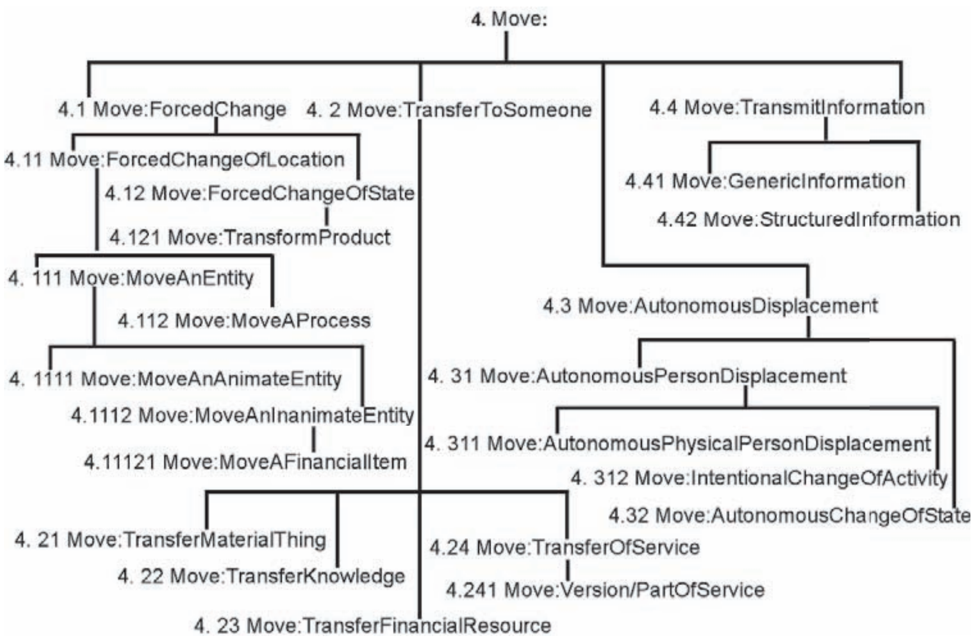
The meaning of the expression "BENF (SPECIF customer_ british_telecom)" in c1 is self-evident: The beneficiaries (role BENF) of the service are the customers of—SPECIF(ication)—British Telecom. The "attributive operator," SPECIF(ication), is one of the four operators that make up the AECS sub-language, used for the set up of the structured arguments (expansions); apart from (SPECIFication = S), AECS also includes the disjunctive operator (ALTERNative = A), the distributive operator (ENUMeration = E), and the collective operator (COORDination = C). The interweaving of the four operators within an expansion is controlled by the so-called "precedence rule" (see Zarri, 1997, 2003).

In the occurrences, the two operators date-1, date-2 materialize the temporal interval normally associated with narrative events; a detailed description of the methodology for representing temporal data in NKRL can be found in Zarri (1998).

About 150 templates are permanently inserted into HTemp; Figure 1 reproduces the "external" organization of the actual state of the MOVE branch in HTemp; this branch includes the Move: TransferOfService template used in Table 1. HTemp, the NKRL ontology of events, corresponds then to a sort of "catalogue" of narrative formal structures that are very easy to "customize" in order to derive the new templates that could be needed for a particular application. This approach is particularly advantageous for practical applications, and it implies, in particular, that: (1) a system-builder does not have to create himself the structural knowledge needed to describe the events properly to a (sufficiently) large class of narrative documents; (2) it becomes easier to secure the reproduction or the sharing of previous results.

What we have expounded until now illustrates the NKRL solutions to the problem of providing a coherent and complete representation of elementary (simple) events. To deal now with those "connectivity phenomena" that arise when several elementary events are connected through causality, goal, indirect speech etc. links, the basic NKRL knowledge representation tools have been complemented by more complex mechanisms

Figure 1. 'MOVE' branch of the HTemp hierarchy



that make use of second order structures created through reification of the predicative occurrences' conceptual labels (see Zarri, 1998, 2003). For example, the "binding occurrences" are NKRL structures consisting of lists of symbolic labels (ci) of predicative occurrences; the lists are differentiated making use of specific binding operators like GOAL and CAUSE. Let us suppose that in Table 1 we would now state that: "British Telecom intends to offer to its customers a pay-as-you-go (payg) Internet service…," where the elementary event corresponding to "British Telecom … (will) offer to its customers a pay-as-you-go (payg) Internet service…" is represented by the occurrence c1 in Table 1. We must first introduce an additional predicative occurrence labeled as c2 that we will represent here, in a very simplified way, as: "c2) BEHAVE SUBJ british_telecom." c2 means: "at the date (date-1) associated with c2, it can be noticed that British Telecom is (mentally) acting in some way." We will then add a binding occurrence c3 to link together the conceptual labels c2 (the intention) and c1 (the intended result); c3 will have the following form: "c3) (GOAL c2 c1)." The global meaning of c3 is: "the activity described in c2 is focalized toward (GOAL) the realization of c1"—c1 is represented in Table 1.

Reasoning in NKRL ranges from the direct questioning of an NKRL knowledge base making use of "search patterns" (the formal NKRL equivalents of natural language queries) that try to unify the predicative occurrences of the base, to high-level inference procedures employing complex inference engines.

For example, the "transformation rules" try to "adapt," from a semantic point of view, the original query/queries (search patterns) that failed to the real contents of the system knowledge base. The principle employed consists in using rules to automatically "transform" the original query (i.e., the original search pattern) into one or more different queries (search patterns) that are not strictly "equivalent" but only "semantically close" to the original one. In this way, an original query posed, for example, in terms of "searching for evidence of having lived in a given country" will be replied in terms of "searching for evidence of an original school/university diploma delivered in that country."

"Hypothesis rules" allow building up "reasonable" answers according to a number of predefined reasoning schemata, such as "causal" schemata. For example, after having directly retrieved information like "Pharmacopeia, an USA biotechnology company, has received $64,000,000 from the German company Schering in connection with an R&D activity," we could be able to automatically construct a sort of "causal explanation" of this information by retrieving in the knowledge base information like (1) "Pharmacopeia and Schering have signed an agreement concerning the production by Pharmacopeia of a new compound" and (2) "in the framework of the agreement previously mentioned, Pharmacopeia has actually produced the new compound."

FUTURE TRENDS AND THE IMPORTANCE OF NKRL IN KNOWLEDGE MANAGEMENT

In these last years, knowledge has been recognized as one of the most important assets of an enterprise and a possible success factor for any industrial organization, on the condition that it could be controlled, shared, and reused in an effective way. Accordingly, the core of the organization can then be conceived the form of a general and shared "corporate memory," (see van Heijst, van der Spek, & Kruizinga, 1996; Brooking, 1998; Beckett, 2000), that is, of an online, computer-based storehouse of expertise, experience, and documentation about all the strategic aspects of the organization. The construction and practical use of corporate memories then becomes the main activity in the knowledge management of a company. As already stated, this corporate knowledge is mainly represented under the from of narrative documents; the possibility of having at one's disposal a tool in the NKRL style becomes then an essential condition for the concrete setup and for the "intelligent" exploitation of non-trivial corporate memories.

In this context, we can remark that the different working groups managed by the W3C are not, apparently, very interested in the problem of dealing in an appropriate way with everyday life and complex narratives. W3C (the World Wide Web Consortium) is coordinated by MIT (USA), ERCIM, the European Research Consortium for Informatics and Mathematics, and the Keio University (Japan), and includes all the main bodies on earth interested in the developments of Internet and the Web. As an at least partial exception to this attitude, we can mention a recent paper from the W3C Semantic Web Best Practices and Deployment Working Group (SWBPD WG) about defining N-ary relations on the Semantic Web (Noy & Rector, 2005). After having recognized that the Semantic Web languages promoted by the W3C, like RDF and OWL, can only support binary relations (properties) between individuals (see the "RDF and OWL " article in this encyclopedia) the authors try to propose some extensions to these languages that could be able to deal with narratives like: "Christine has breast tumor with high probability," "Steve has temperature, which is high, but failing," or "John buys a Lenny the Lion book from books.Example.com for $15 as a birthday gift," which, obviously, cannot be represented, making use only of IsA and property-value relationships. The solutions proposed range from the introduction of fictitious individuals to represent the n-ary relations to the rediscovery of some semantic networks solutions of the 1970s. Interestingly enough, the authors state that "The SWBDP WG does not expect this document to become a Recommendation (i.e., a W3C Recommendation)" (Noy & Rector, 2005, p. 2). In NKRL, the two first examples—"Christine has breast tumor…" and "Steve has temperature…"—are translated as simple instantiations of the template Experience: NegativeHuman/SocialSituation (3.211), and the example about "John buys…" as an instantiation of the template Produce:Buy (6.361).

CONCLUSION

In this article, we have recalled first the importance, from an economic point of view, that "narratives" have in the context of the corporate knowledge. We have then shown that the usual ontological tools, both the "traditional" (frame-based) ones and the new ones proposed in a Semantic Web context, are unable to offer complete and reliable solutions to the problem of a non-trivial representation and exploitation of narratives. After having recalled the existence of early proposals in this field, we have supplied some details about NKRL (Narrative Knowledge Representation Language), a fully implemented, up-to-date knowledge representation and inferencing system especially created for an "intelligent" exploitation of narrative knowledge. The main innovation of NKRL consists in associating with the traditional ontologies of concepts an "ontology of events," that is, a new sort of hierarchical organization where the nodes correspond to N-ary structures called "templates." Templates—150 at present, but new templates can be easily created on the model of the existing ones—represent formally generic classes of elementary events like "move a physical object," "be present in a place," "produce a service," "send/receive a message," and "build up an Internet site." More complex, second order tools based on the "reification" principle allow to encode narratives characterized by the presence of elementary events linked by relationships like causality, goal, indirect speech, co-ordination, and subordination. After having evoked the query/answering and inferencing tools associated with NKRL, the article ends by mentioning the importance of having at one's disposal tools in the NKRL style for the actual setup of non-toy corporate memories.

REFERENCES

Beckett, R.C. (2000). A characterization of corporate memory as a knowledge system. *Journal of Knowledge Management, 4*(4), 311-319.

Bertino, E., Catania, B., & Zarri, G.P. (2001). *Intelligent database systems.* London: Addison-Wesley and ACM Press.

Brooking, A. (1998). *Corporate memory: Strategies for knowledge management.* London: Thomson Business Press.

Ceccato, S. (1961). *Linguistic analysis and programming for mechanical translation.* Milan: Feltrinelli.

Ceccato, S. (1967). Correlational analysis and mechanical translation. In A.D. Booth (Ed.), *Machine translation.* Amsterdam: North-Holland.

Fillmore, C.J. (1966). Toward a modern theory of case. In D.A. Reibel & S.A. Schane (Eds.), *Modern studies of English: Readings in transformational grammar.* Englewood Cliffs, NJ: Prentice Hall.

Lehmann, F. (Ed.) (1992). *Semantic networks in artificial intelligence.* Oxford: Pergamon Press.

Lenat, D.B., Guha, R.V., Pittman, K., Pratt, D., & Shepherd, M. (1990). CYC: Toward programs with common sense. *Communications of the ACM, 33*(8), 30-49.

Noy, N., & Rector, A. (2005). *Defining n-ary relations on the Semantic Web—Editor's draft.* Retrieved June 20, 2005, from www.w3.org/TR/swbp-n-aryRelations#ref-1.

Quillian, M.R. (1966). Semantic memory. In M. Minsky (Ed.), *Semantic information processing.* Cambridge, MA: MIT Press.

Schank, R.C. (1973). Identification of conceptualisations underlying natural language. In R.C. Schank & K.M. Colby (Eds.), *Computer models of thought and language.* San Francisco: Freeman and Co.

Sowa, J.F. (1984). *Conceptual structures: Information processing in minds and machines.* Reading, MA: Addison-Wesley.

Sowa, J.F. (1999). *Knowledge representation: Logical, philosophical, and computational Foundations.* Pacific Grove, CA: Brooks Cole Publishing Co.

van Heijst, G., van der Spek, R., & Kruizinga, E. (1996). Organizing corporate memories. In Gaines, B.R., and Musen, M., (Eds.) *Proceedings of the 10th Banff Knowledge Acquisition for Knowledge-Based Systems Workshop,* Calgary: Department of Computer Science of the University.

Zarri, G.P. (1997). NKRL, a knowledge representation tool for encoding the 'meaning' of complex narrative texts. *Natural Language Engineering: Special Issue on Knowledge Representation for Natural Language Processing in Implemented Systems, 3,* 231-253.

Zarri, G.P. (1998). Representation of temporal knowledge in events: The formalism, and its potential for legal narratives. *Information and Communications Technology Law: Special Issue on Models of Time, Action, and Situations, 7,* 213-241.

Zarri, G.P. (2003). A conceptual model for representing narratives. In R. Jain, A. Abraham, C. Faucher, & van der Zwaag (Eds.), *Innovations in knowledge engineering.* Adelaide, Australia: Advanced Knowledge International.

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Chapter 8.12
Culture-Free or Culture-Bound? A Boundary Spanning Perspective on Learning in Knowledge Management Systems

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ABSTRACT

Knowledge management systems (KMSs) have been criticized as having a North American bias. The cultural dimension of KMSs, particularly the relationship of learning and culture in KM projects, are rarely discussed. This paper addresses these concerns in a review of the conceptual foundations for KM and by examining implementations of KM projects. Despite the evolutionary changes in how KM is viewed, KMSs, as they have been designed, implemented, and reported, do not appear to provide for cultural diversity among users. Instead, the reports of KMSs indicate that such systems seek to create and maintain a homogeneous organizational culture, and the adoption of such a shared culture appears to be a prerequisite for success. The paper discusses KMSs as systems that exhibit boundary spanning objects and processes in three different categories, and an analysis of reported projects reveals that boundary spanning across national and ethnic boundaries is rare.

INTRODUCTION: INFORMATION TECHNOLOGY AND KNOWLEDGE MANAGEMENT

Global enterprises increasingly turn to knowledge management systems (KMSs) to raise productivity and remain competitive. Although there is considerable evidence that applications of information technology (IT) for storage and improved access of information help create value, some observers believe that KMSs are limited in their utility because they have been designed with a North American bias (Nonaka, 1995). To understand why this bias may be of concern, it is useful to consider KM programs in the context of the resource-based view (RBV) of the firm (Penrose, 1959).

The dynamic economic environment and the ever-increasing innovative capabilities of global organizations have renewed interest in the RBV. In the opinion of many writers, the RBV has had a significant impact on how information systems and strategy are viewed. The RBV is closely linked with strategy and sustainable competitive advantage (Barney, 1994, 1996), plays a major role in how the modern economic theory of the firm has developed (Madhok, 2002), and perhaps has become the most influential framework for the theory of strategic management and sustained competitive advantage (Barney et al., 2001). The knowledge-based view (KBV) of the firm, foreseen by Drucker (1988), is a special case of the RBV with a focus on knowledge as an organizational resource (Grant, 1996a,1996b; Spender, 1996).

As in the more general case of the RBV's influence on strategic management and competitive advantage, the KBV provides the conceptual foundation for much of the research and design efforts that link information technology (IT) and systems, strategic IT, organizational learning, and knowledge management systems. The KBV has shaped the discussion of KMSs and the role of information technology in strategy and competitive advantage (Huber, 1991; Mata, 1995; Kogut, 1996; Alavi, 2001). While the KBV is the foundation for IT support of knowledge management, most observers agree that knowledge by itself is not the source of a competitive advantage. Instead, organizations use knowledge to gain a competitive advantage through learning (Stata, 1989), by the development of competencies (Rebentisch & Ferretti, 1995; Alavi, 2001), and through knowledge integration (Grant, 1996b; Kogut, 1996). In other words, the value of KM programs depends not only on the application of IT but on the individual and organizational learning and knowledge integration that comes from revealing and using all the intellectual assets of the organization. This requires a mix of technology and organizational processes.

From the perspective of the KBV, a global enterprise that has members from distinct ethnic and cultural backgrounds would appear to have a potentially large asset in the rich source of tacit and experiential knowledge of its members. KM efforts would be one way to access this potential asset. This paper addresses the question of how and to what extent firms may be taking advantage of the knowledge asset represented by having members with diverse backgrounds.

In the remainder of the paper, we will use the terms "KM" and "KMS" interchangeably; both will refer to the set of activities directed toward knowledge asset management. Our approach is in the spirit of socio-technical systems, thus KM and KMS include physical resources (e.g., computers and communication infrastructures), conceptual resources (e.g., repositories of expressed knowledge, tacit knowledge), and the social and organizational processes associated with the use of these resources.

The paper contributes to the discussion of KM by drawing attention to the importance of culture in KM efforts and proposing that KMSs may be viewed as boundary spanning systems. The cultural boundary is important for two reasons. First, ethnic backgrounds and national cultures represent a potential knowledge asset of the enterprise. Second, culture is a significant factor in how people learn, and learning is required for the organization to take advantage of the potential intellectual assets in the organization. The paper uses Carlile's boundary spanning framework (Carlile, 2002) to review the functions of KMSs and to examine how these systems handle culture.

In the following three sections, this paper provides a synopsis of knowledge management approaches and learning from three perspectives:

a) a summary of the goals and expected benefits of KMSs; b) the role and importance of culture and ethnic background in learning; and c) reports on the implementation and use of KMSs and the role of culture in these implementations. The fourth section reviews these KMS implementations using Carlile's framework of practical boundary spanning systems to gain a better understanding of the relative importance of culture in the design and use of a KMS in a particular organization. Based on this review, most KMSs appear to fulfill the boundary spanning role primarily at two of Carlile's three levels. The KM activities at the third level are not directed at spanning boundaries between or among national or ethnic cultures but rather at spanning hierarchical boundaries. As a consequence, benefits that might accrue from the surfacing of differences in tacit cultural knowledge are unlikely to be realized. The final two sections discuss the contribution of this paper, its limitations, and its potential significance for research and practice.

KMS DIRECT AND INDIRECT BENEFITS: THE VALUE OF CULTURE AND LEARNING

Early studies of KMSs viewed such systems as the application of IT to improve the information value chain (Rayport, 1995) by providing an organizational memory (Walsh & Ungson, 1991) and supporting organizational learning (Huber, 1991). A recent review of KM elaborates on this basic value chain model and summarizes prior studies as being focused on four basic processes in knowledge work: creating, storing/retrieving, transferring, and applying knowledge, with each of these processes being subjected to more detailed analyses (Alavi, 2001, p. 114). This conceptual model views KMSs as systematic attempts to make visible the collective and individual knowledge in an organization, develop a knowledge-intensive culture, and support this culture through an IT-enabled infrastructure (Davenport & Prusak, 1998; Alavi, 2001). Specifically, a KMS is viewed as a class of information systems applied to managing knowledge (Alavi, 2001), and IT is seen as an enabler of the basic processes of creating-storing/retrieving-transferring-applying knowledge.

While much effort is devoted to creating repositories of explicit knowledge, KM efforts also seek to identify sources of tacit knowledge, to surface and improve access to this knowledge, and to enable collaborative learning and integration across functional areas (Alavi, 2001; Leonard, 2002; MacCormack, 2002; Fulmer, 2003). In their study of 31 KM projects, Davenport et al. (1998), identified four broad types of objectives: (1) create knowledge repositories, (2) improve knowledge access, (3) enhance knowledge environment, and (4) manage knowledge as an asset.

Reports of tangible benefits have included cost savings (arising from, among other things, reduced time required for knowledge access by having ready access to needed information) and increased revenue and profit. These benefits are recognized as both direct and indirect. Direct benefits are those associated with having the collective knowledge readily accessible to all organizational members: a corporate memory (e.g., best practices, repositories of projects, compilations of data about clients and suppliers, etc.) and the facilitation of communication among the organization's members (a shared structure and communication infrastructure, meta-information that enables members to locate others that may have the information they require), and knowledge transfer (Fulmer, 2003). These direct benefits are antecedents to indirect benefits: knowledge creation and innovation in products and processes, improved collaboration and the synthesis of tacit knowledge from multiple entities in the organization, the creation and maintenance of core competencies, and improved competitiveness. The indirect benefits require learning and knowledge integration across functional boundaries and may be even more valuable than the direct benefits.

However, as noted by many of the cases, it is easier to see the impact of KM efforts on the direct benefits, and firms are able to assign values to these direct benefits more easily than to indirect benefits (Alavi, 1997; Davenport et al., 1998; Hansen, 2002; MacCormack, 2002; Ng, 2002; Soo, Devinney, et al., 2002). The difficulty of measuring indirect benefits may be overcome by measuring their impact. For example, Soo et al. (2002) suggest measuring changes in the innovative outputs that arise from the KM effort.

A global firm comprises organizations that have individuals from many different ethnic and cultural backgrounds. From the KBV, knowledge from this diverse set of employees represents a potential intellectual asset. Appropriating the benefits from this asset, however, requires learning. The next section reviews the relationship between culture and learning.

LEARNING: THE ROLE OF CULTURE

Learning is defined as "a relatively permanent change in the ability to exhibit a behavior; this change occurs as the result of a successful or unsuccessful experience'' (Klein & Mowrer, 1989, p. 2). This definition is consistent with the experiential learning model (Kolb, 1984) and with a prevailing view in the IT field that "an entity learns, if, through its processing of information, the range of its potential behaviors is changed" (Huber, 1991, p. 89). Although these definitions are consistent—each relates to ability or capability to demonstrate behavior, for example—they have differences: Klein and Kolb emphasize experience as the basis of learning; Huber, as an IS researcher, views the learner as an information (or knowledge) processing entity. Huber also posits that an organization learns if "…any of its units acquires knowledge that it recognizes as potentially useful to the organization" (Huber, 1991, p. 89).

Although a discussion of the similarities and distinctions between individual and organizational learning could be interesting and enlightening (e.g., Dixon, 1994), this paper accepts that individual learning is critically important to (if not, as Huber posits, equivalent to) organizational learning. Consequently, the following discussion focuses on individual learning and looks particularly at contemporary theories about culture-based learning.

The study of learning processes has provided a rich field for psychologists for well over 100 years (Mowrer, 1989). Earlier views of learning focused on the stimulus-response relationship and later (particularly Skinner's work) associated reinforcement (rewards) with behavior. Contemporary learning theory, in contrast, has moved away from global theories and looked more closely at concept formation, problem solving, language, and other cognitive aspects of learning. Even the biological aspects of learning are getting new attention (LoLordo, 1989; Mowrer, 1989; Zull, 2002).

Because learning is related to language and language use, and language rules may be "hardwired" as Chomsky proposed in the 1980s (see Baker, 2001, for recent renewal of these arguments), one might conclude that the basic biological foundation for learning is genetic and therefore would not vary from culture to culture. A common biological base does not prevent the development and evolution of learning skills and abilities along different paths in distinct ethnic groups and cultures.

Indeed, for over 70 years researchers have examined the link between culture (and ethnicity) and learning. Hall (1959) summarizes the relationship between learning and culture by saying, "once people have learned to learn in a given way, it is extremely difficult to learn in any other way […C]ulture reflects the way one learns." In 1930, Vygotsky and Luria proposed a culture-centered approach to learning, and others developed this approach further (Vygotsky et al., 1987; Forman et al., 1993; Kozulin, 1998). In this perspective, culture is a source of differences in cognition as cognitive processes are formed through sociocultural activities. Cole and others developed this into a contextual theory of cognitive functions (Cole, 1971), which has as a foundation the idea that different cultures have different systems of mediated learning experience (MLE). Such systems are important to cognitive development, and differences in development (which can arise from different MLEs) become evident when a learner makes a transition from one system to another.

Some have argued "cross-cultural differences tend to disappear under the influence of systematic exposure to formal schooling" (Kozulin, 1998, p. 110, citing Cole, 1990). However, recent research confirms Hall's general statement and provides empirical evidence for Cole's theory that individual cognitive abilities can develop differently in different cultures. Even within the U.S., studies have indicated that some groups exhibit distinct behavioral styles through which they express their abilities to learn. Individuals who have experienced culturally distinct environments while growing up tend to use the skills gained in these environments even after they are adults (Hilliard, 1992). In studies of young adults who have completed schooling in one culture and move to another culture, the results indicate that the nature of the initial formal schooling makes a difference. This difference is not simply a difference in knowledge base, but rather is associated with the basic skills by which one learns new concepts. The young adults exhibited specific difficulties associated with coding schema, concepts, and graphic and symbolic devices used in communication of ideas (e.g., tables, ordering, plans and maps). The difficulties extend to cognitive activities such as the ability to identify or define problems (that is, the ability to apply their knowledge to a set of data and infer the implicit question or issue), the ability to work with multiple sources of information, etc. In short, the young adults are missing cognitive antecedents that would enable them to excel in their new environment (Kozulin, 1998). Kozulin concludes, "…cross-cultural differences in cognition are most probably related to learning practices characteristic of different cultures and subcultures…" and "Two major determinants of cognitive prerequisites are conceptual literacy and facility with other symbolic psychological tools, and a mediated learning experience responsible for the integration of these tools into the cognitive system of the student" (Kozulin, 1998, p. 129). His work showed that intervention could help learners develop the basic skills that would enable them to learn effectively in the new environment.

Research on western-style education has included considerable recent interest in problem-based learning (PBL) as a distinct pedagogy. The potential benefit of PBL is that it provides a better match of formal learning experience with environmental demands after the completion of formal schooling. While some research reports mixed results, there is considerable enthusiasm for this approach in the sciences and medicine (Culatta, 1994; Boud & Feletti, 1998; Jones et al., 2001). The use of PBL to develop competencies—abilities that enable persons to continue to learn—is suggested by Tien, et al. (2003), who compare the competencies identified as goals by the educational systems in Australia, the UK, the U.S., Canada, and Taiwan. Significantly for this review, the competencies in different countries are similar but not identical in wording. For example, Australia and the UK emphasize instrumental competencies more so than the U.S., Canada, and Taiwan. Taiwan lists "self-understanding and potential development" as one of its ten competencies, a skill not articulated by any of the other countries' educational systems (Tien, 2003). Tien's study illustrates that even with many shared goals, the educational objectives of even industrialized countries have differences; the differences across a wider range of countries might be even greater.

Kozulin's studies suggest that cultural backgrounds can perform a critical role in the development of problem definition and problem solving abilities. Moreover, intervention to develop missing skills may be required for a learner to make a successful transition from one learning system to another. Since many KMSs are intended to support group problem solving and learning across functional boundaries, a PBL approach may be a useful way to bridge cultural differences, as suggested by Tien (2003). However, there are practical difficulties in designing PBL interventions for non-western and non-English speaking students (Walker, 1996; Allen & Rooney, 1998).

KMS IMPLEMENTATIONS AND CULTURE

This study examined published reports of KMSs in the literature and focused particularly on the role of culture in KMS and KM project success. For individual cases, this section draws heavily on teaching cases (business school cases of individual implementations) and other summaries of actual implementations (e.g., Davenport et al., 1998). Table 1 summarizes the findings, including this author's summary of what appear to be critical success factors in each case. Table 2 provides additional examples of the implementations summarized by Davenport et al. (1998).

The results of the studies summarized in Tables 1 and 2 are striking in three ways. First is the emphasis by so many of the implementations on standardization, both technical standards and the format of the content. Second is the frequent mention that an organizational culture of knowledge sharing is a correlate of success. Third is the prevalent, though not universal, use of incentives to change behavior and encourage system use. National culture and ethnic background of the users are rarely mentioned.

Only one case directly discusses the importance of national culture. In the Buckman Laboratories case, national culture and non-English speakers were handled explicitly (Fulmer, 2003). K'Netix, as it evolved, encouraged contributions to the knowledge base in whatever language the contributor felt most comfortable. A key component of the system was a group of translators hired by the firm. The translators translated into English the contributions selected by the forum monitors, making these contributions more accessible to employees whose native language was not English. As the system evolved, separate regional forums began, including a Spanish language case database on best practices. In 1997 there were 1,787 cases in English and 685 in Spanish (Fulmer, 2003). At the last report, however, the firm had standardized on English as the common language for contributions, rather than having separate language forums (Fulmer, 2000). Consequently, the only case that gave attention to national culture appears to have "regressed to the mean" and decided on a standardized approach to knowledge sharing.

This review of KM contrasts with the attention paid to culture in studies of other information systems, (e.g., Walsham, 2002) and in other studies of international management, (e.g., Erez & Earley, 1993). The tendency to ignore cultural background in KM efforts suggests that KMS designers may be implicitly adopting the "culture-free" hypothesis as a basis for design. The culture-free hypothesis expresses the thought that there is universality to organizational design and structures—that organizations are micro social entities that can exist without reference to their immediate societal environment. This is in contrast to the culture-bound view that organizations match their structures to fit their societal environment (Maurice, 1976). For a wide range of production firms, the culture-free hypothesis is supported by a meta-analysis (Miller, 1987). There is some evidence supporting the culture-free hypothesis in banks (Birnbaum, 1985), but research that examines this hypothesis in other professional service work is missing. Perhaps the

Table 1. Characteristics and critical success factors (CSFs) of sample KMSs

Source	Context/Users	Technology and Methods	CSFs (author's summary)	Support for multiple cultures?
(Massey, 2002)	Nortel New Product Development (NPD) teams	Electronic Performance Support System	Financing Standardized process Codified format	No
(MacCormack, 2002)	Siemens ShareNet—multiple (sales, developers, managers)	Knowledge Repository User Network for query-response	Structured inputs Query-Response component Marketing of system use; incentives	No
(Fulmer, 1999; Fulmer, 2000; Fulmer, 2003)	Buckman Labs K'Netix	Monitored but unmoderated Forums Email	Principles Code of Ethics Adaptability Dedicated staff	Sensitive to culture Tried multiple languages; settled on English only
(Ng, 2002)	PwC KnowledgeCurve; 99% of 150,000 world-wide consultants	Intranet; Lotus Notes databases	KM content process (editing/vetting) Users' view as integrated system Access from any location	No
(Leonard, 2002)	NASA/JPL: LLIS, APPL and KSI (face-to-face program); Project Libraries; *Know Who* directory; *Technical Questions* DB; legacy reviews; personal knowledge organizers (oral histories)	Customizable portal; DocuShare, leadership development; Internet; DBs	Resources Culture and commitment (varied from low to high)	No (Focus is on US organization)
(Rukstad, 2001)	DaimlerChrysler Knowledge Management Strategy	CAD/CAM Product DB EBOKs TechClubs	Support Link to performance Top management consensus on required capabilities	No
(Chard, 1997; March, 1997)	E&Y: EYKnowledgeWeb	LotusNotes; multiple platforms	Culture and commitment; built into performance reviews that encouraged use	No
(March, 1997; Hansen, 2002)	Andersen Consulting: Knowledge Xchange	LotusNotes; divergent and specialized forums (GBP); search capabilities	Annual review and incentives to encourage sharing KMs with specialized roles Pre-filtering, context	No
(Alavi, 1997)	KPMG: Kweb	Web-based intranet; links to external	Integration into business processes; incentives to embrace culture	No
(Davenport, Long, et al., 1998)	Multiple (see Table 2)	Multiple	K-friendly culture, change in motivational practice, clear language, 5 others	None mentioned

Table 2. Examples from "successful knowledge management projects" (Adapted from Davenport et al.,1998)

Context/Users	**Technology and Methods**	**Notes**
HP (9 projects)	Electronic Sales Partner Lotus Notes DB	Highly enthusiastic managers ("most successful implementation of software I have seen in 20 years")
Sequent Computer	Sales oriented document respository	Highly enthusiastic managers
BPX	Videoconferencing Document scanning/sharing Education, support	Anecdotal success stories
Microsoft	Breakout of K competencies Link K competencies to staffing and HR	
National Semiconductor	Intranet Lotus Notes	Engineers preferred Intranet; sales and marketing preferred Notes
TelTech Resource Network	Referral of experts (technology not specified) Customer feedback Records of K resources used in proposals and projects compared with "wins"	Basis for business model
Sematech	Formal K transfer practices • K transfer organization • K transfer sessions • Client "assignees"	Face-to-face most effective for K transfer
Consulting firm	Structured K base	Contributions to K base a significant factor in compensation (not entirely successful)
Automobile co.	Specific K application guidelines Decision audits to assess use of Knowledge	Success not established
Automobile co.	Grapevine: interprets, stores, routes competitive intelligence to managers	
Skandia	Intellectual capital audit	
Dow	Review and manage patents	Expect $100 million more in licensing revenue

lack of attention to (national) culture in KM efforts is understandable, particularly given the experience and decision of Buckman Laboratories, but there is no research that supports "culture-free" as a normative approach to knowledge work (or other professional service work).

KMSS AS BOUNDARY SPANNING SYSTEMS

Boundary spanning has been recognized as a necessary component in processes that require coordination and translations among diverse groups (Star & Greisemer, 1989) and different functional groups or "thought worlds" (Dougherty, 1992). Product development is an example of a process requiring such coordination. KM and learning are often discussed in the context of new product development (NPD) processes; (Chapman & Hyland, in press; Verganti, 1998; Ramesh and Tiwana, 1999; Alavi, 2001).

Carlile's (2002) study of boundary spanning objects in an NPD process suggests a useful framework for examining the functions of KMSs. Carlile looked at the four primary functions involved in the creation of a new product (sales/marketing, design engineering, manufacturing engineering, and production) and examined how the new product development team dealt with the specialized knowledge of each area. Each of the four functional areas had different and specialized (in Carlile's terms, "localized and embedded") knowledge, structured in a way that made sense to the group. This knowledge specialization presented a barrier to the effective operation of the NPD team—the team found it difficult to exchange and synthesize knowledge as necessary for the successful development of a new product. Carlile observed that the team overcame this barrier by using boundary spanning objects that operated at three different levels: syntactic, semantic, and pragmatic.

At the syntactic level, repositories enabled communication of facts and agreed-upon tasks and actions. At the semantic level, standardized forms and methods enabled not only communication of facts, but also provided a way for the different groups to clarify differences in meaning. The objects at this semantic level (standard forms and methods) enabled the team to translate the knowledge embedded in one group so that other groups contributing to the product development could understand it. At the pragmatic level, objectives, maps, and models enabled each group to transform embedded knowledge into knowledge that the team (and others not in the group) could understand.

Earlier, Brown and Duguid (1998) pointed out different roles of boundary spanning activity, noting particularly the need for translators between communities. In commenting on Carlile's model, Brown (2002) suggests that Carlile's three levels correspond to three different levels of knowledge ambiguity among communities of practice. At each level, different types of boundary objects are necessary for communication, knowledge transfer, and learning.

At the syntactic level, the differences across the boundaries are explicit, clear, and stable. A shared syntax is a necessary (but not necessarily sufficient) condition for knowledge sharing under these conditions. Taxonomies and classification (e.g., shared databases) provide this syntax and enable the sharing and transfer of knowledge among groups that have a clear understanding of their differences and understand that these differences are relatively stable.

At the semantic level, the differences are neither clear nor necessarily stable (Brown, 2002), and the solution is to provide a means of translating meanings across boundaries. At this level, Carlile (2002) observed the use of standardized forms and methods as boundary objects.

At the pragmatic level, Brown (2002) notes that the knowledge of one group is not neutral to another's. The communities may have different values and/or power relationships, and this level of difference requires boundary objects that provide additional capability beyond the first two levels. At this level, the groups must transform their knowledge and create new (shared) knowledge rather than simply exchanging or transferring knowledge. Resolution of the group differences requires objects such as models and maps, objects that enable the sharing of methods of thinking and the surfacing of assumptions and values. Only when both groups understand these differences can the two communities be co-creators of knowledge that did not exist before the differences were discussed. It is at this level that one might observe the kind of knowledge integration and synergy anticipated by the KBV of the firm.

Considering KM efforts and KMSs as processes to span the boundaries of groups that have different knowledge and experience, one can map the examples from Tables 1 and 2 onto Carlile's framework. At the syntactic level, shared databases (e.g., repositories of best practices, evident in all the cases) provide a way for groups to transfer knowledge. At the semantic level, standard forms and practices (highlighted in Nortel, Siemens, PwC, EYKnowledgeWeb, KPMG's KWeb and Andersen's Knowledge Xchange) provide the means of representation of different knowledge in familiar formats and a means of learning from groups that have a different knowledge base.

At the pragmatic level, where differences in value would be apparent, Tables 1 and 2 provide fewer examples. The use of principles (Buckman Laboratories) as a boundary-spanning object between upper management (the owner) and employees could be considered a pragmatic level object, helping transform the owner's values into practice. An interesting distinction is that the principles are not developed in collaboration with the employees but rather presented to them as a standard—a codified set of behavioral principles that enable them to understand the goals and objectives of the firm. Similarly, one may consider the incentives and efforts to change corporate culture as boundary spanning activities at the pragmatic level.[1] These activities may also be viewed as

Table 3. Levels and functions of boundary spanning processes with KMS examples

Level (Carlile, 2002)	**Community Differences (Brown, 2002)**	**Boundary Object Function or Solution—adapted from (Brown, 2002)**	**KMS Boundary Objects**	**Example KMS**
Pragmatic	Knowledge is not neutral; values and power may differ across boundaries	Transformation Exercise of power	Objectives Maps Models Incentives Forums	Buckman Labs Siemens Andersen E&Y KPMG Others (Davenport, Long et al. 1998) Buckman Labs NASA/JPL
Semantic	Unclear	Translation	Principles Standard methods and procedures Standard, codified forms	BuckmanLabs K'Netix Nortel E&Y Andersen PwC
Syntactic	Clear, stable	Communication Shared knowledge and data base	Repositories	All

Table 4. KMSs as boundary spanning systems

KMS, KM effort	Boundary Objects or Processes	Level in Carlile's Framework: Syntactic	Semantic	Pragmatic
Nortel New Product Development (NPD) teams	Financing	X		
	Standardized process	X	X	
	Codified format	X	X	
Siemens ShareNet—multiple (sales, developers, managers)	Structured inputs	X	X	
	Query-Response		X	
	Incentives			X
Buckman Labs K'Netix	Forums	X	X	X*
	Code of Ethics		X	
	Principles		X	X
PwC KnowledgeCurve; 99% of 150,000 world-wide consultants	Users' view as integrated system	X		
	KM content process (editing/vetting)	X	X	
NASA/JPL: LLIS, APPL and KSI (face-to-face program); Project Libraries; *Know Who* directory; *Technical Questions* DB; legacy reviews; personal knowledge organizers (oral histories)	Resources	X		
	Portal	X		
	DocuShare	X		
	DBs	X		
	Leadership Development		X	X
DaimlerChrysler Knowledge Management Strategy	CAD/CAM	X		
	Product DB	X		
	EBOKs	X		
	TechClubs	X	X	
E&Y: EYKnowledgeWeb	Lotus Notes	X	X	
	Performance reviews			X
Andersen Consulting: Knowledge Xchange	Pre-filtered respositories	X	X	
	K Managers with specialized roles		X	
	Annual reviews		X	X
KPMG: Kweb	Intranet	X		
	Integration into business processes	X	X	X
	Incentives		X	X
Synthesis of Multiple Successful KM Projects (Davenport, Long et al. 1998)	Link to performance, value		X	
	Standard, flexible K structure	X	X	
	"K-friendly" Culture			X
	Clear language	X	X	
	Change in motivational practice			X
	Multiple channels for K Transfer	X	X	
	Senior Management Support			X

** Only this boundary spanning object/process specifically recognizes cultural distinctions; other pragmatic level objects span top executive and employee communities and may relate more to power than to sharing of knowledge* procedures and routines that serve to translate values from the executive level to managers and other employees—procedures that might also be viewed as semantic. In other words, these processes span a hierarchical boundary, not an ethnic or national cultural boundary.

Table 3 summarizes Carlile's levels, Brown's (2002) view of the community differences for which spanning is required, and the corresponding boundary spanning techniques used by KMSs. Note that all of the KM efforts report use of syntactic boundary objects (repositories).

Table 4 presents the examples in Table 1 in terms of the different boundary objects in Carlile's model. Most objects and processes span communities of practice (e.g., different functional groups) at the syntactic or semantic level, and the majority are operating at the syntactic level—that is, most of the KMSs are set up to facilitate the exchange of knowledge at the level where the knowledge differences are, in Brown's (2002) words, "clear and stable." (The leadership development process at NASA/JPL, assuming it includes dialogue among individuals with different values, is an example of a process operating at the pragmatic level, but the literature provides little detail.) All behavioral change processes and exercise of power (incentives, top management support, etc.) are classified as "pragmatic" processes that span the boundary between executives and other employees—a hierarchical boundary spanning process. Only the forums of Buckman Labs explicitly recognize the role of national culture and provide the opportunity for knowledge to be shared across ethnic boundaries and national backgrounds. The latest report suggested that these forums now are using a single language (English) for sharing knowledge.

CONCLUSIONS AND DISCUSSION

The intellectual foundation for KM is the KBV of the firm. For global enterprises, the tacit and experiential knowledge of staff from different cultures is a potential knowledge asset, one that a KM effort might seek to exploit. However, reviews of KMSs and KM efforts revealed little attention directed toward the cultural or ethnic backgrounds of staff. National and ethnic culture are not important considerations in most KM efforts. There is, however, a universal emphasis on creating and maintaining an organizational culture that supports knowledge exchange and the use of the KMS. Indeed, the success of these KM efforts seems linked to establishing and rewarding a shared organizational culture. The research identified only one system—Buckman Labs—that explicitly recognized the potential value in different national cultures. The latest report on this system indicates that the decision has been made to emphasize English and thus provide a common language base for all employees, so the sole example of a KM that had national culture as a significant dimension has discarded this factor in its latest incarnation.

When examined using the lens of Carlile's pragmatic view of boundary objects, current KMSs and knowledge management efforts have emphasized the syntactic (knowledge transfer) and semantic (knowledge translation) levels of boundary spanning. Boundary spanning at the pragmatic (knowledge transformation and learning) level has focused on internal cultural and behavioral change (related to administrative power) rather than capturing and exploiting knowledge from diverse national or ethnic cultures.

Present-day KM efforts are richer in vision and technique than earlier KM implementations that had a primary emphasis on computer-based repositories of readily available data and knowledge—they include processes and forums in which people exchange knowledge face to face, for example. However, even current KM efforts have not explicitly recognized the potential value of objects and processes that operate at the pragmatic level to span cultural boundaries. It may be that boundary spanning at this level is required to realize the full potential of knowledge integration and co-creation of new knowledge from culturally diverse groups.

Based on this review, it appears that current KM efforts have developed consistent with the "culture-free" hypothesis. That is, by not taking into account multiple national cultures or ethnic backgrounds, these KM efforts tacitly adopt the position that a single organizational culture is appropriate without regard for the societal environment.

This finding raises several issues. The "culture-free" hypothesis is not consistent with other studies that examine culture in IT applications such as group support systems (Watson, 1994) and software production (Walsham, 2002). This raises the question of whether KM is going through a temporary phase and will evolve to a more culturally sensitive form of management, or if KM, as organizational processes and structures seem to be doing for production organizations, will appear the same regardless of cultural environment or the cultural composition of the organization. The stated goal of KM efforts is to achieve knowledge integration and benefit from the collective knowledge of the organization through learning. Because learning is so dependent on cultural experience, it remains an open question if the current culture-free approach is better. Can a culture-free approach enable a KM effort to effectively surface, or otherwise benefit from, the tacit knowledge of its staff from different cultures, the component of the "collective knowledge assets" that comes with the staff? More fundamentally, if KM is intended to exploit the entirety of the organization's intellectual assets, why do current systems appear to have ignored this ethnic and cultural component of the organization's collective knowledge? If organizations truly value all components of the collective knowledge, then KM efforts should pay more explicit attention to the use of objects and processes at the pragmatic level to span cultural boundaries.

By reviewing contemporary learning theory and showing the relationship of culture to learning in the context of knowledge management and knowledge management systems, this paper contributes to the KM discussion by directing attention to the cultural aspects of KM. The paper also highlights what may be a limitation of current KM efforts by viewing them as boundary-spanning systems that often operate at two of the levels in Carlile's model—the syntactic and the semantic—but not always at the pragmatic level.

The research in this paper has been limited to secondary reports of KM efforts taken from the management and information systems literature. Consequently, it has all the limitations that come with depending on the reports of others. Constraints of time and space, and the author's judgment on dealing with these constraints mean that the research may have missed significant reports from other fields. The paper also is limited by the scope of the reviewed literature. It represents a review of the recent KM literature and, while it examined the strategic links of KM to the KBV of the firm, the paper did not critically examine the fundamental assumptions in knowledge ontology and epistemology. The paper did not review, for example, ERP systems and other strategic systems that impose structure on entire organizations. A comparison of such systems with KM efforts might lead to different conclusions and different insights. Moreover, the paper did not examine the philosophical, linguistic, and semiotic foundations for the "syntactic, semantic, and pragmatic" levels in Carlile's boundary spanning model. Such an investigation might provide a richer set of explanations and models with which to improve our understanding of the complex practice of sharing and developing knowledge in organizations.

IMPLICATIONS FOR KM RESEARCH AND PRACTICE

The findings raise several questions about the current designs of KMSs and the evolution of KM. Missing in current discussions of KMSs is a discussion of the potential knowledge assets represented by culturally diverse staff in global organizations. Despite the KM goals of tapping into all parts of the collective knowledge in the firm, this cultural aspect of the organization's knowledge appears, from published reports, to be neglected. Without research on its value, one cannot say that this culturally based set of assets has sufficient value to deserve more formal recognition in KM efforts.

KM efforts appear to be adopting, without debate or research support for its efficacy, a culture-free design. Research is needed to determine if this culture-free approach is most appropriate for KM, or if other, more culturally sensitive approaches to KM would enable an organization to realize even greater benefits than it can realize using current practices. As researchers, we may want to look toward the critical review of our models of KM (e.g., (Schultze, 2002), and to consider the suggestion that we re-frame our systems as supporting emergent knowledge (Markus et al., 2002), in order to think "outside the box" of the prevailing view of KM as applications of IT to improve the information value chain. If a culture-free approach is judged to be appropriate, then research is needed to understand if an intermediate step is necessary to enable individuals from non-western (non-North American) cultures to adapt to these approaches.

From a practical viewpoint, the research suggests that current KM efforts may need to give added attention to the learning dimension of their portfolio of activities. Contemporary learning theory shows a strong relationship between learning and cultural experience—individuals learn based on how they have learned in the past, and early ethnic and cultural experiences provide a base of models and abilities that enhance and constrain an individual's capabilities in new situations. The implication of these theories for KM practice is two-fold. First, staff from different ethnic and cultural backgrounds will not necessarily share a basic set of models when they begin with their new firm, and these staff may benefit from efforts to bridge the gap in meta-learning skills and models. The frequent reports of KM efforts to reward use of a KMS (conform to a corporate norm) may reflect one approach to bridging this gap, but typically these have been reported simply as efforts for corporate cultural change. Second, if a firm is to benefit from the tacit knowledge these staff members bring with them, it may need to incorporate processes and techniques that are not evident in current examples of KM efforts.

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REFERENCES

Alavi, M. (1997). *KPMG Peat Marwick U.S.: One giant brain.* Cambridge, MA, HBS: Report No. 9-397-108; 21pp.

Alavi, M., & Leidner, D. E. (2001). Review: Knowledge management and knowledge management systems – Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Allen, R., & Rooney, P. (1998). Designing a problem-based learning environment for ESL students in business communication. *Business Communication Quarterly, 61*(2), 48.

Barney, J., Wright, M., et al. (2001). The resource-based view of the firm: Ten years after 1991. *Journal of Management 27*(6), 625-641.

Birnbaum, P. H., & Wong, G.Y.Y. (1985). Organizational structure of multinational banks in Hong Kong from a culture-free perspective. *Administrative Science Quarterly, 30*(2), 262-277.

Boud, D., & Feletti, G. (1998). *The challenge of problem-based learning.* London: Kogan Page.

Brown, J. S. (2002). *An epistemological perspective on organizations and innovations.* Organizational Knowledge and Learning Conference, Athens.

Brown, J. S., & Duguid, P. (1998). Organizing knowledge. *California Management Review, 40*(1), 90-111.

Brown, J. S., & Duguid, P. (2001). Knowledge and organization: A social-practice perspective. *Organization Science 12*(2), 198-213.

Carlile, P. R. (2002). A pragmatic view of knowledge and boundaries: Boundary objects in new product development. *Organization Science, 13*(4), 442-255.

Chapman, R., & Hyland, P. (n.d.). *Complexity and learning behaviors in product innovation*. Technovation.

Chard, A. M. (1997). *Knowledge management at Ernst & Young*. Stanford, Graduate School of Business, Leland Stanford Junior University: 28.

Cole, M. (1971). *The cultural context of learning and thinking: An exploration in experimental anthropology.* New York: Basic Books.

Culatta, E. (1994). New modes for making scientists. *Science, 266*(5186), 875+877+883-884+888.

Davenport, T. H., Long, D. W. D., et al. (1998). Successful knowledge management projects. *Sloan Management Review, 39*(2), 43.

Davenport, T. H., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Dixon, N. M. (1994). *The organizational learning cycle: How we can learn collectively.* New York: McGraw-Hill.

Dougherty, D. (1992). Interpretive barriers to successful product innovation in large firms. *Organization Science, 3*(2), 179-202.

Drucker, P. F. (1988). The coming of the new organization. *Harvard Business Review, 66*(1), 45.

Erez, M, & Earley, P. C. (1993). *Culture, self-identity, and work.* New York: Oxford University Press.

Forman, E. A., Minick, N., et al. (1993). *Contexts for learning: Sociocultural dynamics in children's development.* New York, Oxford University Press.

Fulmer, W. E. (1999). Buckman Laboratories (B). Cambridge, MA, Harvard Business School: Report No. 9-800-033; 2pp.

Fulmer, W. E. (2000). *Buckman Labs (A) Teaching Note.* Cambridge, Harvard Business School: Report No. 5-800-360.

Fulmer, W. E. (2003). *Buckman Laboratories (A).* Cambridge, MA, Harvard Business School: Report No. 9-800-160;15pp.

Grant, R. M. (1996a). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*(4), 375.

Grant, R. M. (1996b). Toward a knowledge-based theory of the firm. *Strategic Management Journal, 17*(Winter), 109-122.

Hall, E. T. (1959). *The silent language.* New York: Doubleday & Co.

Hansen, M. T., Thomas, H., & Davenport (2002). *Knowledge management at Andersen Consulting*. Cambridge, MA.

Hilliard, A. G., III (1992). Behavioral style, culture, and teaching and learning. *Journal of Negro Education Africentrism and Multiculturalism: Conflict or Consonance, 61*(3), 370-377.

Huber, G. (1991). Organizational learning: The contributing processes and literatures. *Organization Science, 2*(1), 88-115.

Jones, R., Higgs, R., et al. (2001). Changing face of medical curricula. *The Lancet, 357*(9257), 699-703.

Klein, S. B., & Mowrer, R.R. (1989). *Contemporary learning theories: Instrumental conditioning theory and the impact of biological constraints on learning.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science, 7*(5), 502-518.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, NJ: Prentice-Hall.

Kozulin, A. (1998). *Psychological tools: A sociocultural approach to education.* Cambridge, MA; London: Harvard University Press.

Leonard, D., & Kiron, D. (2002). *Managing knowledge and learning at NASA and the Jet Propulsion Laboratory (JPL).* Cambridge, MA: Harvard Business School.

LoLordo, V. M., & Droungas, A. (1989). Selective associations and adaptive specializations: Taste aversions and phobias. In S. B. Klein & R. R. Mowrer (Eds.), *Contemporary learning theories: Instrumental conditioning theory and the impact of biological constraints on learning* (pp. 145-180). Hillsdale, NJ, Lawrence Erlbaum Associates.

MacCormack, A. (2002). *Siemens ShareNet: Building a knowledge network*. Cambridge, MA: Harvard.

Madhok, A. (2002). Reassessing The fundamentals and beyond: Ronald Coase, The transaction cost and resource-based theories of the firm and the institutional structure of production. *Strategic Management Journal, 23*(6) 535.

March, A. (1997). A note on knowledge management. Cambridge, MA.

Markus, M. L., Majchrzak, A., et al. (2002). A design theory for systems that support emergent knowledge processes. *MIS Quarterly, 26*(3), 179.

Massey, A. P., Mitzi, M., Montoya-Weiss, & O'Driscoll, T.M. (2002). Knowledge management in pursuit of performance: Insights from Nortel Networks. *Management Information Systems Quarterly, 26*(3), 269-289.

Mata, F. J., Fuerst, W.L., & Barney, J. B. (1995). Information technology and sustained competitive advantage: A resource-based analysis. *MIS Quarterly, 19*(4), 487.

Maurice, M. (1976). Introduction - Theoretical and ideological aspects of the universalistic approach to the study of organizations. *International Studies of Management & Organization, 6*(3), 3.

Miller, G. A. (1987). Meta-analysis and the culture-free hypothesis. *Organization Studies, 8*(4), 309-326.

Mowrer, R. R., & Klein, S. B. (Eds.). (1989). *A contrast between traditional and contemporary learning theory. Contemporary learning theories.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Ng, P., & Farhoomand, A. (2002). *The PricewaterhouseCoopers Know-ledgeCurve and the spinoff of PwC Consulting.* Hong Kong, The Centre for Asian Business Cases, University of Hong Kong: HKU221; reprinted by HBS as 02/147C; 15pp.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company.* New York; Oxford: Oxford University Press.

Penrose, E. T. (1959). *The theory of the growth of the firm.* Oxford: Blackwell.

Ramesh, B., & Tiwana, A. (1999). Supporting collaborative process knowledge management in new product development teams. *Decision Support Systems, 27*(1-2), 213-235.

Rayport, J. F., & Sviokla, J.J. (1995). Exploiting the virtual value chain. *Harvard Business Review, 73*(6), 75-85.

Rebentisch, E. S., & Ferretti, M. (1995). A knowledge asset-based view of technology transfer in international joint ventures. *Journal of Engineering and Technology Management, 12*(1-2), 1-25.

Rukstad, M. G., & Coughlan, P. (2001). *DaimlerChrysler knowledge management strategy.* Cambridge, MA: HBS. Report No. 9-702-412; 18.

Schultze, U., & Leidner, D.E. (2002). Studying knowledge management in information systems research: Discourses and theoretical assumptions. *Management Information Systems Quarterly, 26*(3).

Soo, C., Devinney, T., et al. (2002). Knowledge management: Philosophy, processes and pitfalls. *California Management Review, 44*(4), 129.

Spender, J.-C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17,* 45.

Star, S. L., & Greisemer, J.R. (1989). Insitutional ecology, 'translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39. *Social Studies in Science, 19,* 387-420.

Stata, R. (1989). Organizational learning: The key to management innovation. *Sloan Management Review, 30*(3), 63-74.

Tien, C.-J., Ven, J.-H., & Chou, S.-L. (2003). Using the problem-based learning to enhance student's key competencies. *Journal of American Academy of Business, 2*(2), 454.

Verganti, R. (1998). Leveraging on systemic learning to manage the early phases of product innovation projects. *Journal of Product Innovation Management, 15*(5), 471-472.

Vygotsky, L. S., Rieber, R. W., et al. (1987). *The collected works of L.S. Vygotsky.* New York: Plenum Press.

Walker, A., Bridges, E., & Chan, B. (1996). Wisdom gained, wisdom given: Instituting PBL in a Chinese culture. *Journal of Educational Administration, 34*(5), 12.

Walsh, J. P., & Ungson, G. R. (1991). Organizational memory. *Academy of Management Review, 16*(1), 57-91.

Walsham, G. (2002). Cross-cultural software production and use: A structurational analysis. *MIS Quarterly, 26*(4), 359-380.

Watson, R. T., Ho, T. H., & Raman, K. S. (1994). Culture: A fourth dimension of group support systems. *Communications of the ACM, 37*(10), 44-55.

Zull, J. E. (2002). *The art of changing the brain: Enriching teaching by exploring the biology of learning.* Sterling, VA: Stylus Publishing.

ENDNOTE

1 The author thanks an anonymous reviewer for pointing out that incentives and other behavioral change processes could be classified in this way.

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Chapter 8.13
Managing Intellectual Capital and Intellectual Property within Software Development Communities of Practice

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INTRODUCTION

In this article, we will develop a framework for educational software development teams that recognizes the conflicts and tensions that exist between the different professional groups and will assist software teams to recognize the intellectual capital created by individuals and teams. We will do so by recognizing the inherent relationship between the tangible elements of intellectual property and the intangible organizational assets that form the basis of intellectual capital and by discussing how knowledge generated by a project team can become an explicit asset.

BACKGROUND

Universities are increasingly becoming developers of complex software-based applications. In-house development ranges from teaching aids and online learning resources to large information systems products that could ultimately become successful commercial ventures. Increased product complexity is easily recognized, yet research shows that the organizational aspects of a software development project are more likely to affect performance and outcomes than technical issues (Xia & Lee, 2004). Successful development and deployment of today's complex educational systems and environments comes with an imperative for an array of different and unique skill sets for the various stages of each project. One can view a software development team as a microcosm of the wider community of practice of software development professionals who work in information and knowledge management in higher education. As Wenger (1998) observes, such communities of practice are not random but constructed around required skills and through a process of negotiation based on mutuality and accountability.

Workforce mobility has increased: academic staff members regularly and easily move between institutions; development and design staff have many opportunities for contract-based work, move to other academic institutions or into the private sector. The ideas that lie behind a successful process or product are increasingly drawn from a wider pool of talent and, as people move around, these ideas are being taken with them and disseminated through informal and new work practices into a wider community of practice. How then does a team, formed to design and develop a technology-rich educational or systems environment, manage and control issues of intellectual capital and intellectual property such that all of those who contribute throughout the life of a project are acknowledged and rewarded fairly and appropriately for that contribution, even after they have left the project?

Team Formation and Relationships

Additional complexity leads to specialization (Jacobson, Booch & Rumbaugh, 1998). New ways of working bring with them a shift in power, where the academic expert will often lack the technical skills, time or resources to turn ideas into reality. Instead, they must rely on a team of experts from other disciplines to interpret their ideas, evolve them, and deliver the finished product. As complexity increases, communication between team members becomes paramount; specialist educational designers are required to translate pedagogy into functional specifications that can be understood by software developers and graphic designers. Modern software teams are project-based, where resources come and go as required.

Software development communities of practice exist within a larger organizational context. Roles and responsibilities will vary and are negotiated depending on the toolset and architecture used, the size of the project, and the culture of the organization (Phillips, 1997; Williamson et al., 2003). Project team members can be full- or part-time employees (academic or non-academic) or contractors retained specifically for the project. As such, these roles exhibit complex relationships and interfaces between each other and the project. In Figure 1, a range of typical roles and relationships found in a tertiary education software development project are shown.

During the various stages of the development process, various players move into prominent roles. One way to illustrate this shifting set of work responsibilities is to list the main players at each stage of the process. We will do this using the classic instructional systems design (ISD) model (Dick & Carey, 1990) as it is so well known. (There are many other models, many of which are discussed in Bannan-Ritland, 2003.) The key players at each stage of the ISD model are listed

Figure 1. Intra-project relationships in software development teams (Williamson et al., 2003, p. 345)

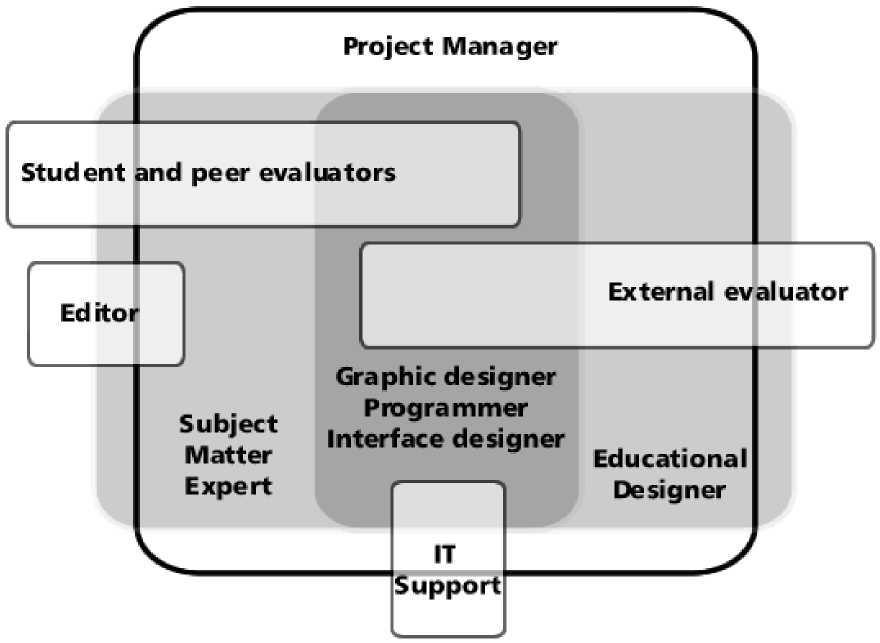


Table 1. Key players at each stage of the ISD model

Stage of the ISD model	Key players
Needs assessment	Subject matter expert
Analysis	Subject matter expert, Educational designer
Design	Subject matter expert, Educational designer, Project manager
Development	Project manager, Graphic designer, Programmer, Interface designer, Editor
Formative evaluation	Student and peer evaluators, Subject matter expert, Educational designer
Revision	Project manager, Graphic designer, Programmer, Interface designer, Editor
Implementation	Subject matter expert, IT support
Summative evaluation	External evaluator
Maintenance	IT support, Subject matter expert (Interface designer)

in Table 1. In reality, each team parcels out the work depending on the skill set of individuals in the team.

It is important to be aware of the different communities of practice that exist in this field and ensure that the role of individual team members is able to be promoted appropriately. Professional recognition can come through either publication, a portfolio of work or through the finished product, and the importance of a successful project to the career development of individuals should not be underestimated. It is important to ensure that academic dissemination of successful projects through publication recognizes the contribution made by all team members, including the non-academic members. Many myths persist in relation to acknowledging the veracity of contribution with regard to educational software, and these often have the potential to leave team members feeling their effort and ideas have gone unrecognized and, at worst, feeling they have been exploited (Williamson et al., 2003). In the second half of this article, we will develop a framework that ensures appropriate outlets for reward and recognition of individual contributions within academic software development teams. Before doing this, we will define what is meant by intellectual capital and intellectual property.

Defining Intellectual Capital and Intellectual Property

Florida (2002) argues that the principal factors for successful software development are talent, knowledge, and intellectual capital (IC). The connection of new ideas and existing knowledge within an organizational context leads to the creation of IC. Stewart (1999) defines IC as the sum of everything everybody in a company, organization, or team knows and which provides some advantage over their competitors. Davidson and Voss (2001) agree, describing individual IC as "the sum of individual imagination, intelligence and ideas" (p. 60). They then extend this definition to encapsulate a model for organizational IC that is based on the talent of individuals (human capital), the knowledge that is captured within systems and processes (structural capital), and the characteristics of relationships with customers and suppliers (customer/supplier capital). Organizational IC comes from the "interplay of all three (structural capital augments the value of human capital, leading to an increase in customer/supplier capital)" (p. 61). In terms of this discussion as it relates to the appropriate recognition and acknowledgement of individual contributions within software development teams, human capital is our primary focus. Human capital is "what walks out of the door at the end of the day" (p. 68); it is a vital intangible.

If IC is the intangible but invaluable contribution of human talent to a project, then Intellectual Property (IP) is a formal measurable subset. It is the tangible product that results from the idea. The UK Patent Office (United Kingdom Patent Office, n.d.) defines four formal types of IP:

- patents for inventions;
- trademarks for brands;
- designs for product appearance; and
- copyright for material (including software and multimedia).

This definition is then extended to cover a much broader and often more intangible grouping that extends to trade secrets, plant varieties, geographical indications, and performers rights. While many see copyright as a way of protecting IP, it is only a subset. Copyright provides recognition of their invention to the creators of software or multimedia products in order for them to be able to obtain economic rewards for their efforts (Macmillan, 2000). Historically, comparisons have been drawn between software development and the traditional arts, such comparisons reinforcing an argument that IP law is focused on the protection of software such that others are not able to modify the source product (White, 1997). It is important to note that copyright extends only to a tangible product, it does not lend protection to the more intangible areas of IC such as ideas and individual contribution. Since copyright has a primarily commercial imperative, it is a limited and perhaps inappropriate mechanism for acknowledging contribution. This is of greater importance in higher educational settings since copyright of educational materials can reside with the institution (particularly with off-campus courses), rather than the individual, and very few educational software products developed for specific content domains in higher education are ever commercialized (Alexander, McKenzie & Geissinger, 1998).

The Relationship between IC and IP

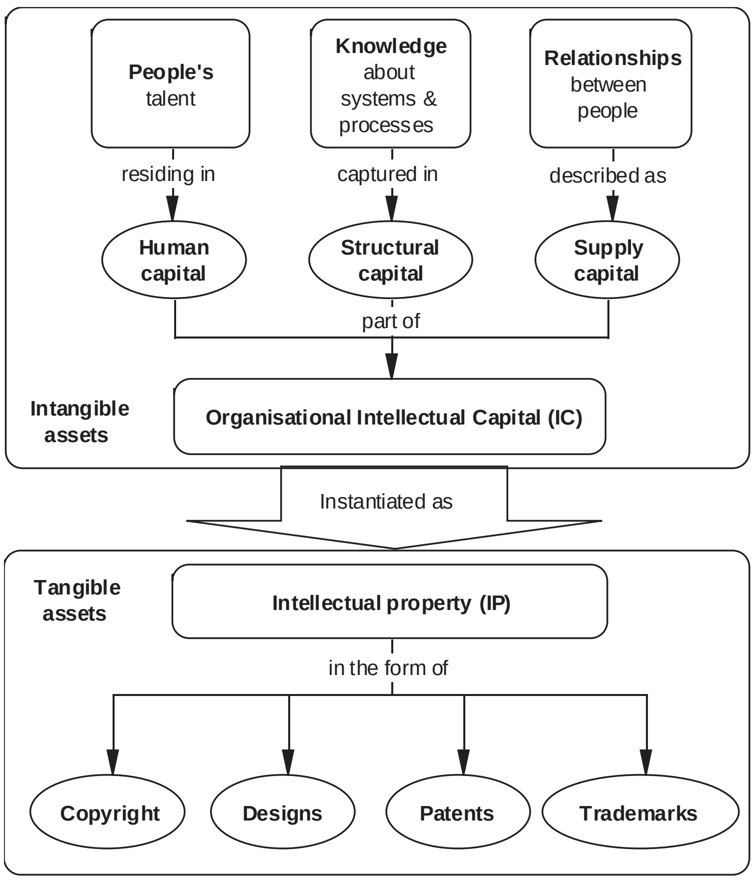
A relationship exists between the tangible elements of intellectual property and the three forms of intellectual capital (the intangible organizational assets) discussed in the preceding section. These are shown in Figure 2.

IC/IP Management Framework

Having addressed the complexity of educational software development teams and defined IC and IP within an educational software context, we will now develop a framework that can be used to ensure proper recognition and reward for individual and collective ideas in such a setting.

Given the critical value of IC in software development (Florida, 2002), it is important that the processes used within educational software development are strengthened and formalized through the adoption of a strong project man-

Figure 2. Intellectual capital and intellectual property (Williamson et al., 2002, p. 342)



agement framework. Project management is a key role in any project involving information and communication technologies and interactive multimedia software, and it requires specific skills and attributes. These include both the hard skills of contract negotiation, budgeting, scheduling, project definition, and scoping as well as the soft skills of human relations, team building, and facilitation (Burdman, 2000; Schwalbe, 2000). Successful teams work well together because they have clear roles and relationships and because the terms of engagement within the team and with external parties are well defined, understood, and agreed by all. This provides a solid platform for the explicit incorporation of IC and IP policies into project documentation so that such issues can be considered early on, preferably during the project scoping phase.

A process and framework are required to recognize knowledge as it is created so that it becomes explicit. Without doing so, knowledge remains tacit and cannot be rewarded or acknowledged, that is, credited to the appropriate team members in the future. Extending this concept, knowledge that is explicit within the team can remain tacit beyond team boundaries if no process is in place to ensure appropriate recognition of contribution. It is, therefore, necessary for teams to negotiate clear, up-front delineation of roles, responsibility, and ownership of both tangible and intangible outputs from the project. This does not prejudge what that ownership might be, merely that the agreement takes place before the project commences. It is important to consider how IC/IP generated during the project's life will be disseminated, in what form, and by whom. Such a clear articulation of roles and responsibilities has the benefit of helping to make the process of dissemination more visible. By doing so, it is hopefully the case that team members will recognize the significance of the different sources of acknowledgment. This in turn will result in up-front agreement on potential opportunities for dissemination of original ideas among the team.

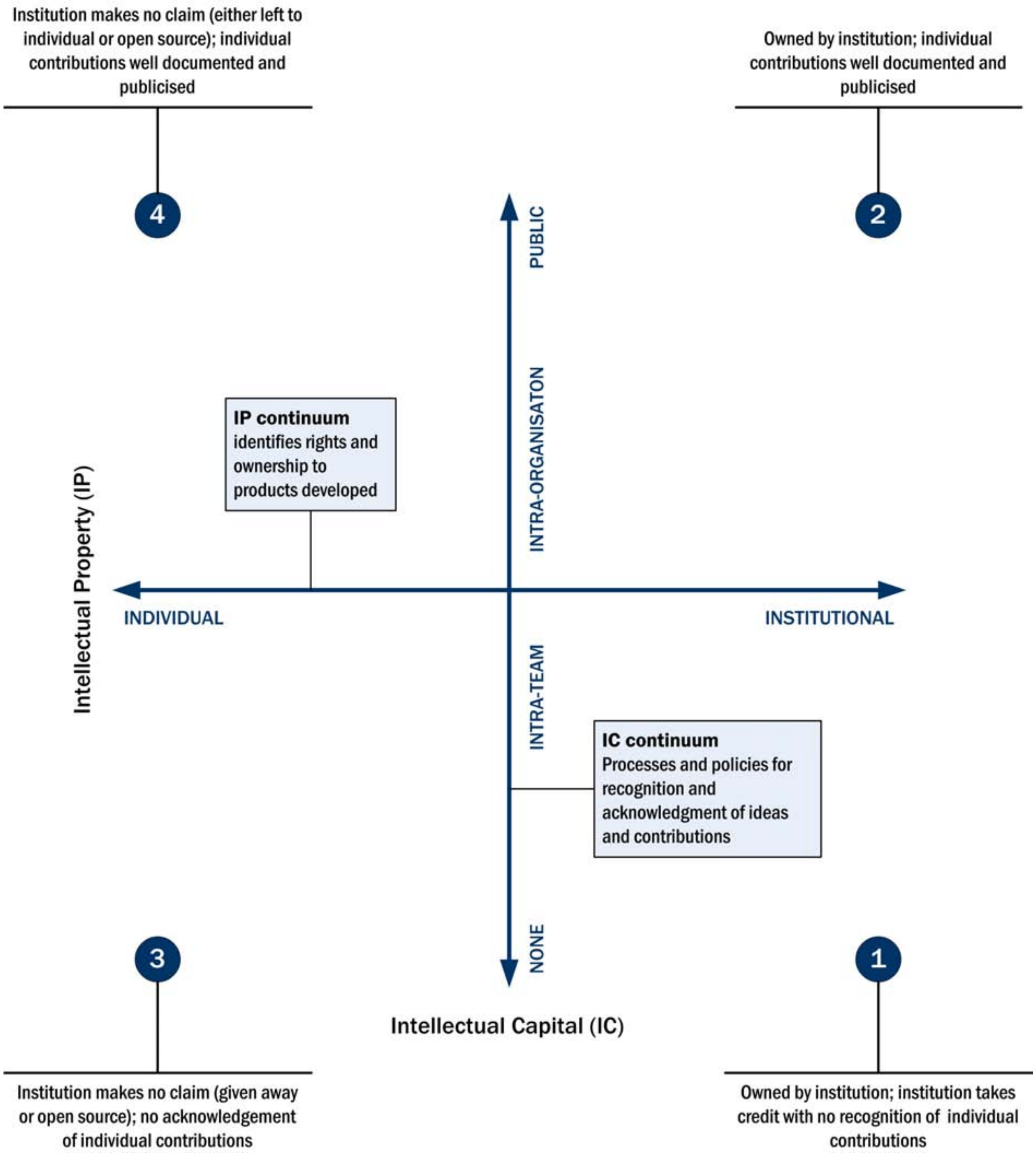
A seldom discussed aspect of the manner in which ideas might be disseminated (and credit obtained) is the potential synergy between individual team members. For example, among academic staff involved in the project, there is a possibility for cross-disciplinary publications.

This framework, shown in Figure 3, maps out two axes: the horizontal axis representing formal ownership of the tangible IP, the vertical axis representing a continuum of recognition for the IC generated during a project, ranging from no acknowledgment of individual effort and contribution to a full public acknowledgment. Intermediate steps include recognition at the team and institutional level.

Enacting the IC/IP Framework

Our discussion so far has shown that, regardless of the nature of the IP ownership, academics and professionals working in software development teams need appropriate recognition for their contributions, but certain factors can prevent this from happening. The challenge, therefore, is to identify a set of project attributes that can be used to inform project management practices such that institutions are cognizant of the need for appropriate recognition. In the following section, we identify seven key attributes of, or processes within, a successful project. The model is developed from a review of the authors' own experiences of software development teams where problems had occurred. This review led to the identification of which weaknesses in the process had resulted in these problems (Williamson et al., 2003). By ensuring that these seven attributes are recognized and actively negotiated by newly forming teams and enacted throughout the life of the team, this model can assist projects in identifying

Figure 3. IP/IC management framework



and filling gaps in the structure of development teams, hence future risk can be mitigated.

In essence, the IC embedded in the members of the project team is articulated in terms of the various IP contributions made by these team members. However, if the focus is exclusively on the tangible products of the process (e.g., software and papers) through only considering the IP, then the worth of ideas (IC) can be underplayed, and their potential may not be realized. We are suggesting that explicit application of these seven guidelines can ensure more successful project outcomes and positive professional outcomes for all members of the team.

The nature of an effective community of practice for software development teams is discussed in terms of Figure 3. The two major axes and the four examples in Figure 3 are used to frame the seven attributes.

Intellectual Property: Individual Affirmation to Institutional Affirmation

Have an IP Acknowledgement Strategy

Highly successful projects exhibit a strong team dynamic which arises when the expertise and knowledge of individual team members can be communicated and shared with others. Part of this process involves ensuring that ideas are fairly acknowledged within and outside the team, whether by portfolio (graphic artists), publication (academics), or product (project managers and programmers).

Have an IP Review Strategy

It does not matter for the purposes of academic critical review whether the subject of study is a written paper, a software product, or a portfolio. Contribution from individual team members needs to be acknowledged through an inclusive authorship policy which is regularly revisited in team meetings. This process can strengthen collegiality and reinforce mutual valuing between team members.

Have a Strategy to Separate IP from IC

The IP might be owned by an organization or institution, but the IC remains with the individuals in the team. Formal acknowledgment of where the ownership of IP lies is important and needs to be negotiated ahead of the commencement of the project. In many higher education institutions, this has become standard practice and involves retaining a competitive advantage and protecting the resources produced by employees of the organization. There are risks associated with key project contributors leaving (for example, a lead programmer) and either taking intellectual property with them or holding a software development team or institution to ransom by withholding access to code or other resources. In some organizations, the IC also remains with the organization via means of a nondisclosure agreement. Communities of practice might consider using a confidentiality agreement as part of a contract or offer of employment in order to keep this issue open and transparent.

Longevity Strategy: Ideas Remain

When a person leaves a team, they cede their IC to the project team or institution, and that contribution should continue to be recognized and acknowledged in project documentation, appropriate publications, and authorship in any finished product. In some projects, this may also involve ceding formal IP to the project (e.g., in the case of commercialization).

Intellectual Capital: No Formal Acknowledgment to Public Acknowledgment

Recognize the Emergent Nature of the Software Development Process and Its Impact on IC/IP for all Team Members

As software becomes more complex, it becomes less and less likely that the original academic imperative that led to the idea for the product will be instantiated in a form initially envisaged by the academic or the organizational unit that initiated the project. The development process and the end result will be strongly influenced by a wide range of individual and group contributions to the process and the product.

Ideas are Perishable

Software has a shelf-life, hence the IC that led to that product is also of limited use. The idea will become superseded and outdated as new ideas and new technologies emerge. For example, there are any number of commercial or free customizable online survey instruments (such as Survey Monkey, http://www.surveymonkey.com) that now exist. Learning Evaluation Online (LEO) was an early system that explored how customizable educational surveys could be developed online using an entirely Web-based interface (Kennedy & Ip, 1998). At the time this was an innovative approach, but it has since been superseded by more robust software. Thus, the IC for LEO has long since expired. The idea behind LEO has been

Table 2. Implications for IP and IC

#	Scenario	Implications for IP and IC
1	IC and IP is owned by institution; institution takes credit with no contribution of individual creativity and effort.	This is a very poor scenario for developing the IC of an institution. Without affirmation, individuals will seek employment elsewhere and take their IC with them.
2	IP and IC are owned by the institution; individual contributions are well documented and publicized.	This is the scenario in a number of institutions worldwide, particularly those involved in distance education. This scenario is problematic when commercial aspects enter the situation as in the case of patents.
3	Institution makes no claim (software is given away or open source); no acknowledgment of individual contributions.	This is often the result of small student projects (although many institutions claim the IP of all undergraduate student work, not postgraduate) undertaken during a course of study). Most software of this type has a very limited life although there are some exceptions (Gunn, 1995).
4	Institution makes no claim (either left to the individual or open source community); individual contributions are well documented and publicized.	This applies to postgraduate work in universities. In many institutions, postgraduate (especially doctoral) students own their IP, and it is up to the student and supervisor to disseminate the details of the project. This aspect is changing as universities try to gain a competitive advantage, and many postgraduate students working in a large research department would do well to consider how the results of their studies might be retained, negotiating with the university in the early phases of the project. For example, some student projects (see moodle.org and moodle.com) have become very high profile products (Dougiamas & Taylor, 2003).

taken up by others and reproduced using different software code. The code is the instantiation of the idea and is the only part of the project subject to IP rights.

Public Acknowledgment of IP/IC Requires the Source Material to be in the Public Domain

Acknowledgment of unpublished work or work not publicly available is not sufficient to acknowledge IC and IP issues in a publication. In the case of academics where affirmation and professional career progress is at least partially a result of publication in accredited arenas such as books and journals, this is clearly not sustainable. Graphic artists, on the other hand, have their portfolios of work with iterations of visual designs that they take with them to the next project or job; and programmers have compilations of code: for these professionals, the publication is less important or substantive in career development. A key issue for an institution is providing the process by which academic publications can be developed without compromising the IP of the individual or trade advantages in the marketplace.

In summary, the implications for the four scenarios in Figure 3 are shown in Table 2.

THE FUTURE: APPLICATION OF THE SEVEN ATTRIBUTES OF THE IC/IP FRAMEWORK

In order to see how these attributes can be enacted in practice, the example of a major Australian multimedia project, An@tomedia, will be used. An@tomedia was designed to support problem-based learning (PBL) of anatomy in the Faculty of Medicine at the University of Melbourne (http://www.anatomedia.com). A number of academic evaluations on the role of An@tomedia in this PBL learning environment have been published (e.g., Kennedy, Eizenberg & Kennedy, 2000; Kennedy, Kennedy & Eizenberg, 2001).

The software has been successfully commercialized by the four subject matter experts (core SMEs or core authors) after other members of the development team ceded any personal commercial claims to the group by means of a legal document to that effect.

Affirmation and acknowledgment involving publishing for academic members (Kennedy et al., 2000; Kennedy et al., 2001), contributions to portfolios for non-academic members, and public acknowledgments in the An@tomedia Web site for every person who contributed in any significant way to the project were not affected by this written agreement. The public affirmation (particularly important for non-academic members of the project team) is illustrated by the observation made by a reviewer of An@tomedia in The Lancet (Marušiæ, 2004) where she mentions the extensive list of credits for all the members of the team (over 60) involved with the project. This process was accomplished quite simply because matters of IP had been previously discussed in the course of project meetings, and the “prior art” that existed and underpinned the educational approach was well known to all project members. Table 3 summarizes the way in which the seven attributes worked in this project.

CONCLUSION

While formalized tools exist for capturing IP generated during a project, most software development teams lack formal explicit processes for ensuring that the IC generated is accurately and adequately apportioned. This article has raised issues relating to how software development project teams are recognized for their contribution and a simple framework for measuring recognition

Table 3. Example of the application of the seven attributes of the IP/IP framework

#	Attribute	Enactment
1	Have an IP acknowledgment strategy	The acknowledgment of IP was never an issue within the project group. Individual contributions were always acknowledged by the core development team, becoming part of the documentation of the project. The extensive documentation ensured that no one was left off the credits on the *An@tomedia* Web site.
2	Have an IP review strategy	The existence of "prior art" was established in the early phases of the project. While the final product did not resemble the initial designs, it was always clear in the project meetings that the team was involved in the instantiation of the educational vision of the project leader (one of the core SMEs).
3	Have a strategy to separate IP from IC	The strategy to separate IP from IC was undertaken by the four principal authors as *An@atomedia* was moved from an interesting project to a commercial product. The documentation resulting from meetings included discussions of commercialization of *An@atomedia* and the associated need to separate IP from IC. The strategy adopted involved consultations with the university's legal advisors and the project team. The IP for the sale and commercial rights to *An@tomedia* were ceded to the four key authors by the other team members; however, the IC remained with members of the project team to use as they required.
4	Longevity strategy: Ideas remain	The credits list contains a list of all members who contributed to the project over a period of many years, including those individuals who either retired (in one case) or moved to other institutions (a number of people). It is possible for all members of the project team to include evidence of contributions to *An@atomedia* by reference to either the Web site or the CD-Roms (the form in which *An@tomedia* is published and sold).
5	Recognize the emergent nature of the software development process and its impact on IC/IP for all team members	The development of *An@tomedia* occurred over a considerable period of time. The genesis of some the clinical approaches adopted in the project were developed by the project leader and occurred well before *An@tomedia* commenced (Eizenberg, 1988, 1991). The use of technology followed as a consequence of the need to develop more effective and engaging approaches to the teaching of anatomy (Driver & Eizenberg, 1995). As the final design of the software emerged, it was always clear in meetings and associated documentation that other members of the project team were involved in the instantiation of prior concepts and developments in new and innovative ways, but the underlying concept derived from the earlier work in paper-based media.
6	Ideas are perishable	*An@atomedia* received a number of awards for innovation and excellence after the first release (see http://www.anatomedia.com/credits.shtml). However, as people come and go from the project, the initial ideas will be superseded or altered to reflect teaching evaluations, changes in the medical curriculum, and improvements in technology. Solutions developed in 1999 or 2000 may not be suitable in 2005. What was once a good idea may not be appropriate in the future, but the three major methods of affirmation remain—publication, portfolio, and vitae for all contributions.
7	Public acknowledgment of IP/IC requires the source material to be in the public domain	The *An@atomedia* Web site provides definitive acknowledgment of the specific contributions of individuals, including the evaluators, programmers, educational consultants, photographers, medical consultants, project managers, dissectors, illustrators, interface and graphic designers, and research assistants, to name a few.

of contribution has been presented. Seven key project attributes or processes have been identified to assist project teams develop an awareness of how project roles and structures can be negotiated so that tacit ideas and knowledge generated can become explicit. Such a model must recognize that the requirements for, and process of, recognition will differ within different multiskilled teams. The application of the framework to one major multimedia project has been discussed.

REFERENCES

Alexander, S., McKenzie, J., & Geissinger, H. (1998). *An evaluation of information technology projects in university learning.* Canberra: Australian Government Publishing Services, Department of Employment, Education and Training and Youth Affairs.

Bannan-Ritland, B. (n.d.). The role of design in research: The integrative learning design framework. *Educational Researcher, 32*(1), 21-24.

Burdman, J. (2000). *Collaborative Web development: Strategies and best practices for Web teams*. Reading, MA: Addison-Wesley.

Davidson, C., & Voss, P. (2001). *Knowledge management: An introduction to creating competitive advantage from intellectual material.* Auckland, NZ: Tandem.

Dick, W., & Carey, L. (1990). *The systematic design of instruction.* Glenview, IL: Foresman/Little.

Dougiamas, M., & Taylor, P. (2003) Moodle: Using learning communities to create an open source course management system. In D. Lassner & C. McNaught (Eds), *ED-MEDIA 2003, Proceedings of the 15th Annual World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 171-178). Honolulu, Hawaii. Norfolk VA: Association for the Advancement of Computers in Education.

Driver, C., & Eizenberg, N. (1995). Constructing and deconstructing the human body: Applying interactive multimedia in the learning of anatomy. In J. M. Pearce, A. Ellis, C. McNaught, & G. Hart (Eds.), *Learning with technology: ASCILITE 95. Proceedings of the 12th Annual Conference of the Australian Society for Computers in Learning in Tertiary Education* (pp. 586-587). The University of Melbourne: The Science Multimedia Teaching Unit.

Eizenberg, N. (1988). Approaches to learning anatomy: Developing a program for pre-clinical medical students. In P. Ramsden (Ed.), *Improving learning: New perspectives* (pp. 178-198). London: Kogan Page.

Eizenberg, N. (1991). Action research in medical education: Improving teaching via investigating learning. In O. Zuber-Skerrit (Ed.), *Action research for change and development* (pp. 179-206). Avebury: Aldershot.

Florida, R. L. (2002). *The rise of the creative class: And how it's transforming work, leisure, community and everyday life.* New York: Basic Books.

Gunn, C. (1995). Useability and beyond: Evaluating educational effectiveness of computer-based learning. In G. Gibbs (Ed.), *Improving student learning through assessment and evaluation* (pp. 168-190). Oxford, UK: Oxford Centre for Staff Development.

Jacobson, I., Booch, G., & Rumbaugh, J. (1998). *The unified software development process.* Reading, MA: Addison-Wesley Longman.

Kennedy, D. M., Eizenberg, N., & Kennedy, G. (2000). An evaluation of the use of multiple perspectives in the design of computer-facilitated learning. *Australian Journal of Educational*

Technology, 16(1), 13-25. Retrieved May 5, 2005, from http://www.ascilite.org.au/ajet/ajet16/kennedy.html

Kennedy, D. M., & Ip, A. (1998). Learning Evaluation Online (LEO): A customizable Web-based evaluation tool. In C. Alvegard (Ed.)*, Computer aided learning and instruction in science and engineering. CALISCE'98 proceedings* (pp. 255-262). Goteborg: Chalmers University of Technology.

Kennedy, G. E., Kennedy, D. M., & Eizenberg, N. (2001). Integrating computer-facilitated learning resources into problem-based learning curricula. *Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, 3*(1). Retrieved May 5, 2005, from http://imej.wfu.edu/articles/2001/1/02/index.asp

Macmillan, F. (2000). Intellectual property issues. In C. McNaught, P. Phillips, D. Rossiter, & J. Winn (Eds.), *Developing a framework for a usable and useful inventory of computer-facilitated learning and support materials in Australian universities. Evaluations and Investigations Program report 99/11* (pp. 189-205). Canberra: Higher Education Division Department of Employment, Education, Training and Youth Affairs.

Marušiæ, A. (2004). Media reviews: Interactive anatomy. *The Lancet, 363*(9404), 254.

Phillips, R. A. (1997). *A developer's handbook to interactive multimedia: A practical guide for educational applications.* London: Kogan Page.

Schwalbe, K. (2000). *Information technology project management.* Cambridge, MA: Course Technology.

Stewart, T. (1999). *Intellectual capital: The new wealth of organizations.* New York: Currency.

United Kingdom Patent Office. (n.d.). *What is intellectual property or IP?* Retrieved May 5, 2005, from http://www.intellectual-property.gov.uk/std/faq/question 1.htm

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* Cambridge, UK: Cambridge University Press.

White, J. A. D. (1997). Misuse or fair use: That is the software copyright question. *Berkeley Technology Law Journal, 12*(2). Retrieved May 5, 2005, from http://www.law.berkeley.edu/journals/btlj/articles/vol12/White/html/reader.html

Williamson, A., Kennedy, D. M., McNaught, C., & DeSouza, R. (2003). Issues of intellectual capital and intellectual property in educational software development teams. *Australian Journal of Educational Technology, 19*(3), 339-355. Retrieved May 5, 2005, from http://www.ascilite.org.au/ajet/ajet19/williamson.html

Xia, W., & Lee, G. (2004). Grasping the complexity of IS development projects. *Communications of the ACM, 47*(5), 69-74.

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Chapter 8.14
A Knowledge Management Roadmap for E-Learning: The Way Ahead

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ABSTRACT

The technological pace and the advent of the knowledge society will set in the next years the new context for e-learning evolution: The convergence of learning and daily life of citizens worldwide will be evident in new services and transparent technologies. Pervasive or ubiquitous learning will be a critical cornerstone and an ultimate achievement of the e-learning research community. Additionally, worldwide efforts will define the social responsibility character of e-learning. In this short visioning paper, we try to address two critical questions: How will knowledge management and relevant technologies affect e-learning in the forthcoming six years? and What are the critical research questions for the new period of e-learning evolution? Many of these aspects could initiate interesting PhD research.

INTRODUCTION

In recent years, the knowledge society has been referred to as our new context of living. Knowledge and learning are anticipated as integrative parts of our strategy toward the promotion of our society. Unfortunately, several obstacles limit the potential value of this new context and its evidence for every citizen.

From this perspective the e-learning research agenda will in the next years realize a qualitative shift in issues that promote the role of e-learning in the context of the knowledge society. The convergence of e-learning and knowledge management will be evident in worldwide initiatives that will foster a constructive, open, dynamic, interconnected, distributed, adaptive, user-friendly, socially concerned, and accessible wealth of knowledge. This seems to be an interesting answer from the scientific community to a volatile world where differences are characterized by points of tension.

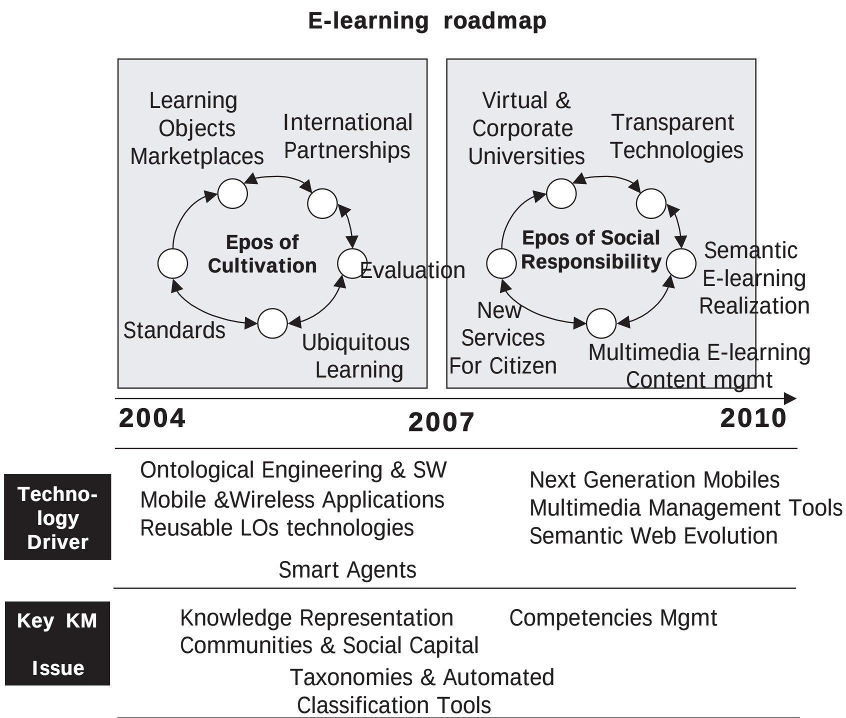
In this short paper, we will provide our point of view for the emerging new era of e-learning. We have decided to distinguish two periods: The epos of cultivation and the epos of social responsibility.

EPOS OF CULTIVATION

In Figure 1, a roadmap for e-learning is presented, where a number of critical milestones provide the significant path for the evolution of the discipline. Toward this direction, knowledge management is a critical enabler. In the following section, we will discuss in more detail the arguments for the presented milestones.

In the first period, 2004-2007, we have classified five important achievements for e-learning:

Figure 1. E-learning roadmap: 2004-2010



- Justification and Communication of Standards: Nowadays, several standardization bodies work toward the specification of standards that refer to different aspects of e-learning, such as technologies, annotation, and interoperability. In the forthcoming years, standardization will include in its agenda themes like quality, semantic annotation and instructional design.
- Development and Exploitation of Learning Objects Marketplaces: In the past years, several initiatives and excellent research works has promoted the discussion of the establishment of distributed marketplaces of learning objects. This trend will continue in the next years. The emphasis will be on the (semi-) automated assembly of learning objects and the extensive development of ontologies that will guide the representation and retrieval of distributed learning content.
- International Partnerships: A challenging milestone for the promotion of e-learning will be the intensive collaboration of academia and industry through several large-scale international partnerships. Several top IT companies will develop important interest in the e-learning market, which will cause an extraordinary effort for the development of several transparent technologies and services that will promote the ubiquitous learning vision. From a knowledge management perspective, this cornerstone will require the exploitation of theories that refer to the networked organization.
- Ubiquitous Learning: Ubiquitous learning stands for the new era of learning services that will be promoted through transparent new technologies and services. The debate in this area has started already, and, from this perspective, e-learning will exploit further new communication medias as well as new instructional models. The ubiquity of knowledge will be an interesting research theme.
- Evaluation of E-Learning: Another interest research stream in the forthcoming years will be the specification of new approaches for the evaluation of the learning outcomes in e-learning. New insights will be based mainly on knowledge management and especially on the codification of the e-learning journey that each learner selects in an adaptive e-learning system. Additionally, knowledge management literature and communities of practice will provide scalable considerations for the evaluation profile, which will constitute qualitative features like social interaction and learner-led semantic annotation of content.

A stream of four technologies will guide this new era of e-learning:

- Ontological Engineering and Semantic Web: The exploitation of ontological engineering and semantic Web, in the context of e-learning, will support new systems and new approaches on content codification as well as new reference models.
- Mobile and Wireless Technologies: These technologies will provide extraordinary challenges for learning content diffusion. The great challenge for knowledge management and e-learning will be to exploit theories of multimedia content management, and, from this perspective, we will face an increased share of synchronous learning content delivery: To go a step further, we believe that the distinction of synchronous and asynchronous delivery mode will be eliminated.
- Reusable Learning Object Technologies: The quest for the development of adaptive and personalized e-learning systems in the last five years was at the top of the e-learning

research agenda. The bet of researchers for the new period is to embed instructional elements in revealing learning objects and to value ingredients that new knowledge management techniques will support. A vision in this direction is the automated argument markup of learning content as well as its semantic annotation.

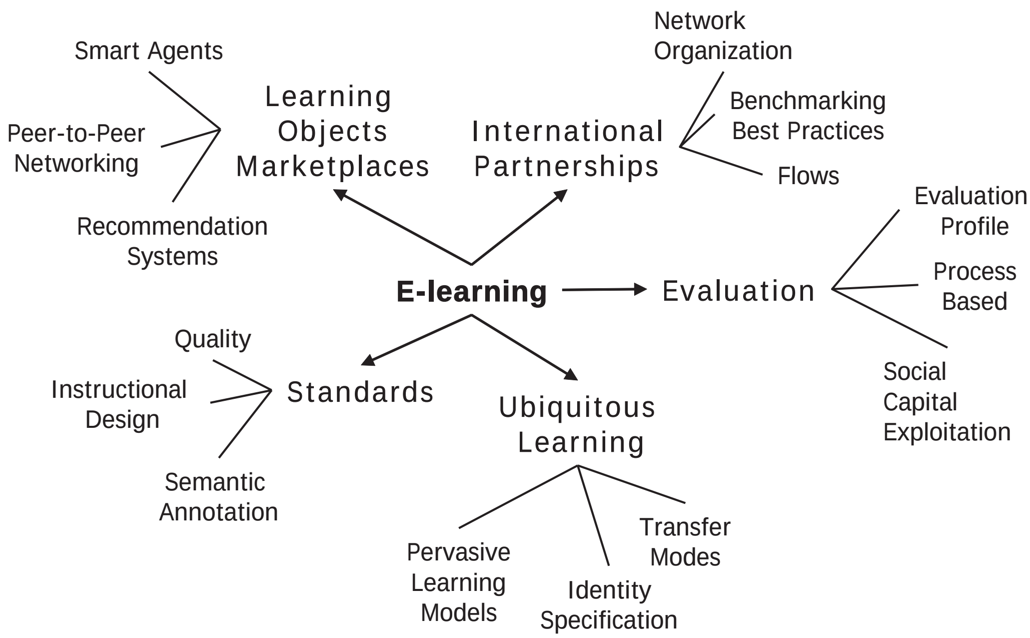
- Smart Agents: The sophistication of e-learning systems and the promotion of value adding services to learners will require an extensive boost on the role of smart agents for e-learning. The critical theme in this context is the practical interpretation of several interesting conceptualizations on agents.

EPOS OF SOCIAL RESPONSIBILITY

Undoubtedly, the advent of the knowledge society reveals the importance of learning as the major process for the formation of a high performance economy. Thus, the second period in our horizon is characterized by a systematic strategy to justify the societal value of e-learning. In this direction, five critical pillars will promote the societal role of e-learning in the context of the knowledge society:

- Virtual and Corporate Universities: It is true that in the last decade several virtual and corporate universities have emerged. In the new e-learning landscape, these institutions

Figure 2. The milestones and critical issues in the epos of cultivation

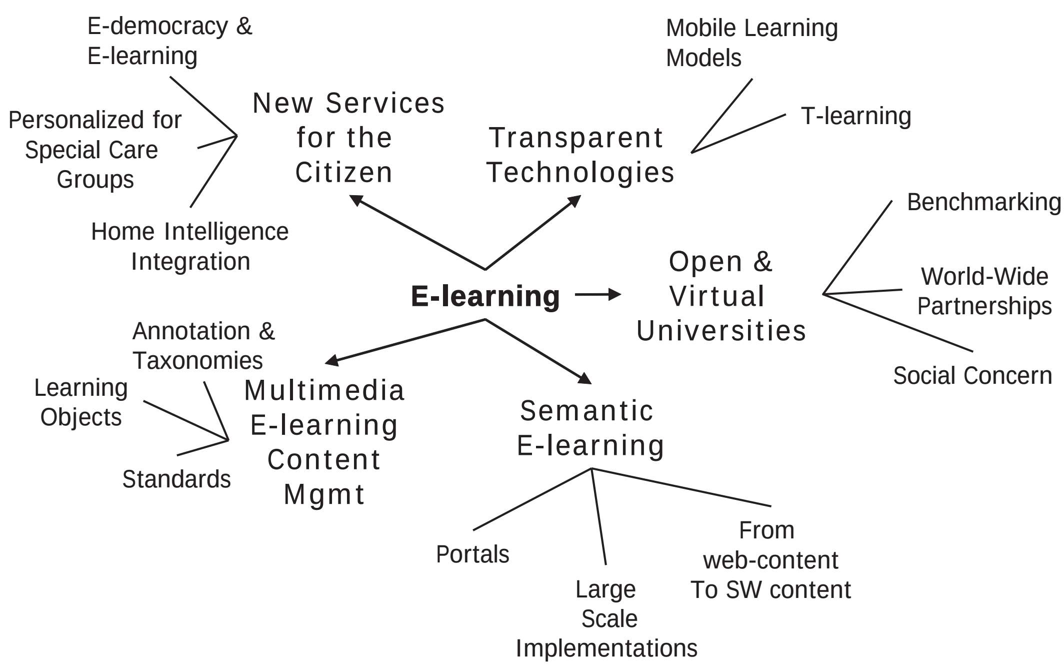


will promote worldwide initiatives that will extend the learning possibilities. Moreover, they will be directed in two general dimensions: academia and industry collaboration; and government funding for targeted e-learning to specific populations.

- Semantic E-Learning Realization: The evolution of the Semantic Web promoted by W3C in terms of standards, languages, and tools will require extensive work in specific scientific fields for the exploitation of its contribution to specific contexts. From this perspective, the semantic Web propositions will provide fertile ground for interesting research concerning the annotation of learning content as well as the provision of Semantic Web-enabled services for learners.
- New Services for the Citizen and Transparent Technologies: Semantic Web evolution, as well as the promotion of mobile and wireless networks worldwide, will help the provision of new services that will incorporate the perception that learning is inevitable in any aspect of human life.
- Multimedia E-Learning Content Management: Within the epos of social responsibility, the interest in multimedia content knowledge management will continue to trigger enormous research effort. At the end of the period, we will realize fully automated tools for natural language semantic Web-enabled recognition, and this will support transformation of multimedia content types (e.g., from speech to text, from text to speech, from video to text, argumentation, etc.).

The key characteristics of this period will be the automation of argumentation, the fully person-

Figure 3. The milestones and critical issues in the epos of social responsibility



alized and adaptive systems, and the move from PC-based e-learning facilitators to mobile smart devices and home intelligence systems. The critical milestone for this second period of e-learning evolution will be the integration of information systems that in previous stages have supported e-learning (e.g., PCs, mobile systems, wireless applications, videoconferencing, etc.) to a single multimedia semantic-enabled and ubiquitous learning environment. This technological pace will subsequently support several value adding services for learners worldwide.

EMERGING KM-ENABLED E-LEARNING RESEARCH AGENDA

The previous discussion of the roadmap on e-learning can be used to outline some critical research questions for e-learning. We have decided to provide a short list through a careful selection of issues in order to help readers, especially readers interested in undertaking research on the convergence of knowledge management and e-learning.

A. Epos of Cultivation

1. Standards
   - Integration of instructional design principles with e-learning content standards
   - Exploitation of peer-to-peer networking as an enabler of learner centric standardization
   - Multimedia e-learning content standardization
2. Learning Objects Marketplaces
   - Automated assembly of distributed knowledge objects toward the provision of e-learning unique experiences
   - Ontology-driven e-learning engineering
   - Data and flow modeling of learning activities
3. Ubiquitous Learning
   - Pervasive learning models toward the integration of multi-channel content delivery
   - E-learners identity specifications
   - Modes of ubiquitous e-learning transfer / learning bouquet
4. Evaluation of E-Learning
   - Justification of the evaluation profile from a social capital perspective
   - Process-based evaluation
5. International Partnerships
   - Benchmarking of e-learning practices
   - Models of network integration in e-learning international partnerships

B. Epos of Social Responsibility

1. New Services for Citizens
   - E-democracy and e-learning convergence: a multifold analysis of managing learner profiles
   - Personalized e-learning services for people with disabilities / special care groups
2. Open, Virtual, and Corporate Universities
   - Open and virtual universities as networks: a knowledge management perspective
   - Benchmarking and best practices
3. Multimedia E-Learning Content Management
   - Annotation of multimedia content management
   - Multimedia learning objects and standards
   - Taxonomies and automated classification tools

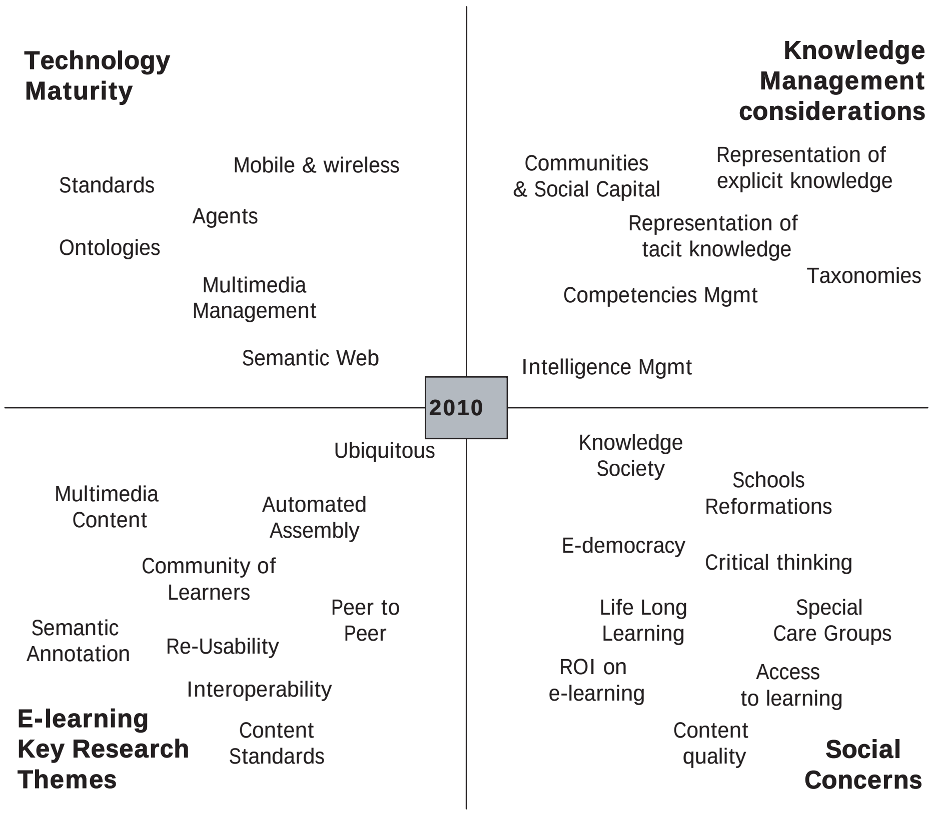
4. Semantic E-Learning Realization
   - Semantic Web portals specifications
   - Methods for the upgrade of Web-based e-learning content to Semantic Web e-learning content

CONCLUSION

This special issue themes relates to an inevitable aspect of e-learning. Knowledge management will continue to develop more and more interest in e-learning for two basic reasons: (1) there is a solid linkage between these two fields, since they represent two critical aspects of human identity; and (2) e-learning as a context is an excellent research field for researchers coming from the KM research community, since learning challenges the representation and the exploitation of knowledge for learning purposes and provides an excellent test bed for experiments and qualitative research.

In Figure 4, we provide our visionary view for the evolution of e-learning. Four dimensions — technology maturity, knowledge management considerations, social concerns, and e-learning key research theme — summarize important shifts and milestones for e-learning. The ultimate depicted objective in 2010 is the realization of a knowledge society with the characteristics of

Figure 4. The challenging new research context of e-learning and knowledge management convergence



ubiquitous learning and the facilitation of intelligence management through the tools and services of the transparent semantic Web.

Toward this direction, we have planned a corresponding issue to this special publication: In early 2005, we will publish with IDEA Group Publishing the edited book, Intelligent Learning Infrastructures for Knowledge Intensive Organizations: A Semantic Web Perspective.

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Chapter 8.15
Knowledge Management as the Future of E-Learning

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PROBLEMS OF EDUCATION IN KNOWLEDGE SOCIETY

Since technological changes are touching many aspects of today's society, education cannot stay behind; in a world where information is the key to progress, the education of its citizens should not be based on expositive means alone (Adell, 1997). The inevitable increase in complexity and quantity of the information that is available and necessary has led to a need for continuous learning. Information handling requires a profound transformation of learning and teaching methods: from a model in which the teacher is the monopolizing agent and the authorized representative of knowledge, we must move towards a model that offers the student room for individual exploration and self-learning. The student needs to build relations, discover the process from within, and feel stimulated to draw his own roadmap (Piaget, 1999). This way, he will not only learn, but learn to extract the relevant information, that is to say, he will "learn to learn" in actual society.

This kind of learning can only be obtained through action strategies that are not perceived as restricting obligations, but rather as interesting learning options. Content, for instance, should be represented not as an object of study, but rather as necessary elements towards a series of objectives that will be discovered in the course of various tests.

Another characteristic of actual education is that students come from different environments and have different ages and education backgrounds, which make it more complicated to integrate them into one single group. Real personalized attention would require many more teachers and much more time. Add to that the increasing demand for continuous education, with flexible timetables and subjects, and it becomes clear that the current programs are much too rigid.

Tele-education platforms try to meet these needs by providing individualization, physical and temporal flexibility, and a higher level of student implication. However, the contents of these platforms remain the same as those of traditional systems, even if their presentation format is adapted, and therefore they do not substantially contribute to the improvement of the learning process (Martínez, 2002).

KNOWLEDGE MANAGEMENT IN EDUCATION

The learning process consists of a modification of our conduct that, by extracting knowledge from acquired experience, enables us to tackle problems (Wiener, 1967). This definition highlights the two basic aspects of all learning processes: knowledge acquisition, and the experience that leads to it (see Table 1).

The way we can access knowledge strongly depends on how it is stored. According to this criterion, three types of knowledge can be distinguished (Wiig, 1995):

- Tacit Knowledge: Knowledge that is so much embedded in the individual's brain that he himself cannot explain it. Since this kind of knowledge is only accessible by observing

Table 1. Summary of current systems for the representation, management, and storage of information

Representation System	Stored Information	Applied Transformations	Obtained Information
Knowledge Management Systems	Explicit knowledge plus mechanisms to share and acquire tacit knowledge	Meetings, put in common knowledge, relations between knowledge	Explicit knowledge as object and process Possibility of acquiring tacit knowledge
Data Mining	News	Relations that can obtain rules or categories	Explicit knowledge as object and process
Knowledge-Based Systems	Data, news, and relations	Rules for making deduction Transformations of frames	Explicit knowledge as object
Databases	Data	Consults: filters with data	News

the individual's behavior (Nonaka & Takeuchi, 1995), at present we cannot physically store it.

- Implicit Knowledge: Knowledge that is embedded either by the organization, which locates it in procedures, models, and techniques, or by individuals who store it in their brain. In this case, the knowledge can only be accessed, located, and communicated by means of questions and discussions.
- Explicit Knowledge: Knowledge that is easily accessible and documented in normal knowledge sources, frequently well organized. One can typically find this knowledge in books and in digital format, and it must be formalized in order to be significant. Actually, only formalized knowledge can be electronically stored, shared, and effectively applied.

After studying the representation, storage, and information management systems that are currently in use (including databases, data mining, knowledge-based systems, and knowledge-management systems, illustrated in Table 1), we have reached the conclusion that the best currently available approach is knowledge management, which issues from the business environment and has proven its success on many occasions (Tissen, Andriessen & Deprez, 2000). A knowledge management system not only stores information in the shape of news, it goes further by making the users a part of the system itself. In addition, this type of system incorporates mechanisms that allow us to share tacit knowledge: meetings, pieces of advice, examples, and so on. In this way, one can say that these mechanisms facilitate the acquisition of every kind of knowledge.

Knowledge management has obtained positive results in the business world and could very well be applied in the educational sector. Apart from being the best currently available way of handling large amounts of knowledge and knowledge interrelations, knowledge management allows the user to personalize the acquisition of knowledge, improving the current systems.

Unfortunately, the intent to include knowledge management in learning systems (Calés, 2002) has so far been limited to including only certain aspects such as lists of "Frequently Asked Questions," or mechanisms for the exchange of tacit knowledge, but without including these contents in the knowledge base or allowing the feedback of the student's experiences.

To improve the learning process, e-learning models should have the following characteristics:

1. Provide individual attention, taking into account the student's preferences about learning strategies, different kinds of materials, their previous knowledge, and so forth.
2. Facilitate all the available information, in different formats coming from different sources, for the students to learn how to choose the most relevant elements for their learning.
3. Join strategies to get and raise students' motivation and encourage their inquisitiveness, relating the available information with the students' interest, proposing the possibility of exploring deeper the same or related subjects and using the computer games strategies that give rise to investigation.
4. Propose an apprenticeship approach by means of works and problems to solve, so that the students' knowledge grows as they go on with the resolution of their works.
5. Provide information from different sources, to allow seeing different points of view of the same realities.

These characteristics can be achieved with the use of actual technology. In short, it is proposed that the use of a knowledge management system—which, using a global ontology, allows us to establish the highest quantity of relationships between the available information and its classification at different levels. From this support of knowledge, we will establish the apprenticeship by means of the task proposal, using computer game strategies, and the system will interact with the student in order to motivate him, to stimulate his capacity of raising questions, and it will show him the information according to his preferences.

A PROPOSAL FOR A MODEL

Tools for the Sharing of Tacit Knowledge

To get an adequate enrichment and working of this system, there must be (synchronous and asynchronous) "meetings" with the following participants:

- Students interested in a series of related subjects
- Tutors meeting in related subjects
- Students and tutors in related subjects

In addition, the same groups may participate in meetings on any subject.

The reason for the proposal of all these sorts of meetings is that, this way, the ideas posed in each one can be quite different. Students talk with more freedom without tutors, and vice versa, but there are points that can interest both groups together.The reason for meeting people interested in different subjects is that from sharing ideas, understandings, and so on, new knowledge is gained through group work which could not be obtained separately.

In a telematic model, where the predominant communications are asynchronous and technology based, there must also remain room for personal meetings (e.g., videoconferencing), and for the revision of already held meetings.

Institutional Memory

Most of works and examples of knowledge management systems in education focus on the philosophy of knowledge sharing and on communications to circulating tacit knowledge. In order to get a more complete system, content should be included in it, to facilitate students to acquire new skills and knowledge. That is to say, there should be an explicit knowledge base or institutional memory, which comprises knowledge and facilities for learning.

This institutional memory must contain thematic units and the processes that the student is supposed to control in each of the units, detailed down to the most basic level of the course and real problems related to each process. In order to implement the relations between elements, we will have to use a global ontology with the aim of separating the conceptual structure from the storage structure (Gruber, 1993). XML or java classes offer different possibilities for the implementation of the ontology.

Help Tools

The student accesses a series of help tools that are structured according to the knowledge management instructions:

- Yellow Pages, which include documents of different formats: images, videos, texts; recommended bibliographies; lists of experts in the field; students that have achieved a similar level; examples of solutions of similar tasks; related or similar tests; links to related subjects.
- Learned lessons including best practices, worst practices, and false maneuvers.
- Frequently asked questions (FAQs).
- Communication tools: e-mail, discussion, chats, videoconferencing.

- Basic material to resolve the tests in various formats.

Personalization

We propose a method that allows us to store and access the knowledge in a progressive way, to embrace the non-linear structure of the information and the experience-based active learning (Pedreira, 2003). Instead of directly presenting the contents that are to be studied, we present tests that, in order to be carried out, require the aimed knowledge. If the student cannot carry out these tests, they will be divided into easier subtests. By using the help tools, the student gradually constructs his own knowledge through practice. Once he finds the solution to a problem, he will be confronted with more complicated tasks that require the previously acquired knowledge. In the course of the learning process, he will be able to use the available communication tools and thus increase the information that is stored in the system.

The design of the tasks follows computer game strategies, whose characteristics stimulate motivation and action. Like in a game, the student knows the final aim, but not the intermediate steps, which keeps his interest level constant. There is a high level of interaction; errors and successful actions are detected immediately; the rhythm of the study is self-regulated; the classical user manual is replaced by an interactive demonstration of the rules; and the student will also have access to information on related subjects, depending on his preferences.

PRACTICAL CASE STUDY

At the Computer Sciences Faculty of the University ORT Uruguay, the Programming I course has carried out an experiment that links learning-through-experimentation to the support of a knowledge management system, with a simplified prototype developed in Java which incorporates basic programming concepts in its knowledge base (Friss de Kereky, 2004). The ontology was implemented with a class scheme and establishes various knowledge types, each with its corresponding attributes. As the experiment was carried out as an addition for attending classes, tacit knowledge can be shared by means of personal communications.

The experiment divided the students into three arbitrary groups: the first group (A) followed the usual theoretical-practical classes, the second group (B) worked on problem solving, and the third group (C) also worked on problem solving, but received the additional help of the developed environment.

The statistical tests carried out analyze: (1) problem comprehension, (2) search for new ways to solve familiar problems, and (3) the ability to apply already known strategies to new problems (transfer of knowledge).

The results reveal the following: (a) none of the cases presents any significant changes in the problem comprehension, and (b) the group that used the environment obtained the best results in the search for new ways to solve problems, followed by the problem-solving group. Both the use of the environment knowledge and the usual classes favor the transfer of knowledge. The comprehension of the problem seems to improve by the use of the environment or the usual classes.

The School for Industrial Design of the University of A Coruña is carrying out a complementary experiment in its Basic Computer Sciences course. This first phase did not make use of a specific system; it used a standard platform of Web-based e-learning that functions as an information repository and incorporates the necessary communication mechanisms for the circulation of the tacit knowledge. The results of this experiment are very positive. At first, the students are puzzled about the problem, but by making use of the information that is available in the system, of the search hints for more information in the Internet, or of the division into sub-problems, they are able to find the solutions within a reasonable time span and they feel motivated to tackle more problems. Half of 140 students were arbitrarily selected to use the platform and follow the proposed tasks; the rest assisted the habitual classes. From the first half, 74% passed the course, in front of the 61% in the second half.

This first approach requires the control and advice of the teacher, but we are working on the development of a system that allows autonomous and personalized learning, in which the biggest workload of the teacher lies in the tasks before the learning process; afterwards, the teacher becomes a tutor who lets the student manage his own learning process.

CONCLUSION

Knowledge management can be an interesting approach to the implementation of a learning system, because it can maintain the existing interrelations of the information, it provides explicit knowledge, and it circulates the tacit knowledge.

The proposed model incorporates the contents in its institutional memory to improve their assimilation, and possesses an ontology that maintains the information and its categorization independently. It also proposes learning through action, while guaranteeing that the acquired knowledge is used in the execution of the tasks. The approximations with reduced prototypes show that the use of the environment allows the student to extend or improve his problem-solving methods and his abilities to transfer knowledge.

REFERENCES

Adell, J. (1997). Tendencias en educación en la sociedad de las tecnologías de la información. *EDUTEC, Revista electrónica de tecnología educative, 7.* Retrieved April 2, 2004, from http://www.uib.es/depart/gte/edutec-e/revelec7/revelec7.html

Calés, J.M. (2002). *La gestión del conocimiento en la UNED mediante el uso de las nuevas tecnologías: Virtual Educa 2002.* Retrieved February 13, 2003, from http://www.virtualeduca.org/virtualeduca/virtual/actas2002/actas02/112.pdf

Friss de Kereki, I. (2004). *Modelo para la creación de entornos de aprendizaje basados en técnicas de Gestión de Conocimiento.* Unpublished doctoral dissertation, Politechnical University of Madrid, Spain.

Gruber, T. (1993). A translation approach to portable ontology specifications. *Acquisition, 5*(2), 199-204.

Martínez, J. (2002). *Contenidos en e-learning: El rey sin corona.* Retrieved February 13, 2003, from http:/stiondelconocimiento.com

Nonaka, I. & Takeuchi, H. (1995). *The knowledge creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Paradela, L.F. (2001) *Una metodología para la Gestión de Conocimientos.* Unpublished doctoral dissertation, Polytechnic University of Madrid, Spain.

Pedreira, N. (2003). *Un modelo de deuteroaprendizaje virtual*. Unpublished doctoral dissertation, University of A Coruña, Spain.

Piaget, J. (1999). De la pedagogía. Buenos Aires: Paidós.

Rodríguez, S. (2002). *Un marco metodológico para la Gestión del Conocimiento y su aplicación a la Ingeniería de Requisitos Orientada a Perspectivas.* Unpublished doctoral dissertation, University of A Coruña, Spain.

Tissen, R., Andriessen, D. & Deprez, F. (2000). *The knowledge dividend.* London: Financial Times Prentice-Hall.

Wiener, W. (1967). *Dios y Golem.* México: Siglo XXI Editores.

Wiig, K.M. (1995). *Knowledge management methods.* Arlington, VA: Schema Press.

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Chapter 8.16
Incentive Structures in Knowledge Management

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INTRODUCTION

The role of incentives in organizational behavior has long been recognized and studied (Whyte, 1955; Hertzberg, 1959). This role becomes ever more paramount in knowledge management (KM), where users also become creators and contributors: The voluntary sharing of knowledge by individuals is a key element in the implementation and success of any knowledge-management endeavor. Having gradually recognized this, the KM community has theorized, examined, and implemented various incentive structures to promote knowledge sharing and system use in organizations. This article investigates some of these incentive structures, their underlying assumptions, as well as the issues and questions that they raise for KM theory and practice in general.

The article continues in the next section with a brief history and a general discussion of incentives in organizations. It then discusses the theoretical underpinnings of different approaches to KM as they relate to issues of incentive, and provides examples of practical incentive structures used by organizations. Next, it presents an analysis of the examples in the previous section, discusses possible future trends, and finally draws conclusions in terms of appropriate incentive structures for knowledge sharing.

BACKGROUND: THE CENTRAL DILEMMA OF KNOWLEDGE MANAGEMENT

Organization and management scientists have long studied the role of incentives in organizational behavior. Whyte (1955), for instance, provides a classic study of "the 5 M's of factory life: men, money, machines, morale, and motivation" (p. 1). The dominant scientific management view, which held sway in the incentive systems of the time, was based on an economic model of rational human beings who seek to maximize their individual material gains. Whyte challenged this model and replaced it with a socioeconomic model that studies human reaction to incentives in the context of their relationships with other human beings (fellow workers, work groups, managers, etc.). He argued that incentives can be symbolic and much broader in character than purely material and monetary, and emphasized that "we change sentiments and activities through changing interaction" (p. 227). The lessons of the latter half of the last century, including those of KM, seem to support Whyte's model as a more realistic picture of human organizational behavior.

The situation in knowledge management is obviously different from the factory-floor situation studied by Whyte (1955). Not only are we dealing with a different work environment in terms of organization, management, culture, technology, and so on, we are facing a new type of economic agent, usually referred to as a knowledge worker in the literature. Although this term implies a different type of economic activity from earlier ones (e.g., factory work), it does not necessarily mean that knowledge workers have a totally novel psychology in their reaction to incentives. To the contrary, we argue that Whyte's original insights are by and large true of the current work environments as well. To demonstrate this, we introduce what might be called the central dilemma of knowledge management.

A widely studied phenomenon in the social studies of cooperative behavior are the situations known as social dilemmas: namely, those where individual rationality (trying to maximize individual gain) leads to collective irrationality (Kollock, 1998; cf Cabrera & Cabrera, 2002). Well-known examples of social dilemmas are the tragedy of the commons, where overuse of a shared resource (such as land) by beneficiaries (such as herders) would result in its ultimate depletion (Hardin, 1968), and the phenomenon of free ride, where individuals are tempted to enjoy a common resource without contributing to it (Sweeney, 1973). It has been suggested that knowledge sharing can be understood as a special case of a social dilemma (Cabrera & Cabrera; Connolly, Thorn, & Heminger, 1992). That is, if we consider knowledge as a common resource of an organization, individual workers are often faced with the questions of whether or not, to what extent, and under what circumstances should they use, relate to, and contribute to this common property. Although there are clear differences between a natural resource, which is physically constrained in the extent of its use, and knowledge, which is not depleted by use, this conceptualization of knowledge sharing as a social dilemma is rather useful. One way to understand this dilemma is through the fact that contribution to a KM system involves cost (in terms of time, expertise, job security, etc.) that may not be accounted for or paid off by the organizational incentive structures. This is the essence of the central dilemma of KM, which can be articulated as follows:

Why should a knowledge worker contribute to the shared knowledge of the organization if the cost of doing so for the individual is higher than its benefits?

This dilemma gives rise to a tension that is inherent in almost any knowledge-management effort. Incentive structures could therefore be broadly understood as attempts to resolve or reduce this tension. Such attempts should at a minimum address the following questions (Cabrera & Cabrera, 2002, p. 691).

- Why do people share or not share information with coworkers?
- What motivates a person to give up personal knowledge to a third party?
- What are the main barriers that an organization may face when trying to foster knowledge sharing among its employees?
- What can an organization do to overcome those barriers?

The ubiquity of the above dilemma turns these into central questions in the theory and practice of KM. The following discussion demonstrates that various approaches to KM partly diverge on the basis of the answers that they give to the above questions.

INCENTIVES IN KM THEORY

There are different ways to classify KM approaches. For our purposes here, we are going to distinguish among three different views of KM: the techno-centric, human-centric, and socio-technical.

The Techno-Centric View

Roughly speaking, the techno-centric or product-oriented view emphasizes knowledge capture as the main objective of KM. This involves two major dimensions: a cognitive dimension that takes knowledge as something that can be codified, organized, stored, and accessed on the basis of need, and a technical dimension that emphasizes the role of new information and communication technologies in the knowledge-capture process. As such, the techno-centric view tends to formulate and answer the above questions in mainly cognitive and technical terms: People share their knowledge to the extent that they can elicit it and their technologies can capture it. The main barriers to such capturing are therefore either cognitive or technical in character, as are the solutions to overcome the barriers.

As we see, the techno-centric view does not pay much attention to issues of incentive and motivation. Nonaka's (1994) well-known quadrant model might be a rough example of this view: Capture and codify knowledge with expert systems, share knowledge with groupware and intranets, distribute knowledge with databases and desktop publishing, and create knowledge with CAD, virtual reality, and so on. Organizationally, the techno-centric view gives rise to an information-systems model of KM (cf Huysman & de Wit, 2002), concentrating KM efforts within IT departments. It might be fair to say that the techno-centric view, in its purest forms, belongs to the early days of KM and does not have much currency today, although its cognitive component is deep rooted and still holds a strong influence on KM thinking.

The Human-Centric View

The human-centric or process-oriented view, on the other hand, emphasizes the social processes that are needed for the development of trust and reciprocal relationships among individuals. As such, it focuses on person-to-person communication and highlights social constructs such as communities of practice as the main vehicles of KM implementation. According to this view, people are driven toward knowledge sharing by their need for knowledge (Lave & Wenger, 1991). Reciprocity and recognition are, therefore, major motivations for them. Knowledge sharing is often emergent, informal, and hard to create top-down. The barriers to knowledge sharing are often issues of trust, and they can be overcome by building and expanding the right social relationships. Organizationally, the human-centric view is associated with the human-capital view of the firm, and leads to a human-resource-management model of KM (Huysman & de Wit, 2002; see, for example, Desouza & Awazu, 2003). The human-centric view has gained some momentum in recent years, especially around the literature on communities of practice (Lave & Wenger).

The Socio-Technical View

Finally, the socio-technical view thinks of KM as people sharing their knowledge with IT-enabled applications. It considers KM as an integrated socio-technical intervention with coordinated efforts to enroll participants, reward high-quality participation, and resolve issues of trust and commitment. This is the view advocated, among others, by the proponents of social informatics (Kling, 2000). Unlike the techno-centric view, social informatics does not consider IT as a silver bullet that automatically energizes knowledge sharing, and in contrast to the human-centric view, it regards best practices as contextual frames rather than isolated practices. It also puts a large emphasis on power relationships in KM practice (Ekbia & Kling, 2003).

Organizationally, the socio-technical view considers knowledge sharing as an orchestrated process that needs to be supported by both top-down managerial interventions and bottom-up employee and practitioner involvement. Although there seems to be a growing enthusiasm for the socio-technical view, it might take a while before the KM community comes to grips with the full complexity of KM as a socio-technical intervention. As the next discussion illustrates, current practices of KM, even when they involve some kind of incentive structure, are still dominated by either the techno-centric or the human-centric views.

INCENTIVES IN KM PRACTICE

Having recognized the importance of incentives in KM, firms and organizations have devised various schemes to support and motivate knowledge sharing among their employees. The following examples are illustrative of some of the more common schemes. Stevens (2000, p. 54) reports various cases of "innovative strategies that encourage knowledge sharing." Briefly, these included examples range from companies that incorporate this into their hiring process to those that try to develop trust by creating a code of ethics; implementing reward systems on the basis of employee contributions; encouraging knowledge sharing through conferences, classes, and mentoring programs; establishing communities by expanding networks of contacts; or creating role models and KM advocates who keep the ball rolling. It is to be noticed that many of these incentive schemes are under the strong influence of either the techno-centric or the human-centric views.

Other studies of incentive structures report more or less similar attempted schemes (Angus, 2000; Ward, 2002; Wright, 1998). Generally speaking, current schemes often take the form of extrinsic incentives such as monetary rewards, recognition, and promotion. Popular accounts of incentive systems also tend to focus on similar schemes and, as a result, often portray a rosy picture of the impacts of incentives on employee performance. A rather different picture emerges, however, when employees' opinions are probed. In a survey conducted on a group of knowledge workers, Rupp and Smith (2003) found that 58% of their respondents feel that there is a discrepancy between their merit increase and performance rating. The authors suggest that in order to improve this situation, organizations need to give more responsibilities to employees.

Austin (1996) introduces the phenomenon of "incentive distortion" to demonstrate some of the complications that arise when incentive systems are not built upon employee responsibility. An example comes from a government organization whose task is to help people find jobs. An incentive system, which rewarded employees on the basis of the number of interviews they conducted, actually resulted in a significant rise in the number of interviews, but it also made employees spend little time on finding referrals. Ideally, for the process to be fruitful, the time spent on conducting interviews and finding referrals should be equally divided. To move toward this ideal, management changed the measure of the reward as the ratio of the number of interviews to the number of referrals, only to find out later that employees were deleting the record of interviews in order to distort the ratio.

Barth (2000) introduces some examples of dysfunctional mismatch between incentives and performance measurement. For instance, as part of their performance reviews, IBM employees were asked to contribute their project experience to a company-wide KM system. However, many employees did not submit their contributions until the very last month preceding the reviews. This can be understood in light of the additional burden of the activity, which would take away employees' time and resources from tasks with more direct returns or from what they probably considered more important tasks. Faced with this situation, IBM management introduced a quality-control component that incorporated a kind of expert peer review to evaluate the content and quality of the submissions in terms of their usefulness to other employees. Aside from employee competition, this introduces issues of overhead and cost efficiency for the whole company. The use of selective incentives such as the above incurs a cost for the organization in terms of the monitoring of participation (in addition to the rewards themselves), and this needs to be taken into account in the evaluation of the KM initiative (Cabrera & Cabrera, 2002).

DISCUSSION: FACING THE DILEMMA

"A man always has two reasons for doing anything—a good reason and a real reason." (J. P. Morgan)

The above examples raise a set of questions. How can incentive structures be tailored to improve employee satisfaction? How can managers and KM practitioners prevent incentive distortions from proliferating? At what point are the costs of selective schemes in terms of company overhead, employee time, and employee satisfaction going to tip off the benefits? These (and our earlier) questions should be taken seriously in order for KM efforts to work, and to answer them, the KM community has largely turned to economic theory for a source of ideas.

Davenport and Prusak (1998), for instance, discuss the idea of a "knowledge market" where buyers and sellers of knowledge negotiate a mutually satisfactory price for the exchange. According to this idea, the perceived gain from the exchange in terms of reciprocity, repute, and altruism serve as an incentive for knowledge sharing. As Ba, Stallaert, and Whinston (2001a) have argued, however, it is difficult to quantify these gains into monetary values so that a benefit can be assigned by the organization. Furthermore, knowledge has the characteristics of a public good in that it is nondepletable, and economic theory itself warns us that treating a public good as a private good leads to the underprovision of knowledge and, hence, to organizational loss (ibid; cf Samuelson, 1954). This is related to the free-rider problem and what we called the central dilemma of KM. Ba, Stallaert, and Whinston (2001b) have applied economic theory to discuss an incentive-aligned market mechanism to optimize investment in KM within a firm, but their account focuses almost exclusively on extrinsic motivations such as monetary rewards. To find about intrinsic motivations such as commitment and job satisfaction, however, we need to look elsewhere outside of economic theory.

Social psychologists distinguish intrinsically, vs. extrinsically, motivated activities as ones for which "there is no apparent reward except the activity itself" (Deci, 1976, p. 23). These are behaviors that a person engages in "to feel competent and self-determining" (p. 61). Therefore, they could be either sought as a means of stimulation or as a way of conquering challenges or reducing incongruities (ibid). Furthermore, industrial psychologists have shown that motivation is a rather fluid and dynamic phenomenon: What motivates one person may not motivate another, what motivates a person may change over time, and people might be always motivated but not necessarily toward organizational goals (Champagne & McAfee, 1989). Similar observations have been made in information-systems research: For example, the report by Constant, Kiesler, and Sproull (1994) reveals that people share knowledge because of their altruistic preferences. These theories and findings might indeed be useful in reducing the tension that arises due to the central dilemma of KM. In her study of a consulting firm with a strong KM initiative, Orlikowski (2000) explains consultants' reluctance to contribute knowledge in terms of the perceived incompatibility between the collaborative nature of the technology, and the individualistic and competitive nature of the organization. Under such circumstances, paying attention to intrinsic motivations might be a key to more effective systems.

What this discussion illustrates is not only that incentive structures are important for KM efforts, but also that they are multifaceted phenomena, the understanding of which requires different levels of analysis from different perspectives: the psychological, social, economical, technical, and so on.

FUTURE TRENDS

Given the multifaceted nature of incentive issues, it would seem that a socio-technical approach, such as proposed by social informatics, holds a stronger promise in addressing them, a trend that is emerging in different quarters of KM theory and practice.

Huysman and de Wit (2002) suggest that, following a first wave where organizations were prone to fall into one of three traps (overemphasis on the role of ICT, individual learning, and managerial needs), KM is moving toward a second wave where the focus is on collective knowledge (social capital) that is routinely shared through personal and electronic networks. Gold, Malhorta, and Segars (2001, p. 187) also introduce an organizational capabilities perspective of knowledge management based on three key infrastructures: the structural (which "refers to the presence of norms and trust"), cultural ("shared contexts"), and technical. Ba et al. (2001a) propose to add an incentive-alignment dimension to the current software-engineering and user-acceptance dimensions of the design and implementation of information systems in organizations.

Cabrera and Cabrera (2002), from the perspective of social dilemmas discussed earlier, suggest a number of interventions with a strong socio-technical character: for example, reducing the cost and increasing the benefits (direct or perceived) of contributing through gain-sharing plans that reward the combined efforts of individuals; increasing the efficacy of contributions through training, feedback mechanisms, and advanced technologies; enhancing group identity and personal responsibility by frequent communication and interaction; and so on.

As these examples indicate, there is a growing trend toward a socio-technical approach that integrates heterogeneous interventions (technical, cultural, structural, etc.) at different levels (micro and macro) of organizational life.

CONCLUSION

The global economy went through a serious transformation in the second half of the 20th century, one aspect of which is the move toward what some analysts call a knowledge economy. Knowledge management is an organizational manifestation of this trend that incorporates novel elements of economic and organizational activity. It would be wrong, however, to conclude from this that everything about the knowledge economy and about knowledge management is novel and unprecedented. There are stable and enduring aspects to all forms of economic activity, and the social psychology of incentive, motivation, and cooperation is one such aspect. Those 21st century factory workers who are unwilling to share their special knowledge (Aeppel, 2002) can probably be explained in similar terms to those that Whyte (1955) used to explain the behavior of their mid 20th century fellow workers, that is, in terms of their material and symbolic relationships to other human beings. By the same token, the reaction of knowledge workers toward incentive structures can also be understood in similar terms.

In this article, we have suggested that KM can be best understood as a socio-technical intervention rather than a purely technological system. A key aspect of this intervention is to motivate individuals to share their knowledge and skills with their fellow workers. This is what turns incentive structures into an indispensable component of any KM effort. The question is how best to implement such structures. To be sure, there is no general answer to this question as particular contexts shape the character of the intervention and structures. But a common lesson that seems to be emerging is that extrinsic motivations alone are not always sufficient and that human beings are often driven by intrinsic motivations such as job satisfaction. It is becoming increasingly clear that even nonmonetary rewards, such as social recognition, can be effective so long as they are public, infrequent, credible, and culturally meaningful (Lawler, 2000). Similar findings are reported in the literature on communities of practice (Lave & Wenger, 1991; Orr, 1996; Schwen & Hara, 2003). The growing phenomenon of free and open software development, which works through the voluntary contribution of very many individuals, is also a case in point.

In summary, a common recognition of the key role of incentive structures in knowledge management and an associated increase of enthusiasm for socio-technical perspectives seem to be shaping. This does not mean that the path of the future is clear, straightforward, and uncontroversial. There are still many outstanding issues in terms of our understanding of the interplay between various elements and levels: the individual and the social, the cognitive and the technical, the material and the symbolic, the intrinsic and the extrinsic, and so on. A good part of the answer to these questions should inevitably come from outside knowledge management, from the social, organizational, and cognitive sciences as well as technical fields such as computer science. The knowledge-management community can greatly contribute to our better understanding of the above issues by its efforts to integrate those insights in its theory and practice. Organizational incentive structures provide a good starting point for such efforts.

REFERENCES

Aeppel, T. (2002, July 1). Tricks of the trade: On factory floors, top workers hide secrets to success. *The Wall Street Journal, A1.*

Austin, R. D. (1996). *Measuring and managing performance in organizations.* New York: Dorset House Publishing.

Ba, S., Stallaert, J., & Whinston, A. B. (2001a). Introducing a third dimension in information systems design: The case for incentive alignment. *Information Systems Research, 12*(3), 225-239.

Ba, S., Stallaert, J., & Whinston, A. B. (2001b). Optimal investment in knowledge within a firm using a market mechanism. *Management Science, 47*(9), 1203-1219.

Barth, S. (2000). KM horror stories. *Knowledge Management Magazine.* Retrieved February 26, 2004, from http://www.destinationkm.com/articles/default.asp?ArticleID=923

Cabrera, A., & Cabrera, E. F. (2002). Knowledge-sharing dilemmas. *Organization Studies, 23*(5), 678-710.

Champagne, M. I., & McAfee, V. W. (1989). *Motivating strategies for performance and opportunity.* New York: Quorum Books.

Connolly, T., Thorn, B. K., & Heminger, A. (1992). Discretionary databases as social dilemmas. In W. B. G. Liebrand, D. M. Messick, & H. A. M. Wilke (Eds.), *Social dilemmas: Theoretical issues and research findings* (pp. 199-208). Tarrytown: Pergamon Press Inc.

Constant, D., Kiesler, S., & Sproull, L. (1994). What's mine is ours, or is it? A study of attitudes about information sharing. *Information Systems Research, 5*(4), 400-421.

Davenport, T., & Prusak, L. (1998). *Working knowledge: How organizations manage what they know.* Boston: Harvard Business School Press.

Deci, E. L. (1976). *Intrinsic motivation.* New York: Plenum Press.

Desouza, K. C., & Awazu, Y. (2003). Knowledge management. *HR Magazine, 48*(11), 107.

Ekbia, H. R., & Kling, R. (2003). Power in knowledge management in late modern times. *Proceedings of the Academy of Management Conference*.

Gold, A. H., Malhorta, A., & Segars, A. H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243-1248.

Huysman, M., & de Wit, D. (2002). *Knowledge sharing in practice.* Dordrecht: Kluwer Academic Publishers.

Kling, R. (2000). Learning about information technologies and social change: The contribution of social informatics. *The Information Society, 16*(3).

Kollock, P. (1998). Persuasive communication: Measures to overcome real-life social dilemmas. In W. B. G. Liebrand, D. M. Messick, & H. A. M. Wilke (Eds.), *Social dilemmas: Theoretical issues and research findings* (pp. 307-318). New York: Pergammon.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation.* Cambridge, MA: Cambridge University Press.

Lawler, E. E., III. (2000). *Rewarding excellence.* San Francisco: Jossey-Bass.

Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science, 5,* 14-37.

Orlikowski, W. (2000). Using technology and constituting structures: A practice lens for studying technology in organizations. *Organization Science, 11*(4), 404-428.

Orr, J. E. (1996). *Talking about machines: An ethnography of a modern job.* Ithaca, NY: Cornel University Press.

Plaskoff, J. (2003). Intersubjectivity and community building: Learning to learn organizationally. In M. Easterby-Smith & M. A. Lyles (Eds.), *The Blackwell handbook of organizational learning and knowledge management.* Blackwell Publishers.

Samuelson, P. (1954). The pure theory of economic expenditure. *Rev. Econom. Statistics, 36*(4), 387-389.

Schwen, T. M., & Hara, N. (2003). Community of practice a metaphor for online design? *The Information Society, 19*(3), 257-270.

Smith, A. D., & Rupp, W. T. (2003). Knowledge workers: Exploring the link among performance rating, pay and motivational aspects. *Journal of Knowledge Management, 7*(1), 107-124.

Stevens, L. (2000). Incentives for sharing. *Knowledge Management,* 54-60.

Ward, S. (2001). Rewarding knowledge sharing at Context Integration, Inc. *KM Review, 5*(1), 3.

Whyte, W. F. (1955). *Money and motivation: An analysis of incentives in industry.* Greenwood Publishing Group.

Write, P. (1998). Do incentive schemes promote knowledge sharing? *Knowledge Management Review, 1*(2), 4-6.

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Chapter 8.17
e-Health with Knowledge Management:
The Areas of Tomorrow[1]

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ABSTRACT

The main purpose of this chapter is to bring out and discuss the central facts pertaining to the importance of incorporating knowledge management in the area of e-health. This is accomplished by focusing on the application of knowledge management in e-health and its effects.

INTRODUCTION

The evolution of the "Information Age" in medicine is mirrored in the exponential growth of medical web pages, increasing number of online data sources, and growing services and publications available on the World Wide Web. The Internet started with a few computers linked by the predecessor in 1969 and has grown to more than six million web sites today, of which at least 2% have health-related content. More than 150 million people currently communicate over the Internet with medical information being amongst the most retrieved information on the web. Health information providers on the web mostly consist of private companies offering medical information, individual patients and health professionals, patient self-support groups, non-governmental organizations, universities, research institutes and governmental agencies. Thus, the importance of e-health has grown tremendously these days and providing e-health coupled with the concept of knowledge management will only serve to enhance the efficiency of e-health initiatives.

E-HEALTH

E-health is a very broad term that encompasses many different activities related to the use of the Internet for healthcare. The rate at which health professionals are using the Internet as a source of consumer information about health and medicine is rapidly increasing. It has been reported by healthcare professionals that large numbers of patients arrive at their offices either with questions related to online medical information or a large variety of health products on the Internet. Some of this content may prove extremely helpful to the health and recovery of a patient. Prior to 1999, e-health was barely in use. Now it seems to be a general "buzzword," used to characterize not only "Internet medicine," but also virtually everything related to computers and medicine (E-Health in the Medical Field, 2003).

Intel, for example, has referred to e-health as "a concerted effort undertaken by leaders in healthcare and hi-tech industries to fully harness the benefits available through convergence of the Internet and healthcare." As the Internet has created new opportunities and challenges to the traditional healthcare information technology industry, the use of this new term to address these issues seems appropriate. The latest challenges for the healthcare information technology industry with respect to e-health fall primarily into the following categories:

1. Institution-to-institution data transmission possibility (B2B = "business to business");
2. Consumers' capability to interact with their systems online (B2C = "business to consumer"); and
3. Peer-to-peer consumer communication possibility (C2C = "consumer to consumer").

E-health can be described as an emerging field at the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies (Eysenbach, 2001). In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking to improve healthcare locally, regionally, and worldwide by using information and communication technology (ibid).

The E's in e-Health

The preceding definition of e-health is broad enough to apply to the dynamic environment of the Internet and at the same time acknowledge that e-health encompasses more than just "Internet and Medicine" (Eysenbach, 2001). It is useful to think of the "e" in e-health not just standing for "electronic," but also a number of other "e's," which together perhaps best characterize what e-health is all about. Specifically, we now present some of the "e"s that serve to represent the "e" in the e-health that have been identified by Gunther Eysenbach, editor, Journal of Medical Internet Research in his editorial comments on what is e-health, as follows:

Efficiency – E-health aims to increase efficiency in healthcare, thereby decreasing costs, in particular transactions costs. This can be realized by avoiding redundant or unnecessary diagnostic or therapeutic interventions, through enhanced communication possibilities between healthcare establishments, and through patient involvement.

Enhancing Quality of care – Increasing efficiency improves quality along with reducing costs. In addition, e-health provides a vehicle for trying to decrease the myriad of medical errors which in turn naturally impact the quality of healthcare treatments in a positive fashion.

Evidence Based – E-health interventions should be evidence-based thus they should be proven by rigorous scientific evaluation and thus no assumptions need be made in this area with respect to treatments.

Empowerment of Consumers and Patients – E-health facilitates patient-centered medicine, and supports wiser patient choice. This is accomplished by making the knowledge bases of medicine and personal electronic records accessible to consumers over the Internet.

Education of not only physicians but also consumers – Today's healthcare sector is complex and physicians must contend with continually updating of their medical knowledge base to keep abreast with new treatment protocols etc e-health offers an effective avenue for this. Education however is not just limited to physicians but all medical and healthcare professional as well as healthcare consumers.

Extending the scope of healthcare in both a geographical sense as well as in a conceptual sense – Via e-health, it is possible for patients to access key knowledge and reach experts who maybe located in different countries for primary or even second opinions. In addition, the area of telemedicine in particular helps to provide needed and a broad range of healthcare services to remote and typically inaccessible areas.

Ethics – E-health involves new forms of patient-physician interaction and poses new challenges and threats to ethical issues such as online professional practice, informed consent and privacy issues. It is important that many of the ethical dilemmas presented by e-health initiatives are to some extent no different to the ethical dilemmas generally created by e-commerce technologies with which all organizations must contend.

Equity – To make healthcare more equitable is one of the promises of e-health, but at the same time there is a considerable threat that e-health may deepen the gap between the "rich" and "poor" and increase the digital divide (Journal of Medical Internet Research, 2001).

THE ROLE OF CONSUMERS

Today, a large number of patients and consumers already use the Internet to retrieve health-related information, to interact with health providers and even to order pharmaceutical products. Physicians mainly use the web to access science databases like PUBMED or MEDLINE, but they lag behind other professions in their use of online information. On the other hand, consumers have taken the lead in adopting the Internet media for the retrieval and exchange of health information. Informed and Internet-savvy patients will play a crucial role in being a major driving force for clinicians to "go online" and for evidence-based medicine. Patients will undoubtedly increase the pressure on physicians to use timely evidence by accessing online information. They also will encourage them to adapt themselves to information technology in order to deliver high quality health services. For the first time in the history of medicine, consumers have equal access to the knowledge bases of medicine — and they are heavily using this access. It has been noted that "the number of Medline searches performed by directly accessing the database at the National Library of Medicine increased from 7 million in 1996 to 120 million in 1997, when free public access was opened; the new searches are attributed primarily to non-physicians" (Sieving PC Factors Driving the Increase in Medical Information on the Web, 1999). Thus, the Internet will act as a catalyst for evidence-based medicine in two ways: First, it enables health professionals to access timely evidence. Second, it enables consumers to draw information from the very same knowledge base, leading to increased pressure on health professionals to actually use the evidence (PricewaterhouseCoopers Healthcare Practice, 2003).

By 2005, 88.5 million adults will use the Internet to find health information, shop for health products and communicate with affiliated payers and providers through online channels, according to Cyber Dialogue (Online Health Information Seekers Growing, 2003). Today, the e-health consumer demands include the need for specific health services, such as obtaining information when faced with a newly established diagnosis.

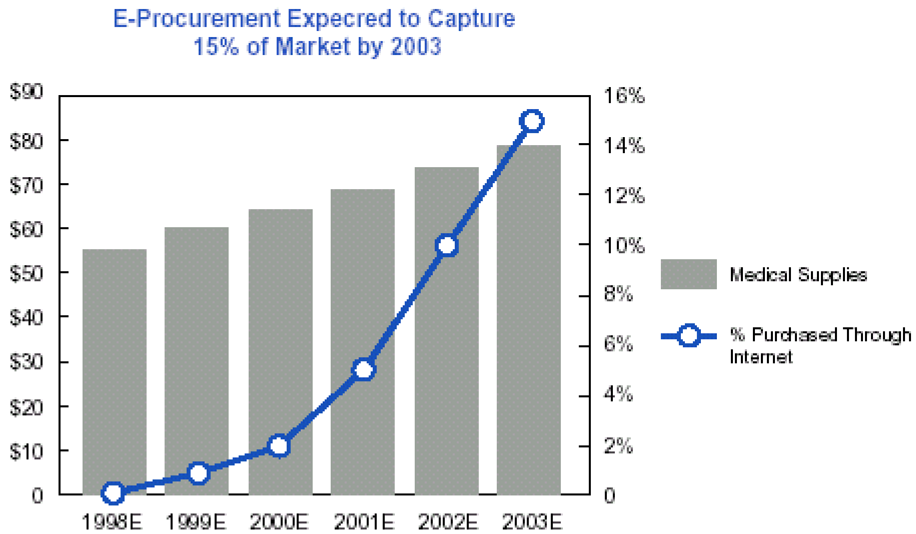
Some key challenges must be met to develop optimal partnerships between consumers and other groups of decision-makers. Some of these include the need for:

- Meaningful collaboration with patients,
- Preparation for upcoming technological developments,
- Efficient strategies to monitor patterns of Internet use among consumers,
- Balance between connectivity and privacy factors,
- Better understanding of the balance between real and virtual interactions, and
- Equitable access to technology and information across the globe.

E-HEALTH ISSUES

Three important issues must be carefully considered in the field of e-health (The Higher the Connection Speed, 2001). These issues tend to be similar to all aspects of e-commerce and typically comprise the areas of procurement, connectivity, and benefits. We discuss each in turn briefly.

Figure 1. e-Procurement market sales



Source: Odyssey Research, 2003

e-Procurement

Health systems must begin to consider how their organizations are going to adapt and leverage Internet-based tools to manage their medical supplies.

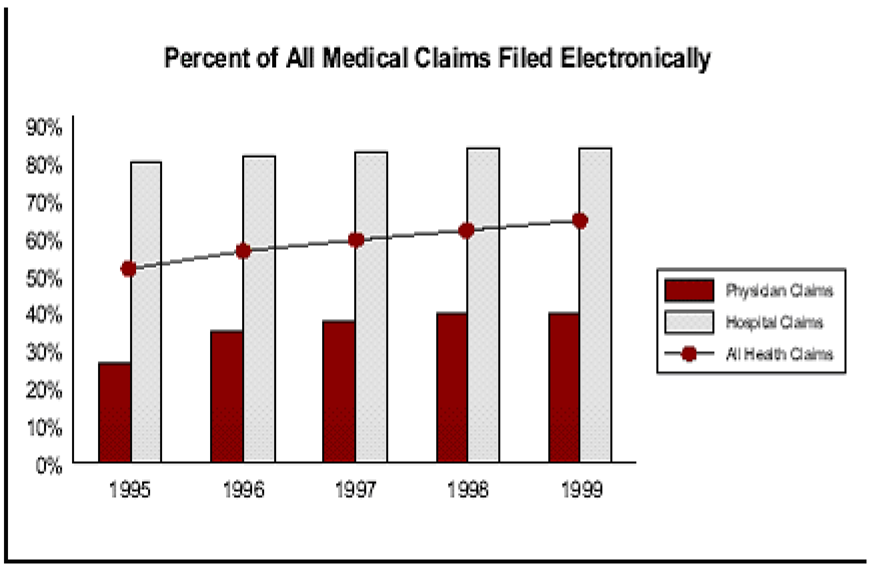
Procurement in healthcare products must move toward an online business platform for data interchange. Producers and consumers also must work together toward standardization, including a universal product numbering system. As shown in Figure 1, in the US, e-procurement of medical supplies is estimated to grow to 15% of medical supply spending in the US by 2003, according to Deutsche Banc Alex Brown (PricewaterhouseCoopers Healthcare Practice, 2003).

e-Connectivity

Healthcare is local, and so is connectivity. Finding that they can not boil the ocean, connectivity companies must pragmatically assess what the industry can reasonably move to on a step-by-step basis. Technology is a tool, but it will not pay for itself unless organizations deploy it in practice and track how their clinicians and administrative workers are using it. To do so, managers must design processes and metrics for productivity. Otherwise, it's like expecting someone to drive a car when his previous experience is limited to a 10-speed bicycle. However, healthcare organizations will find that getting this work stream web-enabled offers the most opportunity now, and that other functions like disease management and demand management can also be Internet-enabled.

Health plans and hospitals are beginning to migrate to the web for claims-related transactions as the first step of a broader Internet strategy. This can be clearly depicted by Figure 2. Because many organizations continue to use Electronic Data Interchange (EDI) for claims submissions, transactions surrounding claims — eligibility,

Figure 2. Increase in the percent of electronically filed claims



Source: Odyssey Research, 2003

referrals, etc., they will be the first to be adopted for e-health connectivity. Those health plans that are adopting Internet connectivity for these functions view them as the foundation upon which to build other Internet-enabled partnerships with patients and providers.

The critical need for automation has risen as the number of healthcare transactions is outpacing the growth of health spending. The number of claims submitted increased by about 7% during the past five years, according to the Health Data Directory. In contrast, healthcare spending has increased at between 5% and 6% during the past five years. Many of the functions associated with claims submissions and payment are repetitive tasks that are more efficiently done by computers. The most expensive processes are not the claims submissions themselves, but the tasks surrounding the claims process, such as eligibility checks and referrals. Coupling that with increasing labor shortages, the onus is on organizations to re-engineer (PricewaterhouseCoopers Healthcare Practice, 2003).

Health plans must understand physicians' needs when designing Internet-based solutions. First-mover advantage is not as important as a system that works. Many e-business companies have benefited from a first-mover advantage, which means they get the most capital, the best partners and brand recognition. However, healthcare is a "show-me" business and successful models will replicate market by market.

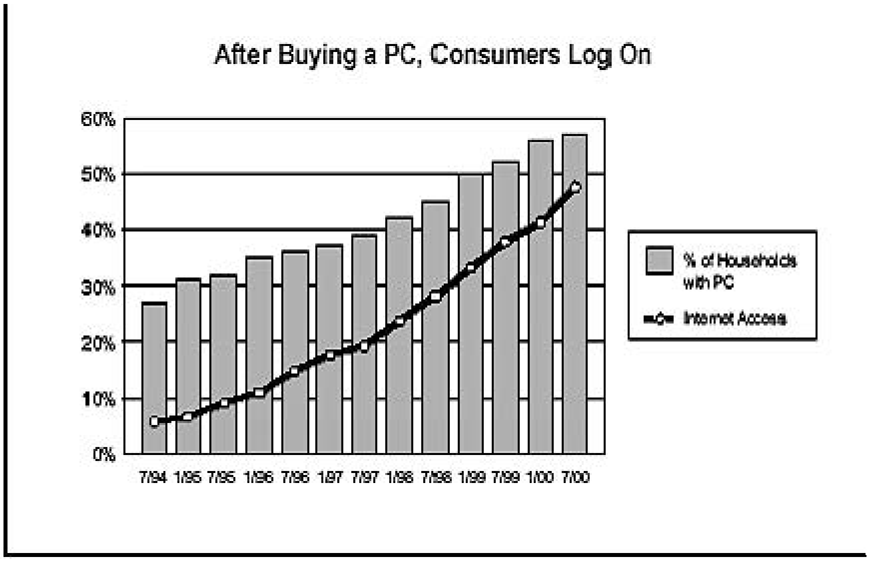
e-Benefits

The health industry has discovered the benefits of online business. Like the conundrum of the chicken-and-the-egg, many employers and health plans are awaiting the development and implementation of e-benefits and e-insurance products. Health plans don't want to deliver web-based products if employees are not ready to use them. Employers can not deliver e-benefits products until health plans develop them. However, starting with online benefits enrollment, e-health is evolving in incremental stages. A by-product of this evolution is the combination of employee responsibility and authorization. Paternalistic urges aside, employers will gradually grant more control for health benefits to employees themselves. One of the primary drivers of e-benefits is the possibility of self-service tools through which employees can customize their own insurance plans and have ready access to them, just as they do with their other online accounts. Employees may become more fiscally responsible about their benefits once their insurance information is made more easily available to them. Finally, they may want complete exposure over all the issues of their benefits.

The process of moving toward an online system cannot be an all-at-once process. Employers will gradually shift responsibility to their employees and proceed further depending on how the new system is being adopted and implemented. The national research conducted by PricewaterhouseCoopers (PricewaterhouseCoopers Healthcare Practice, 2003) indicates that few employers are willing to adopt self-directed, otherwise known as defined contribution, health plans today. However, as they adopt more web-enabled functions, they will move more responsibility for choices to employees. As that balance of responsibility shifts, some employers will need to determine how ready their workforce is to accept increasing levels of responsibility.

Physicians are among the first ones to be directly and adversely affected when a significant portion of the healthcare insurance market moves to self-directed, Internet health benefits accounts. Some defined contribution health plans have medical savings accounts as a centerpiece. In these, employees pay out of a medical savings account for routine expenses up to $1,500 or $2,000. Physicians must be prepared to deal with patients who are paying cash for their visits and who may shop around for the best value. Figure 3 shows the

Figure 3. Internet usage among customers



Source: Odyssey Research, 2003

statistics of the probability of customers using the Internet when they have access to a PC (Odyssey Research, 2003).

The insurers should come up with new e-quote products to assist consumers using the Internet for healthcare benefits. They also must follow the growing and changing needs of people and develop products that assist consumers going through the online process.

Standardization can be chosen as the ascendant theme of Healthcare in the near future. Proper steps are to be taken to penetrate this e-business niche so that employees and employers can make apples-to-apples comparisons. Offering more options without proper insight into the standard benefits may just add more confusion.

E-HEALTH: A CASE EXAMPLE[2]

Let us take the e-health department at a large healthcare organization in the Midwest of North America (ABC Healthcare Organization) as an example to see how the Internet can be used for healthcare and the benefits that can be derived. The ABC Healthcare Organization is one of the world's largest and busiest health centers. It was founded in the early 1920s as a not-for-profit group practice, integrating clinical and hospital care with research and physician education. The ABC Healthcare Organization has more than 1,000 salaried physicians on staff, representing approximately 120 specialties and subspecialities. Last year, they provided for almost 2 million outpatient visits and almost 50,000 hospital admissions. Patients came to ABC Healthcare Organization from across America and from more than 80 nations.

The demand for web-based health will increase rapidly as the Internet is branching out its roots into common households. From 1999 to 2001, there was a 67% increase in the number of people who had requested health information via ABC Healthcare Organization's web site. In 2001, they received an average of 1,500 web mail inquiries per month, including an average of 270 requests for appointments. People requested various types of information online, including second opinions, general health information, and appointment requests.

Many e-mails and phone calls were received by the clinic staff requesting quality second opinions from the famous physicians at ABC Healthcare Organization. Looking at the high volume of requests for second opinions, the organization decided to enter into the e-market.

E-health is one of the important divisions in the Information Technology Department of ABC Healthcare Organization. It has the primary responsibility of making sure that secure and trustworthy information is presented online. It also has to ensure that online patients are getting the same amount and quality of information that regular patients receive.

e-Health Second Opinion

When patients are faced with a serious medical problem, obtaining a second opinion has long been an accepted medical practice. With the rise of consumerism since the late 70s, both patients and healthcare providers adopted the practice of second opinions to get maximum satisfaction from the treatment. Consider this accepted practice juxtaposed against the technology advances with computers, coupled with the phenomenal growth of the Internet. In 2000, 52 million American adults, or 55% of those with Internet access, sought health information online, many of these people seeking specific information about their own or a family member's condition (Efficient Knowledge Making, 2003). As the use of these online medical resources continues to grow exponentially, healthcare organizations have a unique opportunity to leverage consumer interest in the Internet to advance e-market services. Specifically, the demand for medical second opinions, coupled with the acceptance of the Internet, created an opportunity to develop and offer a web-based second opinion service that meets the public's demand for convenient access to credible, quality, patient-directed healthcare while also increasing the efficiency of the physicians who provide these services. In February 2002, ABC Healthcare Organization, launched its e-health Second Opinion Program, an Internet-based service for patients with a life-threatening or life-altering diagnosis who wish to obtain a second opinion from physicians at ABC Healthcare Organization.

The Development

Development of the operational plan for the Internet-based second opinion program was facilitated by the experience of ABC Healthcare Organization with an 80-year history for providing specialty consultations and second opinions. For approximately 65 years, the only portal to the doctor was through the front door of the hospital and clinic and these patients came primarily from the Midwest and its contiguous states.

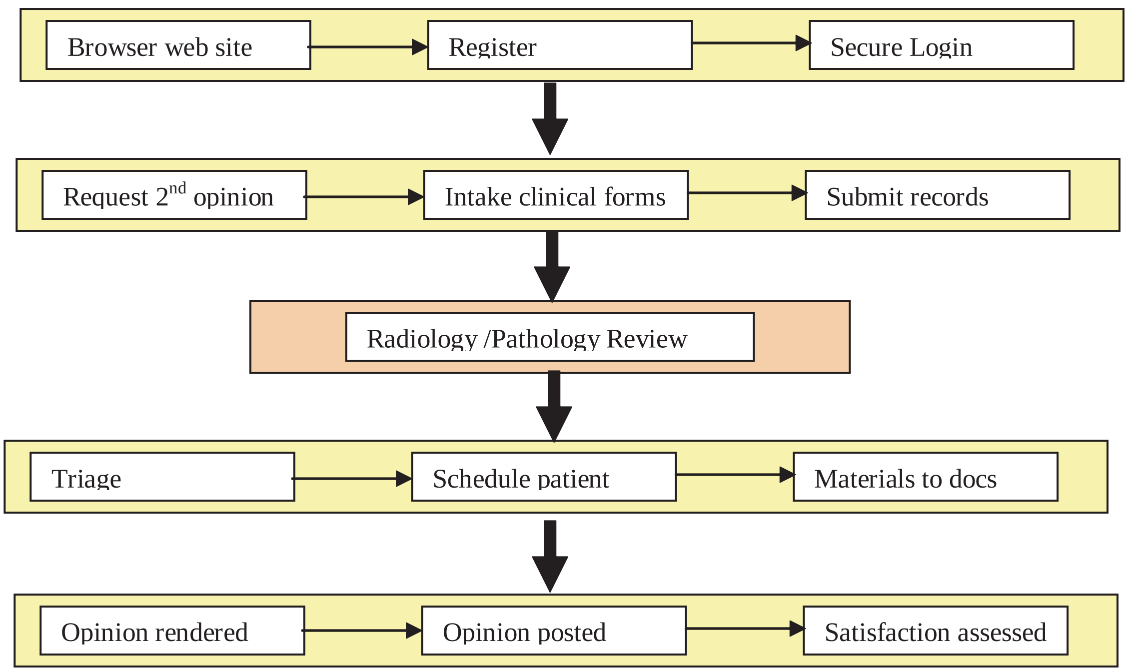
A fundamental shift occurred in the mid-1990s. Patients and potential patients began using technology to gain greater access to healthcare information and healthcare providers, bypassing traditional geographic barriers to service. Additionally, many patients in other countries expressed a desire to have ABC Healthcare Organization physicians render a second opinion when they were faced with a new diagnosis or medical problem. Typically, these requests and the data were sent by fax and overnight courier service. Although connectivity at home is increasing and getting faster — 18% of e-health users have broadband connections (The Higher the Connection Speed, 2001) — the ability to respond to this demand for health information was challenged by the many different methods used for responding to remote patient's inquiries that also integrated existing operational processes and information systems.

E-health second opinion represents in its basic form the transformation of a traditional medical service into an e-health service. The program was designed to handle only second opinions and to require the data upon which the primary diagnosis was based. Each clinical department and the physicians identified the diagnoses in their practices for which second opinions were requested. Since rendering a second opinion is considered by the regulations of most state medical boards as the practice of medicine, an early decision in the development of the second opinion program was to license those physicians who were to participate in the program throughout the States. Since ABC Healthcare Organization is a multi-specialty group practice in which the physicians are credentialed through a single office, this office facilitated the licensing of the ABC Healthcare Organization physicians participating in the e-health program in each state in which the program was being offered.

Integration of Online Second Opinions with the Existing System

ABC Healthcare Organization has a vigorous information system for fast and convenient access to patient information. This makes it necessary

Figure 4. Logical design of the online second opinion



that the integration of the e-health second opinion program into current operational systems should be efficient and seamless. To achieve this, any patient's visit through the Internet is handled in the same way as a physical visit at ABC Healthcare Organization.

Integration of e-health second opinion should not cause any kind of efficiency and response time problems to the current IT system. To ensure this, the same methods of online registration, appointment, e-mail, results reporting, statistical reporting and financial reporting systems are integrated with the online second opinion request forms and requester contact information gathering process. Hence the overall infrastructure is not disturbed. Figure 4 provides a schematic of the logical architecture for the e-health second opinion program.

During the process of requesting a second opinion online, the patient can stop the process at any stage and resume at a later time. The information is saved so that the patient need not start from the beginning when returning within the specified time interval. This feature also gives the patient the ability to talk to experienced nurse practitioners on the team. This has proven to be very useful to the patients and allows them to submit complete and informative second opinion requests. The patients are given the full list of the nurses and their e-mail and telephone contacts to contact at any point during the e-consult process if they have any questions. A registered nurse contacts the patient directly by telephone one to two days following completion of the consultation to ensure the patient understands the content of the second opinion information and that all questions have been answered. Should the patient have further questions, the clinical staff facilitates the discussion with the physician who completed the second opinion. Once all of the steps of the process are completed, the medical records are filed with the Health Data Services department for further action.

Online Healthcare Provision to Patients

With the entrance of the health industry into the World Wide Web, the ability of patients to communicate with physicians or healthcare providers changes radically. In a time of great need, such as when patients have been diagnosed with a life-threatening or life-altering diagnosis, quality information from a trusted source is paramount. Second opinions offer the reassurance and peace of mind that a prescribed course of treatment is the best for each individual. Most importantly, second opinions provide a safeguard against unnecessary or inappropriate treatment.

Various factors both externally and internally were considered before launching second opinion requests in e-space. Integration of the second opinion process into existing operational and information technology systems at ABC Healthcare Organization minimized the operational impact of a new clinical offering. In fact, adding the web expression to already existing services permitted consolidation of many different processes into a unified method by which a second opinion could be rendered remotely for selected diagnoses. By incorporating e-appointments into the physician's routine medical practice, by complying with disparate state licensing regulations, and by communicating the program's features and benefits to providers and patients, ABC Healthcare Organization has launched a second opinion program that satisfies internal constituents whiles responding to external market demands for quality service and convenience. When the consultation is real and the visit is virtual, greater access and value is created for all concerned. Future developments will continue the integration of technology into existing healthcare processes, in addition to the creation of new processes that will more effectively address the clinical needs of patients.

DRAWBACKS OF USING E-HEALTH AND POSSIBLE SOLUTIONS

At the core of the e-health debate is the tension between access and quality assurance. Access to healthcare becomes less hierarchical and nonlinear with e-health as it destroys the single-point, gatekeeper model of access, allowing multiple entry points. Thus on the surface it seems that these technologies should decrease costs and improve access. But, in reality heath information online poses serious issues for quality assurance systems. Systems based on licensure or malpractice law are premised on a single point of entry identifiably located in physical space. These systems will be ineffective to police a delivery system that is no longer based on physicality or the preeminence of the traditional patient-physician relationship.

Lack of physicality can be considered as a major problem in the e-health world. Physically meeting a patient will give the physician a better chance to interact and find out more about the problem. For example, consider the online second opinion: For each diagnosis, sets of questions are predefined and the patient has to fill in the answers. But sometimes some further questions may arise depending on a given answer. Physically, the physician changes his questions depending on the response of the patient, but this is not possible when the patient is being asked questions online. Even if it is made interactive, it cannot be as efficient as asking the patient in person.

As e-health provides more choice and communication (aided by the promise of extracting administrative costs from the healthcare delivery system), access should be dramatically improved. Yet, e-health's lack of physicality, its depersonalization, anonymity, and even coldness challenge usual conceptions of competence and compassion. Further, multipoint entry into the delivery system makes continuity difficult to achieve, while health advice sites based on e-commerce paradigms involve considerable conflicts of interest. Finally, e-health marketing practices and privacy concerns frequently seem to involve the commodification of patients and patient data.

Despite the challenges discussed above, e-health has great potential for good. Highly efficient national medical markets, around-the-clock service and the seamless integration of products and services no longer should be the stuff of dreams. The ability to heavily personalize computer-mediated relationships may rehabilitate patient-physician relationships eroded by years of managed care, while the web's ability to deliver rich information directly to consumers could reverse centuries of damaging informational asymmetry between patient and physician.

To achieve the promise of e-health, ethical and legal structures must be refurbished to further demand the provision of quality medical information, untainted by patient-sorting costs or provider self-interest. Regulatory systems must be changed so that they are no longer premised on ties with some physical place. Legal and ethical constructs must be informed by e-health codes of conduct and computer-mediated data quality solutions.

The US Department of Health and Human Services has sought valiantly to reconcile cost extraction and patient rights in its privacy regulations. This is a positive sign for e-health. In the e-health environment, as information, diagnosis, treatment, and care are delivered through inconversant channels, serious challenges posed by e-health should not be underestimated. However, there is still time to re-engineer legal and ethical codes to marry increased access to quality assurance and avoid the abyss of a computer-mediated sequel to the worst and most dehumanizing aspects of managed care.

INCORPORATING KNOWLEDGE MANAGEMENT IN E-HEALTH

Incorporating the concepts, looks, and strategies of Knowledge Management (KM) can only reveal the full value of e-health. In order to understand this, we now introduce KM before discussing how KM helps e-health. Specifically, we provide the context for why knowledge management is now necessary and briefly discuss the value of knowledge management as well as seven basic considerations for embracing knowledge management in any organizational setting.

Quality of Medical Information

Sometimes the information displayed on the Internet will not be of good quality. This is a major setback, as both the consumers and healthcare providers will not be ready to use and rely on such a system. Studies assessing the quality of health-related web sites, newsgroups or evaluating interactive venues using the method of posing as a fictitious patient have demonstrated that important aspects of quality — like reliability, accessibility, and completeness of information and advice on the Internet — are extremely variable. Though this problem also exists in media which are not web-oriented, like magazines, newspapers, and television, some extra problems — such as the originators of messages and their credibility — are difficult to assess by readers and are more troublesome when it comes to the use of the Internet. Solutions for these concerns — such as the widespread use of evaluative meta-information — have been proposed (Alberthal, 1995) and will, once adopted, help to make the web a more useful tool for patient education. Furthermore, the Internet will open new ways for professional medical education (Knowledge Management, 2003). Knowledge management will provide a great way to achieve good quality, as all the actions will become organized using it.

The e-Knowledge Market as an Enabler of e-Health

The e-knowledge market concept can be a powerful, next generation platform for enabling e-Healthcare.

Knowledge management offers ideas and approaches that can be valuable to disability researchers and service providers. A consumer or patient — centered orientation, a belief that "healthcare is an information business," and a focus on obtaining maximum value from information resources are all important concepts with broad applicability.

In an era of user involvement, consumer empowerment, and the wide dissemination of information on health and health services, it is important that we identify who the consumers of online health information are, what their information needs are, and understand why and how they seek information online. Following this method will enable information to be provided in ways that will have benefits from the worldwide to the individual level. It will also inform current debates over the quantity and quality of information that is provided and issues of privacy and security. Using knowledge management in this process will obviously improve the way in which the data is shown to customers online and thus increases customer satisfaction, which is one of the primary concerns of e-health sites.

Health Knowledge Management

So far, most (if not all) of the technology-based applications to promote knowledge management in health have been a mere transition from paper-based to electronic-based means to process and distribute information in text form. Most of the efforts to date have been developed for and by healthcare providers. The belief remains that in the future the bandwidth of knowledge management will increase and this will allow consumers to communicate more effectively. With these developments one will be to go beyond text to more "natural" or primal ways of representing and exchanging knowledge.

To make knowledge management grow to its full extent and be more useful, projects and applications that will explore innovative ways to synthesize, distill, package, integrate and deliver different types of information (e.g., clinical data, anecdotes, rules of thumb, or intuitive statements) in more engaging and more efficient ways need to be developed.

CONCLUSIONS

From the above discussion we highlight that knowledge management can be a tremendous factor in developing the infrastructure and outcome of e-health. Using the Internet as one of the media to promote health conditions can be of great use if proper security and other issues are taken care of.

The second opinion e-health program at ABC Hospital discussed earlier, also points out the ease with which healthcare is reachable to people using the Internet. Adding web applications to an existing healthcare organization's activities will increase awareness among patients and also spread the news faster and in a more convenient way. Given the rate at Internet use is increasing, it is definitely useful to provide health information online. However, e-health also brings with it many challenges. Knowledge management, when incorporated into e-health applications, can serve to make e-health better and make the process even faster with its efficient organization of critical information and relevant knowledge, thereby providing solutions to many of the current challenges facing e-health initiatives.

The Internet will not be the same in the next millennium. Important developments are likely to improve not only the speed but also the quality of information and retrieval possibilities. The web could evolve into a global medical knowledge base, where diverse medical Internet applications and resources are interconnected and integrated beyond manual "linking." Moreover, the Internet will revolutionize science itself by opening new ways of scholarly communication and electronic publishing. The Internet and related new communication technologies will enable health professionals to reach larger populations with interactive applications, which in turn will open enormous opportunities and challenges. The need for research is clear. "Cyber medicine" research should go beyond the mere development and provision of technical solutions. It should also address social and human factors and evaluate the impact of the Internet on society, healthcare, and public health. As researchers, one has the responsibility not to follow blindly the general Internet hype, but to help physicians and consumers to maximize the use of the Internet by carefully evaluating our interventions and revealing determinants that influence the effectiveness and efficiency of Internet communications in healthcare. Many of these evaluation methods are yet to be developed.

REFERENCES

Alberthal, L. (1995). *Remarks to the Financial Executives Institute.* Dallas, Texas, October 23.

Efficient Knowledge Making. (2003). Retrieved from http://www.jmir.org/2000/3/index.htm

E-Health and the Practicing Physician. (2003). Retrieved from www.medscape.com

E-Health in the Medical Field. (2003). Retrieved from http://www.americantelemed.org/ehealth/ehealthH.htm

Eysenbach, G. (2001). *Journal of Medical Internet Research, 3*(2), e20.

Eysenbach, G., & Diepgen, T. L. (1998). Towards quality management of medical information on the Internet: Evaluation, labeling, and filtering of information. *BMJ, 317,* 1496-1500.

Knowledge Management - Emerging Perspectives. (2003). Retrieved from www.outsights.com

Odyssey Research. (2003). Retrieved from www.odysseyresearch.org

Online Health Information Seekers Growing Twice as Fast as Online Population: Cyber Dialogue. (2000). Retrieved May 23, 2000, from the World Wide Web.

PricewaterhouseCoopers Healthcare Practice. (2003). Retrieved from www.pwchealth.com

Sieving PC Factors Driving the Increase in Medical Information on the Web — One American Perspective. (1999). *Journal of Med Internet Research.* Retrieved from www.jmir.org/1999/1/e3.

Terry, N. P. (2000). Structural and legal implications of e-Health. *Journal of Health Law, 33,* 605-613.

The Higher the Connection Speed, the Higher the Value: Broadband Use as an Indication of Value amongst e-Health Users. (2001). *Cyber Dialogue Cybercitizen Health Trend Report 2001, 49.*

Tiwana, A. (2002). *The Knowledge Management Tool Kit — Practical Techniques for Building a Knowledge Management System.*

ENDNOTES

1 The authors are most appreciative to the work of Harsha P. Reddy in collecting much of the data for this chapter.

2 The data was collected from on-site visits, discussions with key actors and evaluation of numerous internal documents.

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Chapter 8.18
Hybrid Knowledge Networks Supporting the Collaborative Multidisciplinary Research

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INTRODUCTION

Virtual networks are becoming increasingly important instruments for knowledge and collaboration management. In addition, research, development, and innovation performances are among the most important activities in modern organisations. These two issues deal with complex problems that companies, universities, and other organisations can only face with multidisciplinary, geographically widespread teams.

This article describes the setup of a model of a hybrid knowledge network that can group and connect together universities and researchers and enable them to collaborate. The proposed model for the virtual network is based on the conjunction of the personal and organisational aspects of collaboration. Due to this union within the organisational structure, two main levels of collaboration have been envisaged, namely the institutional one and the individual one.

BACKGROUND

Nowadays, it is claimed that the main source of sustainable competitive advantage is based on the possession of valuable information and the capacity to exploit, produce, and obtain new knowledge.

Networks in general, and virtual networks in particular, have gradually become more and more important instruments for knowledge management. Early references in this field can be found in the research made by Drucker (1989), Savage (1990), Keen (1991), Donaht (1998), and Koch, and Wörndl (2001). A huge number of definitions have been identified to characterise collaborative networks and the organisation of communities of practice (Koschtzky, 2001), but it has been quite difficult to define a clear border between the different types of knowledge networks that exist.

In the research and development (R&D) process, there is no doubt that communities of practice as specific forms of such networks have become the most important tools to implement knowledge management and to accelerate the transference of innovation. They bring together people with common goals and interests who are physically remote and are working in different types of organisations. Using new technologies they can join together and work as a team towards the objectives set.

This article deals with a new form of knowledge network which, on one side, groups together elements from the traditional virtual community of interest and from the more sophisticated communities of practice, and on the other side, promotes collaborative multidisciplinary research that produces high-quality research results and stimulates their transfer.

MAIN FOCUS—KNOWLEDGE NETWORKS: CONCEPT AND APPROACHES

The main concept treated in the networks economy theory is the cooperation between organisations based on the mutual trust, without hierarchical structures, and that considers knowledge networks as an intermediary stage between the free market and the rigid organisation. In their theoretical approach to the concept of knowledge networks, Seufert, Krogh, and Bach (1999, p.182) define them as structures established between individuals, groups, and organisations in which not only bilateral relations, but also all activities carried out by the knowledge network are important.

From the socio-economic viewpoint, networks are interpreted as a specific set of linkages between a defined set of actors, with the additional property that the characteristics of these linkages as a whole may be used to interpret the social behaviour of the involved actors (paraphrased from Mitchell, 1969, p. 2, as cited by Alba, 1982, p. 40). Therefore, the term "network" covers strong social relationship and includes players who may be individuals, groups, or even whole companies. From this viewpoint, networks can be structured formally or informally. The relationships that can be identified within them are interpreted as long-term connections, which may be personal/organisational or technological/organisational.

Knowledge networks usually share a series of characteristics among which, most important according to Seufert et al. (1999) and Real Communities Inc. (2000), are the following:

- Networks exist to create and disseminate new knowledge.
- They are structured and operate to increase the rate of creation of new knowledge.
- They provide clear, recognisable benefits to all participants.
- Network membership is by invitation, based on merit or prior review of the purposes of the project.
- Networks are usually inter-disciplinary, and cross over the frontiers between sectors of activity and areas of knowledge.
- Through networking, a transfer between the tacit knowledge of individuals and the explicit knowledge held at organisations takes place.

COMMUNITIES OF PRACTICE

The term "communities of practice" was presented first by Lave and Wenger (1991). These communities are groups of people who share an interest in a domain of human endeavour and engage in a process of collective learning that creates bonds between them. A basic characteristic of the community of practice is the specific way in which learning takes place, through a process of "legitimate peripheral participation" (LPP). Therefore it is not exclusively based on practical teaching, but also comprises a process of development of knowledge based on experience. The elements of legitimacy, participation, and peripheral define specific characteristics of communities of this type (Wenger, 1999).

Communities of practice therefore have the role of integrating specific knowledge¾that is, turning individual knowledge into collective knowledge according to the capabilities of the team involved. In short, the creation of "team knowledge" is the result of interaction between individual and collective knowledge, and between tacit and explicit knowledge, according to the development of the "knowledge spiral" (Nonaka & Takeuchi, 1995).

There are certain features that distinguish communities of practice from formally configured teams (see Table 1).

Some Key Factors for Success of the Communities of Practice

- The knowledge network should be focused on the needs of its members. In line with this, management should seek to study the profiles of members: what knowledge they possess and what they need.
- The knowledge network must invest in content. Much of the effort put in must go into the generation of new content and new contributions, as this is the only way to increase the knowledge of the organisations.
- Adopt the assumption that the community cannot operate on its own. This means that members must identify who can act as informal moderator and lead the remaining

Table 1. Differences between communities of practice and formal teams (Lesser & Storck, 2001)

Communities of Practice	Formal Teams
Relationships are formed around one practice	Relationships are formed when a team is assigned
Authority relationships emerge through interaction around expertise	Authority in teams are organisationally determined
Communities are responsible to their members	Teams have goals which are established by people not involved in the team
Communities develop their own procedures	Teams have processes that are organisationally defined
High flexibility provided by the absence of any hierarchical dependences	Rigid structure with less possibilities to reorganise the work
Bidirectional relations between the members of the community	Unidirectional relations with the organisational structure
Less bureaucracy defined by the absence of contractual arrangements between the members	Strong bureaucracy processes defined by the hierarchical structure

members towards the problems to be dealt with and provide basic working methods.

- External factors like the organisational culture are extremely important. One of the main aims of group moderators must be to achieve a common culture so that knowledge sharing is a natural activity, not a special effort.
- The understanding that the activities of knowledge network are not limited to discussion groups. Communities are much more complicated than that.

As a concluding remark for this section, online communities can be said to hold clear advantages for research groups.

HYBRID KNOWLEDGE NETWORKS

The process of creating a virtual network supporting collaborative multidisciplinary research has its roots in the project "Knowledge Management at a Public University: The Process of Research, Development, and Transfer of Scientific and Technical Knowledge," which was set up in 2000 at the University of the Basque Country in Spain with a three-year timeframe. The project brought together a multidisciplinary group of 22 researchers with the purpose of drawing up a model for knowledge management that could cover the whole process from pure research to the transfer of scientific and technical knowledge from the university to businesses and institutions.[1]

The idea of organising virtual research centres has come a step closer to reality with major advances in technology and the need for researchers to respond to rapid changes in the socio-economic environment and the increasing uncertainty that they bring. Several attempts are currently under way to set up non-physical centres, but doubts remain as to the management method best suited to creating and structuring them so that they are capable of providing an open climate for cooperation. Some schemes in Japan and the U.S. have shown the benefits of cooperation by large groups of researchers from different organisations (Echeverri-Carroll, 1999; Jin, 1999). Many of these knowledge networks were set up with short-term aims, but others are structured as long-term alliances.

The development of these networks has also been fostered by the arrival of the age of cooperation for innovation. The cost of innovation and the speed of change create a major need for cooperation to achieve progress. The promotion of research and pre-competitive cooperation between organisations of different types is an essential factor in reducing R&D&I costs and bringing new products, processes, and services to the market as quickly as possible.

Another aspect is the break-up of the old research process. The frontiers between basic and applied research and between research and innovation are disappearing. The time lapse between obtaining basic research results, developing applications in a specific sector, and marketing those applications is becoming ever shorter, making it harder to distinguish the different phases of the process.

FUTURE WORK

Based on these elements, the idea of developing a new type of network of universities for knowledge management is radically different from the way in which the process is currently organised. First of all, a change is introduced in the purpose of applied research: it no longer has to be contained within a specific framework of action, but can instead be carried on in various areas hitherto untouched, but related to particular topics. Furthermore, this network must bring together people of very different types from different branches of science, public administration, and interested companies.

In view of the foregoing, a virtual research network should set itself the following immediate goals:

- To organise the resources needed for research at the lowest possible cost and the greatest possible speed.
- To attract renowned researchers by offering them broad cooperation, flexibility, and new concepts of organisational culture, along with a policy of openness.
- To promote the principle of blending team spirit with individual creativity to increase competitiveness and create the conditions for a substantial increase in technological development.

The model that we propose for a virtual network of universities for knowledge management is fully in line with this approach. The research is broad in its purpose and can take place in different areas concerned with management of the transfer of knowledge from universities to companies and to society. Furthermore, the scope and variety of the group of researchers and universities who make up the network provides a multidisciplinary outlook on problems with multiple possibilities for cooperation and the appearance of innovative ideas.

We propose to establish two distinct levels for the collaboration, with different names: a "networked virtual centre for universities for knowledge management" and a "virtual network of university personnel for knowledge management."

Membership of the higher level (i.e., the "networked virtual centre") would be restricted to research centres committed to carrying out knowledge management projects concerned with the process of research, development, and transfer of scientific and technical knowledge. Their basic purpose would be to exchange and share information, knowledge, and experience in regard to knowledge management at universities through an online structure, with particular reference to the managing of the transfer of scientific and technical knowledge to businesses and institutions. On this basis, forums, seminars, joint projects, and so forth on the relevant topics can be arranged.

The second level is the virtual network of university researchers for knowledge management (though the possibility of including non-university researchers might be considered, depending on their level of involvement) interested in going deeper into the field of knowledge management in general, and knowledge management at universities in particular, with special emphasis on managing the transfer of scientific and technical knowledge from universities to companies and institutions. This network would work mainly as a forum for discussion and for the exchange of information, ideas, and knowledge online, without excluding the possibility of joint projects and face-to-face meetings.

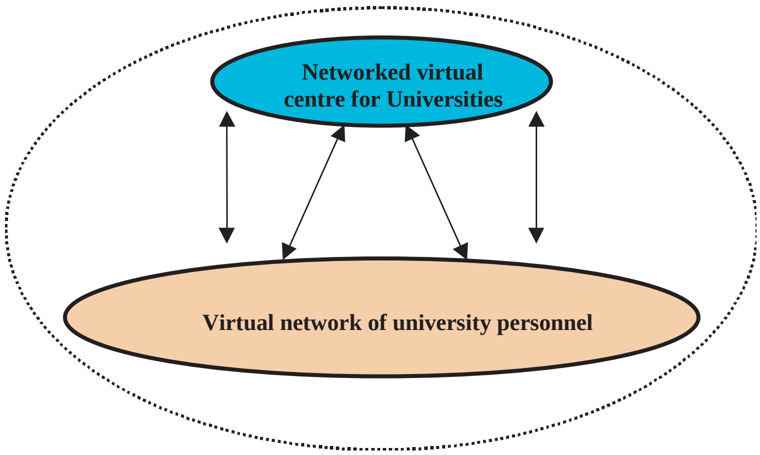
Figure 1 shows the structure of the two-level model proposed.

As can be observed, our proposal to some extent contains elements from both types of knowledge network considered.

Like communities of practice, they have distinct levels of participation, but the distinction in levels is not based, as it is in those communities, on the degree of involvement in tasks, but on such characteristics as the personality of members (individual or institutional), their degree of commitment (drawing up of a knowledge management project or mere commitment to confidentiality), and the type of tasks to be performed (exchange of ideas, knowledge, and experience on projects and even joint projects, or merely a forum for debate and exchange on topics).

Our proposal could therefore be said to envisage two levels of network. As in communities of practice, there may be some process of learning and gradual integration, as researchers from a university may first come into contact with a topic in the virtual network and then undertake a project under the auspices of their university which raises

Figure 1. Model of a virtual network of universities for knowledge management (Rodríguez, Araujo & Ranguelov, 2001)



them to the higher level of the network (i.e., the virtual centre).

CONCLUSION

This article introduced a project that develops a new model of virtual knowledge management network, which groups together universities and research teams, and enables them to exchange information and knowledge, and share their experience in the R&D area.

The proposed model for an innovative virtual network presents two levels of integration, namely a "networked virtual centre for universities for knowledge management" and a "virtual network of university researchers for knowledge management." This hybrid knowledge network includes characteristics of both types of virtual communities considered in the article. The two levels are not based on the degree of involvement in the activities, but on the personality of members, their degree of commitment, and the type of tasks to be performed. Our proposal could therefore be said to envisage two different but connected virtual communities linked by a common theme, though a learning process is possible which would enable movement from one to the other.

On that basis, the presented model introduces four important innovation elements in the field of R&D and network communities. The first element is the creation of mutual trust and adaptation of members' activities and to promote the interdisciplinary research. The second element is the development of an information network, along with virtual and interactive work methods between universities and individual university researchers. The third point considers the development of an exchanging mechanism of knowledge, good practices, and experiences in the field of managing knowledge in the research, development, and transference process. And the fourth element is about the joint management of the knowledge produced inside the knowledge network.

REFERENCES

Adams, E.C., & Freeman, C. (2000), Communities of practice: Bridging technology and knowledge assessment. *Journal of Knowledge Management, 4*(1), 38-44.

Alba, R.D. (1982). Taking stock of network analysis: A decade's results. In S.B. Bacharach (Ed.), *Research in sociology of organizations* (pp. 39-74). Greenwich: JAI Press.

Debakere, K., Clarisse, B., & Rappa, M.A. (1996). Dismantling the ivory tower: The influence of networking on innovative performance in emerging fields of technology. *Technological Forecasting and social Change, 53*(2), 139-154.

Donath, J.S. (1998). Identity and deception in the virtual community. In P. Kollock & M. Smith (Eds.), *Communities in cyberspace.* London: Routledge.

Drucker, P.F. (1989). *The new realities.* New York: Harper Business.

Echeverri-Carroll, E.L. (1999). Knowledge flows in innovation networks: A comparative analysis of Japanese and U.S. high-technology firms. *Journal of Knowledge Management, 3*(4), 296-303.

Jin, Z. (1999). Organizational innovation and virtual institutes. *Journal of Knowledge Management, 3*(1), 75-83.

Koch, M., & Wörndl, W. (2001, September). Community support and identity management. *Proceedings of the European Conference on Computer-Supported Cooperative Work (ECSCW 2001),* Bonn, Germany.

Koschtzky, K. (2001). *Raümliche Aspekte im Innovationsprozess. Ein Beitrag zur Neunen Wirtschaftsgeographie aus Sicht Der Regionalen Innovarionsforschung.* Münster: Lit-Verlag.

Lave, J., & Wenger, E. (1991). *Situated learning. legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lesser, E.L., & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal, 40*(4), 831-841.

Lodge, G.C., & Walton, R.E. (1989). The American corporation and its new relationships. *California Management Journal, 31,* 9-24.

Mitchell, J.C. (1969). The concept and use of social networks. In J.C. Mitchell (Ed.), *Social networks in urban situations* (pp. 1-12). Manchester: Manchester University Press.

Nonaka, I., & Takeuchi, I. (1995). *The knowledge creating company. How Japanese companies create the dynamics of innovation.* Oxford: Oxford University Press.

Real Communities Inc. (2000). *Shared knowledge and a common purpose: Using 12 principles of civilization to build Web communities.* White Paper retrieved from http://www.realcommunities.com/

Rodríguez, A., Araujo, A., & Ranguelov, S. (2001). Redes virtuales de universidades para la gestión del conocimiento. una propuesta. In F.C. Morabito & P. Laguna (Eds.), *Nuova Economia, Vecchi Problemi. Best Papers Proceedings 2001, X International Conference AEDEM* (pp. 891-901), European Association of Management and Business Economics, Reggio Calabria, Italy.

Savage, C. (1990). *Fifth generation management. Integrating enterprises through human networking.* Boston: Butterworth-Heinemann.

Seufert, A., Krogh, G., & Bach, A. (1999). Towards knowledge networking. *Journal of Knowledge Management, 3*(3), 180-190.

Wenger, E. (1999). *Communities of practice: Learning, meaning and identity.* Cambridge, UK: Cambridge University Press.

ENDNOTE

1 More detailed information about this project can be seen in Rodríguez et al. (2001). The project received funding in 2000 and 2001 from the Spanish Ministry of Science and Technology in 2000 and 2001, and from the Programme for fostering the Basque Technological network of the Basque Government in 2001-2002.

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Chapter 8.19
Intelligence and Counterterrorism Tasks

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INTRODUCTION

At the end of the Cold War, the intelligence situation (characterized in the past by a confrontation among equals and information scarcity) changed radically to the current situation of today, characterized as an asymmetric threat: On one side, there is still a nation, but on the other, there is a relatively small group of individuals brought together by a common ideology, usually with ethnic and religious elements. These individuals can only confront their opponent by using subterfuge, deception, and terrorist acts. They try to disguise their activities by infiltrating society at large and seeking refuge in anonymity. This kind of conflict has long been analyzed in the military literature under names like low-intensity conflict (LIC) or operation other than war (OOTW; for more on this perspective, the reader is referred to the classic work by Kitson, 1971). The task of the nations under terrorist threat is to detect the group's individuals and their intentions before they can carry out destructive actions. For this, their intelligence services count with large amounts of raw data obtained from many different sources: signal intelligence, open sources, tips from informants, friendly governments, and so forth. However, this data is not always reliable and almost never complete, and the truly interesting events are usually to be found hidden among large amounts of similar looking facts. To deal with this situation, intelligence officers use sophisticated information technology tools. Several authors have pointed out that this task is not at all dissimilar from the task that strategists in business intelligence (BI) and knowledge management (KM) face: As in KM, in intelligence the challenge is that "the right knowledge must get to the right people at the right time" (Pappas & Simon, 2002). Therefore, intelligence experts may learn something from studying BI and KM, and their history and milestones, while business strategists may also be enlightened by the history and lessons of military intelligence (after all, military intelligence is an ancient discipline; in contrast, KM can be considered a newcomer). In this article, we describe the intelligence analysis cycle and compare it with the KM cycle (we assume the reader is familiar with KM, but not with intelligence tasks). We point out the similarities (and the differences) between the two, and highlight several ways in which military intelligence may benefit from the hindsights and techniques developed by KM practitioners. We also briefly describe tools and methods from military intelligence that KM practitioners may find illuminating. We close with a discussion of future trends and some conclusions.

BACKGROUND: INTELLIGENCE ANALYSIS

The ultimate goal of intelligence analysis is to provide a customer, military or civilian, with the best possible information to help in making policy, strategic, and tactical decisions that affect national security[1]. In this task, intelligence is used to refer to knowledge and information, the basic end product of the analysis. Such analysis is carried out by highly trained analysts who work in a continuous process involving the following steps[2].

- Need Analysis: Customers (policy makers and others) make requests that the analyst must translate to specific requirements and tasks in order to make sure that the final product answers the needs of the customer. Customer demands often need interpretation or analysis before they can be expressed as an intelligence requirement (Krizan, 1996). The customer may have additional constraints on the intelligence product; the request may have time constraints (short term vs. long term) or scope constraints (broad or strategic vs. narrow or tactical).
- Collection: This refers to the gathering of raw (uninterpreted) data. Nowadays, there is an abundance of data due to the variety and richness of sources:
  - Signal intelligence (SIGINT) includes information from radar, telemetry, and intercepted communications.
  - Imagery intelligence (IMINT) refers to images delivered by electronic means, mostly satellites.
  - Measurement and signature intelligence (MASINT) is data produced from sensors (chemical, acoustic, etc.) other than SIGINT and IMINT.
  - Human-source intelligence (HUMINT) refers to data provided by informants, either through clandestine means, official contacts with allied nations, or diplomatic missions.
  - Open-source intelligence (OSINT) refers to publicly available information (radio, television, newspapers, commercial databases, etc.); this is in contract with all previous sources, which are usually classified and not open.
- Processing and Exploitation: In this stage, the raw data is converted to a form suitable for further analysis. This includes the translation of documents in foreign languages, analysis of sensor data, decoding of messages, and so forth. These tasks consume a large amount of resources from intelligence agencies since many of them are labor intensive, and specialized personnel are needed to carry them out. Moreover, in this phase, the evaluation of the accuracy, reliability, and meaning of the raw data (which continues in the next step) gets started.
- Analysis and Production: In this stage, the processed data are integrated, interpreted, and evaluated. In this crucial phase, the analyst must assess how reliable and complete the data pieces are, how distinct pieces of

data can be interpreted, and how they fit in an overall picture. The first task is needed since many times the sources of information are not trustworthy, and an adversary may leave indications that actually mislead an intelligence agency in order to disguise real intentions. The second task is needed since raw data is rarely unambiguous; the same act (for instance, buying fertilizer) may signal completely different intentions depending on the context (to work on a farm or to prepare explosives). The last task is needed since data is rarely complete; after all collection is done, analysts usually have only fragmented and sometimes unrelated evidence. Finally, even after some conclusion is reached, there are two tasks left. First, analysts try to verify their work by correlating finished intelligence with data from other sources, looking for supporting evidence and/or inconsistencies. Because the process is far from exact, and is based on partial, tentative evidence, all conclusions reached are by necessity also tentative, best estimate interpretations. Note that in this step we go from facts to interpretation and judgment; hence, it is in this step that the danger is greater for presumptions, biases, and other problems to arise. Second, the created intelligence must be tailored to the customer, and an effort must be made to make sure that the product answers the customer's needs. In particular, the information produced must be relevant to the original answer, as accurate as possible (and, if uncertain, accompanied by some measure of its certainty), objective, usable (i.e., actionable), and timely.

- Dissemination: This is simply the process of delivering the finished product to the consumer. Sometimes, this is followed by the consumers providing feedback to the intelligence analyst so that the process can be improved.

While some intelligence is produced in response to a specific demand from a consumer, other intelligence is produced simply in order to keep track of ongoing events, to detect trends and patterns, or to be aware of events that may develop. As a result, finished intelligence can be of one of several categories, depending on its origin, subject, type of analysis, and/or intended use. With regard to origin, intelligence may be analyst driven, event driven, or scheduled (periodical). With regard to subject, intelligence may be economic, geographic, political, scientific, and so forth. With regard to the type of analysis, intelligence can be descriptive or inferential; in the latter case, it can be about the past, the present (warnings), or the future (forecasts; Waltz, 2003).

In the United States alone, there are several intelligence agencies that are collectors of data and/or producers of finished intelligence based on several departments. Collaborations among these agencies have been notably absent in the past.

KM IN INTELLIGENCE ANALYSIS

The idea that KM has a role to play in intelligence analysis is not new. In a seminar paper, Brooks (2000) already stated our main thesis, namely, because of similarities in goals, issues, and tasks, KM could lend significant insight when analyzing intelligence work and vice versa. The book by Waltz (2003) has this very same thesis at its core. Moreover, the 9/11 Commission has stated that some of the most serious failures in intelligence that had been observed (the lack of communication between the FBI and CIA, and the obsolete information technology deployed at the FBI) stem from not having an adequate knowledge management strategy in place: "In essence, the agency didn't know what it knew." Also, the book by Krizan (1996) starts with a prologue under the subtitle "National Intelligence meets Business Intelligence." But the most revealing proof of the influence of KM in intelligence work may be the creation, by the Central Intelligence Agency, of a nonprofit enterprise (In-Q-Tel) devoted to identifying promising technologies and funding companies developing them. In this article, we focus on the influence of KM on intelligence work, concretely on techniques and tools of KM that could have an impact on intelligence tasks. We will also briefly mention aspects in which intelligence work is influencing KM, although this is not our main topic.

In order to achieve our goal, we start by listing similarities and differences between KM and intelligence as this will help us understand which methods may transfer.

- Relationship with a Customer: Both BI and intelligence have the need to satisfy a customer (the policy maker or military command in the intelligence case, the company executive in the BI case). Furthermore, in both cases, customers may not articulate the exact needs in terms conducive to the intelligence task, but in terms that make sense to themselves. Also, in both cases, the customer requires actionable intelligence, that is, information that supports decision making and planning. It is up to the analyst to ensure that the final product of analysis has, at least to some degree, several characteristics that will make it useful to the customer: It is to be accurate, objective, usable, relevant, and timely. Finally, because we live in an era where access to information is easy, both BI and intelligence analysts need to add value, going beyond what the customer already knows (which may be quite a lot) by offering analytical skills.
- Data Analysis: Both in the BI and intelligence cases, analysts have at their disposal large amounts of raw data (usually from open sources); however, the information sought is usually hidden within this massive set of uninterpreted, unconnected set of facts. Both BI and intelligence rely on IT to deal with this large amount of data (Waltz, 2003). However, there is no procedure that will yield the needed results on each case. Several techniques must be used in the analysis, and many times the analysis relies also on the intuition and experience of the analyst. Another similarity is the fact that scenarios under analysis have widened considerably. In BI, it is routine now to watch data on many different fields, from technology to politics to the weather. Also in intelligence, routine political analysis is being complemented by historical, economical, and other analyses.
- Transformation of Tacit Knowledge: Both companies and intelligence organizations have a large deal of tacit (implicit) knowledge in the heads of senior personnel and in the informal networks developed over time as a byproduct of work processes. Analysts, either in business or intelligence, absorb and internalize information; this manifests itself externally in social interaction (meetings, memos, etc.; Waltz, 2003). In both cases, it is very important to leverage (by making explicit, recording, and cataloguing) as much as possible this internal knowledge. This is a difficult task but it offers the possibility of a large payoff in the form of expertise that is kept in house when people leave the organization (Von Krogh, Ichijo, & Nonaka, 2000).

An important difference is the adversarial nature of the intelligence scenario. Each party tries to protect information about itself by hiding it and by deception. While in industry there is also a need and a practice for a certain amount of secrecy, there is usually no need for deception (at least not on a large, organized scale). Hence, intelligence must deal with information that may not be trustworthy; the sources must be carefully considered and the information has to be cross-checked with other available information. BI does not have to bother itself with these issues. As a consequence, the amount of what we called processing and exploitation is much smaller in BI than it is in Intelligence. The analysis phase also takes on a different character. Because of the need to evaluate the reliability of sources in intelligence work, evaluating and selecting evidence is an important part of the analysis; this step is rarely needed in BI.

Another important difference is the reserved nature of sources in intelligence work. This has consequences throughout the intelligence cycle: Sometimes it is not possible to go back to the source for additional information, and sometimes results cannot be disseminated as this would compromise the source of some data. This is why sometimes the intelligence process has been described as "the process of the discovery of secrets by secret means" (Waltz, 2003, p. 2).

Finally, a crucial difference is the extreme need for security in intelligence work. While companies are more and more aware of the need for security (due to industrial espionage, market competition, and malicious attacks to their networks), in the intelligence world there are a series of long standing procedures to restrict access, usually based on credentials (clearance levels) and on policies like need-to-know.

KM TECHNIQUES IN INTELLIGENCE

Based on our previous analysis, we can sketch a list of KM techniques that are bound to be beneficial for intelligence analysis.

- Creation of an Organizational Memory, including a Best-Practices Repository: Since much work by the analyst relies on his or her experience and intuition, such experience and intuition are great resources that must be kept and shared. Best-practices repositories do just that. Such repositories help not only to improve ongoing analysis, but they aid in the purpose of training (Clift, 2003; Pappas, & Simon, 2002). The intelligence community has recognized the importance of this approach and has tried to incorporate it into its practice, for instance, by collecting best practices (called tradecraft in the intelligence world); however, this has been done mainly in print (Product Evaluation Staff, Directorate of Intelligence, Central Intelligence Agency, 1996) without the support of IT tools that would facilitate searching and dissemination (Watson, 2002).
- Creation of Communities of Interest and Communities of Expertise: Many times, intelligence analysis requires considerable expertise in more than one area: Economical, political, military, and historical knowledge may be needed for a single task. No person is likely to possess all the knowledge so the analyst must frequently consult experts. Connecting analysts to the right person to consult for a given task would increase the quality of the analysis. Note that, in creating such communities, the intelligence agencies face the same problems that companies do, for instance, the common good problem (the cost of the effort to providers outweigh the benefit to consumers since the provider does not benefit). Several solutions applied in business may be useful here, too: Reduce the cost to providers (make it as easy as possible to give advice, etc.) and/or reward them. Ultimately, one should strive to achieve equilibrium (mutual reciprocity) as providers also become consumers; at this point, the problem goes away. However, starting may be difficult since communities need critical mass: They are only good if enough people use them. In fact, bootstrapping the com-

munity may be the hardest part (Clawson & Conner, 2004).

- Information Management Tools: KM has special information management needs that databases do not fulfill, so certain tools and techniques are of special interest in KM. The same tools could be very useful to the intelligence analyst. Among them, we point out the following:
- Document Management Tools: A considerable amount of information accessed by the analyst is disseminated in documents of several types: memos, reports, and so forth. Clearly, one of the challenges in the intelligence process is to find the relevant facts from among all the data available from different sources. Databases can easily index, sort, and access with efficiency-structured data, that is, data that has been entered in a certain format, usually specified in advance by a database designer. However, data in documents tend to be semistructured (i.e., they have irregular, dynamic structures) or unstructured (i.e., any structure is implicit and not known beforehand), and databases tend not to deal well with this sort of data. On the other hand, information retrieval (IR) systems deal well with such data, but usually offer only limited search capabilities (keyword-based processing). A new generation of tools, however, is emerging around information extraction (IE) technology to specifically address the challenges of managing document-based information. Such tools can be a valuable aid for the analyst, especially since often the information in documents (e-mails, memos, etc.) may lead to tacit knowledge (Asprey & Middleton, 2003). As an example, what people write in e-mails, memos, and so forth gives strong clues as to what their expertise is. In the context of intelligence work, though, such tools must include sophisticated access control (separate privileges for viewing, versioning, annotating, and printing, for instance) in order to deal with security issues (Mena, 2004).
- Collaborative Tools: Due to the complexity of today's intelligence analysis, most analysts are experts in a well-defined domain. This specialization means that complex problems that are best attacked from several angles must be tackled by groups, not individuals. However, successful teams require good organization, effective communication, cooperation, and a shared mental model or at least vocabulary. Therefore, collaborative tools (groupware, communication tools, etc.) could be used in this regard. Intelligence agencies are well aware of this situation: Collaborative tools using commercial web technologies are being developed through the Joint Intelligence Virtual Architecture program to assist today's analyst in locating and accessing valuable data, assessing such data, producing an informed analytic product, and moving that product to where it will be of value. (Clift, 2003) Common in KM, such tools are only recently being adopted by the intelligence community, probably because of concerns about security and access. However, the potential payoff of such systems is high, especially if the dissemination of information (based on predefined profiles or dynamic requests) is added to the process being modeled.
- Work Flow Management (WM) Tools: Because each step in the intelligence process (see above) is likely to be given to a different expert, the final product is the result of a collaborative process, a true team effort. The members of this team must communicate easily and effectively; the better the communication, the more likely the final product will be of high quality. WM tools help control collaborative processes and

therefore are very relevant in this area. Thus, just like collaborative tools address collaboration at the process level, work flow management tools support collaboration at the analysis level.

- Intelligent Indexing and Search Tools for Multimedia Data: Due to the variety of sources, intelligence analysts work with data in several formats. The need to link all available data, unearthing unknown connections, means that all data should be indexed and tagged to facilitate further analysis. These tools are especially important nowadays because they help combat information overload and because with abilities like push-pull (subscribe query) dissemination and intelligent text processing (sometimes in multilingual environments), the tools support the knowledge exchange cycle, facilitating the transformation between tacit and explicit knowledge (Waltz, 2003).
- Cognitive or Analytical Tools: Used especially in the analysis and production phase, these tools focus on the reasoning process itself: keeping track of hypotheses, goals, and their interrelationships, choosing among alternatives, and performing what-if analysis. The importance of these tools is that they help counteract natural biases and shortcomings of the analyst's mental model. Because these are part of internalized knowledge, such biases are difficult to identify and deal with, and they constitute a serious problem in intelligence work (Heuer, 1999) where dealing with deception and hard-to-interpret information is part of everyday work (Waltz, 2003).

Note that the above list relies heavily on IT tools and techniques. Clearly, there is more to KM than IT. In fact, it is well known that managerial and organizational changes are needed in order to support KM (Davenport & Prusak, 1998; O'Leary, & Studer, 2001). Therefore, strategies to make the tools work within the organization are an integral part of KM. Some authors state that real KM is not achieved until there is a culture change in the organization (Brooking, 1999; Davenport and Prusak). To support organizational learning, collaboration, and team problem solving, businesses have adopted a variety of strategies (Choo & Bontis, 2002). Such experiences are another source of knowledge from which intelligence agencies may greatly benefit since historically they have worked on a very different mindset-one that encouraged secrecy.

INTELLIGENCE IN KM

As it is often the case, the adoption of KM techniques in intelligence (and in the military at large) has resulted in the adaptation of old techniques to new circumstances, or even the development of new ones. As a result, intelligence officers have also contributed some concepts that are useful to KM at large. It is notable, in this context, that military strategy has recently become trendy in business circles, with books like the classic Art of War by Sun-Tzu being recommended literature for executives. Another notable trend is the adoption of KM techniques in the military at large; in fact, the Army has declared "information superiority" as one of the key concepts of the Army of the future in the "Joint Vision 2020," a report from the U.S. Joint Chiefs of Staff issued in 20003. One area where intelligence leads the way is the emphasis on security. As stated above, in a business environment, the situation is not openly adversarial but is competitive nonetheless. Malicious network attacks by hackers, disruptive tactics used by competitors in other countries (industrial espionage, etc.), and the fact that a country's economy is also a target in terror warfare have made businesses more and more aware of the need for strict security policies and methods. Data mining techniques, common in business to better understand clients and the market, are also being used to protect from internal and external threats: "To protect from insider threat, an organization could mine employee's information to learn about travel patterns, emails, phone conversations, work habits, computer usage, [and] Web usage" to determine if an individual is likely to betray the organization (Thuraisingham, 2003, p. 359). Measures like compartmentalization, access based on clearance levels, and need-to-know policies will help in this regard, although they must be carefully implemented so that they do not restrict the flow of information or collaborative efforts.

Another area in which intelligence agencies are well versed is the need for appropriate training. Because analysts must have a thorough formation phase to be useful to their agency, several practices (including mentoring from senior analysts) have been adopted that should be considered in a business setting.

Finally, some concrete techniques seem to have great potential for transfer. For instance, the institution of postmortem analysis, especially of failures, facilitates the creation of an institutional memory and is a great resource for further analysis, like "meta-analysis of the causes and consequences of analytical success and failure" (Heuer, 1999). Such practices, therefore, should be readily adopted in the business world, although resistance to them should be expected and will have to be dealt with through managerial measures. Another particular technique developed in the intelligence community is link analysis: the search for relationships among seemingly unrelated pieces of information in order to uncover previously unknown connections. This technique forms the basis for social network analysis (Sageman, 2004) and could prove very useful in BI. Finally, there are tools like modeling and simulation tools (especially in the modeling and simulation of the analysis process) and data visualization tools, which are already in use in the intelligence community but are still not as common in BI. It is very likely that such tools will become more and more important in the latter.

FUTURE TRENDS

There is no doubt that the future will see still further interaction between the KM and intelligence communities. Their similarities mean that they will continue learning from each other and influencing each other. On the intelligence side, as the commoditization of sensors and other data acquisition technologies means that all parties will have access to most of the same data, the emphasis will shift to analysis and synthesis (Waltz, 2003). Also, a fast changing environment means that the ability to cope with change will be needed by the intelligence community. The business world, having recognized this need some time ago, has already addressed the problem (although not all techniques from the business world will be readily applicable, like sharing information with business partners and suppliers, due to security concerns; Bennet & Bennet, 2003). Overall, KM processes and methods will become more and more relevant. Thus, it is likely that, in the near future, each area surveyed in this article will continue to be developed and lead to further interaction.

Some areas that will require further attention in the near future include how to share data securely; it will be necessary to track how information is being accessed and used in order to make sure that security is not compromised. Thus, collaboration tools will have to add this ability. Also, the stress on information access and dissemination means that new techniques for personalization, profiling, and distribution (like push-pull systems; Glance, Arregui, & Dardenne, 1998) will become more and more appealing to intelligence organizations.

Finally, the introduction of collaboration and other tools will foster the development of informal communities in intelligence organizations. Efforts in the business world to nurture and sustain such communities will provide guidance to the intelligence community (Clawson & Conner, 2004).

CONCLUSION

There is a strong connection between knowledge management and intelligence work that only now has begun to be explored with the depth it deserves. Several authors have already pointed out that intelligence organizations need KM due to the size and complexity of the data being processed, the level of expertise needed to process the data, and the sophistication of the final product, which must have the qualities of actionable knowledge. Here we have provided only a short introduction to this line of work. Some preliminary conclusions can be drawn already: The parallelisms this analysis unearths are resulting in a cross-pollination of techniques and tools that can only be beneficial to professionals on both sides, and there are still many parallelisms to be uncovered. Thus, it is important to continue work in this direction, especially in times of need like the present one.

REFERENCES

Asprey, L., & Middleton, M. (2003). *Integrative document and content management: Strategies for exploiting enterprise knowledge.* Hershey, PA: IGP.

Bennet, A., & Bennet, D. (2003). *Organizational survival in the new world: The intelligent complex adaptive system*. Amsterdam: Elsevier. (Kmci Press Series).

Berkowitz, B., & Goodman, A. (2000). *Best truth: Intelligence in the information age.* New Haven, CT: Yale University Press.

Borghoff, U., & Pareschi, R. (Eds.). (1998). *Information technology for knowledge management.* Berlin: Springer-Verlag.

Brooking, A. (1999). *Corporate memory: Strategies for knowledge management.* London: International Thomson Business Press.

Brooks, C. C. (2000). Knowledge management and the intelligence community. *Defense Intelligence Journal, 9*(1), 15-24.

Choo, C. W., & Bontis, N. (2002). *The strategic management of intellectual capital and organizational knowledge.* New York: Oxford University Press.

Clawson, J., & Conner, M. (Eds.). (2004). *Creating a learning culture: Strategy, technology, and practice.* Cambridge University Press.

Clift, A. D. (2003). Intelligence in the Internet era. *Studies in Intelligence, 47*(3). Retrieved from http://www.cia.gov/csi/studies/vol47no3/article06.html

A consumer's guide to intelligence. (1998). Arlington, VA: Office of Public Affairs, Central Intelligence Agency.

Davenport, T., & Prusak, L. (1998). *Working knowledge.* Cambridge, MA: Harvard Business School Press.

Donnely, H. (2003). Portal open army doors. *Military Information Technology, 7*(5). Retrieved September 28, 2004, from http://www.mit-kmi.com/

Glance, N., Arregui, D., & Dardenne, M. (1998). Knowledge pump: Supporting the flow and use of information. In U. Borghoff & R. Pareschi (Eds.), *Information technology for knowledge management* (chap. 3, pp. 35-53). Springer-Verlag.

Heijst, G. V., van der Spek, R., & Kruizinga, E. (1998). The lessons learned cycle. In U. Borghoff

& R. Pareschi (Eds.), *Information technology for knowledge management* (chap. 2, pp. 17-34). Springer-Verlag.

Heuer, R. J. (1999). *Psychology of intelligence analysis.* Center for the Study of Intelligence, Central Intelligence Agency. Retrieved from http://www.cia.gov/csi/books/19104/index.html/

Kitson, F. (1991). *Low intensity operations: Subversion, insurgency and peacekeeping.* London: Faber and Faber.

Krizan, L. (1996). *Intelligence essentials for everyone.* Washington, DC: Joint Military Intelligence College.

Mena, J. (2004). *Homeland security techniques and technologies.* Charles River Media.

O'Leary, D., & Stude, R. (2001). Guest editors' introduction: knowledge management—An interdisciplinary approach. *IEEE Intelligent Systems, 16*(1), 24-25, January 2001.

Pappas, A., & Simon, J. M. (2002). The intelligence community: 2001-2015. *Studies in Intelligence, 46*(1). Retrieved from http://www.cia.gov/csi/studies/vol46no1/article05.html

Popp, R., Armour, T., Senator, T., & Numrych, K. (2004). Countering terrorism through information technology. *Communications of the ACM.*

Product Evaluation Staff, Directorate of Intelligence. (1996). *A compendium of analytic tradecraft notes* (Vol. 1), Langley, VA: Central Intelligence Agency.

Sageman, M. (2004). *Understanding terror networks.* Philadelphia: University of Pennsylvania Press.

Schreiber, G., Akkermans, H., Anjewierden, A., de Hoog, R., Shadbolt, N., Van de Velde, W., et al. (2000). *Knowledge engineering and management: The Common KADS methodology.* Cambridge, MA: MIT Press.

Thuraisingham, B. (2003). *Web data mining and applications in business intelligence and counterterrorism.* Boca Raton, FL: CRC Press.

Von Krogh, G., Ichijo, K., & Nonaka, I. (2000). *Enabling knowledge creation: How to unlock the mystery of tacit knowledge and release the power of innovation*. New York: Oxford University Press.

Waltz, E. (2003). *Knowledge management in the intelligence enterprise.* Norwood, MA: Artech House Information Warfare Library.

Watson, I. (2002). *Applying knowledge management: Techniques for building corporate memories.* San Francisco: Morgan Kaufmann.

ENDNOTES

[1] In this article, we will not distinguish between national and military intelligence (Waltz, 2003) as we are interested in a high-level analysis for which this distinction is not very productive.

[2] Our description of the intelligence cycle is, out of necessity, highly summarized; the interested reader is referred to A Consumer's Guide to Intelligence (1998), Krizan (1996), and Waltz (2003).

[3] As an example of KM tools already in use in the U.S. Army, the Program Executive Office Command, Control and Communications Tactical (PEO C3T) has developed a knowledge-center Web portal that has served as a precursor and model for the service-wide Army Knowledge Online (AKO) Internet site. The portal has a variety of technology products and capabilities, such as project-management tools, repositories, work-flow applications, and similar tools, and it serves as the daily operations center of the workforce for PEO C3T and other

Army agencies. This tool has put recent emphasis on externalizing tacit knowledge. Efforts to capture knowledge and create communities of practice among subject-matter experts have also been extended (Donnelly, 2003). Outside the Army, the FBI has recently developed the Secure Collaborative Operational Prototype Environment for Counterterrorism (SCOPE), a data mart with more than 34 million documents related to counterterrorism, in which several knowledge-management tools (like collaboration tools) are being used.

Chapter 8.20
Knowledge Management in Smart Organizations

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ABSTRACT

This chapter looks at the deployment of appropriate information and communication technologies in helping smart organizations to manage knowledge. Taking a management perspective, smart organizations can be regarded as those that can make smart strategic decisions and put into practice such managerial principles as value creation, continual learning, embracing uncertainty, and empowerment. Making good decisions would involve gathering and synthesizing the appropriate knowledge—knowledge about the market, products, suppliers, customers, competitors, and others. Different schools of knowledge management theories and the related technologies will be discussed. The author hopes that understanding the knowledge management technologies and related practices would assist researchers and practitioners in gaining some insights into managing the knowledge required for making smart decisions in organizations.

INTRODUCTION

The 21st century witnesses innovative organizational or work arrangements such as digital factory, virtual, or smart organizations. This kind of organization is like a network of independent production units working together, and is flexible and responsive to the challenges and uncertainty of the ever-changing business environment. The increasingly popular deployment of information and communication technologies facilitates these organizations in establishing unconventional work arrangements, networking with fellow co-workers or business partners, and seizing the opportunities as offered by the uncertainty in the current business climate.

Whether these organizations are forming innovative work arrangements, networking with stakeholders, or tapping into new opportunities, they are making strategic decisions in the Knowledge Age. The common thread running through such activities is knowledge—the ability to find, use, store, share, and retrieve the relevant organizational knowledge to make the right move and gain a competitive edge.

The term "smart organization" is used for organizations that are knowledge-driven, internetworked, dynamically adaptive to new organizational forms and practices, learning as well as agile in their ability to create and exploit the opportunities offered by the new economy (Filos & Banahan, 2000).

This chapter focuses on the knowledge sharing, network, and management in smart organizations. It will look closely at the management aspects of smart organizations and how knowledge management fits into the overall organizational management. Taking a management-oriented approach, the notion "smart organizations" appears to be originated from the book Smart Organisation: Creating Value through Strategic R&D (Matheson & Matheson, 1998). The authors consider "smart organizations" as those organizations that develop world-beating products on a continuing basis at prices that establish value leadership. They also regard "being smart" as making good decisions.

We are in the era of the Knowledge Economy. The basis of competition is "knowledge." Mastery of the relevant, crucial, and up-to-date knowledge would enable businesses and organizations to survive well and gain a competitive edge in this age. As stated above, "being smart" means making good decisions. Making good decisions would involve gathering and synthesizing the appropriate knowledge—knowledge about the market, products, suppliers, customers, competitors, regulatory environment, and other aspects. Such knowledge, if well utilized, would facilitate making good decisions so that the related organizations can develop world-beating products and services—befitting to be regarded as "smart organizations."

It would therefore be imperative to look at knowledge management in the context of smart organizations. This chapter will start off by introducing to the readers the general theoretical framework and the nine principles of smart organizations as indicated by Matheson and Matheson (1998), with the focus on how knowledge could be seen as a common thread running through these nine principles. This will be followed by an elaboration of the development and theory relating to knowledge management. It will then focus on how knowledge management helps realize the potential of smart organizations by implementing each of their nine principles. The relevant knowledge management technologies will also be discussed.

BACKGROUND

Smart Organizations

There are different definitions of "smart organization." Some take a broader perspective, while others may be based on a narrower context. These definitions may have some differences according to the field of approach—such as management, information technology, or human resources. A management-oriented definition of "smart organization" can be found in Matheson and Matheson (1998), which will be elaborated immediately below. This chapter focuses on knowledge management in smart organizations as seen from this management-oriented approach.

The term "smart organization" appears to be originated from the title of the book The Smart Organisation by David Matheson and Jim Matheson (1998). They regard smart organizations as those companies that develop world-beating products and services and deliver them at prices that can establish value leadership. They are also of the opinion that "being smart" and "acting smart" would guarantee businesses to succeed in this fast-changing and increasingly competitive market.

They define "being smart" as making good strategic decisions. The authors consider "acting smart" as "the activity of effectively carrying out those decisions." Having said that, what are qualities expected of smart organizations? They conducted a benchmarking of best practices for strategic decision-making in R&D (research and development) in the early 1990s identified organizational characteristics determining whether companies would be successful in adopting best practices. They name these characteristics the "nine principles of the smart organisation" (Matheson & Matheson 2001). These nine principles about smart organizations as indicated in Matheson and Matheson (1998) are as follows:

- Value Creating Culture: The purpose of the organization should be maximizing the value created for customers and captured by the enterprise.
- Creating Alternatives: Choice means that several good alternatives should be created and that the related organization would choose the best one.
- Continual Learning: One of the main objectives of an organization should be learning continually about what would create value and how to deliver it.
- Embracing Uncertainty: People should endeavour to understand all sources of uncertainty and use that knowledge when making decisions.
- Outside-in Strategic Principle: The organization aims at understanding the dynamics of its industry and customers and using this perspective to frame and evaluate strategic decisions at all levels.
- Systems Thinking: It is advisable that the organization answers complex questions by thinking through cause-and-effect relationships in the context of the whole business and identifying leverage points, feedback loops, and key factors.
- Open Information Flow: It is crucial that in the organization, information is available to whomever wants it and that it is used to create value. Such flow of information should cross functional boundaries.
- Alignment and Empowerment: The people involved are empowered and trusted to pursue value creation and that the organization is guided by a shared understanding of its strategies for creating value.
- Disciplined Decision Making: This refers to a decision-making process that identifies strategic choices, involves the relevant people and information, and selects alternatives based on the highest value.

Smart organizations demonstrate most, if not all, of the above nine principles (Matheson & Matheson, 2001), which would enable them to make good strategic decisions. One could therefore argue that a common thread running through these nine principles is knowledge—gathering, utilizing, and understanding the relevant knowledge—knowledge about the industry, market, products, suppliers, customers, competitors, and other related issues to facilitate the organization in making good strategic decisions, rendering them to be considered as "smart." It is therefore imperative for smart organizations to understand the practices of knowledge management and the related enabling technologies so that they could make the best use of such practices and technologies to implement each of the nine principles.

Knowledge Management

Some wonder what is meant by "knowledge" and how it is different from information and data.

Schoderbek, Schoderbek, and Kefalas (1985) regard "data" as " … unstructured, uninformed facts so copiously given out by the computer. Data can be generated indefinitely; they can be stored, retrieved and updated and again filed…." They are also of the view that "information" refers to facts with meaning or evaluated data. One of the world's leading experts in knowledge management, Karl-Erik Sveiby, stated that information simply exists and is all waiting to be interpreted, to have meaning attached by people, and becomes knowledge at the moment of its human interpretation (Miller, 1999).

One of the management gurus, Earl (2001), is of the opinion that theoretical insights into how knowledge might be managed are available from several disciplines, including economics (Silberston, 1967), philosophy and epistemology (Kuhn, 1970), computer science (Hayes-Roth, Waterman, & Lenat, 1983) and sociology (Polanyi, 1958; Polanyi, 1966).

One of the world-renowned knowledge management gurus, Yogesh Malhotra, stated that the term "knowledge management" has been appearing in information systems literature over the past two decades, since the 1980s. This is because the knowledge management systems were traditionally included into the information systems research domain, with a heavy artificial intelligence and expert systems emphasis (Malhotra, 1999).

Throughout the 1990s, knowledge management as a discipline received more attention as managers in the post-Industrial Age had become more aware of the phenomenon that knowledge may be the most critical resource, rather than land, machines, or capital (Drucker, 1993). From a more practical perspective, knowledge management was considered to be central to product and process innovation and improvement, to executive decision-making, and to organizational adaptation and renewal (Earl, 2001). Different schools of thought regarding knowledge management emerged during the 1990s, which will be discussed immediately below.

IT Track and People Track

Karl-Erik Sveiby concurred with the above view that knowledge management has a technology-oriented origin. His observation was that during the 1990s and leading up to 2000, knowledge management specialists were from the "IT track." They were researchers and practitioners that have their education in computer and/or information science, and were involved in constructing information management systems, artificial intelligence, reengineering, and groupware. This "IT track" went through three rapid phases: (1) The first phase started around 1992 and focused on productivity issues such as "How can we use IT systems to prevent reinventing the wheel?" (2) The second phase had a customer focus addressing such concerns as "How can we leverage what we know about our customers to serve them better?" and (3) The third phase was sometime around 1999 to 2001, coinciding with the dot.com boom and there was much discussion about interactive IT Web pages, e-business, and online transactions (Sveiby, 2001).

During the knowledge management evolution along this IT track, there was the emergence of various schools of thought focusing more on the non-technical aspects of knowledge management, or one could name that as the "people track" (Sveiby, 2001)—that knowledge is an organizational resource and that people play a key role in the process of creating, utilizing, and managing knowledge. One of these is the "intellectual capital" school of thought led by Leif Edvinsson. He is probably the world's first corporate director in intellectual capital. In his capacity as the intellectual capital director of Skandia, the Swedish insurance and financial services company, he engineered the publishing of the world's first intellectual capital annual report (Anonymous, 1997). He advocated that such intangible assets as intellectual capital (like an employee with a PhD) could be measured, and the resulting value

Table 1. Knowledge management schools of thought: IT track and people track

IT or People Track?	Development Phase or Focus	Main Issue
IT Track	First Phase – Productivity Focus	How can we use IT systems to prevent reinventing the wheel?
	Second Phase – Customer Service Focus	How can we leverage what we know about our customers to serve them better?
	Third Phase – Dot.com Boom	Discussion about interactive web pages, e-business and online transactions.
People Track	Market Value and Competitive Advantage	Organisations can understand, analyse, measure and manage their intellectual assets and turn their organizational knowledge into market value.
	Knowledge Creation	SECI Model – Organisational knowledge creation process involves four stages: socialization, externalization, combination and internalization.
	Narrative and Context	We manage knowledge as a flow and not as a thing.

could be included in the annual financial statements (Edvinsson & Malone, 1997).

Advocates of the "people track" of knowledge management tied in knowledge management with business strategy and generating value. Thomas Davenport and Larry Prusak drew on their work with more than 30 knowledge-intensive organizations and examined how different kinds of companies can effectively understand, analyse, measure, and manage their intellectual assets, turning corporate knowledge into market value (Davenport & Prusak, 1997). Two Japanese experts, Nonaka and Takeuchi, offered a refreshing approach to knowledge management when they published their book The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation in 1995 (Nonaka & Takeuchi, 1995). They proposed a SECI model for understanding the organizational knowledge creation process, which involves four stages: socialization, externalization, combination, and internalization (Nonaka & Takeuchi, 1995; Ursin, 2000). They further commented that the traditional Western view, emphasizing the organizational importance of knowledge that is codified and stored through such technical means as the databases, should be broadened to include tacit knowledge, which is knowledge based on experiences, insights, hunches, and perspectives, and often remains in human brains. Dave Snowden advocates that we should grow out of managing knowledge as a thing, but rather as a flow—which means we should focus more on narrative and context when sharing or managing knowledge, rather than just the content. This emphasis on narrative suggests that we can always know more than we can tell and we will always tell more than we can write, because the process of writing reflective knowledge is time consuming and involves loss of control over its subsequent use (Snowden, 2002).

Technocratic, Economic, and Behavioural Approaches

The "IT track" and "people track" approaches as proposed by Sveiby (2001) could be one way of viewing the developments of the knowledge management field. Earl (2001) suggested an alternative model of viewing such developments—three approaches consisting of seven schools. The first three schools are labelled "technocratic," as they are based on the premise that information technology supports and, to various degrees, conditions employees (or knowledge workers) in their daily tasks. The first school is the systems school, whose fundamental idea is to capture specialist knowledge in knowledge bases (from conventional databases through CD-ROMs to expert systems), which other specialist or "qualified" people can access. The second school is the cartographic school, which is concerned with mapping organizational knowledge and aiming at recording and disclosing who in the organization knows what by building knowledge directories to ensure that knowledgeable people in the organization are accessible to others for advice and consultation. The third school is the process school, which is a derivative or outgrowth of business process engineering. There are two ideas driving this school:firstly, performance of business processes can be enhanced by providing operating personnel with knowledge relevant to their tasks, and secondly, management processes are more knowledge-intensive than business processes (Earl, 1994,2001).

While the first approach emphasizes the "technocratic" aspect, the second approach is "economic" in nature because it has a business orientation explicitly creating revenue streams from the exploitation of knowledge and intellectual capital. It is perhaps what Davenport, De Long, and Beers (1998) described as "managing knowledge as an asset," where knowledge or intellectual assets consist of patents, trademarks, copyrights, and know-how (Earl, 2001).

The third approach is "behavioral" in nature, as it seeks to stimulate and orchestrate managers or managements to be proactive in creating, sharing, and using knowledge as a resource, and there are three schools of thought under this head. The organizational school emphasizes using organizational structures or networks to share or pool knowledge. They are often described as "knowledge communities," which are groups of people with common interests, problems, or experiences. These communities are designed and maintained for a business objective, and could be either interorganizational or intraorganizational in terms of arrangement. Although such communities may be supported by technology, this school is still under the "behavioural" approach because the essential feature of these communities is that they exchange and share knowledge interactively and often in nonroutine, personal, and unstructured ways, as an interdependent network. Another school is the spatial school, which centers on the use of space—or spatial design—to facilitate knowledge exchange or sharing. Typical examples include the metaphors quoted in modern management journalism—such as the water cooler as the meeting place, the kitchen as a "knowledge café" or the open-plan office as a "knowledge building." These are essential "spaces" for knowledge transfer within modern organizations, as most people are social beings who like human contact and often prefer conversation to documents or information systems. Tacit knowledge is most likely to be discovered and exchanged when people socialize within such spaces—and an alternative label for this school could be social school, because the rationale is to encourage socialization as a means of knowledge exchange.

Finally, the strategic school is primarily concerned with raising consciousness about the value creation possibilities available from recognizing knowledge as a resource, and this explains why some corporate mission and purpose statements embrace knowledge as an important item on the organizational agenda (Earl, 2001).

KNOWLEDGE MANAGEMENT PRACTICES AND TECHNOLOGIES: IMPLEMENTING THE NINE PRINCIPLES

As stated above, there are generally nine principles characterizing an organization to be a smart organization and that one could argue that knowledge is the common thread running through these nine principles, as smart organizations need to make good strategic decisions in the knowledge age. Below will be a discussion on how common knowledge management practices and technologies would help implement or realize each of the nine principles, rendering an organization smart. During the discussion, current knowledge management theories and schools of thought will be included as appropriate.

Value Creating Culture

It is crucial for a smart organization to aim always for value creation. Within such organization, it would be ideal if every person saw his or her final job as creating the greatest value. There could be changes or exceptions to rules if these rules stand in the way of creating value. In respect to organizational culture, it aims at rewarding those who work to create more value and encourages different functions to collaborate to create value. In case there are disagreements within the organization, the policy is that they should be resolved in favor of attaining the greatest value (Matheson & Matheson, 1998).

Table 2. Different schools of thought regarding knowledge management

Approach	**School of Thought**	**Main Issue**
Technocratic	Systems	Capture specialist knowledge in knowledge bases (e.g. databases) which specialist people can access.
	Cartographic	Map organizational knowledge by building knowledge directories so that others in the organisation can consult them.
	Process	Business processes can be enhanced by providing operating personnel with relevant knowledge. Management processes are more knowledge-intensive than business processes.
Economic	Economic	It has a business orientation explicitly creating value streams from the exploitation of knowledge.
Behavioural	Organisational	It emphasizes using organizational structures or networks to share or pool knowledge such as “knowledge communities”.
	Spatial	It centres on the use of space to facilitate knowledge exchange or sharing.
	Strategic	It is concerned with raising consciousness about the value creation possibilities available from recognizing knowledge as a resource.

The conventional way of understanding "value creation" in the past two decades has been influenced by the notion of industrial logic, in which value is added in sequential stages based on the premise that each part can be optimized individually and therefore contributing to the overall organizational value creation (Ramirez, 1999; Roberts, 2000; Skoog, 2003). During the past two decades, nonlinear models have been challenging this traditional value creation framework (Heskett, Jones, Loveman, Sasser, & Schlesinger, 1994; Simons, 1995; Ramirez, 1999; Roberts, 2000; Skoog, 2003). These new perspectives emphasize the role of different actors (stakeholders) as coproducers or creators of organizational value. They appear to stress the significance of combinations and connectivity among the related actors or stakeholders and assert that a significant part of the value creation cannot be expressed in mere monetary terms (Heskett et al., 1994; Simons, 1995; Ramirez, 1999; Roberts, 2000; Skoog, 2003) because "value," or the currency in the current knowledge economy is "knowledge," which is an intangible asset not normally measured in terms of money.

Our knowledge economy is characterized in terms of the nature of its products and services being knowledge-based. Value creation in the knowledge age is therefore very much related to strategically leveraging an organization's intellectual or knowledge capital. It is important for an organization to have the capacity to coordinate, orchestrate, and deploy its knowledge resources toward creating value in the pursuit of its future vision. In fact, the nature and rationale of intellectual capital is about creating value through developing and deploying knowledge-based competitive advantages faster than the competitors or the pace of change in the industry (Rastogi, 2003). Knowledge and its exploitation for creating value are the conjoint outcomes of organizational learning (Senge, 1990; Rastogi, 2003). During this process, an organization may have to meet many challenges and exploit various opportunities in its quest for value creation (Rastogi, 2003). Effectively managing knowledge would help organizations to overcome such challenges and make the best use of such opportunities so as to achieve the ultimate goal of creating value.

Extranets

Our current business environment is becoming more competitive, with customers having a wide variety of consumption choices, each alleging to be offering high-quality products or services with a relatively lower price. In this context, "value'" can be seen in the context of the relationship between supplier offerings and customer purchases by identifying how the supplier fulfils the customer's needs (Band, 2000; Porter, 1998; Clarke, 2001). Mastering the knowledge about the customer's needs or requirements would be of utmost importance in creating value for a smart organization.

The knowledge management technology of extranets could help organizations better understand customers' needs and deliver a better service and thereby create value. Extranets are secure Internet protocol-based networks linking the information infrastructures of various extranet participants—in the business context, usually one or more of the following parties: suppliers, vendors, customers, and business partners (Bushko & Raynor, 2001). Extranets are a result of the evolution of electronic document exchange (EDI) technology, which has been used for many years to connect organizations together for supply chain integration. EDI used the automated exchange of simple, highly structured electronic forms over private networks, whereas extranets dramatically extend the benefits of interorganizational integration through the intertwining of EDI with Internet technologies. Since the Internet is a public and international network based on the Internet protocol (IP) and related standards, it provides a standard of interconnecting networks so that any system can communicate with any other system. Hence, extranets have the advantage of allowing various organizations having different hardware and software to communicate given extranets' use of the Internet's open standards (Yen & Chou, 1999, 2000).

One of the common purposes of extranets is to allow various organizations to share their information resources and knowledge storage, facilitate their knowledge flow, and work with their suppliers, customers, distributors, and other businesses to reach a common goal. The knowledge flow could be in relation to the customers' knowledge about the vendors' products and services, or business partners sharing their knowledge about certain target markets with the view of setting up joint ventures there. The essence of the extranets, from a knowledge management perspective, is allowing each of the extranet partners to access certain permitted areas of their business partners' networks in order to gain access to the requisite knowledge.

Such knowledge management could add value to the service delivered to the clients. For instance, extranets linking an organization with its customers or clients are instrumental in strengthening client relationships and creating value for clients. An example would be Deloitte Consulting's UK practice developing a highly technologically sophisticated extranet to link up a client firm in respect of a major strategy project. It uses the extranet to communicate sensitive information to a select audience (in this case, the client firm), keep the clients and other stakeholders informed of the strategy formulation process, and allow the clients access to the detailed information about the project as the project goes on (Bushko & Raynor, 2001). The added "value" as exemplified in this case is enhanced client service quality—in the sense that in addition to Deloitte providing high-quality consulting service, the client firm can actually get access to the relevant information sources at Deloitte to keep track of the internal workings of the project and thereby facilitate consultant/client relationship.

Customer Relationship Management Systems

While extranets connecting an organization's networks to its customers may have the potential of enhancing the service quality, the technology of customer relationship management systems would help manage knowledge about customers' needs and customer relationships and enable the organization to create value. Customer relationship management is about using information technology in implementing relationship marketing strategies. Berry (1983) first introduced the term "relationship marketing," which is concerned with how organizations manage and improve their relationships with customers for long-term profitability (Ryals & Payne, 2001). He defined relationship marketing as "attracting, maintaining, and … in multi-service organizations … enhancing customer relationships" (Berry, 1983). Since then, the field of relationship marketing has generated much interest and attention (Sheth, 2000). The longer the customer relationship lasts, the more profitable customers are shown to be, and therefore the focus of customer relationship management is on the lifetime value of the customer, rather than the profitability in any single period (Reichheld, 1996). Relationship marketing advocates view the customer relationship as an asset that can be managed and that requires investment. Technology can help organizations manage the information that they need to understand customers, so that appropriate relationship marketing strategies can be formulated (Ryals & Payne, 2001). This is where customer relationship management systems play a role.

Kutner and Cripps (1997) contend that customer relationship management is based on four premises: (1) manage customers as important assets; (2) customer profitability varies, and not all customers are equally desirable; (3) customers vary in their needs, preferences, buying behaviour, and price sensitivity; and (4) by understanding customers drivers and profitability, organizations can tailor the products and services they offer in order to maximize the overall value of their customer portfolio (Ryals & Payne, 2001). Kotler (1990) is of the view that organizations should make the best use of technology to manage their customer relationships. They could build and use customer databases to keep track of what customers are buying and what they are interested in, therefore utilizing such information to serve customers better (as quoted in Caruso, 1992; Ryals & Payne, 2001).

Such information can be used to strengthen the relationship with the customer and increase customer value over time (Gronroos, 1997). For instance, First Direct bank uses the data from a previous transaction in a proactive way in order to strengthen the relationship by personalizing a later transaction. The customer, who wishes to use his First Direct bank card in an American ski resort, asks for information about automated teller machines there. In a subsequent transaction, a different call center operator uses this information to check whether this customer had a satisfactory experience. External data sources can also be added to the store of knowledge about customers. Market research results or information from other databases can also be added to this customer knowledge store (Ryals & Payne, 2001).

As mentioned above, creating value requires knowledge and understanding of the customers, their needs and requirements, and other related factors. These factors could be the market, competitors, and regulatory environment, which could impact the customers' needs. Such an understanding would help the organization evaluate alternatives and the business environment, find the appropriate strategic position, and make a wise decision rendering the organization to add value to the customers.

Creating Alternatives and Disciplined Decision-Making

Disciplined decision-making is a process identifying strategic choices, engaging the right information and people and selecting alternatives based on the highest value. People working in smart organizations should understand the nature, importance, and process of decision quality and initiate the appropriate process in addressing the strategic decisions. Part of the culture of the smart organizations is that a quality decision is applied to every important decision, including portfolio, technology, and R&D project strategy (Matheson & Matheson, 1998).

As disciplined decision-making involves identifying strategic choices, there would be a preceding step, which is creating alternatives. The notion of creating alternatives is about looking for high-value alternatives that are desirable, safe, and rewarding. It also requires committing to evaluating alternatives honestly and without prejudice, if possible. Generating alternatives would pave the way and allow for more choices when it comes to the stage of identifying strategic choices. Choice means creating various good alternatives and selecting the best one as appropriate for the situation (Matheson & Matheson, 1998).

The processes of alternative creation and disciplined decision-making—generating, identifying, and evaluating options and selecting the most appropriate one—would be facilitated by knowledge sharing and retrieval. This is because one that is well-equipped with the requisite knowledge would be in a position to generate the relevant alternatives and make an informed decision. Sharing knowledge among people concerned and retrieving knowledge from databases or other knowledge storage places would help maximize the knowledge base on which an organization or each individual within that organization can create alternatives and make a good strategic decision. The knowledge base could be in relation to the knowledge about the industry, markets, customers, suppliers, competitors, and other stakeholders.

Knowledge sharing and knowledge retrieval can be enabled by the related knowledge management technologies. Part of the organizational knowledge generation process consists of sharing knowledge in the first place and surfacing current knowledge and assumptions, making it available for critical scrutiny (Despres & Chauvel, 2000). Knowledge can also be retrieved from where it is stored for understanding, analysis, and utilization. The knowledge management technologies of intelligent agents could enable the knowledge sharing and retrieval processes, providing the knowledge base for generating alternatives and engaging in disciplined decision-making.

Intelligent Agents

An "agent" in the legal sense is empowered to act on behalf of another (Feldman & Yu, 1999). An "intelligent agent" is one that can learn the behavioural patterns or the rules concerning certain actions and transactions, and then act accordingly on behalf of its "boss" (Feldman &Yu, 1999) or user. While there would be various definitions of "intelligent agents," most current researchers agree that agents have the following characteristics: autonomy, adaptiveness, collaborative behaviour, and mobility (Feldmand & Yu, 1999).

Agents have knowledge retrieval, profiling, and filtering capacities. They can search and retrieve information brokers or document managers (Stenmark, 2003). They often play a collaborative roleproviding information and expertise on a specific topic by drawing on relevant information from other information agents. The architecture of an agent is that each agent contains a domain model (providing descriptions of the classes of objects in the domain, relationships between these classes, and other domain-specific information) and information resource models (providing descriptions of both the contents of the information sources and the relationship between those models and the domain model) (Knoblock, Arens, & Hsu, 1994).

The system uses these mappings for transforming a domain-model query into a set of queries to the appropriate information sources. Information retrieval query processing requires developing a plan for obtaining the data. This includes selecting the information sources to provide the data, the processing operations, the sites where the operations will be performed, and the order of performing (Ambite & Knoblock, 1997). The organization of agents needs a common communication language and protocol to interact and collaborate. A common content language is the Loom knowledge representation language (MacGregor, 1990), which is a language for representing hierarchies of classes and relations, as well as efficient mechanisms for classifying instances of classes and reasoning about descriptions of object classes (Knoblock et al., 1994).The knowledge query and manipulation language (KQML) is a common protocol to organize the dialogue between agents (Ambite & Knoblock, 1997), as explained above.

Knowledge Interchange Format

While the intelligent agents are looking for the relevant information, they may have to communicate or establish links with databases or knowledge sources residing in disparate computer systems. Knowledge interchange format is a language designed for use in the interchange of knowledge among disparate systems, which could be those created by different programmers, at different times or in different languages. The purpose of knowledge interchange format is quite analogous to that of Postscript, which is commonly used by text and graphics formatting systems in communicating information about documents to printers. Postscript is a programmer-readable representation facilitating the independent development of formatting programmes and printers. While knowledge interchange format is not as efficient as a specialized representation for knowledge and not as perspicuous as a specialized display, it is a programmer-readable language capable of facilitating the independent development of knowledge-manipulation programmes (Genesereth, 2004).

The features essential to the design of knowledge interchange format include: (1) The language has declarative semantics so that it is possible to understand the meaning of an expression in a language without appeal to an interpreter for manipulating that expression; (2) The language is logically comprehensive in the sense that it provides for the expression of arbitrary logical sentences; and (3) The language provides for the representation of knowledge about knowledge, allowing the user to make knowledge representation decisions explicit and permitting the user to introduce new knowledge representation constructs without changing the language (Genesereth, 2004).

As explained above, intelligent agents with information retrieval and filtering abilities have a major characteristic distinguishing them from search engines: its proactive nature. Search engines such as Yahoo! and Google are inherently reactive (an information seeker has some query in mind, puts in some keywords, and the programme reacts to such query by displaying the search results). Retrieval and filtering agents are proactive in the sense that they keep watching a user's environment (usually a computational environment such as e-mail or a Web page that a user is reading) and present information to the user without requiring any continual action of the part of the user (Rhodes & Maes, 2000).

Creating alternatives and engaging in disciplined decision-making would need the decision-makers to align the organizational goals, because any alternative created or decision made without the possibility of ultimately attaining organizational goals would not lead to success for the organizations concerned. Such alternative creation and disciplined decision-making processes could also employ systems thinking involving the consideration of various factors or possibilities before reaching a final decision.

Alignment, Empowerment, and Systems Thinking

Smart organizations encourage participation in the decision-making process to achieve alignment of goals and the understanding required to make empowerment effective. The organization is guided through a shared sense of understanding of its strategies for creating value, and that people are empowered and trusted in pursuing value creation. Employees in the organization should feel empowered to act and take on the responsibility of acting, as well as for maintaining a shared sense of purpose. The organizational culture should be encouraging strategic decisions to be through a participative process and horizontal and vertical dialogue in realigning the organization through various periods of change (Matheson & Matheson, 1998).

While the organization is going through the decision-making process to achieve alignment of goals, it would be advisable that it deploys systems thinking—considering various factors before making a strategic decision. Systems thinking involves answering complex questions by thinking through cause-and-effect relationships from the perspective of the whole business and identifying leverage points, feedback loops, and key factors (Matheson & Matheson, 1998). The system approach can be described as a method to assemble and organize information, knowledge, and activities to attain greater efficiency (Vallee, 2003).

Systems thinking also requires an agile mind and a keen appreciation of how various parts of the world (the system) are linked together. Employees in an organization promoting systems thinking are expected to understand how their jobs and their actions are part of a larger system, and work to incorporate multiple and whole-system approaches into their thinking. Decision-makers in this kind of organization expect people to think through the full implications of their proposals and bring multiple perspectives to each important choice (Matheson & Matheson, 1998).

Organizational Decision Support Systems

The knowledge management technology of organizational decision support systems may be able to help organizations utilize the collective knowledge of various individuals within the organization, encouraging participation in decision-making and deploying systems thinking by considering various factors before making a strategic decision. Decision support technologies, including decision support systems, are computer-based tools developed to provide managers with the relevant information about internal operations and its business environment, together with experts' knowledge and models to facilitate their decision-making (Cascante, Plaisent, Bernard, & Maguiraga, 2002). Given that alignment of goals, one of the characteristics of smart organizations, involves encouragement of participation in the decision-making of the organization, organizational decision support systems that aim to support organizational decision-making that cuts across functional boundaries (Kim, Graves, Burns, & Myung, 2000) appear to be most suitable among various other kinds of decision support technologies.

The key notions in the organizational decision support systems frameworks are distributed problem-solving by human and machine knowledge processes, communication among these problem-solvers or decision-makers, and coordination of interrelated problem solving or decision-making efforts in the interest of solving an overall decision problem (Holsapple & Winston, 1996; Kim et al., 2000). Organizational decision support systems refer to a collection of individual decision support systems that communicate with each other to support collective organizational decision-making. Each constituent decision support system depends on the while but capable of supporting local decision-making. While the objective of an individual decision support system is to improve the performance of individual decision-making, the goal of organizational decision support systems is to improve the performance of collective organizational decision-making (Kim et al.) by having the systems take into account the collective knowledge sources and organizational goals, and assisting the decision-makers to reach an optimum decision compatible with such goals.

While there may be variations from one type of organizational decision support system to another, a typical organizational decision support system architecture consists of four components: (1) organizational participants; (2) language subsystem; (3) messaging subsystem; and (4) public resource management subsystem (Kim et al., 2000). The organizational participants are either human or machine processors, which communicate with each other to solve overall organizational problems (Kim et al.). The Language Subsystem provides the user with the interface to accept requests from participant nodes and to display the results of the request (Holsapple & Whinston, 1996; Burns, Rathwell, & Thomas, 1987). The Messaging Subsystem involves communication among participant nodes, such as notification of actions of a participant node to others (Holsapple & Whinston, 1996; Swanston & Zmud, 1989; Burns et al., 1987). The Public Resource Management System manages the public resources, including data and models such as a directory of the participant nodes' names and operators' names that each decision support system wants to be available to (Burns et al., 1987; Kim et al.).

One example of how an organizational decision support system assists with collective decision-making is an organizational decision-making system helping a television station to forecast television viewership, which helps formulate its marketing and planning strategies. Factors influencing television viewership are closely related to the relevant knowledge in respect of sociocultural factors affecting viewership such as different lifestyles, the viewers' ages and program preferences, and weather conditions. Forecasts for the television viewership done manually relied on the experience of the people doing such forecasts, and producing such results was a very long process based on individual subjective assessments. The results were inaccurate because there was no quest for supporting evidence and the person who did the forecasting might have had all types of prejudices and limitations that usually appear in judgmental forecasting (Patelis, Metaxiotis, Nikolpoulos, & Assimakopoulos, 2003).

An organizational decision support system called FORTV was proposed, which can help decision-makers identify various factors affecting television viewership and the competitive environment, such as total viewership, market share of each TV channel, viewership of each TV station, the program's viewership and the commercials' viewership, and to have such relevant body of knowledge incorporated into the analysis process. The system can perform the function like a knowledgeable human being by forecasting television viewership in the future to help the organization plan its programs and devise its strategies (Patelis et al., 2003).

Empowering individuals within an organization to align organizational goals and deploy systems thinking in reaching a strategic decision would also require taking an outside-in perspective—appreciating the impact of the business environmental circumstances and the uncertainty they often represent, and evaluate how such external circumstances and uncertainty could affect the organization and its success.

Outside-in Strategic Perspective and Embracing Uncertainty

The essence of an outside-in strategic perspective is to see and act on the "big picture," appreciate its importance for strategy, and distance oneself from his or her personal circumstances. The organization would need to understand the dynamics of the industry and customers and use this perspective to frame and evaluate strategic decisions at all levels. The organizational culture should encourage actively seeking information about what is outside of the organization and use it in decision-making, and view inside-out frameworks with suspicion (Matheson & Matheson, 1998).

If gaining knowledge about the world outside of the organization is crucial for strategic decision-making, the organization would also need to have the qualities to embrace uncertainty given that the environment in which businesses operate these days is characterized by uncertainty and the only constant is change. Perceived environmental uncertainty exists when decision-makers are not confident about understanding what the major events or trends are in an environment, or that they feel unable to accurately assign probabilities to the likelihood that particular events and/or changes will occur (Miliken, 1987). Scanning the environment could also be a difficult organizational process because the environment is complex (Cyert & March, 1963) and becoming more uncertain.

People of a smart organization should seek to understand all sources of uncertainty and apply such knowledge when making decisions (Matheson & Matheson, 1998), as strategic action depends on perceptions and interpretations of the environment (Schneider & De Meyer, 1991), and the environment is a major source of uncertainty for managers (Elenkov, 1997). It has been said that strategies are formulated in light of the perceived environmental conditions (such as uncertainties about the competitors, customers, and the environment) as well as internal capabilities (Parnell, Lester, & Menefee, 2000).

Research has identified multiple dimensions of the environment, such as dynamism, complexity, munificence, and uncertainty (Dess & Beard, 1984; Sharfman & Dean, 1991). Uncertainty has been defined as a combination of such perceived dynamism and complexity as they are held by the managers (Duncan, 1972; Koberg, 1987). Members of the organization are recommended to recognize that amid such uncertainty, decisions can be controlled but outcomes cannot. They need to understand uncertainty within their area of expertise, communicate such uncertainty accurately, and articulate it in terms of possibilities and probabilities with a realistic understanding of what they can influence and what may be beyond their control. The related organizational culture is one that promotes treating uncertain information as ranges or probability distributions. Forecasts are never turned into commitments because of the awareness of the uncertainty factor in the forecasts, and the decision-making process requires explicit consideration for risk and return (Matheson & Matheson, 1998).

Taking an outside-in strategic perspective requires knowledge about the external environment (such as knowledge regarding the customers, suppliers, and competitors) and embracing uncertainty calls for utilizing such knowledge to frame an analytical framework from which solutions and ideas in managing such uncertainty come up. Knowledge about customers, supplier, competitors, and industry may be gathered from various information sources within the organization, such as customer records and customer service survey results, market segmentation analysis, suppliers' order records, competitors' intelligence reports, and industry forecast. These various pieces of information may be scattered in different sections of the organization—for example, in customer service, marketing, logistics, and strategy planning departments respectively. The organization cannot have a complete picture of the external environment if it possesses knowledge of only one or two aspects of the environment—for instance, just the competitors and the industry. It needs knowledge of all relevant aspects of the environment, and this is where the knowledge management technology of enterprise informal portals comes in.

Enterprise Information Portals

An enterprise information portal can be defined as a single point of access for the pooling, organizing, interacting, and distributing of organizational knowledge (Aneja, Brooksby, & Rowan, 2000; Kendler, 2000; Schroeder, 2000). Enterprise portals have quite complex structures and features, but their basic functions and elements are relatively easy to define (Raol, Koong, Liu, & Yu, 2002). Firstly, from an operational point of view, the strength of enterprise portals lies in its ability to provide Web-based access to the organizational information, applications, and processes (Raol et al., 2002). Secondly, from a functional perspective, enterprise portals leverage existing information systems, data stores, networks, workstations, servers, and applications, as well as other knowledge bases, to give each individual within the organization immediate access to an invaluable set of organizational data anytime and anywhere (Kendler, 2000; White, 2000). As mentioned above, it is important for the organization to have knowledge about all relevant aspects of the environment when it takes an outside-in strategic perspective, and this function of enterprise portals being able to gather an integrated set of relevant information would help the organization in gathering the related knowledge in taking such perspective.

Enterprise portals could help an organization tap into not only its internal knowledge bases, such as the customer records, market segmentation reports, and industry forecasts, but also external sources about the environment, and therefore assist with the organization to take an outside-in perspective. In addition to ubiquity and ease of use of the Web browser interface, one of the important features of the enterprise portals is the availability of innumerable new data sources on the public Internet, in addition to the data sources across the organization (Kim, Chaudhury, & Rao, 2002). This has to do with the two-layered architecture of many enterprise portals, as explained below.

Aneja et al. (2000) comes up with a generic framework of an enterprise portal showing some of the major applications, entities, capabilities, tools, and their relationships, which was reproduced in Raol et al. (2002). The enterprise portal framework essentially contains two primary layers. At the core of any enterprise portal framework are the applications that it purports to support, which can range from unit-specific to organizational-wide capabilities, staff to administrative support functions, and individual to system-wide inquiries. Examples of such applications are office documents, decision support systems analysis/reporting, business content such as marketing and human resources information, personal or group Web sites, as well as collaboration facilities like e-mail and calendar (Aneja et al., 2000). The second layer consists of various Web-based drivers (Raol et al., 2000) leading to external information sources such as Web sites, news feeds, stock and weather information, or travel reservations (Aneja et al., 2000). These drivers are the means for the openness and easy access capabilities to the disparate databases and reports generated. Some of the core enterprise portal software functions include customization and personalization, collaboration and community, content management, ease of use, dynamism, and security (Raol et al., 2000).

The current political, business, and social environment is characterized by constant change. Individuals and organizations that are able to rise to the challenge of taking an outside-in perspective and appreciating the uncertainty of such an environment are those that engage themselves in learning about new events, circumstances, ideas, and people. Open information flow as a way for individuals within the organizations to gather new knowledge, as well as continual learning, are of crucial importance in this context.

Open Information Flow and Continual Learning

The purpose of having an open information flow in an organization is to "inform and be informed." The flow of information crosses functional boundaries, with virtually all information available to whomever that wants it. Information is routinely captured, packaged, shared, and applied, and used in various ways to create value. People in a smart organization feel safe sharing what they know, and feel obliged to contribute to information sharing systems and are excited about learning and teaching. The prevailing organizational culture should support an ethic of both "giving and getting" in relation to information sharing, and this would hopefully discourage information hoarding (Matheson & Matheson, 1998). The organizational culture drives the overall value system, providing norms for information sharing and reaching a consensus on its meaning (Sinkula, 1994). Such information sharing is essential for the organization to learn continually, so as to address and overcome various challenges arising from operating in this increasingly complex and ever-changing business environment.

A smart organization should have the purpose of learning continually about what creates value and how to deliver it (Matheson & Matheson, 1998). Learning would enrich the intellectual capital of both individuals and organizations, and such capital is a significant resource in generating value in today's knowledge economy. For a number of years, some of the world's most proactive observers of societal change have predicted the emergence of a new economy in which intellectual prowess, not machine capability as valued in the industrial economy, would be the critical resource (Graham, 1996).

It would be ideal if people in a smart organization were not only excited about learning and growing, but also willing to accept constructive comments and new ideas and apply the same to themselves and their organization (Matheson & Matheson, 1998). All individuals within the organization are continually engaged in learning, helping each other to learn, and sharing their learning (Lawler, 1988) to the extent that it would become a "learning organisation." A learning organization is an organization that purposefully adopts structures and strategies that encourage learning (Dodgson, 1993). When such an organization emphasizes continual learning, the organizational culture would be viewing change as important, emerging, and profitable, and as something routine leading to improvements (Matheson & Matheson, 1998). The organization should also adopt a critical attitude questioning organizational myths and assumptions, and even welcoming "bad news," which will be used to initiate improvements (Matheson & Matheson, 1998).

Learning occurs when organizations seek not just to synthesize but also institutionalize people's intellectual capital and learning, their memories, cultures, routines, and core competencies. Though people may come and go in an organization, its memories preserve the individuals' behaviour, norms, and values as accumulated over time, and gradually build an organizational structure that will become the repository for lessons learned as the organization addresses and solves its problems on its way. As the members of the organization leave and new ones join, it is crucial that the knowledge and competence of the former staff can be transferred to the new ones across generations of learning (O'Keeffe, 2002). The related knowledge management practices and technologies could facilitate this cross-generational learning process.

Communities of Practice

Knowledge management advocates support the idea of forming communities of practice in facilitating organizational learning process. The idea of a community of practice was developed by Lave and Wenger (1990) as a theory for practice-based learning in which one could undertake "legitimate participation" to serve a kind of apprenticeship with a group of "insiders" in an organization, organizations consisting of a range of different disciplinary groups or collectives, each charged with specific areas of responsibility. Wenger and Snyder (2000) later depicted a community of practice as a "group of people informally bound together by shared expertise and passion for a joint enterprise," with members inevitably sharing knowledge in order to solve problems in their organization (Russell, Calvey, & Banks, 2003).

Wenger (1998) incorporated both informational and interactive elements of knowledge into his community of practice theory through the concepts of reification and participation. Reification is "the process of giving form to our experience by producing objects [including symbols and texts] that congeal this experience into 'thingness'" (Wenger, 1998, p. 58). Reification represents the concreteness apparent in the informational view of knowledge. Participation gives the active and social element of knowledge through engagement in the activity. Reification and participation together form a duality interacting in the process of knowing (Iverson & McPhee, 2002).

Wenger (1998) further identified three characteristics of communities of practice: (1) mutual engagement, (2) negotiation of a joint enterprise, and (3) a shared repertoire. Mutual engagement involves interaction with other members within the community of practice during which members are motivated to negotiate their practices and the meanings of their actions. By being mutually engaged with one another, knowledge is shared and enacted. Members can offer to each other insights, adopt others' practices, critique practices, and share frustrations, and hopefully the members will learn from each other through open flow of information during such interaction. Negotiation of a joint enterprise gives a sense of purpose and coherence to the community of practice. It can be said to be the common purpose binding people together and providing a unifying goal and coherence for their actions. Wenger states that this negotiation process creates more than "just a stated goal but creates among participants relations of mutual accountability that become an integral part of the practice (Wenger, p. 76). The third characteristic is shared repertoire, which refers to the community's set of resources for negotiating meaning. Knowing the shared repertoire such as jargon, stories, and other forms of a stock of understood information and techniques as utilized by the community members can be a proof of membership (Iverson & McPhee, 2002).

Intranets

Intranets incorporating the feature of online discussion would be a useful knowledge management technology helping communities of practice to share knowledge and promote open flow of information and continual learning.

An intranet is an "internal corporate Internet," or a private network inside a company or organization allowing colleagues to communicate with each other and access corporate information (Chan, 2000). It is also possible to view the

Table 3. Knowledge management (KM) technologies/practices in smart organizations (SO)

SO Principle	**KM Technology/Practice**	**Features**
Value Creating Culture	Extranets	Secure Internet protocol-based networks linking the information infrastructures of various extranet participants.
	Customer Relationship Management Systems	They help manage customer relationships and facilitate relationship marketing.
Creating Alternatives and Disciplined Decision-Making	Intelligent Agents	They can learn the users' behavioural patterns and can have knowledge retrieval, profiling and filtering capacities.
	Knowledge Interchange Format	It is a language designed for interchanging knowledge among disparate systems.
Alignment, Empowerment and Systems Thinking	Organisational Decision Support Systems	They are systems providing managers with the relevant internal and external to facilitate their decision-making.
Outside-in Strategic Perspective and Embrace Uncertainty	Enterprise Information Portals	A portal is a single point of access for the pooling, organizing, interacting and distributing of organizational knowledge.
Open Information Flow and Continual Learning	Communities of Practice	Groups of people are informally bound together by similar expertise for sharing knowledge.
	Intranets	An intranet is an internal corporate Internet for communication and accessing corporate information.

intranet as a shared knowledge space for content, communication, and collaboration (Choo, Detlor, & Turnbull, 2000; Stenmark, 2002), as it provides a private space giving the employees in the organization the ability to organize information, readily access that information, manage documents, and enable efficient collaboration, all in a Web-based environment (Intranets.Com, 2004). From a knowledge-sharing point of view, an intranet provides a context where the essence of knowledge-sharing—dialogue, reflection, and perspective-making—could happen (Stenmark, 2002).

Intranets are said to facilitate collaboration, communication, and change mechanisms within organizations, achieving rapid transitions when the pace of change is critical (Ali, 2001). Recent research has shown that an interorganizational virtual team adapted to the use of a collaborative technology (an intranet) and achieved its objective of manufacturing a highly innovative product (Majchrzak, Rice, Malhotra, King, & Ba, 2000). The intranet serves newsgroups that facilitate exchanges of information between members, resulting in a corporate "knowledge base." The organization's members could subscribe to and view a screen with subject lines, authors, and news articles numbers. Each of these items serves as the beginning of a "thread" that started when someone sent out an article or e-mail; readers can then trace these threads deeper as they wish. In these ways, individuals with the organization can share knowledge and enhance the communication in the community of practice. Employees remain faithful to the informal social networks of "community of practice" as the principal mode of sharing and developing knowledge (Ali, 2001).

CONCLUSION AND FUTURE DIRECTION

As argued above, the common thread running the nine principles characterizing a smart organization is knowledge. In order to become smart, an organization needs to have knowledge about the customers' needs and how it can better satisfy their needs in order to create value. Extranets linking the information networks of the organization and the customers could help enhance customer service quality and deliver better value.

Creating alternatives and engaging in disciplined decision-making requires acquiring the knowledge about possibilities and probabilities, evaluating each of them, and selecting the most appropriate option. The proactive intelligent agents facilitate the knowledge discovery and sharing processes, maximizing the knowledge base on which creative ideas are formed and informed decisions are made. Alignment of goals and empowering individuals to act on a shared sense of purpose and deploy systems thinking would be achieved if the individuals within the organization managed complex issues by looking at the cause-and-effect relationships and examining the implications in relation to the big picture. Decision support systems would be able to help by weighing different factors, taking into account the goal and making the optimum choice.

Taking an outside-in strategic perspective and embracing uncertainty would involve gathering knowledge about such environmental factors as the suppliers, competitors, industry, and customers, and utilizing the same to make an appropriate strategic decision. Enterprise portals acting as a single gateway to organizational knowledge sources, both internal and external, would help with collecting information about the uncertain business environment to enable taking an outside-in strategic perspective. Open information flow and continual learning are essential if an organization wants to gain a competitive advantage in the knowledge age, because "knowledge" is the basis of competition; the technology of intranets would facilitate the process.

While there has been a substantial body of literature on knowledge management, as summarized above, recent literature search shows that little research has been done on knowledge management in the context of various aspects of smart organizations such as operations, strategy, human resources, and marketing. What has been proposed above—how knowledge management practices and technologies could help realize each of the nine principles characterizing smart organizations—is based on a theoretical perspective and personal insights rather than empirical evidence. It is based on the author's understanding of and insights into the theories relating to both knowledge management and smart organizations.

This could be regarded as the beginning of setting a future research direction—conducting empirical studies on proving, disproving, extending, or criticizing these theoretical insights to fill in the knowledge gap relating to how knowledge management could make a worthy contribution to smart organizations. For instance, one would look at how the related knowledge management technologies impact recruitment procedures in organizations from a human resources perspective. Another possibility would be examining how knowledge management technologies could innovate supply chain processes. Such studies would make a worthy contribution to the practitioners so that the latter could have a better understanding of how knowledge management technologies generate business value. They would also contribute to academia because little has been done on synergizing knowledge management theories with theories of other management or business disciplines, such as human resources, marketing, or finance. As we are in an era where boundaries are breaking down in various ways—politically, economically, and geographically, for instance—an interdisciplinary approach crossing academic disciplinary boundaries to understand knowledge management and other business disciplines would be timely.

REFERENCES

Ali, Y. (2001). The intranet and the management of making and using skills. *Journal of Knowledge Management, 5*(4), 338-348.

Ambite, J. L., & Knoblock, C. A. (1997). Agents for information gathering. *IEEE Expert, September/October,* 2-4.

Aneja, A., Brooksby, B., & Rowan, C. (2000). Corporate portal framework for transforming content chaos on intranets. *Intel Technology Journal, 11*, 21-28.

Anonymous (1997). Intellectual capital: Realising your company's true value by finding its hidden brainpower. *Research Technology Management, 40*(5), 59-60.

Band, W. (2000). Creating value for your customer. *Sales and Marketing Management in Canada, 31*(2), 4-6.

Berry, L. L. (1983). Relationship marketing. In G. L. S. Berry & G. D. Upah (Eds.), *Emerging perspectives on services marketing* (pp. 25-28). Chicago: American Marketing Association.

Burns, A., Rathwell, M., & Thomas, R. (1987). A distributed decision-making system.*Decision Support Systems, 3*, 121-131.

Bushko, D., & Raynor, M. (2001). Extranets and client relationships. *Consulting to Management, 12*(2), 3-4.

Caruso, T. E. (1992). Kotler: Future marketers will focus on customer data base to compete globally. *Marketing News, 26*(12), 21-22.

Cascante, L. P., Plaisent, M., Bernard, P., & Maguiraga, L. (2002). The impact of expert decision support systems on the performance of new employee. *Information Resources Management Journal, 15*(4), 64-79.

Chan, S. (2000, September 22). *Legal issues for extranets and e-commerce.* Web Review. Retrieved March 10, 2004, from http://www.catdancers.com/webmags/webrevu/2000/09_22/strategists/09_22_00_2.html

Choo, C. W., Detlor, B., & Turnbull, D. (2000). *Web work: Information seeking and knowledge work on the World Wide Web.* Dordrecht: Kluwer Academic Publishers.

Clarke, I. (2001). Emerging value propositions for m-commerce. *Journal of Business Strategies, 18*(2), 133-149.

Cyert, R. M., & March, J. G. (1963). *A behavioural theory of the firm.* Englewood Cliffs, NJ: Prentice-Hall.

Davenport, T., & Prusak, L. (1997). *Working knowledge: How organisations manage what they know.* Boston: Harvard Business School Press.

Davenport, T. H., De Long, D. W., & Beers, M. C. (1998). Successful knowledge management projects. *Sloan Management Review, 31*(4), 11-27.

Despres, C., & Chauvel, D. (2000). *Knowledge horizons: The present and the promise of knowledge management.* Woburn: Butterworth-Heinemann.

Dess, G. G., & Beard, D. W. (1984). Dimensions of organisational task environments. *Administrative Science Quarterly, 29*(1), 52-73.

Dodgson, M. (1993). *Technological collaboration in industry.* London: Routledge.

Drucker, P. F. (1993). *The post capitalist society.* Oxford, UK: Butterworth-Heinemann.

Duncan, R. B. (1972). Characteristics of organisational environments and perceivedenvironmental uncertainty. *Administrative Science Quarterly, 17,* 313-327.

Earl, M. (1994). The new and old of business process redesign. *Journal of Strategic Information Systems, 3*(1), 5-22.

Earl, M. (2001). Knowledge management strategies: Toward a taxonomy. *Journal of Management Information Systems, 18*(1), 215-233.

Edvinsson, L., & Malone, M. S. (1997). *Intellectual capital: realising your company's true value by finding its hidden brainpower.* New York: Harper Business.

Elenkov, D. S. (1997). Strategic uncertainty and environmental scanning: The case for institutional influences on scanning behaviour. *Strategic Management Journal, 18*(4), 287-303.

Feldman, S., & Yu, E. (1999). Intelligent agents: A primer. *Searcher, 7*(9). Retrieved January 18, 2003, from http://www.infotoday.com/searcher/oct99/feldman+yu.htm

Filos, E., & Banahan, E. (2000). Will the organisation disappear? The challenges of the new economy and future perspectives. In L. M. Camarinha-Matos, H. Afsarmanesh, & R. J. Rabelo (Eds.), *E-business and virtual enterprises* (pp. 3-20). Dordrecht: Kluwer.

Genesereth, M. R. (2004). *Knowledge interchange format.* Retrieved March 10, 2004, from http://logic.stanford.edu/kif/dpans.html

Graham, A. (1996). *The learning organisation: Managing knowledge for business success.* New York: The Economist Intelligence Unit.

Gronroos, C. (1997). Value-driven relational marketing: From products to resources and competencies. *Journal of Marketing Management, 13,* 407-419.

Hayes-Roth, F., Waterman, D. A., & Lenat, D. B. (1983). An overview of expert systems. In F. Hayes-Roth, D. A. Waterman, & D. B. Lenat

(Eds.), *Building expert systems* (pp. 3-29). Reading: Addison-Wesley.

Heskett, J. L., Jones, T. O., Loveman, G. W., Sasser, W. E., & Schlesinger, L. A. (1994). Putting the service-profit chain to work. *Harvard Business Review, March-April,* 164-175.

Holsapple, C. W., & Whinston, A. B. (1996). *Decision support systems: A knowledge-based approach.* St. Paul, MN: West Publishing.

Intranets.com (2004). *What is an Intranet?* Retrieved March 10, 2004, from http://www.intranets.com/ProductInfo/FAQs/What_Is_An_Intranet.asp?l=n

Iverson, J. O., & McPhee, R. D. (2002). Knowledge management in communities of practice. *Management communication quarterly, 16*(2), 259-267.

Kendler, P. B. (2000). Portals customise information access. *Insurance and technology, 25*, 47-51.

Kim, G. J., Graves, E. G., Burns, J. R., & Myung, R. (2000). An architecture for organisational decision support systems that utilise a model coordination subsystem. *Journal of End User Computing, 12*(3), 23-35.

Kim, Y. J., Chaudhury, A., & Rao, R. (2002). A knowledge management perspective to evaluation of enterprise information portals. *Knowledge and Process Management, 9*(2), 57-71.

Knoblock, C. A., Arens, Y., & Hsu, C. (1994). Cooperating agents for information retrieval. *Proceedings of the Second International Conference on Cooperative Information Systems.* Toronto, Canada: University of Toronto Press. Retrieved January 18, 2003, from http://www.isi.edu/info-agents/papers/knoblock94-coopis.pdf

Koberg, C. S. (1987). Resource scarcity, environmental uncertainty and adaptive organisational behaviour. *Academy of Management Journal, 30*(4), 798-807.

Kotler, P. (1990). *Speech presented at the Trustees Meeting of the Marketing Science Institute, Boston.*

Kuhn, T. S. (1970). *The structure of scientific revolution.* Chicago: University of Chicago Press.

Kutner, S., & Cripps, J. (1997). Managing the customer portfolio of healthcare enterprises. *The Healthcare Forum Journal, 4*(5), 52-54.

Lave, J., & Wenger, E. (1990). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Lawler, E. E. (1988). Choosing and involvement strategy. *Academy of Management Executive, 2,* 197-204.

MacGregor, R. (1990). The evolving technology of classification-based knowledge representation systems. In J. Sowa (Ed.), *Principles of semantic networks: Explorations in the representation of knowledge.* San Mateo: Morgan Kaufmann.

Majchrzak, A., Rice, R. E., Malhotra, A., King, N., & Ba, S. (2000). Technology adoption: The case of a computer-supported inter-organisational virtual team. *MIS Quarterly, 24*(4), 569-584.

Malhotra, Y. (1999). *Who started writing about knowledge management?* Retrieved March 6, 2004, from http://www.brint.com/wwwboard/messages/3332.html

Matheson, D., & Matheson, J. E. (1998). *The smart organisation: Creating value through strategic R&D*. Cambridge, MA: Harvard University Press.

Matheson, D., & Matheson, J. E. (2001). Smart organisations perform better. *Research Technology Management, 44*(4), 49-55.

Miliken, F. J. (1987). Three types of uncertainty about the environment: State, effect and response uncertainty. *Academy of Management Review, 12,* 133-143.

Miller, F. J. (1999). *I = 0. Information has no intrinsic meaning.* Retrieved October 17, 2004, from http://www.sveiby.com/articles/Miller99.html

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation.* New York: Oxford University Press.

O'Keeffe, T. (2002). Organisational learning: A new perspective. *Journal of European Industrial Training, 26*(2-4), 130-142.

Parnell, J. A., Lester, D. L., & Menefee, M. L. (2000). Strategy as a response to organisational uncertainty: An alternative perspective on the strategy-performance relationship. *Management Decision, 38*(8), 520.

Patelis, A., Metaxiotis, K., Nikolpoulos, K., & Assimakopoulos, V. (2003). FORTV: Decision support system for forecasting television viewership. *The Journal of Computer Information Systems, 43*(4), 100-109.

Polanyi, M. (1958). *Personal knowledge*. Chicago: University of Chicago Press.

Polanyi, M. (1966). *The tacit dimension*. London: Routledge & Kegan Paul.

Porter, M. E. (1998). *Competitive advantage: Techniques for analysing industries and competitors.* New York: The Free Press.

Ramirez, R. (1999). Value co-production: Intellectual origins and implications for practice and research. *Strategic Management Journal, 20,* 49.

Raol, J. M., Koong, K. S., Liu, L. C., & Yu, C. S. (2002). An identification and classification of enterprise portal functions and features. *Industrial Management and Data Systems, 102*(7), 390-400.

Rastogi, P. N. (2003). The nature and role of IC: Rethinking the process of value creation and sustained enterprise growth. *Journal of Intellectual Capital, 4*(2), 227-248.

Reichheld, E. (1996). *The loyalty effect.* Boston: Harvard Business School Press.

Rhodes, B. J., & Maes, P. (2000). Just-in-time information retrieval agents. *IBM Systems Journal, 39*(3/4), 685-704.

Roberts, H. (2000). Classification of intellectual capital. In J. E. Grojer & H. Stolowy (Eds.), *Classification of intangibles* (pp. 197-205). Jouy-en-Josas, France: Groupe HEC.

Russell, D., Calvey, D., & Banks, M. (2003). Creating new learning communities: Towards effective e-learning production. *Journal of Workplace Learning, 15*(1), 34-45.

Ryals, L., & Payne, A. (2001). Customer relationship management in financial services: Towards information-enabled relationship marketing. *Journal of Strategic Marketing, 9,* 3-27.

Schneider, A. C., & De Meyer, A. (1991). Responding and interpreting to strategic issues: The impact of national culture. *Strategic Management Journal, 12*(4), 307-320.

Schoderbek, P. P., Schoderbek, C. G., & Kefalas, A. G. (1985). *Management systems: Conceptual considerations.* Plano, TX: Business Publications.

Schroeder, J. (2000). Enterprise portals: A new business intelligence paradigm. *MIS Quarterly, 23,* 124-126.

Senge, P. (1990). *The fifth discipline.* New York: Double Day/Currency.

Sharfman, M. P., & Dean, J. W. (1991). Conceptualising and measuring organisational environment: A multidimensional approach. *Journal of Management, 17,* 681-700.

Sheth, J. N. (2000). Relationship marketing Paradigm shift or shaft? In J. N. Sheth & Parvatiyar (Eds.), *Handbook of relationship marketing* (pp. 609-620). Thousand Oaks: Sage Publications.

Silberston, A. (1967). The patent system. *Lloyds Bank Review, 84*(April 1967), 32-44.

Simons, R. (1995). *Levers of control: How managers use innovative control systems to drive strategic renewal.* Boston: Harvard Business School Press.

Sinkula, J. M. (1994). Marketing information processing and organisational learning. *Journal of Marketing, 58*(January), 35-45.

Skoog, M. (2003). Visualising value creation through the management control of intangibles. *Journal of Intellectual Capital, 4*(4), 487-504.

Snowden, D. (2002). *Complex acts of knowing—Paradox and descriptive self-awareness.* IBM Global Services: July 2003. Retrieved March 10, 2004, from http://www-1.ibm.com/services/files/complex.pdf

Stenmark, D. (2002). Information vs. knowledge: The role of intranets in knowledge management. *Proceedings of the 35th Hawaii International Conference on System Sciences 2002.* Retrieved March 10, 2004, from http://w3.informatik.gu.se/~dixi/publ/ddoml02.pdf

Stenmark, D. (2003). *Research: Agents. Dick Stenmark's* (Volvo Information Technology Department and Viktoria Institute's Knowledge Management Group) Home Page. Retrieved January 16, 2003, from http://w3.informatik.gu.se/~dixi/agent/class.htm

Sveiby, K. (2001). *What is knowledge management?* Retrieved March 1, 2004, from http://www.sveiby.com/articles/KnowledgeManagement.html

Swanston, E. B., & Zmud, R. W. (1989). *Organisational decision support systems: Conceptual notions and architectural guidelines. Information systems and decision processes workshop.* Tucson, AZ.

Ursin, J. (2000). *Group dynamics in the production of new knowledge—A theoretical framework.* Retrieved March 7, 2004, from http://www.leeds.ac.uk/educol/documents/00001609.htm

Vallee, M. (2003). System thinking for quality management and continuous improvement in mining. *CIM Bulletin, 96*(1068), 48-58.

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity.* New York: Cambridge University Press.

Wenger, E. C., & Snyder, W. M. (2000). Communities of practice: The organisational frontier. *Harvard Business Review, 1*, January.

White, M. (2000). Corporate portal: Realising their promises, avoiding costly failure. *Business Information Review, 17,* 71-81.

Yen, D. C., & Chou, D. C. (1999/2000). Extranet: Current developments and future analysis. *The Journal of Computer Information Systems, 40*(2), 46-54.

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Chapter 8.21
Knowledge Management Metrics:
A Review and Directions for Future Research

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ABSTRACT

Metrics are essential for the advancement of research and practice in an area. In knowledge management (KM), the process of measurement and development of metrics is made complex by the intangible nature of the knowledge asset. Further, the lack of standards for KM business metrics and the relative infancy of research on KM metrics points to a need for research in this area. This article reviews KM metrics for research and practice, and identifies areas where there is a gap in our understanding. It classifies existing research based on the units of evaluation such as user of knowledge management systems (KMS), KMS project, KM process, KM initiative, and organization as a whole. The article concludes by suggesting avenues for future research on KM and KMS metrics based on the gaps identified.

INTRODUCTION

Knowledge management (KM) has become an accepted part of the business and academic agenda. Organizations have high expectations for KM to play a significant role in improving their competitive advantage (KPMG, 2000). Measuring the business value of KM initiatives has become imperative to ascertain if the expectations are realized.

Metrics are measures of key attributes that yield information about a phenomenon (Straub, Hoffman, Weber, & Steinfield 2002). Metrics are key to advancement of research and practice in an area. In research, they provide comparability of studies between individuals, time periods, organizations, industries, cultures, and geographic regions (Cook & Campbell, 1979). They also provide a basis for empirical validation of theories and relationships between concepts. Measures that are reliable and valid enable accumulation of research in a topic area, and free subsequent researchers from the need to redevelop instruments (Boudreau, Gefen, & Straub, 2001).

For practitioners, metrics are a way of learning what works and what does not. In fact, measuring business performance is the focus of the entire field of management accounting. In KM, performance measures serve several objectives including securing funding for KM implementation, providing targets and feedback on implementation, assessing implementation success, and deriving lessons for future implementation. Measures can assist in evaluating the initial investment decision and in developing benchmarks for future comparison.

Measurement is typically a complex process fraught with errors. What is easy to measure is not always important and what is important is often difficult to measure (Schiemann & Lingle, 1998). KM metrics are particularly distinct from other metrics due to the intangible nature of the knowledge resource (Glazer, 1998). Something such as knowledge that is difficult to define and has multiple interpretations is likely to be difficult to value and measure. Due to such considerations and the complexity of assessing organizational initiatives in general, research (Grover & Davenport, 2001) and practice (Bontis, 2001) on the assessment of KM initiatives and knowledge management systems (KMS) is not well developed.

In light of the above motivations, this study seeks to review metrics in practice and research and identify areas for further investigation. Previous research on metrics for KM and KMS is classified based on the elements of evaluation such as user of KMS, KMS project, KM process, KM initiative, and organization as a whole.

In the next section, some basic definitions of metrics and KMS are provided. This is followed by the review of practice KM metrics, classification of research on KMS and KM metrics, and finally a discussion of areas for further investigation.

DEFINITIONS

Metrics and Measures

At the outset it is important to distinguish what is meant by a metric and a measure. The IEEE standard glossary of software engineering provides the following definitions of measures and metrics. A measure is a standard, unit, or result of measurement (IEEE, 1983). A metric is a quantitative measure of the degree to which a system, entity, or process possesses a given attribute (IEEE, 1990). An example of a measure is a patient's temperature value of 99 degrees Fahrenheit. Without a trend to follow or an expected value to compare against, a measure gives little or no information. It especially does not provide enough information to make meaningful decisions. A metric is a comparison of two or more measures, for example, body temperature over time. It allows a trend or pattern to be seen in the measure. Therefore, a measure by itself doesn't provide much understanding unless it is compared with another value of the measure—that is, it becomes a metric. Hence the focus of our review is on metrics for KMS and KM initiatives.

KM and KMS

KM involves the basic processes of creating, storing and retrieving, transferring, and applying knowledge. The ultimate aim of KM is to avoid reinventing the wheel and leverage cumulative organizational knowledge for more informed decision making (Alavi & Leidner, 2001). Examples of ways in which knowledge can be leveraged include: transfer of best practices from one part of an organization to another part, codification of individual employee knowledge to protect against employee turnover, and bringing together knowledge from different sources to work on a specific project.

Information technology (IT) is recognized as a key enabler of KM (although there are many other factors that are necessary for KM success). Without the capabilities of IT in terms of both storage and communication, leveraging of knowledge resources would hardly be feasible (Alavi & Leidner, 2001). A variety of tools are available to organizations to facilitate the leveraging of knowledge. These tools (KMS) are defined as a class of information systems applied to managing organizational knowledge. That is, they are IT-based systems developed to support and enhance the organizational processes of knowledge creation, storage/retrieval, transfer, and application (Alavi & Leidner, 2001). Common KMS technologies include intranets and extranets, search and retrieval tools, content management and collaboration tools, data warehousing and mining tools, and groupware and artificial intelligence tools, like expert systems and knowledge-based systems.

Two models of KMS have been identified in information systems research (Alavi & Leidner, 1999), both of which may be employed by organizations to fulfill different needs. These two models correspond to two different approaches to KM—the codification approach and the personalization approach[1] (Hansen, Nohria, & Tierney, 1999). The repository model of KMS associated with the codification approach focuses on the codification and storage of knowledge in knowledge bases. The purpose is to facilitate knowledge reuse by providing access to codified expertise. Electronic knowledge repositories (EKRs) to code and share best practices exemplify this strategy (Alavi & Leidner, 2001). A related term, organizational memory information system (OMIS), refers to any system that functions to provide a means by which knowledge from the past is brought to bear on the present in order to increase levels of effectiveness for the organization (Stein & Zwass, 1995).

The network model of KMS associated with the personalization approach attempts to link people to enable the transfer of knowledge. One way to do this is to provide pointers to location of expertise in the organization, that is, who knows what and how they can be contacted. This method is exemplified by knowledge directories, commonly called "yellow pages" (Alavi & Leidner, 2001). It has been noted that in order to access the knowledge in an organization that remains uncodified, mapping the internal expertise is useful (Ruggles, 1998).

A second way is to link people who are interested in similar topics. The term communities of practice (COPs) has come into use to describe such flexible groups of professionals informally bound by common interests who interact to discuss topics related to these interests (Brown & Duguid, 1991). KMS that provide a common electronic forum to support COPs exemplify this approach (Alavi & Leidner, 2001). The two models of KMS allow us to make sense of existing KMS metrics (since metrics for a particular type of KMS are similar) and identify directions for further evaluation of KMS.

KM AND KMS METRICS IN PRACTICE

KM Metrics

Most practice metrics of KM initiatives focus on measuring knowledge assets or intellectual capital (IC) of a firm, assuming the outcome of a KM initiative is its impact on IC. The majority of respondents of practice surveys think that IC should be reported and knowledge measurement would improve performance (Bontis, 2001). Even the process of measuring IC is considered important, whether as an internal management tool or for external communication on financial balance sheets.

Three general-purpose approaches to measuring the impact of KM initiatives include House of Quality (Quality Function Deployment or QFD), Balanced Scorecard, and American Productivity Center (APQC) benchmarking approach (Tiwana, 2000). The House of Quality (Hauser & Clausing, 1988) method involves the development of a metrics matrix (house). The desirable outcomes of KM initiatives are listed on the left wall of the house, the roof consists of the performance metrics, the right wall consists of the weights (relative importance of the outcomes), and the base of the house consists of targets, priorities, and benchmark values. By looking at the correlations within the body of the matrix, management can decide to focus on those areas of KM that are most likely to affect overall firm performance. A number of software tools such as QFD designer are available to automate the analysis process.

The Balanced Scorecard technique developed by Kaplan and Norton (1996) aims to provide a technique to balance long-term and short-term objectives, financial and non-financial measures, leading and lagging indicators, and internal and external perspectives. Typically four views—customer, financial, internal business, and learning and growth—are used to translate high-level strategies to real targets. Within each view, the goals, metrics, targets, and initiatives are listed. Relationships between views must also be considered. The views (dimensions) can be suitably adapted to assess the current state of KM and evaluate the impact of initiatives in this area. Here also software tools are available, though in general the balanced scorecard is more difficult to develop than QFD. However, it is likely to yield more "balanced" goals with a built-in consideration of the causal relationships.

The APQC process classification framework (PCF) provides a detailed taxonomy of business processes derived from the joint effort of close to 100 U.S. businesses (APQC, 1998). The PCF can be employed to benchmark and assess impact on business processes as a result of introduction of KM initiatives. Other general measures of firm performance such as Economic Value Added (EVA) and Tobin Q can also be used for evaluating IC (Stewart, 1997).

Three other metrics specific to KM are the Skandia Navigator, IC index, and Intangible Assets Monitor. The Skandia Navigator (Edvinsson & Malone, 1997) consists of 112 IC and traditional metrics (with some overlap between metrics) in five areas of focus (financial, customer, process, renewal and development, human). These areas are similar to the balanced scorecard views, except for the additional human focus area in the Skandia metric (more areas can also be added in Balanced Scorecard as desired, though a limit of seven areas is suggested). Out of all the indicators, the monetary indicators are combined into a single dollar value C, while the remaining percentage completeness measures are combined into an efficiency indicator I which captures the firm's velocity or movement towards desired goals. The overall IC measure is a multiplication of I and C.

The IC index (Roos, Roos, Dragonetti, & Edvinsson, 1998) is an extension to the Skandia IC metric that attempts to consolidate measures into a single index and correlate this index with changes in the market, that is, it focuses on monitoring the dynamics of IC. It consists of monitoring both IC stock and IC flow. A third technique is the Intangible Assets Monitor (Sveiby, 1997). Intangible asset value is defined as the book value of the firm minus the tangible assets and the visible debt. Three components of intangible assets are external structure (brand, customer, and supplier relations), internal structure (management, legal, manual, attitude, software), and individual competence (education, experience, expertise). For each intangible asset component, three indicators focus on growth and renewal, efficiency, and stability of that component. Other KM-specific techniques include Technology Broker (Brooking, 1996) and Citation-Weighted Patents (Hall, Jaffe, & Trajtenberg, 2000).

Whether it is the more general purpose or the more KM-specific techniques for business performance evaluation, the efficacy of all techniques depends on the competence of management in applying these techniques. Although the above-mentioned techniques attempt to provide systematic and comprehensive indicators, there are a number of subjective judgments to be made in applying these techniques, including determining which objectives are more important than others and which indicators need to be given greater weight. As pointed out in previous studies (Bontis, 2001), a further limitation on these IC techniques is that many of them use different terms to label similar measures. A lack of standards leads to proliferation of measures and difficulty in comparison. Also, since most of the evidence on KM assessment is on a case-by-case basis, there is a lack of generalizable results on this topic.

KMS Metrics

Organizations employ a variety of metrics to assess their KMS (Department of Navy, 2001). System-level measures for EKR include number of downloads, dwell time, usability surveys, number of users, and number of contributions and seeks. Measures for electronic COPs include number of contributions and seeks, frequency of update, number of members, and ratio of number of members to the number of contributors. System-level measures have been used for evaluating and monitoring particular KMS implementations. Here also the literature is mainly in the form of individual case studies (e.g., Wei, Hu, & Chen, 2002), and generalizable measurement techniques are lacking.

PREVIOUS RESEARCH ON KM AND KMS METRICS

Grover and Davenport (2001) suggested a pragmatic framework for KM research based on the knowledge process and the context in which the process is embedded. The knowledge process can be divided into generation, codification, transfer, and realization. The elements of the embedded context include strategy, structure, people/culture, and technology. The framework can be applied for processes at individual, group, and organization levels. We adopt a similar classification for categorizing previous research on KM and KMS metrics based on elements of evaluation (user, system, project, process, and organization level).

The previous research articles have been selected based on the following criteria. First, they are empirical articles that have proposed and tested metrics for evaluating KMS users, KMS project, KM process, or organizational outcomes. Second, they are chosen from reputed journals such as MIS Quarterly, Management Science, Information Systems Research, ACM Transactions, IEEE Transactions, Journal of the American Society for Information Science and Technology, Journal of Management Information Systems, Organization Science, Administrative Science Quarterly, Journal of Strategic Information Systems, Decision

Support Systems, Information and Management, Harvard Business Review, Sloan Management Review, and California Management Review, as well as established IS conferences such as the International Conference on Information Systems, Hawaii International Conference on Systems Sciences, and Americas Conference on Information Systems. The articles span the period from 1998 to present, with the exception of the Constant, Sproull, and Kiesler (1996) article that is one of the first research articles in its area.

User Evaluation

The articles on user evaluation are tabulated according to the type of user (contributor or seeker), type of KMS, and the sample of the empirical study (Table 1). The bulk of previous research at the user level has been studies to evaluate the motivation of users to contribute to or seek knowledge from different types of KMS, and in a few studies the consequent usage of KMS. Research has investigated both contributor and seeker motivations for using both repository and network model KMS. Most of the samples for the studies have been drawn from one organization or one online forum.

KMS Evaluation

The articles on KMS evaluation are tabulated according to the type of KMS, performance criteria suggested, and the sample of the empirical study (Table 2). It can be seen that a variety of performance criteria have been proposed focusing on user, task, KM process, and organizational outcomes for different KMS. The samples in these studies have been drawn both from single organizations as well as multiple organizations.

Table 1. Selected studies on KMS users

Study	User	KMS	Sample
Constant, Sproull, & Kiesler 1996	Contributor factors on seeker	Email distribution list	Tandem Computers, 48 seekers & 263 contributors
Goodman & Darr 1998	Contributor and seeker	Repository + electronic COP	Office equipment distributor, 1500 respondents
Kankanhalli, Tan & Wei 2001	Seeker	Repository	128 knowledge workers
Wasko & Faraj 2000	More emphasis on contributor	Electronic COP	3 Usenet groups, 342 participants
Kuo, Young, Hsu, Lin, & Chiang 2003	Contributor and seeker	Electronic COP	264 teachers in an online forum
Zhang & Watts 2003	Seeker	Electronic COP	145 participants in a travel forum
Jarvenpaa & Staples 2000	Contributor and seeker combined	All electronic media	1 University, 1125 employees
Bock & Kim 2002	Contributor	All electronic media	4 Public organizations

Table 2. Selected studies on KMS evaluation

Study	KMS	Performance Criteria	Sample
Ackerman 1998	Answer Garden Knowledge Repository (FAQ) + Electronic COP (via email)	• Usage - heavy, intermittent, tire-kicker • User evaluation in seeking answer • Expert evaluation of providing answer	2 univ lab sites, 49 users (seeker), 7 experts (contributor)
Baek & Liebowitz 1999	Knowledge repository	Contributor • Simplicity, richness, flexibility of creation • Ease of consistency checking, ease of knowledge change management Seeker • Ease of knowledge navigation and searching Both • Awareness, timeliness, fairness	2 multimedia design teams (3 members & 4 members)
Jennex, Olfman, Panthawi & Park 1998	Organization memory information system	• Individual job time, number of assignments, completeness of solutions, quality of solutions, complexity of assignment, client satisfaction • Organizational unit capability (problem correct) Unplanned scrams (problem solve)	120 engineers in 2 nuclear power plants
Jennex & Olfman 2002	Organization memory information system	• Integration • Adaptation • Goal attainment • Pattern Maintenance	83 engineers
Hendriks & Vriens 1999	Knowledge based system (expert system)	Assessment of current knowledge • Establishment of strategic value of knowledge • Comparison of knowledge to competition • Establishment of required knowledge • Creation of new knowledge • Distribution of knowledge • Application of knowledge • Evaluation of knowledge	17 organizations (government, bank, insurance, manufacturing)
Nissen 1999	Koper Knowledge based system	KM effects • Knowledge capture, organization and formalization • Knowledge distribution and application • Analytical consistency and completeness • Knowledge integration	Large multisite enterprise
Gottschalk 2000	Data warehouse, executive IS, expert system, enterprise wide system, intranet	IT support for KM • Generating knowledge • Accessing knowledge • Transferring knowledge • Sharing knowledge • Codifying knowledge	73 law firms in Norway
Ruppel & Harrington	Intranet implementation	Level of implementation for knowledge sharing	44 organizations (different industries)
Maier 2002	Knowledge management system	DeLone and McLean IS success model based criteria	73 organizations

Project Evaluation

Relatively fewer articles were found on KM metrics related to project evaluation (Table 3). These articles are tabulated based on the nature of the project, the performance criteria, and the sample of the study. The projects include software development, new product development, and process improvement projects. In the first study of the table, the performance criteria are in terms

Table 3. Selected studies on project evaluation

Study	Project	Performance Criteria	Sample
Verkasalo & Lappalainen 1998	Hypertext annual plan project	Efficiency index for knowledge utilization • Process width = number of employees • Process delay = time taken to spread / distribute • Process effort = time to document, distribute, and perceive use (not collect and compile)	Nokia telecom factory
Hansen 1999	New product development project	Project completion time (conception to market)	120 projects in a large electronics company
Mukherjee, Lapre, &Wassenhove 1998	Total quality management project	Project performance, goal achievement, ability to specify impact, change in attention rules	62 projects in a Belgian multinational steel wire manufacturer

Table 4. Selected studies on organizational-level KM evaluation

Study	Impact of	Performance Criteria	Sample
Khalifa, Lam, & Lee 2001	Overall KM initiative	KM effectiveness (organizational performance impacts)	185 KM practitioners from discussion forums
Becerra-Fernandez & Sabherwal 2001	Knowledge internalization, externalization, combination, socialization + all KM tools use	KM satisfaction (availability, effectiveness of knowledge, KM at task, directorate, across organization, knowledge sharing)	Kennedy Space Center, 159 employees from 8 sub-units
Gold, Malhotra, & Segars 2001	KM capability: Knowledge infrastructure, Knowledge process	Organization effectiveness • Innovation and commercialization, coordination of unit • Anticipate and identify opportunities • Speed and adaptation to market • Avoid redundancy and streamline	323 executives, finance and manufacturing, large organizations
Tanriverdi 2002	IT Knowledge relatedness	Market based performance Tobin's Q	315 firms, manufacturing and service

of the knowledge process, whereas in the other two studies, knowledge processes (sharing and creation) appear as mediators. All these studies are tested on single or multiple projects within a single organization.

KM Process and Organizational-Level Evaluation

A relatively popular area of research on KM and KMS metrics has been at the KM process and organizational level. Similar to the practice business performance metrics, the research metrics at this level also attempt to tease out the relationships between KM initiative, process, or capability, and firm performance, albeit with a theoretical emphasis. Literature in this area is tabulated based on the independent variables, performance criteria, and the sample (Table 4). Effectiveness outcomes have been studied in single and multiple organizational settings.

DIRECTIONS FOR FUTURE RESEARCH

From our literature review we can infer certain gaps in research on KM and KMS metrics in terms of unit or level of study. At the intersection of user and system level, most research tends to investigate motivations of users. There is a lack of research on usability of KMS and limited studies on usage of KMS. Both usability and usage studies, if well designed, can provide a good indicator of user acceptance of KMS. For example usability studies of both interactive and integrative KMS may be undertaken. Also, comparative studies of KMS usability may prove fruitful. Studies across multiple organizations or forums can add to existing studies.

At the system level, the majority of studies appear to focus on EKR, OMIS, knowledge-based systems, and overall KM technologies. There appears to be a lack of evaluation studies on electronic COPs since the majority of studies on COPs appear to be anecdotal in nature. Therefore future research can investigate suitable metrics for evaluating electronic COPs, an integral part of the network model of KMS. Further, review studies can help to infer commonalities and differences among the metrics for different forms of KMS.

There appears to be a relative paucity of KM evaluation studies at the group and team levels, except for a few virtual team studies (e.g., Alavi & Tiwana, 2002). Although there have been studies at the project level (Table 3) which could be interpreted as group-level evaluations, these studies did not investigate group characteristics and team dynamics in relation to evaluation of KM. This area presents an opportunity for future research on team effectiveness in terms of KM. For example, studies of how effective KMS are in terms of facilitating group, team, and project KM may be useful. Additionally, a greater variety of projects can be studied to draw inferences about what metrics are useful for particular types of projects. Alternatively, metrics for a particular type of project can be compared across different organizations.

In relation to Grover and Davenport's (2001) framework, there appears to be a lack of studies focusing purposefully on evaluation of KM strategy and KM structure. Considering that both elements can be vital to the success of KM initiatives, research on these elements is required. Additionally there is a gap between the micro-level assessment studies (user and system level) and the macro-level assessment studies (organization level). Possibly more research on team, project, and business unit level KM evaluation may serve to bridge this gap. Aggregation from user and system-level evaluation to team, project, and business unit-level evaluation—and subsequently to organization-level KM evaluation—could provide a worthwhile avenue for future research.

Although limited by the fact that a complete review of literature cannot be claimed, this study sheds light on the existing research on KMS and KM metrics. It also serves to identify potential areas where further evaluation research would be useful. Given that organizations are expending significant resources towards implementing KM initiatives and KMS, more research on metrics in these areas is warranted.

REFERENCES

Ackerman, M.S. (1998). Augmenting organizational memory: A field study of answer garden. *ACM Transactions on Information Systems, 16*(3), 203-224.

Alavi, M., & Leidner, D.E. (1999). Knowledge management systems: Issues, challenges and benefits. *Communications of AIS, 1*, 1-37.

Alavi, M., & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quarterly, 25*(1), 107-136.

Alavi, M., & Tiwana, A. (2002). Knowledge integration in virtual teams: The potential role of KMS. *Journal of the American Society for Information Science and Technology, 53*(12), 1029-1037.

APQC. (1998). *Process classification framework.* Retrieved from http://www.apqc.org/portal/apqc/site/generic2?path=/site/metrics/list_of_measures.jhtml

Baek, S., & Leibowitz, J. (1999). Designing a Web-based knowledge repository in a virtual team and exploring its usefulness. *Proceedings of the Americas Conference on Information Systems,* Milwaukee, Wisconsin.

Becerra-Fernandez, I., & Sabherwal, R. (2001). Organizational knowledge management: A contingency perspective. *Journal of Management Information Systems, 18*(1), 23-55.

Bock, G.W., & Kim, Y.G. (2002). Breaking the myths of rewards: An exploratory study of attitudes about knowledge sharing. *Information Resources Management Journal, 15*(2), 14-21.

Bontis, N. (2001). Assessing knowledge assets: A review of the models used to measure intellectual capital. *International Journal of Management Review, 3*(1), 41-60.

Boudreau, M., Gefen, D., & Straub, D.W. (2001). Validation in IS research: A state-of-the-art assessment. *MIS Quarterly, 25*(1), 1-24.

Brooking, A. (1996). *Intellectual capital: Core assets for the third millennium enterprise.* London: Thomson Business Press.

Brown, J.S., & Duguid, P. (1991). Organizational knowledge and communities of practice. *Organization Science, 2*(1), 40-57.

Constant, D., Sproull, L., & Kiesler, S. (1996). The kindness of strangers: The usefulness of electronic weak ties for technical advice. *Organization Science, 7*(2), 119-135.

Cook, T.D., & Campbell, D.T. (1979). *Quasi-experimentation: Design and analysis issues for field settings.* Boston: Houghton Mifflin.

Department of Navy. (2001). *Metrics guide for knowledge management initiatives.* Retrieved September 21, 2004, from http://openacademy.mindef.gov.sg/OpenAcademy/Central/HTML%20Folder/KM/bcp/downloads/KM_Metrics_Guide _Final_15AUG01.doc

Edvinsson, L., & Malone, M.S. (1997). *Intellectual capital: Realizing your company's true value by finding its hidden brainpower.* New York: Harper Business.

Glazer, R. (1998). Measuring the knower: Towards a theory of knowledge equity. *California Management Review, 40*(3), 175-194.

Gold, A.H., Malhotra, A., & Segars, A.H. (2001). Knowledge management: An organizational capabilities perspective. *Journal of Management Information Systems, 18*(1), 185-214.

Goodman, P.S., & Darr, E.D. (1998). Computer-aided systems and communities: Mechanisms for organizational learning in distributed environments. *MIS Quarterly, 22*(4), 417-440.

Gottschalk, P. (2000). Knowledge management in the professions: The case of IT support in law firms. *Proceedings of the Hawaii International Conference on Systems Sciences.*

Grover, V., & Davenport, T. (2001). General perspectives on knowledge management: Fostering a research agenda. *Journal of Management Information Systems, 18*(1), 5-22.

Hall, B., Jaffe, A., & Trajtenberg, M. (2000). *Market value and patent citations: A first look.* NBER Working Paper No. W7741, Cambridge, MA.

Hansen, M.T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization sub-units. *Administrative Science Quarterly, 44*(1), 82-111.

Hansen, M.T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Hauser, J., & Clausing, L. (1988). The house of quality. *Harvard Business Review, 3,* 63-73.

Hendriks, P.H.J., & Vriens, D.J. (1999). Knowledge-based systems and knowledge management. *Information and Management, 35,* 113-125.

IEEE. (1983). *IEEE standard glossary of software engineering terminology.* IEEE Std 729.

IEEE. (1990). *IEEE standard glossary of software engineering terminology.* IEEE Std 610.12.

Jarvenpaa, S.L., & Staples, D.S. (2000). The use of collaborative electronic media for information sharing: An exploratory study of determinants. *Journal of Strategic Information Systems, 9*(2-3), 129-154.

Jennex, M., Olfman, L., Panthawi, P., & Park, Y. (1998). An organizational memory information systems success model: An extension of DeLone and McLean's I/S success model. *Proceedings of the Hawaii International Conference on Systems Sciences.*

Jennex, M., & Olfman, L. (2002). Organizational memory/knowledge effects on productivity: A longitudinal study. *Proceedings of the Hawaii International Conference on Systems Sciences.*

Kankanhalli, A., Tan, B.C.Y., & Wei, K.K. (2001). Seeking knowledge in electronic knowledge repositories: An exploratory study. *International Conference on Information Systems,* New Orleans, LA.

Kaplan, R., & Norton, D. (1996). *Translating strategy into action: The balanced scorecard.* Boston: Harvard Business School Press.

Khalifa, M., Lam, R., & Lee, M. (2001). An integrative framework for knowledge management effectiveness. *Proceedings of the International Conference on Information Systems,* New Orleans, LA.

KPMG. (2000). *Knowledge management research report 2000.*

Kuo, B.F.Y., Young, M., Hsu, M., Lin, C., & Chiang, P. (2003). *A study of the cognition-action gap in knowledge management. International Conference on Information Systems,* Seattle, WA.

Maier, R. (2002). *Knowledge management systems: Information and communication technologies for knowledge management.* Berlin: Springer-Verlag.

Mukherjee, A.S., Lapre, M.A., & Wassenhove, L. (1998). Knowledge-driven quality improvement. *Management Science, 44*(11), S35-S49.

Nissen, M.E. (1999). Knowledge-based knowledge management in the re-engineering domain. *Decision Support Systems, 27,* 47-65.

Roos, J., Roos, G., Dragonetti, N.C., & Edvinsson, L. (1998). *Intellectual capital: Navigating in the new business landscape.* London: Macmillan.

Ruggles. (1998). The state of the notion: Knowledge management in practice. *California Management Review, 40*(3), 80-89.

Ruppel, C.P., & Harrington, S.J. (2001). Sharing knowledge through intranets: A study of organizational culture and intranet implementation. *IEEE Transactions on Professional Communication, 44*(1), 37-50.

Schiemann, W.A., & Lingle, J. (1998). Seven greatest myths of measurement. *IEEE Engineering Management Review, 26*(1), 114-116.

Stein, E.W., & Zwass, V. (1995). Actualizing organizational memory with information systems. *Information Systems Research, 6*(2), 85-117.

Stewart, T. (1997). *Intellectual capital: The new wealth of organizations.* New York: Doubleday.

Straub, D.W., Hoffman, D.L., Weber, B.W., & Steinfield, C. (2002). Measuring e-commerce in Net-enabled organizations: An introduction to the special issue. *Information Systems Research, 13*(2), 115-124.

Sveiby, K.E. (1997). *The new organizational wealth: Managing and measuring knowledge-based assets.* San Francisco: Barrett-Kohler.

Tanriverdi, H. (2002). Does IT knowledge relatedness differentiate performance of multi-business firms? *International Conference on Information Systems,* Barcelona, Spain.

Tiwana, A. (2000). *The knowledge management toolkit: Practical techniques for building a knowledge management system.* Upper Saddle River, NJ: Prentice-Hall.

Verkasalo, M., & Lappalainen, P. (1998). A method of measuring the efficiency of the knowledge utilization process. *IEEE Transactions on Engineering Management, 45*(4), 414-423.

Wasko, M.M., & Faraj, S. (2000). "It is what one does": Why people participate and help others in electronic communities of practice. *The Journal of Strategic Information Systems, 9*(2-3), 155-173.

Wei, C., Hu, P.J., & Chen, H. (2002). Design and evaluation of a knowledge management system. *IEEE Software, 19*(3), 56-59.

Zhang, W., & Watts, S. (2003). Knowledge adoption in online communities of practice. *International Conference on Information Systems*, Seattle, WA.

Zack, M.H. (1999). Managing codified knowledge. *Sloan Management Review, 40*(4), 45-58.

ENDNOTE

[1] These two models have alternately been labeled as integrative and interactive architectures, respectively (Zack, 1999).

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